

Abstracts

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ADSA Midwest Branch**

**March 16-18, 2015
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ANIMAL BEHAVIOR, HOUSING, & WELL-BEING: HOUSING AND TECHNOLOGY TO ADDRESS ANIMAL WELFARE

- 001 **Associations among temperament, feather pecking behavior, and meat quality characteristics in two strains of turkeys.** M. A. Erasmus*, H. C. Lee, I. Kang, J. C. Swanson, *Michigan State University, East Lansing.*

Research with several species has demonstrated that individual differences in behavior or temperament influence animal well-being and economically important characteristics such as meat quality. In particular, differences in fearfulness are related to feather pecking in laying hens and meat quality in pigs and cattle. Associations between temperament, feather pecking, and meat quality have not been examined in turkeys. The objectives of this research were to 1) compare responses of male turkeys of a commercial (COMM) and randombred (RB) strain in an open field (OF) test, which is often used to assess fear and activity levels in poultry; 2) examine strain differences in feather pecking and meat quality characteristics (pH and L*, a*, and b* color values); and 3) examine relationships among OF behavior, feather pecking, and meat quality. Turkeys were housed in groups of 16 in 4 pens/strain and individually tested in an OF (2.74 × 2.74 m, divided into 81 squares) at 11 wk. Turkeys were classified as high responders (HR: COMM $n = 31$; RB $n = 25$) or low responders (LR: COMM $n = 13$; RB $n = 22$) based on OF behavior (latency to walk, s , numbers of steps taken, and defecations produced). Meat quality characteristics were evaluated after processing at 15 to 17 wk (COMM, $n = 44$) and 20 to 21 wk (RB, $n = 47$). Commercial turkeys defecated less (PROC MIXED, SAS; lsmean ± SE; COMM: 0.3 ± 0.1 ; RB: 0.6 ± 0.1 ; $P = 0.04$) and took longer to start walking in the OF (PROC LIFETEST, SAS; median [25 to 75% range]; COMM: 600 [163 to 600]; RB: 337 [83 to 600]; $P = 0.05$). There were no strain differences in the frequency of feather pecking or meat quality characteristics. Within strains, LR were the recipients in a greater number of feather pecking events per bird per day vs. HR (PROC NPAR1WAY, SAS; median [25 to 75% range]; COMM LR: 0.06 [0.04 to 0.09] vs. COMM HR: 0.03 [0.03 to 0.05], $P = 0.02$; RB LR: 0.03 [0.02 to 0.07] vs. RB HR: 0.02 [0.02 to 0.04], $P = 0.08$). However, there were no differences in meat quality characteristics between HR and LR of either strain. Under the conditions of this study, there was little difference in meat quality between the smaller RB

and larger COMM male turkeys. Results further revealed that within strains, turkeys that were less active in the OF (LR) were pecked more frequently compared with HR, but individual differences in OF behavior did not appear to be associated with differences in meat quality.

Key Words: behavior, meat quality, turkey

- 002 **The effect of overgrown claws on behavior and claw lesions of sows in farrowing crates.** J. A. Calderón Díaz¹, I. M. J. Stienezen¹, F. C. Leonard², L. A. Boyle^{1,*}, ¹*Pig Development Department, Teagasc Animal and Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork, Ireland,* ²*University College Dublin, Dublin, Ireland.*

This study evaluated the relationship between overgrown rear claws and other types of claw lesions (CL), and their effect on behavior of sows in farrowing crates. The study used 24 multiparous sows (mean parity 4.7), 13 with overgrown (OG) rear claws (68 ± 12.6 mm) and 11 controls (48 ± 5.2 mm). All front and hind weight bearing claws were examined for CL on the day of transfer to the farrowing crate (d 110 of gestation) once the sows were lying down. Claw lesions were scored according to severity using a 4-point scale. A total lesion score for the front and hind feet and overall total lesion score were calculated. Behavioral measurements focused on the period prior to farrowing and 1 wk later. Twenty sows (13 control and 9 OG sows) were video recorded for approximately 12 h before farrowing to capture postural behavior for 6 h prior to the birth of the first piglet. An index of the proportion of time spent in different postures was calculated by sampling sow postural behavior every 10 min. Lying-down behavior and sow behavior while standing at feeding were directly observed during 3 feeding events within a week of farrowing, commencing approximately 10 min prior to feed delivery and terminating once the sows resumed lying. For the behaviors while standing, the average number of bouts/min was calculated. Data were analyzed using the Kruskal Wallis test in PROC NPAR1WAY of SAS. There was no difference ($P > 0.05$) between treatments in the lesion scores of the front claws on d 110. Sows on the OG treatment had higher scores in the hind claws for cracks in the wall ($P < 0.05$), cork screw dew claws ($P < 0.05$), and higher total hind feet lesion score ($P < 0.05$) on d 110. There was no difference between treatments in the time sows spent in the different postures prior to farrowing ($P > 0.05$). One week after farrowing, sows on the OG treatment spent less time standing ($P < 0.05$) and feeding ($P < 0.01$) and

slipped ($P < 0.05$) and shifted their weight ($P < 0.05$) between the hind feet more frequently than control sows. Sows on the OG treatment also made more attempts to stand up ($P < 0.01$) and had a shorter latency to lie-down ($P < 0.01$) after feeding. Overgrowth of the hind claws was associated with increased scores for other types of claw lesions, with an increase in slipping and weight shifting and disruptions to feeding and lying/standing behavior in the farrowing crate.

Key Words: lactating sows, lying-down behavior, overgrown claws, postural behavior

003 **The effect of corrective claw trimming on gait analysis of sows.** A. Tinkle^{1,*}, K. J. Duberstein¹, M. E. Wilson², M. A. Parsley³, M. K. Beckman², M. J. Azain¹, C. R. Dove¹, ¹*University of Georgia, Athens*, ²*Zinpro Corporation, Eden Prairie, MN*, ³*Zinpro Corporation, Sheridan, IN*.

Problems with feet and legs are a continuous issue and major cause of early culling in sow herds. This is of great concern to producers, as demands for changes to sow housing and flooring are made. The objective of this study was to ascertain kinematic adaptations following corrective claw trimming of sows. In this study, 17 sows individually walked a semicircular track (4 m diameter) immediately pre-, 1 h post-, and 48 h posttrimming. Pigs exited the track through a circular then straight chute (0.6 m wide) system, where they were video recorded. As sows moved perpendicularly to 2 synchronized cameras, they were simultaneously filmed on each side. The straight chute consisted of 2.4 m prerecording distance, followed by 2.4 m recording frame, and 1.7 m postrecording distance. A third camera was positioned to film sows from the rear as they passed through the recording frame. Pigs were timed electronically, as they walked through the recording frame, and repetitions falling outside of a 10% deviation from the mean were eliminated. Each pig was walked until 5 useable repetitions were achieved. After the pre-trimming video, claws were correctively trimmed to between 5 and 5.5 cm in length. Videos were analyzed using a 2-dimensional kinematic software program (Kinovea) to assess duration of swing, stance, and breakover, in addition to 2- and 3-limb support phases. Stride duration, swing:stance ratio, stance as a percentage of stride duration, and breakover as a percentage of stride duration were also calculated. Data were analyzed using the PROC MIXED procedure of SAS. Analysis revealed a decrease ($P < 0.05$) in overall stride duration (1.0335, 1.0024, 0.9786 s for pre-, 1 h post-, and 48 h posttrimming, respectively). Decrease stride duration was also indicated by decreased swing time ($P < 0.05$; 0.4146, 0.4086, 0.3903 s for pre-, 1 h post-, and 48 h posttrimming, respectively) and breakover duration (0.1522, 0.1392, 0.1290 s for pre-, 1 h post-, and 48 h posttrimming, respectively). This data supports the practice of claw trimming to improve gait quality of the sow, which may influence sow longevity and culling rate.

Key Words: gait analysis, locomotion, sow, swine

004 **Selection of variables for predicting and comparing number of skin lesions.** K. E. Wurtz^{1,*}, J. P. Steibel^{1,2}, R. O. Bates¹, C. W. Ernst¹, J. M. Siegford¹, ¹*Department of Animal Science, Michigan State University, East Lansing*, ²*Department of Fisheries and Wildlife, Michigan State University, East Lansing*.

Legislative and consumer pressure to improve sow welfare is driving the transition to group housed systems for gestating sows. While group housing provides increased space and socialization, there is increased potential for aggression that can cause injury and stress leading to poor production and increased culling rates. This work is part of a larger study aimed at estimating genetic and environmental sources of variation affecting aggression in group housed prepubertal and gestating sows. The objective of this work is to estimate systematic environmental effects affecting the number of skin lesions, which are a proxy for inferring levels and types of aggressive interactions between pigs. Three-hundred-and-twenty purebred Yorkshire pigs are being housed in groups of 10 pigs/pen (0.21 m²/pig) in nursery pens and 13 to 15 pigs/pen (0.84 m²/pig) in finisher and gilt pens. Remixing by weight to emulate mixing in commercial settings occurs at weaning, at transition to grow-finish, and at gilt retention for breeding. At each mixing, the number of familiar and unfamiliar pigs is held constant for each group. Numbers of fresh lesions (<24 h old) were collected premixing, 24-h postmixing, and 3 wk postmixing to examine individual response to mixing and performance in established social settings. Analysis was performed using a generalized over-dispersed Poisson mixed model. Fixed effects included phase of production (3 levels), observer (2 levels), sex (2 levels), measure (3 levels), and a live weight covariate. All fixed effects were deemed significant ($P < 0.0001$). Both nursery pigs and market weight gilts had significant differences in total lesions prior to mixing and 3 wk postmixing, as well as between 24-h postmix and 3 wk postmix ($P < 0.01$). There was no significant difference between premixing and 3 wk postmixing lesion numbers, suggesting that pigs return to premixing levels of aggression (Nursery: $P = 0.8479$, Sow: $P = 0.1865$). Finishing pigs had significant ($P < 0.0001$) differences in total number of lesions between each measure; however, the least square mean differences between premix and 3 wk postmixing were minor (0.7404 compared with 1.1608 and 1.9012). These preliminary results are encouraging because they suggest that there is extensive variation in skin lesions that can be modeled and attributed to systematic factors. Given the variation observed in the phenotype, it is recommended to increase the sample size to 1120 pigs across 8 replications as planned in future stages of this study.

Key Words: group housing, lesions, pigs

005 Lameness detection trial in a commercial environment using an embedded microcomputer based force plate system.

B. M. McNeil^{1,*}, J. D. Stock¹, J. A. Calderón Díaz¹, T. D. Parsons², A. K. Johnson¹, L. A. Karriker³, S. T. Millman³, S. J. Hoff⁴, K. J. Stalder¹, ¹*Department of Animal Science, Iowa State University, Ames*, ²*Department of Clinical Studies, School of Veterinary Medicine, University of Pennsylvania, Kenneth Square*, ³*Iowa State University College of Veterinary Medicine, Ames*, ⁴*Agricultural and Biosystems Engineering, Iowa State University, Ames.*

Visual locomotion scoring systems are commonly used to evaluate lameness; however, their reliability depends on observer training and experience. Therefore, developing a more accurate lameness detection method is needed. The embedded microcomputer based force plate system (force plate) is an objective measuring tool that uses the sow's weight distribution to detect lameness, which has been used in lab-based lameness trials with induced lameness and proven successful. The objective of this study was to identify whether the force plate differed from visual scoring in lameness detection in a commercial setting. The force plate system was installed under 1 of 2 electronic sow feeders in a dynamic group pen with 120 multiparous sows for 21 d. Force distribution was recorded continuously during the 21 d. Force recordings were made once per second beginning when feed was provided to the sow and all 4 feet were on their specific quadrants. The average force distribution measurement per week was calculated, and a cutoff of 10% difference in force distribution between limbs was used to classify a sow as lame or nonlame for each week. Additionally, sows were visually evaluated using a 0 to 3 lameness assessment scale (0 = normal and 3 = severely lame) every week by an experienced observer and then classified as nonlame (score ≤ 1) or lame (score ≥ 2). Data were analyzed using generalized estimated equations in SAS PROC GENMOD. Model included lameness scoring method, measuring week, and their interaction. There was no difference in lameness classification between the 2 scoring methods (odds ratio = 1.0; CI = 0.43 to 2.32; $P > 0.05$). There was an increase in the number of sows classified as lame, by both the force plate and visual assessment, on wk 1 (Odds ratio = 1.28; CI = 0.80 to 2.04; $P < 0.05$) compared with wk 2, but there was no difference in the number of lame sows between wk 2 and 3 ($P > 0.05$). The results of this research suggest that the force plate system can work in a commercial system to identify lameness in group-housed sows. Further work is necessary to investigate how lameness progresses over time and to create a decision tree to improve force plate lameness detection accuracy when lameness is evaluated on a daily basis.

Key Words: lameness detection, sow, weight distribution

Table 006. Production results of sows in EM, PS, and LM treatments.

Parameter	EM	PS	LM	SEM	<i>P</i>
Conception rate, %	97.62	94.05	86.9		0.028
Wean to service interval, d	4.06	4.51	4.31	0.28	0.672
Total born	15.18	15.64	15.45	0.46	0.708
Born alive	13.72	12.86	12.93	0.45	0.312
Still born	0.88	1.28	1.35	0.16	0.078
Mummies	0.34	0.32	0.41	0.09	0.777

006 Mixing strategies for group-housed gestating sows: Effects on production. J. A. Brown^{1,*}, Y. M. Seddon¹, Y. Li², M. M. Bouvier¹, ¹*Prairie Swine Centre, Saskatoon, SK, Canada*, ²*University of Minnesota, West Central Research and Outreach Center, Morris.*

Social stress from mixing sows has the potential to negatively affect sow production and welfare. Housing sows in stalls from weaning until 5 wk after breeding is a common strategy used to prevent aggression and ensure control over individual feeding during breeding, conception, and implantation. However, pressure to reduce stall use will likely continue, and alternative management options should be explored. This study compared the effects of 3 mixing strategies on sow performance in fully-slatted pens. A total of 252 sows were studied over 6 replicates, in groups of 14 sows/pen (2.2 m²/sow). Treatments consisted of: i) early mixing (EM): sows mixed into groups at weaning; ii) late mixing (LM): sows stall-housed at weaning and mixed at 5 wk gestation; iii) presocialization (PS): sows mixed for 2 d after weaning, then stall housed for breeding up to 5 wk gestation, after which they were mixed (same sows). Sows were fed once daily in free-access stalls, after which they were locked out of the stalls, ensuring that sows spent up to 22 h/d in the loafing area. Breeding and farrowing performance was recorded. Production data were analyzed for differences between treatments using the GLIMMIX procedure of SAS, with treatment, parity, replicate, and their interaction included in the model. Where applicable, total born was included as a covariate. The number of animals to conceive after 1 service was analyzed by Fisher's exact test. Production results are shown in Table 006. The lower conception rate of the LM sows may reflect suboptimal stimulation of estrus during stall housing. In comparison, the EM and PS groups received mixing stress immediately postweaning, which may have stimulated follicular growth and clearer estrus expression. A tendency for fewer stillborn piglets in EM sows may result from improved fitness and/or activity levels during early gestation. For other variables, EM sows performed similarly to PS and LM sows. These results suggest that, under good management conditions, mixing sows at weaning does not negatively impact sow performance.

Key Words: gestation, grouping, production, sows

007 **Effect of feeding system (dry vs. liquid) on the behavior of wean to finish pigs.** D. Menon*, D. P. Pangeni, J. Kim, P. Ren, X. Yang, S. Baidoo, *Southern Research and Outreach Center, University of Minnesota, Waseca.*

A study was undertaken to compare the behavior of wean to finish pigs that have been acclimatized to liquid and dry feeding systems. Randomly selected pigs ($n = 192$; Yorkshire \times Large White) \times Duroc); 100 ± 4 d of age) of both sexes (barrows and females), were housed in groups of 8 each (12 replicates) and fed 2 dietary treatments (liquid and dry). Four pigs from each pen were randomly selected as focal pigs for behavioral observations. The pigs on liquid feed were fed equal meals, 6 times daily (liquid feeding system, Big Dutchman Pig Equipment, Vechta, Germany), whereas those on dry feed were fed ad libitum from single space feeders. Water was available for all pigs ad libitum. A time lapse video recording system (Nuvico AI1600) was used to record continuously the behavior of the focal pigs over a period of 3 h in the morning (8-11 am) and 3 h in the afternoon (1 to 4 pm) for 2 d/wk, for 2 mo. The recordings were analyzed using the Noldus Observer XT v.11.5, and data analyzed using the GLM procedure of SAS version 9.3. The data were arcsin square root transformed. Comparisons were made between the sexes, feeding systems and periods of the day. None of the behavior variables were affected by sex. The major behavior categories (based on % time spent) identified were standing ($5.97 \pm 1.5\%$), resting ($51.93 \pm 2.4\%$), locomotion ($8.51 \pm 1.32\%$), feeding ($9.39 \pm 1.23\%$), drinking ($1.95 \pm 0.52\%$), exploring the pen ($11.65 \pm 1.46\%$), agonistic behaviors ($3.63 \pm 0.83\%$), and comfort behaviors ($7.35 \pm 1.73\%$). The total activity times were not significantly different in the 2 systems. The pigs were significantly more active in the morning ($P < 0.01$) than afternoon, while agonistic ($P < 0.001$) and comfort behaviors ($P < 0.001$) were significantly more in the afternoon. The pigs on liquid feed were found to spend significantly more time resting ($P < 0.05$), doing agonistic activities ($P = 0.05$), and exploring the pen ($P = 0.001$) when compared those on liquid feeding system. Pigs on dry feed spent significantly more time standing ($P < 0.01$), and showed significantly more locomotory ($P < 0.05$) activities in the morning when compared with those on liquid feeding system. Time spent on agonistic behaviors was significantly more in liquid feeding system as the pigs have to compete for feed at the time it is dropped. In conclusion, the feed restriction in liquid feeding system affected the behavior patterns of wean to finish pigs.

Key Words: behavior, dry feed, liquid feed, pigs

008 **Effect of shade on performance, carcass quality, and welfare of finishing cattle fed a beta-adrenergic agonist in a commercial feedlot.** J. A. Hagenmaier*, S. J. Bartle, C. Reinhardt, D. Thomson, *Kansas State University, Manhattan.*

Finishing feedlot cattle fed a beta-adrenergic agonist ($n = 1,395$; BW= 568 ± 43 kg) were used to evaluate the effects of shade on performance, carcass quality, and welfare during the summer in a Kansas commercial feedlot. Cattle were randomly assigned to 1 of 2 treatments: 1) no shade or 2) shade. At 26 to 53 d prior to slaughter, 7 pens of predominately black steers or heifers (4 and 3, respectively, $n = 7$ replications per treatment) were randomly divided and allocated to 2 pens across the feed alley from each other: 1 pen shaded and 1 pen nonshaded. Pen served as the experimental unit. Prevalence of cattle open-mouth breathing was recorded at least once weekly based on expected daily ambient temperature, humidity, and wind. Weather data were collected continually throughout the trial using a National Weather Service (NWS) weather station located 1.6 km away from the feedlot. Both pens within a replicate were shipped and harvested at the same slaughter facility on the same day. Duration of trial (mean = 38.4 d, range = 26 to 53 d) and shade area per animal within shaded pens (mean = $1.46 \text{ m}^2/\text{animal}$, range = 1.13 m^2 to $1.78 \text{ m}^2/\text{animal}$) varied between replicates. No difference in ADG was observed between shaded and nonshaded cattle (1.94 vs. 1.97 ± 0.17 kg; $P = 0.27$). Shaded cattle had greater DMI than nonshaded cattle (10.77 vs. 10.52 ± 0.78 kg; $P = 0.01$). Shaded cattle tended to be less feed efficient (5.64 vs. 5.37 ± 0.25 kg; $P = 0.09$). No difference in HCW was noted between treatments (404 vs. 402 ± 30 kg; $P = 0.30$). Percentage of cattle grading choice or better tended to be greater for the shade-treatment cattle (72 vs. $67 \pm 8\%$; $P = 0.12$). Shade-treatment cattle had a greater dressing percentage than nonshaded cattle (65.4 vs. $65.05 \pm 0.3\%$; $P = 0.01$). Shade reduced the prevalence of cattle open-mouth breathing on observation days (4% vs. 1% ; $P < 0.001$). During the relatively mild summer of 2013 (mean daily maximum temperature = $31.44, \pm 4.36$ C), providing shade for finishing cattle during the final 26 to 53 d on feed resulted in fewer cattle open-mouth breathing, increased dressing percentage, and tended to increase quality grade. Shaded cattle had greater feed intake; however, the nonshaded cattle tended to be more feed efficient and no difference in ADG was observed between treatments.

Key Words: animal welfare, dry matter intake, feedlot cattle

**BILLY DAY SYMPOSIUM:
HISTORY AND CURRENT STATUS
OF SOME MILESTONES IN SWINE
REPRODUCTION RESEARCH**

009 Control of the estrous cycle, ovulation, time of insemination, and subsequent farrowing in swine.

S. K. Webel^{1,*}, R. R. Kraeling², ¹*JBS United, Inc., Sheridan, IN*, ²*L&R Research Associates, Watkinville, GA*.

The quest to develop methods for control of the estrous cycle in swine began almost 80 yr ago. However, Dr. Day and co-workers (C. Polge and T. W. Groves) were the first to describe a method for estrous cycle and ovulation control in gilts in 1968. Dr. Day and co-workers demonstrated that insemination at a predetermined fixed time, without estrus detection, resulted in pregnancy rates comparable to conventional insemination methods. Although the methods described in this publication are not available in the United States today, predetermined fixed-time insemination in swine has become a reality 4 decades later. This presentation will review research and discuss development of pharmaceutical products that support and accomplish the objectives implied in this pioneering paper "to examine techniques for controlling ovulation and insemination at a predetermined time and eliminate the need for estrus detection." We will present data and discuss products recently approved by the FDA for estrous cycle control and ovulation induction which makes synchronization of the time of insemination possible. In addition, the authors will review Dr. Day's early work on parturition induction and discuss the research that led to development of products that enable swine producers to inseminate gilts and sows at a predetermined fixed time and to subsequently schedule sows to farrow on a predetermined day. This technology will allow pig farmers to control and schedule key production activities, increase piglet survival, and improve farm efficiency.

Key Words: estrous synchronization, farrowing induction, fixed-time insemination

010 In vitro maturation and fertilization. H. Funahashi*, *Okayama University, Okayama, Japan*.

Technologies associated with in vitro maturation (IVM) and fertilization (IVF) of porcine oocytes have been developed with a number of research trials for the past quarter century. However, the efficiency to produce blastocysts in vitro through these technologies is expected to have further drastic improvement for a couple decades. The origin of oocytes, such as sexual maturation of donor females, estrous cycle, and follicular size, is known to affect the efficiency of in vitro embryo production. Brilliant Cresyl Blue assay has also been confirmed to be useful in several species to select cumulus-

oocyte complexes (COCs) with a higher developmental competence. To improve the successful rate of embryo production, it is very effective to supplement various factors secreted from oocytes and/or cumulus cells, as well as to regulate cumulus plasma cyclic adenosine monophosphate (cAMP) levels during IVM. Activities of glucose metabolism, fatty acid beta-oxidation and mitochondria during IVM also affect the early development to the blastocyst stage following IVF. Through these modifications, not only COCs from middle-size follicles (MF; 3-6 mm in diam.), but also those from small follicles (SF; 1 to 3 mm in diam.) have been used for in vitro production of porcine embryos, though the developmental competence of SF oocytes is still lower than those from MF. Efforts to expand gamete resources for IVM-IVF may contribute to prepare materials for bioengineering and also accelerate genetic improvement in pigs.

Key Words: in vitro fertilization, in vitro maturation, pig

011 Evolution and adoption of artificial insemination in the United States. W. Flowers*, *North Carolina State University, Raleigh*.

Some of the first published reports on swine AI in the United States date back to the early 1960s. At this time, 8.2 million sows were kept on mostly outdoor operations and were 1 component of diversified farms. Use of AI was sporadic. Currently, there are 5.8 million sows that are housed in specialized indoor production facilities and over 90% are bred artificially. The objective of this presentation is to review key events that led to the implementation of AI by the U.S. swine industry. In the late 1960s, spiral-tipped Melrose catheters were introduced by scientists from universities in Missouri and Illinois upon their return from sabbaticals in Europe. This design simplified insemination; decreased sperm losses; and allowed researchers to focus on determining optimal insemination doses. During the 1970s and 1980s, much of the work was devoted to the evaluation of extenders that could maintain both the viability and fertility of initially frozen and later fresh semen. Beltsville Thawing Solution was developed during this period by scientists working at the USDA Animal Reproduction Laboratory in Beltsville, MD, and still is one of the most popular and effective porcine semen extenders. It was also during the 1980s when the inaugural meetings of the International Conference on Pig Reproduction and the International Conference on Boar Semen Preservation were held. Both continue to meet every 4 yr and have contributed significantly to the growth of AI by providing forums for scientific exchange and by fostering international collaborations. During the late 1980s and through most of 1990s, consolidation and specialization within the commercial sector resulted in the growth of large, specialized sow farms and major pork processors adopted carcass-merit buying programs. These structural changes within the industry gave AI distinct economic advantages over natural service by reducing produc-

tion costs and increasing the value of market animals. It has been estimated that the proportion of sows bred artificially in the United States increased from about 10% in the late 1980s to at least 85% by 2000. During the past 15 yr, improvements have been made in most AI technologies including freezing semen. Identification of putative fertility markers and development of transcervical insemination techniques are 2 notable ones that hold potential to further transform how swine AI is routinely done on U.S. farms.

Key Words: artificial insemination, swine, United States

012 **Nonsurgical embryo transfer in pigs.** E. A. Martinez*, C. Cuello, I. Parrilla, J. L. Vazquez, J. M. Vazquez, J. Roca, M. A. Gil, *University of Murcia, Murcia, Spain.*

There is enormous potential for the use of embryo transfer (ET) in pigs because it allows the movement and introduction of new genetic material into a herd with minimal risk of disease transmission, reduced transportation costs, and no effect on animal welfare. Despite these advantages, the commercial use of ET in pigs is very limited due to the lack of effective nonsurgical ET procedures. Although the first pregnancy in pigs through nonsurgical ET was reported 45 yr ago (Polge and Day, 1968; *Vet Rec* 82:712), nonsurgical ET was considered as an impossible technique for many years because of the complex anatomy of the swine genital tract. However, in the 1990s, several nonsurgical techniques to deposit embryos directly into the uterine body were developed, although most of them were not successful, achieving farrowing rates of 5 to 41% and litter sizes of 5 to 7.5 piglets. To overcome some physiological and practical limitations of nonsurgical uterine body ET, in 2000, in collaboration with the laboratory of Dr. B. N. Day at the Animal Science Research Center, University of Missouri-Columbia, we developed a simple, safe, and quick procedure for the nonsurgical transfer of embryos deep into a uterine horn (NsDU-ET) of gilts and sows with acceptable farrowing rates (71.4%) and litter sizes (6.9 piglets). With the recent improvement of the procedure, the results have been greatly increased when using fresh morulae and blastocysts cultured for 0 to 6 h or fresh morulae cultured for 24 h (80 to 90% farrowing rate and 9.0 to 9.5 piglets born). Although a period of 24 h of culture permits the international transport of embryos, cryopreservation of embryos is obviously preferred. Currently, a high percentage (80 to 95%) of untreated morulae and blastocysts survive the vitrification procedure and high farrowing rates (75%) and litter sizes (10 piglets) are obtained when these embryos are surgically transferred into the recipients. However, when embryo vitrification and NsDU-ET are combined, the farrowing rates are decreased (50%), although the litter sizes are maintained. The excellent reproductive performance of recipients following nonsurgical transfer of fresh embryos and the promising results obtained with vitrified embryos represent a fundamental advance for the widespread commercial

use of ET by the pig industry in the near future. Supported by MINECO-FEDER (AGL2012-38621), Madrid, Spain, and Fundación Séneca (GERM 04543/07), Murcia, Spain.

Key Words: blastocyst, porcine, transfer

BREEDING AND GENETICS: FUNCTIONAL GENOMICS

013 **The value of a systems biology approach in cattle nutrition.** J. C. McCann*, J. J. Loor, *University of Illinois, Urbana-Champaign, Urbana.*

The inception of high-throughput, genome-enabled technologies (e.g., microarray, next-generation sequencing) in combination with advances in biology-driven bioinformatics has been essential for the creation of modern systems biology and concurrent decline in a reductionist approach. Systems biology is a field of study that seeks to improve the understanding of complex biological interactions occurring within cells and tissues by information at the gene, protein, and metabolite level. These systems concepts are an ideal fit for investigating the interaction between nutrition, the microbiome, and the physiological state with tissue metabolism and function during key life stages of livestock. Within the systems context, single time point studies in nutriphysiogenomics are reductive and are unable to identify the dynamics in biological adaptations; thus, longitudinal time-course experiments are essential. With the current ease of generating large transcriptome and metabolite data sets, robust bioinformatics tools are becoming more essential to obtain meaningful interpretation of the data. The dynamic impact approach (DIA) was originally developed to help link the longitudinal physiological adaptations to lactation occurring simultaneously in liver, adipose, and mammary tissues. Results based on our own and publically available data sets indicate that DIA is robust for physiological systems analysis of complex transcriptome data sets within a tissue or among tissues and allows simultaneous visualization for the complex intertissue adaptations to nutrition. This tool, in addition to the gene and transcriptional factor (TF) network analyses using popular software suites, such as ingenuity pathway analysis, is well-suited to interpret high-throughput data sets. An example of this approach using liver, mammary, and adipose tissue during the transition period is presented. Furthermore, we present examples of novel insights obtained from the interaction between epithelial tissue and ruminal microbiome involving nutritional management of beef and dairy cattle. Overall, we demonstrate that an integrative approach across and within tissues provides a more complete understanding of the complex dynamic physiological responses to nutrition in cattle. Longitudinal analyses of functional and TF networks within liver, skeletal muscle, epithelium, and adipose in response to nutrition may be useful for fine-tuning nu-

tritional management of beef and dairy cattle. Specific goals also include identifying key molecular players in tissue adaptations to relevant nutritional management.

Key Words: bioinformatics, nutrition, systems

014 **Adventures in next generation sequencing of transcriptomes and genomes.** J. F. Taylor*, P. C. Tizioto, N. V. Grupioni, J. Kim, J. E. Decker, R. D. Schnabel, *University of Missouri, Columbia.*

Next generation sequencing (NGS) has become a powerful tool for the identification of a variety of classes of variation within the genome, as well as for the characterization of gene expression, regulatory RNAs, and epigenetic marks such as methylation. The cost of sequencing has decreased to the point that whole genomes can be sequenced to coverage depths of up to 30× for less than \$5,000. As a consequence, at least 3,000 bovinds have now been sequenced and many more samples have been analyzed for global transcriptome profiling. We have sequenced or traded 25.5 total born (TB) of whole genome sequence on 476 animals from dog (125), water buffalo (64), bison (3), and 17 cattle breeds (284), and these are being used to identify Mendelian loci responsible for disease or reproductive failure (early embryonic lethals) as well as for the elucidation of the causal variants underlying large-effect QTL. The imputation of Illumina BovineSNP50 or BovineHD genotypes to full sequence variation can be accomplished with remarkable accuracy, and breeds such as American Angus now have more than 60,000 animals genotyped with the BovineSNP50 assay. Imputation of these genotypes to full sequence enables the identification of moderate frequency variants that occur as homozygotes in frequencies much less than expected under Hardy Weinberg Equilibrium, suggesting that they are likely to be lethal or severely deleterious. Genomewide association study performed on sequence level data will likely result in the rapid identification of the variants that underlie large-effect QTL particularly when these variants segregate in multiple breeds and differences in the patterns of linkage disequilibrium across breeds can be used to differentiate between causal and associated variants. We have also generated 2.3 TB of RNA-seq (sequence) data on 153 animals to identify genes that are involved in the immune response to the pathogens responsible for bovine respiratory disease and those differentially expressed among animals that differ in feed efficiency. As a consequence, much of the work within the lab has evolved from wet-lab to computational activities, and the ability to program in Perl or Python is requisite for a student's survival in a modern livestock genomics environment. Limitations to the utility of NGS data continue to be the inadequacy of the reference assemblies and their annotation particularly for the locations of regulatory elements including enhancers and repressors, the lack of reference assemblies for indicine or for other important taurine breeds, and the lack of a high quality transcriptome includ-

ing isoforms. These are high priorities for all livestock species and USDA NIFA funding must be allocated to quickly resolve these deficiencies.

Key Words: genome sequencing, Mendelian loci, quantitative trait loci

015 **Beef cattle metabiomes and their relationships with economically important phenotypes.** P. R. Myer*, J. E. Wells, T. P. L. Smith, L. A. Kuehn, H. C. Freetly, *USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE.*

The selection and optimization of economically important phenotypes in cattle, such as feed efficiency, has long been an effort devoted to host genetics, management, and diet. Feed costs remain the largest variable cost in beef production, and consequently, the improvement of feed efficiency is of significant economic and environmental importance. However, the various microbial populations within the gastrointestinal tract as a whole are critical to the overall well-being of the host and need to be examined when determining the interplay between host and nonhost factors affecting feed efficiency. To address this, we examined the microbial communities within the rumen and locations throughout the lower gastrointestinal tract (GIT) from steers differing in feed efficiency. Within 2 contemporary groups of steers, individual feed intake (FI) and BW gain were determined from animals fed the same ration. Within contemporary group, BW was regressed on FI, and the 4 most extreme steers within each Cartesian quadrant were sampled ($n = 16/\text{group}$). Bacterial 16S rRNA gene amplicons were sequenced from the GIT content using next-generation sequencing technology. Although no differences were detected by bacterial diversity and richness metrics, changes in the relative abundances of microbial populations and operational taxonomic units did reveal differences between feed efficiency groups. These studies suggest the GIT microbiome differs at the 16S level in cattle that vary in efficiency of weight gain. It is not clear whether host factors are driving changes in the microbiome or changes in the microbiome are contributing to differences in feed efficiency. Partially funded by National Institute of Food and Agriculture Grant 2011-68004-30214 National Program for Genetic Improvement of Feed Efficiency in Beef Cattle. USDA is an equal opportunity provider and employer.

Key Words: 16S rRNA, feed efficiency, microbiome

016 **Mass spectrometry based proteomics and metabolomics: Phenotyping in the Postgenomics Era.** C. D. Broeckling*, J. E. Prenni, *Colorado State University, Fort Collins.*

While genome data is more readily available than ever before, the genome in isolation fails to describe the phenotype of an organism in a given condition. This limitation has driven the development of high throughput and broad scale phenotyp-

ing efforts. Metabolomics and proteomics are 2 phenotyping platforms which aim to describe the biochemical phenotype of an organism, and how it responds to the environment. This presentation will describe these 2 'omics' fields broadly, introduce the chromatographic and mass spectrometry technology that is being used toward these ends, and describe selected case studies implementing these platforms.

Key Words: metabolomics, phenotype, proteomics

017 **Metabolomic differences in early and late lactation first-parity gilts.** L. A. Rempel*, J. R. Miles, *USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE.*

Investigating the metabolome provides the evaluation of all cellular processes occurring while accounting for environmental influence, and may provide additional information for selection criteria to fully evolve. Blood samples and body condition measurements were acquired from 68 first-parity gilts at postfarrowing and weaning. Twenty gilts were retrospectively selected for similar ($P \geq 0.4475$) number of piglets born and nursed, and similar ($P \geq 0.3141$) body condition traits postfarrowing, yet exhibited minimal or extreme change ($P \leq 0.0094$) in BW (-8.6 ± 1.48 and -26.1 ± 1.90 kg, respectively) and backfat thickness (-1.3 ± 0.67 and -4.7 ± 0.86 mm, respectively) from postfarrowing to weaning. The plasma metabolome at postfarrowing and weaning was investigated using nontargeted ultrahigh pressure liquid chromatography-mass spectrometry (UPLC-MS) and gas chromatography-mass spectrometry (GC-MS). Retention time alignment and feature detection and matching were performed in XC-MS using raw spectral data. Grouping of features yielded approximately 700 compounds from each of the 2 techniques. An ANOVA was performed on each detected compound in R for time of collection, body condition change, and the interaction, followed by a false discovery correction. No differences were detected for the interaction, and only 2 compounds were different for extreme vs. minimal body condition change. However, several compound differences ($P \leq 0.10$) were identified between postfarrowing and weaning. Thirty-two of the 84 significant compounds detected by UPLC-MS had at least a fold change of ± 1.0 , while only 18 compounds had a fold change of ± 0.6 for the significant GC-MS compounds. Annotation of several compounds implicated various metabolic pathways. Unsurprisingly, creatinine was greater at weaning ($P = 0.0224$), and others have reported increased serum concentrations of creatinine in response to BW loss. A liver metabolite associated with protein catabolism was also greater ($P = 0.0007$) at weaning. Phospholipid compounds were greater ($P \leq 0.0347$) at weaning. Two putative inositol-related compounds were greater ($P \leq 0.0236$) at weaning. Inositol compounds have been implicated in second messenger signaling in the brain, while others may exert insulin-like effects. A fructose epimer was greater ($P = 0.0731$) at weaning and has several physiologically relevant

traits including glucose suppression, reactive oxygen species scavenging, and neuroprotective activity. Lactation is a metabolically demanding event that may have unfavorable impacts on sow lifetime potential. Plasma biomarkers may prove useful as nutraceuticals or aide in metabolome-genomewide association studies to ascertain genetic points of interest relevant to body condition loss during lactation. USDA is an equal opportunity provider and employer.

Key Words: gas chromatography-mass spectrometry, gilts, lactation, liquid chromatography-mass spectrometry, metabolomics

018 **Annotation of functional regulatory elements in livestock species.** H. Zhou^{1,*}, P. J. Ross¹, I. Korf¹, M. E. Delany¹, H. Cheng², J. F. Medrano¹, A. L. Van Eenennaam¹, C. W. Ernst³, C. K. Tuggle⁴, ¹*University of California, Davis*, ²*USDA-ARS Avian Disease and Oncology Laboratory, East Lansing, MI*, ³*Genetics Program, Michigan State University, East Lansing*, ⁴*Bioinformatics and Computational Biology Program, Department of Animal Science, Iowa State University, Ames.*

Genomics is playing an increasing role in improving animal production, health, and well-being. In order for a genome to be fully utilized, it needs to be well annotated. The goal of this project is to improve the annotation of regulatory regions for 3 of the most important farm animal genomes: chicken, cow, and pig. These genomes have been assembled, but there is very limited information on the enhancers, promoters, and insulators of the currently annotated genes. Recent work by the human and mouse ENCODE projects provide a blueprint for identifying the functional roles of regulatory elements in the human and mouse genomes, that can be implemented for similar efforts on animal genomes. Our specific goals are: 1) identify promoter, enhancer, and silencer regions using DNase-seq and CHIP-seq for specific chromatin marks, 2) determine functional roles of regulatory regions by integrating CHIP-seq, DNase-seq, and RNA-seq (sequence) data, and 3) freely distribute all data to the public including the UCSC and Ensembl genome browsers. As a part of the Functional Annotation of ANimal Genomes (FAANG) initiative and supported by the NRSP8 Cattle, Chicken and Swine and commodity groups, we have ensured that the proposed tissues, assays and protocols are consistent with currently developing FAANG guidelines. This study will set a cornerstone for initiating farm animal ENCODE projects by providing a valuable resource for exploring the functional landscapes of the chicken, bovine, and swine genomes, and provide a valuable tool for a deeper and more meaningful understanding of complex biological systems.

Key Words: annotation, ENCODE, farm animal, Functional Annotation of ANimal Genomes initiative, regulatory elements

BREEDING AND GENETICS I

- 019 **Estimates of genetic parameters and response to 10 generations of selection for residual feed intake in Yorkshire pigs.** W. L. Hsu^{1,*}, J. M. Young², E. D. Mauch¹, J. C. M. Dekkers¹, ¹*Iowa State University, Ames*, ²*North Dakota State University, Fargo*.

Objectives were to estimate response to 10 generations (G) of divergent selection for residual feed intake (RFI = observed feed intake – expected feed intake) in Yorkshire pigs and to estimate genetic parameters for growth performance traits. The low RFI (LRFI) line was selected for decreased EBV for RFI during grow-finish. The high RFI (HRFI) line was randomly selected until G4 and then selected for increased EBV for RFI from G5 to G10. Both lines were maintained with ~50 litters by ~12 boars, avoiding full- and half-sib matings with ~70 gilts per generation, except ~10 boars and ~40 gilts that produced ~30 litters in the first 4 generations of the HRFI line. Records analyzed were for pigs with off-test BW > 102 kg (n = 2,224). ASReml software was used to estimate variance components, EBV, and responses to selection. The mixed model for analysis of ADFI, ADG, and feed conversion ratio (FCR = ADFI/ADG) included the fixed effects of pen within contemporary group, sex, and a covariate of on-test age, and random effects of additive genetic, litter, and residual. The model for ultrasound traits of backfat (BF), loin muscle area (LMA) also included off-test BW as a covariate. Estimates for RFI were based on analysis of ADFI with additional covariates of on-age, on-test BW, off-test BW, ADG, BF, and average metabolic BW. Responses to selection based on EBV were compared with results from separate phenotype-based analyses of each generation using the MIXED procedure of SAS and to genetic trends obtained from separate genetic analyses by line. Estimates of heritability of RFI, ADFI, ADG, BF, LMA, and FCR were 0.28 ± 0.05, 0.45 ± 0.05, 0.38 ± 0.05, 0.49 ± 0.06, 0.53 ± 0.06, and 0.29 ± 0.05, respectively. Estimates of genetic correlations of RFI with ADFI, ADG, BF, LMA, and FCR were 0.69 ± 0.07, 0.16 ± 0.13, 0.23 ± 0.12, -0.32 ± 0.11, and 0.68 ± 0.08, respectively. After 9 generations of selection, the LRFI line had 201.4 g/d lower RFI (3.0 genetic SD), 276.9 g/d lower ADFI (2.1 SD), 29.1 g/d lower ADG (0.5 SD), 2.29 mm lower BF (0.82 SD), 1.48 cm² greater LMA (0.43 SD) and 0.26 g/g lower FCR (1.88 SD) than the HRFI line. In conclusion, feed efficiency based on RFI is moderately heritable and responds to selection. This work was supported by USDA-NIFA-AFRI-2011-68004-30336.

Key Words: pig, residual feed intake, selection

Table 020. Genomic prediction accuracies when training in 1 RFI line and validating on the other

Method	Training	ADFI	ADG	BF	LMA	FCR	RFI
Bayes-B	L-RFI	0.36	0.36	0.24	0.36	0.06	0.31
	H-RFI	0.39	0.32	0.29	0.22	0.18	0.34
Bayes-C	L-RFI	0.35	0.34	0.23	0.30	0.28	0.32
	H-RFI	0.40	0.32	0.20	0.26	0.14	0.43

- 020 **Genomic prediction accuracies of residual feed intake and component traits of feed efficiency in pigs divergently selected for residual feed intake.** N. V. L. Serão^{1,*}, E. D. Mauch¹, W. L. Hsu¹, A. Wolc^{1,2}, M. F. Rothschild¹, J. C. M. Dekkers¹, ¹*Iowa State University, Ames*, ²*Hy-Line International, Dallas Center, IA*.

The objective of this work was to evaluate the accuracy of genomic predictions for residual feed intake (RFI) and component traits of feed efficiency in 2 lines of pigs selected for high (H-RFI) and low (L-RFI) RFI (defined as observed feed intake minus expected feed intake). Phenotypic and genotypic data on 994 L-RFI pigs from Generations 0 to 10 of selection and 698 H-RFI pigs from Generations 4 to 10 were used in this study. Pigs were on-test at 95 ± 15 d of age (39.8 ± 10.9 kg BW) and off-test at 202 ± 17 d of age (115.8 ± 7.4 kg BW). Phenotypic data included average daily feed intake (ADFI), ADG, backfat depth (BF), loin muscle area (LMA), feed conversion ratio (feed-to-gain ratio; FCR), and RFI (ADFI adjusted for ADG, LMA, BF, and metabolic BW). All animals were genotyped using the Illumina PorcineSNP60 BeadChip, and after quality control, 51,098 SNP were used for analyses. For genomic prediction, 1 line was used as the training dataset and the other for validation. Marker effects were estimated for all SNP using the genomic prediction methods Bayes-B and Bayes-C, fitting as many SNP as degrees-of-freedom available after accounting for fixed-effects in the model. Accuracy of genomic prediction was calculated in the validation set as the correlation of genomic predictions with phenotype pre-adjusted for fixed effects, divided by the marker-based heritability. Results are in Table 020. Overall, accuracies were sizeable, considering that training and validation were separated by at least 5 generations of selection, and both Bayesian genomic prediction methods resulted in similar results. The only trait with inconsistent results was FCR, in which Bayes-B resulted in low accuracy (0.06) and Bayes-C in moderate accuracy (0.28) when training on L-RFI and validating on H-RFI. These results suggest that RFI and component traits can be predicted between divergent lines selected for RFI using high-density SNP genotypes. Financial support from AFRI-NIFA grant No. 2011-68004-30336 is appreciated.

Key Words: feed intake, genetic improvement, single nucleotide polymorphisms

Table 021. Heritability and prediction accuracy (correlation) from BayesC and BayesB.

Trait	h^2	BayesC	BayesB
Birth weight	0.42	0.65	0.71
Weaning weight	0.24	0.52	0.54
Yearling weight	0.27	0.52	0.54

021 Genomic prediction of growth traits in Brangus

beef cattle. Z. Q. Weng^{1,*}, H. Su¹, J. Lee¹, J. Zeng¹, D. J. Garrick², ¹*Iowa State University, Ames*, ²*Massey University, Palmerston North, New Zealand*.

The availability of a variety of SNP panels could influence the cost-effectiveness or the accuracy of genomic prediction in cattle. The objective of this study was to evaluate the prediction accuracy of direct genomic breeding values (DGV) for growth traits in Brangus beef cattle. Estimated breeding values of the 3 studied traits (birth weight, weaning weight, and yearling weight) in 1495 progeny-tested Brangus cattle were obtained from the American Brangus Breeder Association along with their assumed heritabilities (Table 021). The cattle were genotyped using one or another of different SNP panels (Bovine50K, GGPHD77K, or BovineHD770K), then all animals were imputed to BovineHD770K using Fimpute. After quality control, 736,053 segregating SNP remained. Deregressed estimated breeding values (DEBV) were derived from EBV and corresponding accuracies and then fitted in a weighted Bayesian analysis to estimate SNP effects using GENSEL. BayesB and BayesC models were both applied in this study. The population was divided into 5 mutually exclusive groups using K-means clustering methods, in order to perform cross-validation. The accuracy of prediction was assessed as the genetic correlation between DEBV and DGV. The prediction accuracies were sizeable in these 3 traits, ranging from 0.52 to 0.71 (Table 021). The accuracies from BayesB were slightly higher than those from BayesC. The results indicated that it is promising to apply DGV for routine evaluation in Brangus cattle. Breeders could improve prediction accuracy in young animals and therefore increase selection response by selecting on DGV.

Key Words: Brangus, deregressed estimated breeding value, genomic prediction

022 Genetic variance and covariance components for feed intake, average daily gain, and postweaning gain in growing beef cattle.

K. J. Retallick^{1,*}, J. M. Bormann¹, R. L. Weaber¹, M. D. MacNeil¹, H. L. Bradford¹, H. C. Freetly², W. M. Snelling³, R. M. Thallman², D. W. Moser¹, L. A. Kuehn², ¹*Kansas State University, Manhattan*, ²*USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE*, ³*USDA, ARS, US MARC, Clay Center, NE*.

Feed is the single most expensive cost related to a beef cattle production enterprise. Data collection to determine feed efficient animals is also costly. Currently, a 70 d performance test is recommended for accurate calculation of efficiency. Previous research has suggested intake tests can be limited to 35 d; however, decreased lengths in gain tests have been suggested to have detrimental effects on accuracy. The objective of this study was to estimate genetic parameters for growth and intake traits. On-test ADFI, on-test ADG, and postweaning gain (PWG) records on 5,606 growing steers and heifers were obtained from the U.S. Meat Animal Research Center in Clay Center, NE. The 3-generation pedigree contained 9,211 animals from 27 different breed groups. On-test ADFI and ADG data were collected from a minimum of 62 to 148 d testing days. Independent quadratic regressions were fitted for BW on time, and on-test ADG was predicted from the resulting equations. The PWG was calculated by subtracting 205-d weights from 365-d weights and dividing by 160 d. Heritability and genetic and residual correlations were estimated using multiple trait animal mixed models with ADG, ADFI, and PWG for both sexes as dependent variables. Postweaning gain and feed efficiency contemporary groups were fitted as fixed effects. Covariates included age on test, age of dam, direct heterosis, and breed origin. Variance components were estimated with ASReml 3.0. Heritability estimates \pm SE for ADG, ADFI, and PWG of steers were 0.09 ± 0.03 , 0.43 ± 0.05 , and 0.37 ± 0.05 , respectively; and corresponding estimates for heifers were ADG 0.14 ± 0.04 , ADFI 0.39 ± 0.05 , and PWG 0.42 ± 0.05 . These estimates confirm genetic improvement of feed efficiency can be made. The genetic correlations between steer ADG and ADFI, PWG and ADFI, and ADG and PWG were 0.73 ± 0.12 , 0.58 ± 0.06 , and 0.81 ± 0.15 , respectively; and corresponding estimates for heifers were 0.64 ± 0.13 , 0.77 ± 0.05 , and 0.65 ± 0.12 . The genetic correlations between ADG and PWG for both sexes were strong. This indicates PWG is a strong proxy for ADG on-test and long test periods may not be necessary. A shorter testing period would allow more animals to be tested per year with a given set of facilities.

Key Words: beef cattle, feed efficiency, genetic parameters

023 Accuracies of genomic and pedigree based predictions for swine litter size traits in Large White and Landrace breeds.

A. M. Putz^{1,*}, K. A. Gray², C. Maltecca¹, M. Knauer¹, F. Tiezzi¹, ¹*North Carolina State University, Raleigh*, ²*Smithfield Premium Genetics, Rose Hill, NC*.

Breeding value accuracy of young animals is a key determinant of achievable genetic gain. The objective of this study was to compare the accuracy of prediction for young animals using GEBV from single-step GBLUP vs. traditional pedigree EBV for litter size traits. Four years of sow performance data were provided by Smithfield Premium Genetics (Rose Hill, NC) on

4810 Large White and 4418 Landrace sows. Traits included: total number born (TNB), number born alive (NBA), litter size at d 5 (LS5), litter size at weaning (LSW), and number weaned (NW). Litter size at d 5 and LSW were calculated by subtracting preweaning mortalities with age < 5 d or total deaths from TNB, respectively, according to the biological litter. Number weaned was recorded as the number of piglets that were removed from the sow at the time of weaning. Genotyping was completed with the Illumina Porcine 60k BeadChip. After editing, the total number of effective SNP was 32,719 and 31,350 for Large White and Landrace, respectively. The number of animals genotyped for Large White and Landrace was 3264 and 1976, respectively. Accuracy of prediction was defined as the correlation between adjusted phenotype with GEBV and EBV for dams with genotypes, after accounting for the effect of year-season, farm, and parity. Full datasets included 16 year-seasons over the 4 yr. Validation datasets included the last 3 year-seasons of the full dataset; 29 and 27% for Large White and Landrace, respectively. Heritability estimates for TNB, NBA, LS5, LSW, and NW were 0.05, 0.06, 0.06, 0.06, and 0.05 for Large White and 0.07, 0.07, 0.08, 0.09, and 0.07 for Landrace, respectively. The GEBV (EBV) accuracies for Large White were 0.082 (0.073), 0.104 (0.085), 0.101 (0.096), 0.099 (0.107), and 0.058 (0.088) for TNB, NBA, LS5, LSW, and NW, respectively. GEBV (EBV) accuracies for Landrace were 0.101 (0.144), 0.118 (0.149), 0.210 (0.185), 0.269 (0.236), and 0.223 (0.192) for TNB, NBA, LS5, LSW, and NW, respectively. Accuracies were greater for Landrace than Large White and inconsistent between breeds for each trait. Results showed that the GEBV had a greater correlation with adjusted phenotype than EBV in 6 out of the 10 comparisons. Further research will need to be completed to understand accuracy of prediction in litter size traits for young animals.

Key Words: accuracy, litter size, piglet mortality

024 Improved accuracy of genomic prediction combining linkage disequilibrium and co-segregation by fitting haplotypes in addition to SNP genotypes.

X. Sun*, R. L. Fernando, D. J. Garrick,
J. C. M. Dekkers, *Iowa State University, Ames.*

In livestock populations, evidence has been increasing that genomic prediction models that fit SNP genotypes (SNP model) have high accuracy only when prediction candidates are closely related with the training population. Further, increasing SNP density generally has limited impact on prediction accuracy. Results from field datasets suggest that historical linkage disequilibrium (LD) between QTL and SNP may be low because many QTL have low minor allele frequency (MAF), while SNP used for genotyping typically have moderate to high MAF. In these cases, prediction accuracy comes mainly from cosegregation (CS) between QTL and SNP that is implicitly captured by SNP genotypes. In this study, fitting 1-cM haplotypes across the genome to explic-

Table 024. Average prediction accuracies and standard errors (in parentheses) in the 1st (Gen1) and 8th (Gen8) validation generation across 50 replicated datasets with different MAF of QTL and the number of SNP per cM (No. SNP/cM). MAF of SNP were between 0.06 and 0.5.

MAF of QTL	No. SNP/cM	SNP model			SNP-haplotype model		
		Gen1	Gen8	Decrease	Gen1	Gen8	Decrease
0.01–0.5	20	0.920 (0.004)	0.862 (0.010)	0.058 (0.008)	0.918 (0.004)	0.859 (0.010)	0.059 (0.008)
0.01–0.06	20	0.815 (0.016)	0.637 (0.035)	0.178 (0.027)	0.849 (0.013)	0.708 (0.032)	0.141 (0.024)
0.01–0.06	200	0.861 (0.013)	0.663 (0.038)	0.198 (0.028)	0.895 (0.010)	0.753 (0.031)	0.142 (0.023)

itly capture CS information, in addition to fitting SNP genotypes to capture historical LD information (SNP-haplotype model), is proposed to improve accuracy when historical LD between QTL and SNP is low. Datasets were simulated for a pedigree with 13 nonoverlapping generations. The first 5 generations, with 2,455 individuals in total, were used for training to predict breeding values for each of the following 8 generations, each with 600 individuals. Results showed that the SNP-haplotype model had significantly higher prediction accuracy across validation generations than the SNP model when historical LD was low, but had similar accuracy as the SNP model when historical LD was high. When the SNP density increased from 20 to 200 SNP per cM, the increase in accuracy was greater for the SNP-haplotype model than for the SNP model (Table 024). In conclusion, when historical LD is low, the accuracy from the SNP model is mainly contributed by CS information that is implicitly captured by SNP genotypes. Fitting haplotypes increases accuracy under low LD by explicitly capturing CS information. Increasing SNP density substantially improves the CS information between haplotypes and QTL, but has little effect on the LD between QTL and SNP when they have different MAF.

Key Words: accuracy, co-segregation, haplotype

025 Comparison of a QTL versus marker effects model for genomic prediction with training across families, generations, or breeds.

J. Zeng*, D. J. Garrick, R. L. Fernando, *Iowa State University, Ames.*

Accurate prediction of genetic merit of selection candidates using dense marker genotypes requires a large training dataset. In practice, the number of training individuals from the same contemporary group as the selection candidates is usually limited. Thus, genotypic and phenotypic records from other contemporary groups such as other families, generations, or breeds are pooled together to increase the training size. However, association signals between contemporary groups may not be consistent due to different linkage disequilibrium (LD) patterns in founders and different co-segregation patterns in nonfounders. Marker effects models such as GBLUP and

BayesC do not account for the heterogeneous association signals across contemporary groups. Therefore, accuracy of prediction may not improve with increasing training size. In this study, a QTL effects model is developed to accurately model the heterogeneous association patterns across contemporary groups, where putative QTL are assumed in every centimorgan chromosomal segment. LD is modeled through the conditional gene frequency at the putative QTL given the surrounding marker haplotypes in founders, which is assumed to be the same for all contemporary groups from a breed. Co-segregation is modeled by tracing the inheritance of the putative QTL alleles along with the surrounding marker haplotypes in nonfounders. The marker and QTL models were compared using simulated training populations consisting of multiple contemporary groups that went across families, generations, or breeds, with candidates from a single contemporary group that was not included in training. The simulated genome had one 1-morgan chromosome with 20 QTL and 20,000 markers that were segregating in the founders. Three scenarios were simulated, where QTL and markers were in strong LD, weak LD, or linkage equilibrium (LE) in the founders, while markers were always in LD. In the strong LD scenario, BayesC and the QTL model had similar accuracy, which was up to 11.0% higher than GBLUP with SE < 0.8% across 16 replicates, as the number of contemporary groups for training increased. In the weak LD scenario, the QTL model had accuracy up to 12.9% (SE < 0.8%) higher than BayesC and up to 17.7% (SE < 0.9%) higher than GBLUP. In the scenario with LE between QTL and markers, accuracy from BayesC and GBLUP diminished with increasing number of families or breeds, whereas accuracy from the QTL model was persistent and up to 39.7% higher than BayesC and up to 40.5% higher than GBLUP (SE < 1.7% for both). In conclusion, the QTL model had higher accuracy of prediction when training population consisted of multiple contemporary groups.

Key Words: combined training dataset, genomic prediction, quantitative trait loci effects model

026 Genome-wide association and genomic prediction of response to infection for two isolates of Porcine reproductive and respiratory syndrome virus.

E. H. Waide^{1,*}, N. V. L. Serão¹, A. Hess¹, R. R. R. Rowland², J. K. Lunney³, G. S. Plastow⁴, J. C. M. Dekkers¹, ¹Iowa State University, Ames, ²Kansas State University, Manhattan, ³USDA, ARS, BARC, APDL, Beltsville, MD, ⁴University of Alberta, Edmonton, Canada.

The Porcine reproductive and respiratory syndrome (PRRS) Host Genetics Consortium and Genome Canada projects aim to identify genetic loci associated with response to PRRS virus (PRRSV) infection. The objective of this study was to analyze data from 13 trials of ~200 nursery piglets infected with 1 of 2 PRRSV isolates, NVSL97-7985 (NVSL) and KS2006-

72109 (KS06). Phenotypes included weight gain (WG) from infection to 42 d postinfection (dpi) and viral load (VL; area under the curve of log-PCR viremia from 0 to 21 dpi). Piglets were genotyped using the Illumina PorcineSNP60 Beadchip. Previous results using the NVSL trials of this data identified a large QTL on *Sus scrofa* chromosome (SSC) 4 that influenced both VL and WG. Genomic association analyses of VL and WG using all data and data from each PRRSV isolate separately were performed using Bayes-B. Genomic prediction accuracies were calculated as the correlation between genomic prediction and phenotype preadjusted for fixed effects, divided by square root of heritability. Marker-based heritabilities when analyzing all data were 0.43 for VL (0.47 for NVSL; 0.53 for KS06) and 0.35 for WG (0.36 for each isolate). The SSC4 QTL explained the largest amount of genetic variance for VL for both isolates (13.4% for NVSL; 7.5% for KS06) and also for WG in the NVSL trials, 10.8%. This QTL was not associated with WG in the KS06 trials (explained 0.11% of genetic variance), possibly because KS06 is less virulent, resulting in lower VL than the NVSL isolate. All other 1-Mb windows explained less than 2.2% (VL) and 3.6% (WG) of the genetic variance for both isolates and were not consistent between isolates. Accuracies of genomic prediction for KS06 data when training on NVSL were 0.32 (VL) and 0.40 (WG), respectively, while accuracies for NVSL data when training on KS06 were 0.42 (VL) and 0.17 (WG). When the SSC4 QTL genotype was included as a fixed-effect in the model and its correspondent 5-Mb region was removed from the genomic analyses, accuracies for VL based on the rest of the genome decreased to 0.14 for both training data analyses but remained unchanged for WG. These results show that there are genomic regions other than the SSC4 region that explain genetic variation in response to both PRRS isolates and that genomic prediction of host response to PRRSV infection for 2 isolates is possible. Support from PRRS-CAP, USDA-NIFA 2008-55620-19132, Genome Canada, and the breeding companies that provided pigs.

Key Words: genome-wide association study, prediction, PRRS

027 A comparison of viremia profiles between piglets infected with one of two isolates of Porcine reproductive and respiratory syndrome virus.

A. Hess^{1,*}, Z. Islam², R. R. R. Rowland³, J. K. Lunney⁴, A. Doeschl-Wilson⁵, S. C. Bishop⁵, G. S. Plastow⁶, J. C. M. Dekkers¹, ¹Iowa State University, Ames, ²Roslin Institute, University of Edinburgh, Edinburgh, Scotland, ³Kansas State University, Manhattan, ⁴USDA, ARS, BARC, APDL, Beltsville, MD, ⁵The Roslin Institute and R(D)SVS, University of Edinburgh, Midlothian, UK, ⁶University of Alberta, Edmonton, Canada.

Log serum viremia under Porcine reproductive and respiratory syndrome virus (PRRSV) infection has been shown to be appropriately modeled by the Wood's curve, which is often used to

model lactation yield in dairy cattle. Previously, infection with PRRSV isolate KS-2006-72109 (KS06) was found to result in 5.8 ± 0.7 units lower viral load (VL), defined as area under the curve of log viremia for 0 to 21 dpi, than infection with PRRSV isolate NVSL-97-7895 (NVSL). The objectives of this study were to: 1) compare 3 parameters that describe viremia profiles based on the Wood's curve between these 2 isolates of PRRSV, and 2) estimate the heritabilities of these parameters for each isolate. The parameters were: time to peak viremia (TP), peak viremia (PV), and rate of postpeak clearance (CL). This study used data on 3 commercial crosses paired across 5 PRRSV infection trials with NVSL and 3 trials with KS06, in which ~200 piglets per trial were experimentally infected with virus at 28 to 35 d of age. Viremia was determined from serum collected periodically from 0 to 42 d postinfection (dpi). A Wood's curve and a biphasic extended Wood's curve were compared with identify piglets with a rebound in viremia. To evaluate differences in TP, PV, and CL between isolates, phenotypes for these parameters were analyzed in a model in SAS (v.9.4) that included isolate, parity, and rebound (yes or no) as fixed effects, age and weight at infection as covariates, and trial, pen within trial, sire, and litter as random effects. Compared with KS06, NVSL infected piglets reached peak viremia 1.87 ± 0.60 ($P = 0.0161$) d sooner, had 1.03 ± 0.15 ($P = 0.0002$) log higher PV, and cleared viremia $8.91 \pm 2.88\%$ ($P = 0.0170$) more quickly. To estimate heritabilities of these parameters, a similar model was run in ASReml 3.0 for each isolate, replacing sire with the genetic effect of animal using a within-breed genomic relationship matrix generated from the PorcineSNP60 Beadchip, and excluding virus and trial within virus. Heritability of TP was similar for NVSL (0.36 ± 0.08) and KS06 infections (0.27 ± 0.11). Heritability of PV for KS06 infections (0.43 ± 0.09) was triple that for NVSL (0.13 ± 0.07), and heritability of CL was higher for NVSL (0.36 ± 0.08) infections than KS06 (0.22 ± 0.10). This study shows that TP, PV, and CL are moderately heritable, and differences in these parameters are responsible for the difference in VL between NVSL and KS06. This work was supported by Genome Canada, USDA ARS, and breeding companies of the PHGC and PigGen Canada.

Key Words: pigs, PRRSV, viremia profile

028 **Genomic prediction of host response to co-infection with PRRSV and PCV2b using a PRRSV-only infected training population.** J. R. Dunkelberger^{1,*}, E. H. Waide¹, N. V. L. Serão¹, J. K. Lunney², R. R. R. Rowland³, J. C. M. Dekkers¹, ¹*Iowa State University, Ames*, ²*USDA, ARS, BARC, APDL, Beltsville, MD*, ³*Kansas State University, Manhattan*.

The objective of this study was to evaluate the accuracy of genomic prediction of host response to co-infection with Porcine reproductive and respiratory syndrome virus (PRRSV) and porcine circovirus type 2b (PCV2b) using a PRRSV-only infected training population. The training dataset included 9 PRRS Host Genetics Consortium (PHGC) trials of PRRSV-

infected commercial crossbred nursery pigs: 6 trials infected with the NVSL isolate ($n = 1055$) and 3 trials with the KS06 isolate ($n = 528$). The PRRS viral load (VL; area under the curve [AUC] of log-PCR viremia from 0 to 21 d postinfection [dpi]), and weight gain (WG) from 0 to 42 dpi were evaluated. Effects of 40,813 SNP were estimated using Bayes-B for the following training scenarios: NVSL trials, KS06 trials, and all trials, with or without genotype for the WUR SNP (previously associated with response to PRRSV infection) as a fixed effect, to evaluate predictive ability of the remainder of the genome. Data from an independent, unrelated PHGC trial in which commercial nursery pigs ($n = 203$) were co-infected with PRRSV and PCV2b were used for validation. For the validation dataset, PRRS and PCV2b VL were defined as AUC from 0 to 21 and 0 to 42 dpi, respectively, and were preadjusted for fixed effects, including or excluding WUR. Accuracy of genomic prediction was assessed as the correlation between estimated and preadjusted phenotypes. Since the training population was infected with PRRSV only, PCV2b VL of the validation dataset was predicted using PRRS VL. Pedigree-based heritability estimates in the validation data were 0.17 ± 0.15 , 0.28 ± 0.13 , and 0 for WG, PRRS, and PCV2b VL, respectively. When WUR was not fitted as a fixed effect for the training data, prediction correlations were 0.14, 0.07, and 0.22 for PRRS VL, 0.11, 0.12, and 0.10 for WG, and ~0 for PCV2b VL when training on both isolates, NVSL, and KS06, respectively. When WUR was excluded from predictions, corresponding correlations were 0.12, 0.14, and 0.11 for WG, -0.03, -0.11, and 0.03 for PRRS VL, and -0.13, -0.14, and -0.03 for PCV2b VL. The latter negative correlations with PCV2b VL may suggest a negative genetic correlation between PRRS VL of a PRRSV-only infected population, and PCV2b VL in a population co-infected with PRRSV and PCV2b. In conclusion, genomic predictions from a PRRSV-infected population appear to have some predictive ability for host response in pigs co-infected with PRRSV and PCV2b. This work was supported by the USDA ARS NIFA award 2012-38420-19286 and by PIC/Genus and Choice Genetics.

Key Words: PCV2b, pigs, PRRSV

BREEDING AND GENETICS II

029 **Selection for maintenance energy requirements in mice: Lifecycle biological efficiency.** A. S. Bhatnagar^{*}, M. K. Nielsen, *University of Nebraska, Lincoln*.

Divergent selection for heat loss as an indication of maintenance energy requirements in mice resulted in low (ML) and high (MH) maintenance lines, and an intermediate control line (MC) in 3 replicates. Improved individual feed efficiency has been observed in ML mice, which would be economi-

cally beneficial in livestock species. However, previous work showed evidence of unfavorable correlated responses in reproductive performance and body composition of ML mice compared with MH mice. Therefore, the objective of this study was to use these lines to model a lifecycle similar to a livestock production system and determine if these correlated responses diminish the benefit of improved individual feed efficiency by calculating lifecycle efficiency. Feed intake, reproductive performance, productivity, and body composition were recorded on 21 mating pairs and sampled offspring from each line by replicate combination. Pairs were cohabitated at 7 wk of age and maintained for up to 1 yr unless culled, and offspring were maintained from 21 to 49 d of age. Results from mixed-model analysis of recorded data were used to calculate total lean output of offspring and culled mating pairs and total energy intake of offspring and mating pairs. Lifecycle efficiency was calculated as the sum of offspring and parent output divided by the sum of offspring and parent input. Survival was measured as number of parities achieved by a mating pair. Hypothetical parity distribution of 100 pairs at equilibrium was calculated using survival analysis results assuming a maximum of 4, 8, or 12 parities, and efficiency was calculated separately for each scenario. High maintenance mice consumed 7 to 20% more feed for maintenance per unit body mass than ML mice. Control mice had greater BW, total numbers weaned, and weaning weights compared with MH and ML animals, while there were no significant differences between MH and ML mice for these traits. Control mice had greater survival rates overall, although ML mice had greatest survival rates up to 5 parities, while MH mice had greater survival rates in later parities. Although ML mice were more efficient over a lifecycle than MH mice, they were nearly identical to MC mice due to poorer productivity. Differences in BW and numbers weaned had the greatest effect on lifecycle efficiency, therefore selection for reduced maintenance energy requirement should be utilized as part of selection indices, which also include positive emphasis on output, or in terminal sire lines, to minimize negative responses.

Key Words: feed efficiency, heat loss, maintenance energy

030 Selection for feed efficiency: Direct and correlated responses on production traits in two rabbit lines selected under ad libitum and restricted feeding.

H. Gilbert^{1,*}, L. Drouilhet¹, J. Ruesche¹, A. Tircazes¹, M. Theau-Clément¹, T. Joly², E. Balmisse¹, H. Garreau¹, ¹INRA UMRI1388 GenPhySE, F-31326 Castanet-Tolosan, France, ²ISARA-Lyon, F-69007 Lyon, France.

Two alternative traits to feed to gain ratio (feed conversion ratio, FCR) were studied in growing rabbits to compare strategies for the genetic improvement of feed efficiency: Residual feed intake (RFI), to select low ad libitum feed intake inde-

pendently from production level, and ADG under fixed restricted feeding (ADG_R, 80% of ad libitum). One line has been selected for each trait (Generations 0 to 9) from the same population G0. Records comprised about 2,450 rabbits per line, for BW at weaning (30 d of age, BW30) and slaughter (63 d of age, BW63) and feed consumption, ADG, FCR, and RFI were computed. Heritability and genetic correlations were computed, together with responses to selection in each line. Selection criteria showed similar heritabilities (0.21 ± 0.04 for RFI, 0.29 ± 0.05 for ADG_R) and responses to selection in the 2 lines (-0.34 genetic SD, σ_a^2 , per generation for RFI, $+0.29 \sigma_a^2$ per generation for ADG_R). Responses to selection were $-0.30 \sigma_a^2$ per generation on FCR in both lines, and genetic correlations with selection criteria were close to unity. Genetic correlations between selection criteria and BW30 and BW63 differed between lines: estimates with BW30 and BW63 were 0.72 ± 0.33 and 0.10 ± 0.17 , respectively, with RFI, and -0.44 ± 0.19 and 0.63 ± 0.15 with ADG_R. The genetic correlation in the RFI line between RFI and ADG was -0.09 ± 0.14 . Consequently, responses to selection were null on ADG and limited on BW63 in the RFI line, whereas they were highly significant in the ADG_R line. To further examine responses to selection, in Generation 9, the 2 selected lines have been compared with the G0 control population (using frozen embryos) under ad libitum and restricted feeding by testing 30 individuals per line and feeding level combination. All lines had the same BW30. The ADG_R animals fed ad libitum ate the same amount as G0 animals. When fed ad libitum RFI animals grew at the same rate as G0 rabbits and ADG_R animals grew faster than these groups ($P < 0.001$), whereas both selected lines grew faster than G0 animals when restricted ($P < 0.001$). As a result, despite different feed intakes and BW63, independently from the feeding level both selected lines had a similar improved G:F (2.62 ± 0.02) compared with the G0 line (2.82 ± 0.02). Thus, the breeding objectives for BW at slaughter and feed intake are the key to choose a selection criterion to improve feed efficiency, together with the feeding level during selection.

Key Words: average daily gain, feed efficiency, residual feed intake

031 Statistical methods for eQTL mapping using

RNA-seq data. D. Velez-Irizarry*, C. W. Ernst, R. O. Bates, P. D. Reeb, Y. L. Bernal Rubio, N. E. Raney, J. P. Steibel, *Department of Animal Science, Michigan State University, East Lansing.*

Mapping expression quantitative trait loci (eQTL) provides insight into gene expression regulation. When RNA-seq (sequence) data is used to fit eQTL, proper statistical analysis requires addressing issues such as: 1) Shrinking variance component estimates to increase power of eQTL detection in small samples, and 2) Accounting for population structure to avoid spurious associations. The goal of this research is to propose statistical models for eQTL analysis with applica-

tion to crosses of outbred livestock populations. We used LM RNA-seq and SNP genotype data for 24 female pigs from the F2 generation of the MSU Duroc × Pietrain population. We compared 2 analysis models. The first model is GBLUP-based GWA, which fits all markers simultaneously, 1 transcript at a time. The advantages of this model are that it can prescreen transcripts by their heritability and account for population substructure through the genomic relationship matrix. Its disadvantage is that fitting 1 transcript at a time does not result in borrowing information across genes. An alternative is to fit a differential expression model implemented in the package LIMMA. LIMMA fits markers 1 at a time for all transcripts simultaneously. This provides the advantage of shrinking variance components and borrowing information across genes, at the price of not being able to model random effects, thus, not easily accounting for population stratification. To overcome this limitation we propose fitting $k = 4$ principal components (PC) of the relationship matrix as fixed effects, accounting for 34% of relationship matrix variation. With GBLUP-based GWA, the h^2 was not significantly different from 0 for any transcript after correcting for multiple testing, thus there were no eQTL detected. We attribute this to a flat likelihood surface due to small sample size. On the other extreme, the LIMMA model detected 33,000 eQTL ($qvalue < 0.1$) if PC were excluded, and 4,000 eQTL ($qvalue < 0.1$) when PC were fit as fixed effects. Similarly, the number of putative hotspots detected (markers associated with more than 1000 transcripts) reduced from 14 to 4 when PC were fit. We hypothesize that the difference is due to an excess of false positives when population structure is ignored. To test this hypothesis, we performed permutation of phenotypes with respect to genotypes and confirmed that including PC reduced the number of false positive eQTL. We conclude that LIMMA had more power for eQTL detection than GBLUP, but population structure needs to be accounted for using PC.

Key Words: expression quantitative trait loci, RNA-sequence, pigs

032 **Evidence of RNA editing in pig longissimus dorsi muscle.** S. A. Funkhouser^{1,*}, J. P. Steibel², R. O. Bates², N. E. Raney², C. W. Ernst^{1,2}, ¹*Genetics Program, Michigan State University, East Lansing,* ²*Department of Animal Science, Michigan State University, East Lansing.*

RNA editing refers to posttranscriptional modifications of an RNA transcript (excluding processes such as splicing or polyadenylation) that alter its sequence such that it no longer reflects the corresponding DNA sequence. In swine, as in all mammals, most RNA editing is thought to be catalyzed by adenosine deaminase acting on RNA, which substitutes adenosine for inosine in a site-specific and tissue-dependent manner. This is observed as an adenosine to guanine edit of RNA with respect to DNA in next-generation sequencing, where inosine is

converted into guanine during cDNA library preparation. Our objective was to use next-gen sequencing data to identify potential RNA editing sites in pigs. We used genomic DNA and LM total RNA from an F2 pig from the Michigan State University Duroc-Pietrain resource population. Non-strand-specific polyA RNAseq data from LD was used to call candidate RNA editing sites. Whole genome sequence was used to call genotypes. DNaseq and RNAseq sequence reads were aligned to SScrofa 10.2 using Bowtie 2 and TopHat, respectively. To minimize mapping error, only high quality bases (Phred score > 25) from uniquely mapped reads were used in the analysis. Candidate editing sites were required to have homozygous genotypes in DNaseq data, with a sequencing depth of at least 10 reads, with 95% or more of the reads in agreement. Five or more RNAseq reads with an alternative allele were required to give sufficient evidence for a possible editing event. A total of 686 candidate RNA editing sites were observed with A to G edits being the most common. These sites were found across all autosomes and the X chromosome, with the majority located in upstream and downstream gene proximal regions, intronic variants and untranslated regions. Since this analysis was done using a non-strand-specific protocol, A to G and T to C sites cannot be distinguished a priori; the combined frequency of A to G and T to C sites observed was 38.34%. Results of this initial study indicate the overall composition of transcriptome-wide RNA editing in swine resembles other studies in primates, where A to G edit sites are the most common. In primates, RNA editing levels have been associated with diseases such as ALS, tumors, and depression. Future efforts are warranted to identify RNA editing events in additional pig tissues, as well as determine the impacts of RNA editing on transcriptional regulation and economically important phenotypes.

Key Words: ADAR editing, RNA editing, transcriptional regulation

033 **Effect of hair coat shedding on ADG in weaned Angus calves.** B. N. Richardson*, A. J. Cross, J. P. Cassady, *South Dakota State University, Brookings.*

A retained winter hair coat into the summer months of a subtropical climate can be detrimental to cattle. Heat stress in cattle from decreased evaporative cooling due to a dense winter coat is a common occurrence in states that experience hot, humid summers. Hair coat shedding (HCS) has previously been studied in Angus dams and calf weaning weight was shown to be impacted by dam HCS (Gray et. al, 2011). A pilot study indicated that calves that shed their winter hair coat earlier in the summer were heavier and had greater ADG during late summer months (Richardson and Cassady, 2013). The objective of the current study was to further examine the relationship between HCS and postweaning gain in calves. Data were available on Angus calves ($n = 211$) grazing pasture at the Upper Piedmont Research Station in Reidsville, NC, over 2 consecutive years.

Calves were scored for HCS 3 times during the summer by 2 trained technicians using a 1 to 5 scale, with 1 being a slick, summer coat and 5 being a full, winter coat. Body weight was recorded at time of HCS. For analysis, calves were classified into 1 of 3 groups based on HCS for Date 3. These groups represented an early (n = 74), middle (n = 73), and late shed groups (n = 64). Data were analyzed using the Proc Mixed procedure of SAS. The model included fixed effects of sex, year, and shed group and random effect of sire. Traits analyzed were BW at Date 3 and ADG from Date 2 to Date 3. Body weight was affected by sex, year, and shed group, with calves in the early shed group weighing 18.3 kg more than calves in the middle shed group and 28.5 kg more than calves in the late shed group ($P < 0.05$). The ADG was affected by sex, year, and shed group, with calves in the early shed group gaining 0.23 kg/d more than calves in the middle and late shed groups ($P < 0.05$). It was concluded that significant differences in calf growth were associated with hair coat scores. At current market prices, the 18.3 kg difference in weight found between early shedding calves and the middle shed group is worth more than \$100.00 per animal.

Key Words: beef cattle, growth, heat stress

034 **Estimation of the relationship between intramuscular fat, testosterone, and scrotal circumference in yearling Angus bulls.**

J. T. Parham^{1,*}, C. S. Whisnant², G. B. Huntington², M. H. Poore², K. A. Gray³, J. P. Cassady¹, ¹South Dakota State University, Brookings, ²North Carolina State University, Raleigh, ³Smithfield Premium Genetics, Rose Hill, NC.

The objective of this study was to estimate the correlation between intramuscular fat (IMF), testosterone levels, and scrotal circumference (SC) of Angus bulls. Angus bulls (n = 317) were put on an 84 d growth trial at an average age of 276.1 ± 1.15 d with an ADG of 1.51 ± 0.013 kg. The study was conducted in 5 replications over a 5 yr period. Bulls were weighed every 14 d, and individual feed intake was recorded daily. During the first and last week of the trial, SC was measured and blood samples were taken for the purpose of measuring circulating plasma concentrations of testosterone. At those same time points, a certified ultrasound technician captured images which were later evaluated by the National CUP Lab and Technology Center, Ames, IA, to predict IMF, 12th rib fat, and rump fat. Partial correlations were calculated using 3 different statistical models. Each model included the fixed effect of year. Testosterone, IMF, and SC were adjusted using a regression covariate of either d 84 BW, rib fat, or rump fat. Correlations that differed from 0 ($P < 0.01$) were only consistent in traits adjusted for rib fat. Correlations between SC and testosterone, IMF and testosterone, and SC and IMF were 0.46, 0.42, and 0.59, respectively. There were also correlations between testosterone and IMF (0.12; $P < 0.05$) as well as SC and testosterone (0.23; $P < 0.01$) when adjusted for rump fat and IMF and testosterone

(0.19; $P < 0.01$) when adjusted for 84 d weight. When adjusted to a common rib fat there were positive, favorable correlations among testosterone, IMF, and SC. This supports the existing literature. Selection for increased IMF in Angus bulls would not be expected to negatively impact testosterone or SC which are 2 important components of male fertility.

Key Words: beef cattle, fertility, intramuscular fat

035 **The effect of calf sex on dam milk yield in the New Zealand dairy cattle population.**

M. K. Hayr^{1,*}, A. Hess¹, D. J. Garrick², ¹Iowa State University, Ames, ²Massey University, Palmerston North, New Zealand.

Studies in U.S., Canadian, and French dairy cattle have ignited debate over whether the sex of calves influences milk yield of their dams. North American studies have shown milk yield is increased when either the calf born to initiate lactation or the calf in utero during lactation is female. A French study found a small effect of calf sex on milk yield in favor of males and concluded that this effect was too small to have any real effect on profit. The objectives of this study were to 1) investigate whether the sex of the calf born at the beginning of the current lactation or calf sex in neighboring lactations affects milk yield in 274,000 New Zealand Holstein Friesian and 85,000 Jersey cows, and 2) determine whether including an effect for calf sex in national evaluations is likely to affect selection response. Lactations 1 to 3 were analyzed separately. An animal model with fixed effects for herd-year and calf sex across the first 3 or 4 parities was fitted. This model was expanded to include a sex-specific slope for days-in-milk. Spearman rank correlations of breeding values were calculated separately for cows and bulls between the expanded model and an animal model with herd-year as a fixed effect and days-in-milk as a covariate. In the model ignoring days-in-milk, giving birth to a female rather than a male in the current lactation was associated with an increase of between 0.24 ± 0.09 and $1.1 \pm 0.45\%$ milk yield, depending on breed and lactation number. Calf sex in the preceding parity had an effect on milk yield for second lactation Holstein Friesians and third lactation Jerseys. There were significant interaction effects between calf sex in different parities in all lactations. After accounting for days-in-milk, the main effect of calf sex was not significant except for second parity calf sex in the second lactation Holstein Friesians. The rank correlation between breeding values in the models that included or ignored calf sex was 1.00 for both bulls and cows in all lactations and both breeds. This indicates the calf-sex effect was primarily attributed to decreased lactation length in cows that gave birth to male calves, which can be attributed to their increased gestation length. Lactation ceases for the whole herd at once, so the delayed calving date will shorten lactation length. Including information on calf sex is unlikely to have any effect on selection response in New Zealand dairy cattle.

Key Words: breeding values, calf sex, milk yield

036 **Effect of litter size on piglet birth weight and birth weight as an indicator of pig quality.**

C. E. Abell*, R. Komenda, T. Rathje, *DNA Genetics, Columbus, NE.*

Swine maternal line selection programs place large emphasis on litter size. Increasing litter size improves sow production efficiency, but can reduce piglet birth weight. Piglet birth weight is associated with survivability and growth rate. Increasing litter size while maintaining or improving pig quality would maximize production efficiency and profitability for a commercial swine operation. The objective of this study was to determine the effect of litter size on birth weight and the effect of birth weight on growth rate and survivability. All fully formed pigs, including stillborns ($n = 7896$), from 459 Duroc and 248 Yorkshire litters born January to May 2013 at a single farm in Nebraska were weighed at birth. The average birth weight was 1.40 kg for Durocs and 1.21 kg for Yorkshires. Selected pigs were put on-test at $79.6 (\pm 4.9)$ d and taken off-test at $151.1 (\pm 23.8)$ d. Using a model with breed and sex as fixed effects, a random litter effect, and birth weight and age as covariates, a 1 kg increase in birth weight was associated with a 3.54 kg ($P = 0.03$) increase in on-test weight. Using a similar model for off-test weight, there was a 10.72 kg ($P = 0.03$) increase in off-test weight for a 1 kg increase in birth weight. The relationship between total born and piglet birth weight was estimated using a model with fixed effects of breed and sex, a random litter effect, and a covariate for total born. For every 1 pig increase in total born, birth weight was reduced by 0.03 kg ($P = 0.05$). A generalized linear model with fixed effects for sex and breed, a random litter effect, and a covariate for birth weight was used to analyze survival to weaning. Pigs weighing > 1.5 kg had at least a 90% chance of survival to weaning, and Yorkshire pigs had a higher chance of survival compared with Durocs. Recognizing the relationship between birth weight and litter size as well as later performance will allow swine genetic companies to focus on maintaining pig quality when selecting for increased litter size. Determining the genetic correlations between birth weight, litter size, growth rate, and survivability would be important if birth weight were to be incorporated into a swine breeding program.

Key Words: birth weight, litter size, swine

037 **Characterization and symmetry study of objective feet and leg joint measurements in five separate lines of maternal gilts.**

J. D. Stock^{1,*}, B. E. Mote², T. J. Baas³, M. F. Rothschild³, K. J. Stalder¹,
¹*Department of Animal Science, Iowa State University, Ames,* ²*Fast Genetics Inc., Saskatoon, SK, Canada,* ³*Iowa State University, Ames.*

The objectives of this study were to characterize the feet and leg joint angle measures from 5 replacement gilt lines and to evaluate the symmetry between same angles from each leg pair.

In total, 319 maternal gilts at 21.6 ± 1.8 wk average age (range 19 to 25 wk) were video recorded in a 3 d time span. In total, 1767 profile digital images (857 left and 910 right), and 671 rear stance digital images were extracted from the video recordings using computer software based on gilt body position and image quality, resulting in an average of 2.7 left, 2.8 right, and 2.1 rear stance images per gilt. Joint angles for the knee, front and rear pastern, hock, and rear stance were measured using the angle feature in image analysis software. Mixed model equations were used to evaluate the effect of gilt line and age at measurement (included as a continuous linear covariate) as well as the symmetry of joint angle between the pairs of legs evaluated. The average measurements for each joint angle are as follows: knee $159.9 \pm 3.2^\circ$, front pastern $56.5 \pm 7.0^\circ$, hock $140.1 \pm 7.4^\circ$, rear pastern $58.3 \pm 7.8^\circ$, and rear stance $92.3 \pm 6.3^\circ$. Significant differences ($P < 0.05$) between gilt genetic lines were observed in the front and rear pastern angle measurements. Knee and hock angles increased as age at measurement progressed ($P < 0.05$). Joint measurements were symmetric between the gilts left and right legs ($P > 0.05$) except for the knee where a difference of $0.69 \pm 0.26^\circ$ ($P < 0.05$) was observed with the right being a higher degree angle. Results suggest that genetic line may play a role in pastern angle differences, and most of the difference was observed in the rear legs. Results appear to suggest that the knee should be measured separately on each gilts leg, or could warrant further examination of the technique in which the knee is measured. Further investigation is required about the biological implications of the angle changes on the knee and hock as age progress as well as knee asymmetry on replacement gilts as they enter the breeding herd. The individual importance of the range of these measurements will be evaluated using production records upon completion of the gilts' first parity.

Key Words: digital imagery, feet and leg conformation, swine

038 **Assaying the metabolic network of the bovine rumen microbiome.**

T. M. Taxis*, S. Wolff, C. Zhang, J. Dai, R. D. Schnabel, J. F. Taylor, M. Kerley, J. C. Pires, W. R. Lamberson, G. C. Conant,
University of Missouri, Columbia.

Diverse populations of microbes inhabit the ruminant's digestive system, helping to degrade substrates that are inaccessible to the enzymes encoded in the host's genome. Variation in the metagenome is associated with factors including feed efficiency, methane production, and overall animal health. Gene transfer among microbes in rumen makes the taxonomic structure of the ecosystem an imperfect representation of its functional structure. The objective of this study is to elucidate the metabolic interface between the ruminal metagenome and the host metabolic network. Rumen fluid samples were collected from 2 crossbred steers fed a concentrate feedlot diet. DNA was extracted using the QIAamp DNA Stool Mini Kit, libraries were constructed, and shotgun sequencing was completed

on the Illumina GAI platform. Paired-end reads were quality filtered. Filtered reads were compared with a reference database of 16S rDNA genes. Reads with $\geq 97\%$ sequence identity defined operational taxonomic units (OTU), or groups of like species. To infer the metabolic network of the metagenome, all 6 frame-translations were computed from each paired-end read. Any translation where both pairs had open reading frames (ORF) longer than 45 AA in opposite orientations were retained and queried against an enzyme database allowing comparison of the animals' similarity in OTU distributions and ruminal enzymes. To assess the metabolic interface between the microbiome and the host animal, a host metabolic network was defined. Using comparative genomics, bovine orthologs of the human enzymes in MetaCyc were linked to the microbial enzymes with a list of potentially shared metabolites. OTU distributions were not identical for the 2 animals, Spearman's $\rho = 0.45$ ($P < 10^{-6}$); however, the metabolism of the metagenomes was more similar, Spearman's $\rho = 0.93$ ($P < 10^{-10}$). A distance metric on the metabolic network was calculated by using the list of metabolites potentially taken from the microbiome by the host. While the 2 animals were quite similar in copy number for enzymes with potential interactions with the host metabolic network, they were more dissimilar in more distant parts of the metabolic network. Thus, the taxonomic studies of microbial ecosystems may overstate the amount of functional variation in those ecosystems; however, despite this, the ecosystems do differ in their enzymatic structure. The nature of those differences suggest that, even when there is strong external pressure, it is possible to construct ecosystem-scale metabolic networks that differ in their composition but where those differences are partly masked by a common metabolic interface.

Key Words: metabolic network, metagenomics

DAVID H. BAKER AMINO ACID SYMPOSIUM

039 **The influence and consequences of free versus protein bound amino acids on the efficacy of analytical methods.** T. P. Mawhinney*, *University of Missouri, Columbia.*

Analysis of sample protein-bound AA via acid hydrolysis and chromatographic identification has long been the standard method of quantitation for foods and feeds, and for an endless list of other matrices. The Association of Official Analytical Chemists, International (AOAC), Official Methods of Analysis 982.30 (a,b,c) and 994.12 address the 3 separate basic steps that go into the making of a final report of uncorrected results, that is, acid hydrolysis, oxidation of cysteine and methionine followed by acid hydrolysis, and tryptophan analysis. Little difficulty is encountered with the analysis of free supplement

Table 040. Crude protein (added L-lysine HCl) of experimental diets for each feeding phase (% as fed)

Phase	C	RCP1	RCP2	RCP3
1	20.64 (0.350)	18.82 (0.512)	18.43 (0.549)	16.68 (0.716)
2	19.38 (0.334)	16.85 (0.558)	16.50 (0.590)	14.70 (0.763)
3	16.75 (0.285)	14.68 (0.468)	14.08 (0.523)	12.48 (0.675)
4	14.99 (0.253)	13.05 (0.424)	12.61 (0.464)	11.11 (0.607)
5	17.98 (0.300)	16.60 (0.424)	16.20 (0.462)	14.60 (0.614)

tal AA, via AOAC Official Methods of Analysis 999.13, or other more suitable method that addresses a specific sample type. For samples possessing both free and protein-bound AA, such as complex feeds, foods, rumen supplements and samplings, digesta, hypoallergenic foods, and more, analytical quantitation of each necessitates difference methodological approaches as significant underestimation of free AA and total AA will result if solely analyzed by acid hydrolysis and reported. This presentation will discuss the influence and consequences of free vs. protein bound AA, their analytical outcomes, the comparisons of amino acid hydrolysis curves and methods of addressing them.

Key Words: amino acids, analytical methods

040 **Effect of feed-grade amino acid supplementation in reduced crude protein diets formulated on a net energy basis on performance and carcass characteristic of growing-finishing pigs.**

J. K. Apple^{1,*}, C. V. Maxwell¹, T. C. Tsai¹, H. J. Kim¹, D. G. Cook¹, K. J. Touchette², J. E. Thomson³, J. Less⁴, J. J. Chewning⁵, ¹*Department of Animal Science, University of Arkansas Division of Agriculture, Fayetteville,* ²*Ajinomoto Heartland, Inc., Chicago, IL,* ³*Evonik Degussa Corp, Kennesaw, GA,* ⁴*Archer Daniels Midland Co., Decatur, IL,* ⁵*Swine Research Services, Inc., Springdale, AR.*

Barrows and gilts (n = 216) were used to test the effects of feed grade AA supplementation of reduced crude protein (RCP) diets (formulated on a NE basis) on performance and carcass traits. Pigs were blocked by BW, and pens (3 barrows and 3 gilts/pen) within blocks were assigned randomly to either control corn-soybean meal diets (C) or 1 of 3 RCP diets supplemented with feed-grade AA to meet standardized ileal digestible (SID) AA ratios during each of the 5 feeding phases (23 to 41, 41 to 59, 59 to 82, 82 to 104, and 104 to 127 kg BW). Paylean (10 mg/kg) was included in all diets during the last 3 wk of finishing. Pig BW and pen feed disappearance were recorded at the end of each feeding phase to calculate ADG, ADFI, and G:F. Additionally, 10th rib backfat depth (10RFD) and LM depth (LMD) were measured ultrasonically on 1 randomly selected barrow and gilt/pen at the end of each phase. The ADG was similar ($P > 0.22$) among treatments in Phases 1, 2, and 4, but decreased at the highest level of CP (linear effect, $P \leq 0.02$) in Phases 3 and 5, as well as across the entire feeding trial. The ADFI increased, then decreased

Table 041.

Item	Thermoneutral		Heat stress		SEM	Diet	Environment
	Control	Low	Control	Low		<i>P</i> -value	<i>P</i> -value
Sow FI, kg/d	5.20	5.56	4.28	4.28	0.26	0.299	0.011
Sow DBW, kg/d	-0.30	-0.63	-0.84	-0.84	0.19	0.368	0.044
Piglet ADG, g/d	263.3	279.2	236.7	235.2	9.70	0.426	0.001
Sow DBF, mm	-1.46	-2.74	-3.22	-2.17	1.01	0.680	0.445
WtE, d	7.68	7.22	7.00	5.67	1.13	0.777	0.971
HR, beats/min	69.38	69.87	89.98	91.00	7.23	0.960	0.042
RR, breaths/min	71.74	69.37	93.81	93.27	6.37	0.951	0.014
BT, °C	36.83	37.66	37.77	38.02	0.86	0.830	0.420
MUN, mg/dL	9.46	2.35	9.83	1.92	0.72	<0.0001	0.979
TMP, %	4.47	4.29	4.64	4.55	4.30	0.184	0.028
Ammonia, g/d	34.2	11.2	26.8	12.9	2.9	<0.0001	0.351

(quadratic, $P = 0.06$) at the highest level of CP reduction during Phase 2, but reductions were greater in pigs fed RCP3 diets during Phases 4 and 5, and across all 5 feeding phases (linear effect, $P \leq 0.02$). Feeding RCP diets reduced G:F during phase 3 (linear, $P = 0.05$), but increased G:F (linear, $P = 0.06$) across the feeding trial. Linear increases ($P \leq 0.07$) in 10RFD with decreasing dietary CP were observed at the end of each feeding phase, whereas LMD was reduced (linear, $P = 0.06$) by RCP diets only at the end of Phase 4. Results suggested that CP can be replaced with feed grade AA to meet the requirement of the first 5 limiting AA (RCP2) without negatively impacting growth performance or carcass traits when diets are formulated on NE basis; however, further CP reductions resulted in more variable performance.

Key Words: amino acid supplementation, performance, reduced crude protein, swine

041 Impact of reduced dietary crude protein concentration with crystalline amino acid supplementation on lactation performance and ammonia emission of sows housed under thermo-neutral and thermal-heat stress environments.

D. Chamberlin^{1*}, W. J. Powers¹, D. W. Rozeboom¹, T. M. Brown-Brandl², S. Erwin¹, C. Walker¹, N. L. Trottier¹, ¹Michigan State University, East Lansing, ²USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE.

The objective of this study was to test the hypothesis that feeding a diet containing lower dietary CP and supplemental crystalline AA (CAA), compared with a diet meeting Lys requirement without supplemental AA, reduces ammonia emission and maintains lactation performance in sows housed under thermo-neutral and thermal-heat stress environments. Thirty-six multiparus sows were allocated to a 2 × 2 factorial arrangement of 2 temperatures, thermo-neutral (21°C; TN) and heat stress (31.5°C; HS), and 2 diets, 17.16 (Control) and 11.82% CP (Low), in a randomized complete block design. The HS sows were acclimated during late gestation to increasing temperature from 21 to 31.5°C. During lactation, temperature for HS sows were incrementally changed (24 to 31.5°C and 31.5 to 24°C) from 0500 to 1500 and 1800 to 0500, re-

spectively. Control diet met the standardized ileal digestible (SID) Lys requirement with no added CAA, and Low diet contained added crystalline Lys, Thr, Trp, Val, and Phe. Compared with Control, piglet ADG, sow feed intake (FI), true milk protein (TMP), weight loss (DBW), heart rate (HR), and respiration rate (RR) of Low sows did not differ. Compared with Control, MUN and ammonia emissions decreased for sows fed Low ($P < 0.0001$). Change in back fat (DBF), body temp (BT), and days postweaning to estrus (WtE) did not differ between diets. Compared with TN, DBW, HR, and RR of HS sows were greater ($P < 0.05$). Compared with TN, piglet ADG of HS sows was less ($P < 0.05$). In conclusion, feeding reduced CP diet to lactating sows improved N utilization and did not impact lactation performance of sows under either thermo-neutral or thermal-heat stress environments. These results indicate that reduction of dietary CP in conjunction with aggressive CAA supplementation may be implemented for lactating sows to mitigate ammonia emissions while maintaining lactation performance.

Key Words: amino acid, ammonia emission, sow

042 Leucine supplementation to improve the efficiency of utilization of dietary protein for lean growth.

T. A. Davis^{*}, D. A. Columbus, R. Manjarin, M. L. Fiorotto^{*}, ^{USDA/ARS-Children's Nutrition Research Center, Baylor College of Medicine, Houston, TX.}

Most premature infants experience extrauterine growth restriction by hospital discharge and many remain small to adulthood. Similarly, early weaning of piglets may reduce food intake resulting in growth faltering. Thus, strategies are needed to improve the efficiency of utilization of dietary AA for lean growth in early life. Studies in the neonatal pig model have shown that the sharp increase in muscle protein synthesis after eating is mediated by the rise in AA and insulin. Amino acids and insulin induce protein synthesis by activating independent signaling pathways that converge at mechanistic target of rapamycin complex 1 (mTORC1), leading to the activation of key regulators of translation. Leucine is the most effective single AA in triggering translation initiation factor activation. Acute parenteral leucine administration at physi-

ological levels increases muscle protein synthesis in neonatal pigs and this effect is due to the activation of mTORC1 and its downstream targets, including eukaryotic initiation factor 4E-binding protein 1 and ribosomal protein S6 kinase-1. Although acute administration of the other branched-chain amino AA, isoleucine and valine, is less effective, the leucine metabolites, α -ketoisocaproic acid and β -hydroxy- β -methylbutyrate, stimulate muscle protein synthesis by activating mTORC1-dependent translation to the same extent as leucine. The stimulation of protein synthesis by parenteral leucine can be sustained for prolonged periods, but requires the maintenance of the supply of other AA to support protein synthesis. Pulsatile administration of leucine during continuous orogastric feeding of a milk replacer enhances muscle protein synthesis by stimulating translation initiation. Enteral leucine supplementation of a low protein meal stimulates protein synthesis to the same extent as a high protein meal but this effect diminishes with more prolonged supplementation. Whether the anabolic effects of leucine can be sustained chronically to promote lean growth requires further study. Supported by NIH AR444474, NIH HD072891, USDA NIFA 2013-67015-20438, and USDA/ARS 6250-51000-055.

Key Words: amino acids, growth, muscle

**043 Amino acid nutrition of lactating dairy cows:
Applying the concept of ideal protein.**

C. G. Schwab*, *Schwab Consulting, LLC,
Boscobel, WI.*

The dairy industry has been slowly developing and adopting the ideal protein concept. Research beginning over 40 yr ago has established Lys and Met as generally the 2 most limiting AA, and that the sequence and extent of their limitation is determined by the amount and AA composition of rumen escape feed protein. The first computerized model to predict directly the “content” of AA in duodenal protein was the AA submodel of Rulquin et al. (1998), which used the INRA (1989) PDI system to predict flows of protein fractions. The second was the AA submodel in NRC (2001). While different approaches were used for predicting the AA composition of duodenal protein, both models provided for a true integration of the AA submodel with the protein model and allowed for minimal biases of prediction. Dose-response relationships were subsequently developed for both models that related changes in predicted concentrations of Lys and Met in digestible protein to measured changes in milk protein production. This was the first step in defining the ideal profile of absorbed AA in lactating cows. By using these models and balancing for the model-determined optimal levels of Lys and Met in digestible protein, field nutritionists have been able to take the first step in applying the concept of ideal protein in ration formulation. After its release, the NRC model was used, in conjunction with published experiments with measured

yields of milk and milk components, to arrive at initial estimates of Lys and Met requirements. The resulting regression equations have been implemented in Formulate2, a ration formulation program that is fully compliant with the NRC 2001 model. Based on field observations, this has been a huge step forward in balancing diets for Lys and Met. By integrating data from experiments in which individual and combinations of AA were infused posturally in dairy cows, Canadian researchers have proposed ideal profiles of absorbed AA for lactating cows when using the NRC model. Researchers are debating how to further develop and validate the concept of ideal protein for lactating cows. There are several reasons for this and these will be discussed. While progress in developing the concept of ideal protein has been slow, it is known that an improved balance of digestible AA increases efficiency of utilization of AA for milk protein production and reduces need for rumen escape feed protein.

Key Words: amino acids, ideal protein,
lactating dairy cows

044 Amino acid nutrition and immunophysiology.

R. N. Dilger*, *University of Illinois, Urbana.*

Immune activation and the acute-phase response following infection produces a coordinated reduction in feed intake and growth performance in livestock species. As such, whole-body protein metabolism is altered to repartition AA away from synthesis of skeletal muscle protein and toward the production of specialized immune cells and proteins. In addition to the nonspecific symptoms associated with infection, normal gastrointestinal function may be compromised due to decreases in nutrient digestion and absorption, especially if the animal is exposed to an enteric pathogen. From a nutritional perspective, these circumstances are quite challenging to manage because not only do sick animals consume less feed, but they experience shifts in AA metabolism, which are expensive from a livestock production standpoint. Therefore, it will become increasingly important to develop dietary strategies that can potentially prevent or alleviate performance losses during and after an infective period. In broiler chickens, coccidiosis is an economically-important disease resulting from infection of any 1 of 9 *Eimeria* protozoan parasitic species. Our laboratory has recently focused on how acute immune activation due to *Eimeria* infection influences metabolic priorities of AA for the bird during and after infection. Key outcomes measured in this research include growth performance, markers of skeletal muscle protein breakdown, plasma carotenoid and proinflammatory cytokine concentrations, and ileal AA digestibility coefficients. We hypothesize that aligning the dietary AA profile with the composition of acute-phase proteins synthesized during an acute *Eimeria* infection will minimize growth performance deficits. Perhaps owing to the mismatch between AA compositions of skeletal muscle and acute-phase proteins,

early evidence suggests dietary supplementation of phenylalanine, tyrosine, tryptophan, and serine can improve growth performance of birds during an acute coccidiosis infection, even when serum α -1-acid glycoprotein, an important acute-phase protein, remains elevated. Finding ways to manage the magnitude and duration of an acute inflammatory response is key to maximizing productive performance and profitability, and progress may occur by focusing on the postinfection (i.e., compensatory gain) period with regard to dietary AA strategies.

Key Words: amino acids, chicken, immunology

045 Lactation performance in sows fed diets with graded levels of crystalline amino acids as substitute for crude protein at lysine requirement.

D. Chamberlin*, D. W. Rozeboom, S. Erwin, N. L. Trotter, *Michigan State University, East Lansing.*

The objective of this study was to test the hypothesis that lactation performance of sows fed diets containing 3 and 6% less CP will not differ, when supplemented with crystalline amino acid (CAA) to meet standardized ileal digestible (SID) requirement, compared with a diet solely based on protein-bound AA. Multiparous purebred Yorkshire sows ($n = 48$) were allocated to 1 of 3 dietary treatments: 17.16 (Control), 14.48% (MCP), and 11.82% CP (LCP), in a randomized complete block design. Diets were formulated to meet the SID Lys requirement. Control diet did not contain CAA and exceeded SID requirement in all other AA. The MCP and LCP diets contained the following CAA: Lys, Thr, Trp, and Val, in addition to Phe for LCP diet only. Voluntary feed intake was measured daily. Sow and piglet BW were measured on d 0, 3, 6, 9, 12, 15, 18, and 21, and milk samples collected on d 4 and 16. Data was analyzed as a randomized complete block design with parity, day, and diets as fixed classification effects, and sow as random effect. Compared with Control, voluntary feed intake (kg) of sows fed MCP and LCP did not differ ($P = 0.373$), and was 5.85, 5.64, 5.66 (± 0.1150) for Control, MCP, and LCP, respectively. Compared with Control, piglet ADG of sows fed MCP and LCP did not differ ($P = 0.757$) and were (g/d) 263.5, 277.2, and 274.0 (± 13.9 , respectively). Compared with Control, milk urea nitrogen (MUN, mg/dL) decreased ($P < 0.001$) for MCP and LCP, and was 8.57, 6.85 and, 2.94mg/dL (± 0.93), respectively. In conclusion, feeding reduced CP diets with CAA supplementation did not impact lactation performance and reduced MUN. These results are the first to suggest that aggressive CAA can be implemented in lactating sow diets to optimize N utilization.

Key Words: amino acid, lactation, sow

EXTENSION – BEEF/SMALL RUMINANT

046 Collection method affects hay waste estimates.

D. J. Tomczak^{1,*}, N. E. Mertz¹, W. J. Sexten²,

¹*University of Missouri, Columbia,* ²*Division of Animal Sciences, University of Missouri, Columbia.*

Two waste collection methods, cumulative (CUML) and daily (Daily), were used to evaluate differences in hay waste estimates. Small (128.3 ± 3.19 cm), Medium (160.7 ± 6.38 cm), or Large (187.7 ± 3.52 cm) tall-fescue round hay bales (85.5% DM, 8.2% CP, 66% NDF, 152 cm wide) were placed in hay feeders equipped with cradle chain (CONE) or without (RING) in a 3×2 factorial design randomly assigned to a 6×6 Latin square. Bale replacement intervals (Small = 2 d, Medium = 3 d, Large = 5 d) ensured ad libitum hay access. Waste was collected daily or at bale replacement as the Latin Square subplot. Bales were placed on flat end in round bale feeders (230 cm diameter, 170 cm height) with 16 feeding stations and metal sheeting on top (50 cm) and bottom (60 cm). We hypothesized hay waste estimates would not differ due to collection method. CUML increased waste compared with DAILY as percentage of initial bale (20.8 vs. 17.3%, $P = 0.005$), percentage of disappearance (37.6 vs. 30.0%, $P = 0.01$), and average $\text{kg} \cdot \text{animal}^{-1} \cdot \text{d}^{-1}$ (3.46 vs. 2.93, $P = 0.005$). Collection method \times feeder ($P < 0.01$) and collection method \times bale size ($P < 0.02$) interactions were observed for dry waste as percentage of total waste and average $\text{kg} \cdot \text{animal}^{-1} \cdot \text{d}^{-1}$. Interactions resulted from a greater magnitude of difference between CUML and DAILY as total waste amount increased for percentage dry waste and average dry waste $\text{kg} \cdot \text{animal}^{-1} \cdot \text{d}^{-1}$ estimates. Clean, contaminated and total waste ash content was greater for CUML than DAILY ($P < 0.05$). CUML waste having greater ash content than initial bale suggests increased contamination could increase waste estimate. Different conclusions were reached when analyzing CUML compared with DAILY due to greater variance in CUML estimate. In conclusion, CUML is a more variable estimate and increased contamination increases waste estimation.

Key Words: bale feeder, collection method, hay waste

047 **Relationship between preweaning gain, age at puberty, and reproductive tract development in Angus heifers.** R. A. Cushman^{1,*}, A. K. McNeel¹, E. C. Wright-Johnson¹, O. L. Amundson², S. C. Tenley³, E. L. Larimore², B. N. Richardson², C. C. Chase, Jr.¹, G. A. Perry⁴, A. S. Cupp³, ¹USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE, ²South Dakota State University, Brookings, ³University of Nebraska-Lincoln, Lincoln, ⁴Department of Animal Sciences, South Dakota State University, Brookings.

Beef heifers should initiate reproductive cycles by 12 mo of age to ensure multiple estrous cycles before the start of the breeding season to maximize fertility. Previous research indicated that preweaning gain positively influenced the onset of puberty and antral follicle numbers. Therefore, the objective of the current study was to examine differences in ADG and reproductive tract development between heifers that attained puberty before or after 12 mo of age. Angus heifers born in the spring of 2012 (n = 84) and 2013 (n = 115) were weaned and developed in a feedlot to attain 55% of estimated mature weight by the start of the breeding season. From March (322.3 ± 1.3 d) until May, heifers were examined monthly (age) by ultrasonography to determine pubertal status, antral follicle count, ovarian size, and uterine horn diameter. Heifers were classified as those that reached puberty prior to 12 mo of age (n = 65) and those that reached puberty after 12 mo of age (n = 134). Average daily gain and BW were analyzed using the MIXED procedure of SAS with pubertal group as a fixed effect and year as a random effect. Antral follicle count and development of the reproductive tract were analyzed using the MIXED procedure of SAS with age, pubertal group and the interaction as fixed effects, and heifer and year as random effects. Body weights, postweaning ADG, and age were not different between pubertal groups ($P > 0.05$); however, preweaning ADG was greater for heifers that achieved puberty by 12 mo than those that did not ($P = 0.03$; 0.91 ± 0.02 vs. 0.87 ± 0.03 kg/d). There was a significant effect of age on antral follicle count and ovarian size ($P < 0.01$), but these traits did not differ between heifers that attained puberty before 12 mo and those that did not ($P > 0.05$). There was a tendency for an interaction of age and puberty group on uterine horn diameter, such that heifers that attained puberty before 12 mo had a greater uterine horn diameter at a younger age ($P = 0.06$). These data indicate that preweaning ADG and uterine horn diameter are better predictors of puberty than age or BW. Since selection on BW increases cow size, replacement heifers should be selected using assessment of reproductive tract development rather than BW.

Key Words: beef heifer, puberty, reproductive tract development

048 **Factors affecting the adoption of grazing systems and grass-based management by beef and sheep producers in Ohio.** J. S. McCutcheon^{1,*}, L. W. Morton², H. N. Zerby³, S. C. Loerch⁴, L. Miller⁵, F. L. Fluharty⁴, ¹The Ohio State University, Mount Gilead, OH, ²Iowa State University, Ames, ³The Ohio State University, Columbus, OH, ⁴The Ohio State University, Wooster, OH, ⁵Small Farm Institute, Millersburg, OH.

Relying solely on forage for livestock production (grass-based) is a system for raising animals to a marketable weight in many parts of the world, yet adoption of the practice is not common in the United States. A random-sample mail survey sent to Ohio beef and sheep farmers was used to determine what influences the decision to adopt grass-based management and the adoption of the associated use of a grazing system. A response rate of 45% resulted in 344 usable surveys. Logistic regression procedures were used to analyze the underlying factors that influence a decision to use grass-based management or use a grazing system. Producer demographic information including, age, number of beef cows managed, number of feeder calves sold, number of finished beef sold, number of ewes managed, number of market lambs sold at less than 41 kg or from 41 to 54 kg, number of hectares owned, and income were used to create dummy binary variables for both logistic regression analysis. Factor scores created from principal component analysis of 4 separate questions used in the survey to determine underlying conceptual factors postulated to influence the decision of adoption were also included in the logistic regressions. Only 18% of the respondents identified their operation as grass-based while 73% of respondents identified their operation as using a grazing system. Factors found to influence the adoption of both grass-based management and use of a grazing system ($P < 0.05$) were the respondent's perception of the importance of pasture, their social interactions, and management of beef cows. Factors that were not a significant ($P > 0.05$) influence in the adoption of both grass-based management and use of a grazing system were age, number of feeder calves sold, number of finished beef sold, number of ewes managed, number of market lambs sold, number of hectares owned, and income. Results from the analysis indicate that adoption of grass-based or grazing systems by ruminant livestock producers in Ohio are producer specific and not just an economic decision.

Key Words: beef, grass-based, sheep

049 **Comparison of the host immune response to the footrot pathogenic bacteria in different genotypes of Katahdin sheep.** S. Azarpajouh^{1,*}, T. Wuliji², A. Bax², ¹*Department of Animal Sciences, University of Missouri, Columbia*, ²*Department of Agriculture & Environmental Sciences, Lincoln University, Jefferson City, MO.*

Polymorphism at the DQA2 and DQA2-like loci located within the Major Histocompatibility Complex (MHC) was utilized to develop a gene marker screening test to identify resistant and susceptible genotypes for Katahdin ewes. The objective of this study was to compare the host immune response by IgG to *Dichelobacter nodosus* in footrot resistant vs. susceptible genotype for sheep. Fifty-four Katahdin ewes, 18 each of high resistant footrot gene markers (HR), medium resistance (MR), and low resistance (LR), were selected. Ewes were divided into control and treatment groups. Cultures of *D. nodosus* were inoculated to the interdigital skin of the treatment group and held there with bandages for 7 d. Blood samples were collected for 5 wk to measure the immune response. The blood collected in a Vacutainer (10 mL) from the jugular vein of sheep in both control and treatment groups during the footrot pathogenic challenge was centrifuged at 2000 RPM for 5 min to separate the serum. The IgG level (mg/mL) was measured by using an Enzyme-linked immunosorbent assay (ELISA) kit (GenWay, Biotech, Inc.). The data were analyzed by using mixed model procedures of SAS and $P < 0.05$ was considered as significant. The IgG level in sera (mg/mL) was not different ($P = 0.45$) among different marker groups, and between the beginning and the end of trial ($P > 0.05$). The IgG level in sera of both treatment and control groups was in the normal range (7.6 to 40 mg/mL), however; it was greater in treatment than control group ($P < 0.0001$). Since no active infection happened in animals, the IgG level in sera remained in the normal range in both control and treatment groups and the higher level of IgG in treatment group might be due to bacteria inoculation or higher stress perception.

Key Words: footrot, genotype, sheep

050 **Heifer intake and feed efficiency as indicators of cow intake and efficiency.** C. Cassady^{1,*}, J. Adcock¹, K. M. Retallick², D. W. Shike¹, ¹*University of Illinois at Urbana-Champaign, Urbana*, ²*California Polytechnic State University, San Luis Obispo.*

Objectives were to determine the relationship between post-weaning feed efficiency and intake in heifers, and subsequent cow performance and reproduction as 2-yr-old cows. Post-weaning DMI, ADG, and backfat were evaluated on Angus and SimAngus heifers ($n = 511$) over a 5-yr period. Heifers received similar forage-based diets, and individual DMI were recorded using the GrowSafe (Airdrie, AB) system. Residual feed intake (RFI) and residual BW gain (RG) were calculated.

Heifers were classified into high, medium, or low RFI, RG, and DMI groups. Cow forage DMI, hip height, BW, BCS, and backfat via ultrasound were recorded at 60 d (lactating) and 240 d (dry) postpartum; 24-h milk production was estimated at 60 d. Cow predicted DMI was estimated by regressing DMI on metabolic BW, backfat, and 24-h milk production. Cow efficiency (cow_RFI) is the difference between actual and predicted DMI. The RFI classification did not affect ($P \geq 0.12$) reproductive traits; calf birth or weaning BW; cow BW, milk production, backfat, or BCS. Cows, classified with the most desirable heifer RFI, had reduced DMI ($P < 0.01$) and most desirable cow_RFI ($P < 0.01$) during lactation. Similarly, during the dry phase, cows within the low heifer RFI group tended ($P = 0.06$) to eat less when compared with cows in the high heifer RFI group. The RG classification did not affect ($P \geq 0.06$) reproductive traits; calf birth or weaning BW; cow BW, hip height, BCS, milk production, backfat, cow_RFI, or DMI. Heifers, classified as low DMI, were less frequently ($P < 0.01$) kept as replacements compared with medium and high DMI heifers, and were younger ($P = 0.04$) at first calving compared with heifers classified as high DMI. Calves from cows, classified as high DMI heifers, had the greatest ($P < 0.01$) birth BW; yet, there were no differences ($P = 0.47$) in weaning BW. Intake classification had no effect ($P \geq 0.24$) on cow BCS, backfat, or milk production. Cows, classified as low DMI heifers, weighed the least ($P = 0.02$) compared with cows from other heifer DMI groups. Cows, classified as high DMI heifers, had greater ($P < 0.01$) hip heights than cows within the low DMI group, the medium DMI group was intermediate. Cows, classified as low DMI heifers, had reduced ($P \leq 0.02$) DMI and improved ($P = 0.04$) cow_RFI compared with cows within the high heifer DMI group, the medium heifer DMI group was intermediate. This study suggests that selection for improvements in heifer RFI can result in reduced cow DMI without compromising production traits.

Key Words: beef cow, efficiency, intake, residual feed intake

051 **Ensiled high moisture corn stover as an alternative forage in gestating and lactating beef cow diets.** W. T. Meteer^{*}, W. C. Meteer, W. P. Chapple, D. W. Shike, *University of Illinois at Urbana-Champaign, Urbana.*

The objective of this study was to evaluate ensiled high-moisture corn stover (HMCS) as an alternative forage in gestating and lactating beef cow diets. In Exp. 1, multiparous Simmental and Angus \times Simmental cows ($n = 96$) in mid to late gestation were utilized. A randomized complete block design was used with cows blocked by BW. Dietary treatments were: 1) 60% HMCS, 25% ground cornstalks, and 15% corn gluten feed (STALK); 2) 60% corn silage, 25% ground cornstalks, and 15% corn gluten feed (SIL); and 3) 60% hay, 25% ground cornstalks, and 15% corn gluten feed (HAY). Diets were limit-

fed from 108 ± 14 to 38 ± 14 d prepartum to achieve a DMI of 1.5% BW. In Exp. 1, BW gain was greatest ($P < 0.01$) for cows fed SIL, intermediate for cows fed STALK, and least for cows fed HAY (63 kg vs. 34 kg vs. 17 kg). While all cows started and ended the trial in good body condition, cows fed SIL and cows fed STALK had a greater ($P = 0.04$) increase in BCS than cows fed HAY. Feed cost, in order from least to greatest, was STALK ($\$1.33 \cdot \text{cow}^{-1} \cdot \text{d}^{-1}$), HAY ($\$1.66 \cdot \text{cow}^{-1} \cdot \text{d}^{-1}$), and SIL ($\$1.68 \cdot \text{cow}^{-1} \cdot \text{d}^{-1}$). Manure analysis indicated no difference ($P \geq 0.17$) in N, P, or K between treatments. In Exp. 2, lactating Simmental and Angus \times Simmental cows ($n = 79$) were randomly allotted at calving to 2 treatments: 1) 75% HMCS, and 25% dried distillers grains (DDGS) on a DM basis (STALK2); and 2) 70% corn silage and 30% DDGS (SIL2). Diets were limit fed to achieve NRC requirements for maintenance and lactation; thus, cows fed STALK2 received 15.3 kg total DM, whereas cows fed SIL2 received 12.7 kg total DM. In Exp. 2, BW gain was greater ($P < 0.01$) for cows fed SIL2 compared with cows fed STALK2 (32 kg vs. -6.0 kg). No differences ($P \geq 0.16$) were detected in BCS change, milk production, or subsequent AI conception rates. Feed cost for cows fed STALK2 was calculated at $\$1.77 \cdot \text{cow}^{-1} \cdot \text{d}^{-1}$, while SIL2 was calculated at $\$2.16 \cdot \text{cow}^{-1} \cdot \text{d}^{-1}$. Ensiled HMCS may serve as an alternative forage for feeding gestating beef cows. While lactating cows fed ensiled HMCS had poorer BW gain than cows fed corn silage, the reduced feed cost of HMCS warrants more investigation into its use in lactating beef cow diets.

Key Words: alternative forage, beef cow, corn stover

052 **Long term effect of corn residue grazing on crop yields.** M. E. Drewnoski*, J. C. MacDonald, G. E. Erickson, K. Hanford, T. J. Klopfenstein, *University of Nebraska, Lincoln.*

A 36 ha irrigated field was used to study long term effects of grazing corn residue on crop yields. Half of the field was planted to corn and the other half was planted to soybeans, and crops were alternated yearly. Each half was divided into 2 replicates of 3 grazing treatments beginning in 1997: 1) fall and winter grazed (FG) in November to mid-February, 2) spring grazed (SG) in mid-February to April, and 3) not grazed (NG). Calves (227 to 319 kg BW) were stocked at 3 hd/ha in FG and 3 hd/ha in SG up until 2000 (5 yr) and then increased to 7.4 hd/ha in SG. For FG, no-till planting was utilized throughout the 16 yr. However, yield data in FG is only available from the harvest of 2004 through 2013 (10 yr). Within the SG and NG, 3 tillage treatments: no-till, ridge-till or spring disk-till, were imposed after corn with no-till being used following the soybean crop. These tillage treatments were maintained through 2007, at which time only the no-till treatments were continued. Therefore, the comparison of SG vs. NG under no-till is available for 16 yr, the split plot comparison of SG vs. NG under 3 tillage strategies is available for 9 yr, and the comparison of SG, FG, and NG under no-till is available for 10 yr. No in-

teraction ($P \geq 0.55$) between tillage and grazing was observed for soybean or corn yield. Across all tillage treatments, SG of corn residue increased ($P < 0.01$) soybean yields and had no effect ($P = 0.58$) on corn yields. Similarly, over 16 yr, SG under no-till increased ($P = 0.03$) soybean yields (3.90 vs. 4.00 \pm 0.036 t/ha for NG and SG, respectively) and had no effect ($P = 0.96$) on corn yields. Over 10 yr, FG (4.41 t/ha) improved ($P < 0.01$; SEM = 0.053) soybean yields over both SG (4.28 t/ha) and NG (4.18 t/ha), whereas SG tended ($P = 0.07$) to increase soybean yields when compared with NG, and no effects ($P = 0.55$) of grazing in either season were observed on corn yields (12.8, 13.0, 13.1 \pm 0.24 t/ha for NG, SG and FG, respectively). These data suggest that grazing of corn residue at stocking rates that would result in consumption of approximately half of the leaf and husk appears to have slightly positive or no impacts on subsequent soybean or corn yields.

Key Words: corn residue, crop yield, grazing

053 **Evaluation of the anthelmintic efficacy of a single subcutaneous injection of LongRange™ in stocker calves when compared with a positive (Dectomax™) and a negative (saline) control.**

A. C. Vesco^{1,*}, A. K. Sexten¹, C. S. Weibert¹, B. E. Oleen¹, W. R. Hollenbeck¹, L. C. Grimes¹, D. A. Blasi², ¹*Kansas State University, Manhattan*, ²*Department of Animal Science & Industry, Kansas State University, Manhattan.*

Stocker cattle are commonly impacted by subclinical parasitism. Single dose anthelmintics have shown to reduce internal worm load for approximately 30 d. LongRange™ is the first single dose extended-release anthelmintic providing parasite control for a minimum of 100 d. Crossbred heifers ($n = 288$; 115.4 \pm 13.3 kg, respectively) were completely randomized by initial weight across 15 pastures. Pastures were randomly assigned to either: 1) LongRange™ administered at 1 mL/50kg; 2) Dectomax™ administered at 1 mL/50 kg with Cyonara Plus™ insecticide given at 10 mL/272.16 kg; or 3) Saline administered at 1mL/45.4 kg, with 5 pastures per treatment. Weights were taken on individual heifers and fecal samples were taken from 5 randomly selected heifers per pasture. Weights and fecal samples were taken on d 0, 47, and 96. Heifers did not exhibit a level of fecal egg counts (FEC) that would negatively impact performance. The fly counts began on d 50 and continued on a weekly basis until end of trial. Three heifers were randomly selected per pasture and pictures were taken of each heifer using a digital single lens reflex camera with a telephoto zoom lens. Pictures of heifers were uploaded to a computer program where flies were highlighted and counted by hand. Weight gains were similar between treatments ($P \geq 0.27$) throughout the 96 d study. On initial collection ($P = 0.37$) and mid collection ($P = 0.34$), FEC were similar among treatments. However, on final collection, Dectomax™ had lower ($P = 0.05$) FEC compared

with the Saline and LongRange™ treatments. The highest FEC on trial heifers was 10.8 eggs per gram, which is well below the economic threshold. LongRange™ treated heifers had lower ($P = 0.04$) fly counts than Dectomax™ and Saline treated heifers. Worm loads in heifers were not high enough to impact performance, making it difficult to determine the efficacy of the anthelmintics.

Key Words: anthelmintic, fly count, stocker

054 **Determining growth performance implications on meat goat kids fed soybean hull or corn based pelleted diets.** A. C. Vesco*, C. K. Jones, L. C. Grimes, T. H. Fountain, B. R. Faris, A. K. Sexten, *Kansas State University, Manhattan.*

The meat goat industry is rapidly expanding, yet there is limited knowledge on feeding kids to market weight, providing opportunities for research in this area. This study investigates the option of an alternative energy source to corn for a growing kid ration. Eighty-four Boer × Spanish kids (30 kg; 8 mo) were used in a randomized complete block design to determine the effects of a soybean hull based diet on growth performance and blood serum mineral composition. Kids were blocked by sex and randomly assigned to 1 of 2 treatments: 1) corn and soybean meal based pellet (Corn) or 2) soybean hull and soybean meal based pellet (Soyhull). Kids were allowed a 10-d pen and diet adaptation period. Feed was delivered once daily at 0600 with daily intake adjustments to maintain ad libitum intake of pellets and brome hay for 70 d. There were 7 pens per treatment with 6 animals per pen; sex was divided equally between treatments. Weights for all kids were recorded every 2 wk. Pellet and hay grab samples were collected daily, composited by 2-wk period, oven dried, and ground to be analyzed for DM, ash, N, NDF, and ADF. Blood samples were taken on d 0, 28, and 70, and serum was analyzed for levels of Na, K, Cl, Ca, P, and Mg. Initial BW was similar ($P = 0.24$) between treatments. Body weights remained similar ($P \geq 0.12$) between treatments for each weigh date for the entire 70-d feeding period. Overall gain and ADG were likewise not different ($P \geq 0.18$) between treatments. Kids consuming the Soyhull diet had greater ($P \leq 0.001$) DMI throughout the study compared with kids consuming the Corn diet. Overall DMI averaged $1.37 \text{ kg} \cdot \text{kid}^{-1} \cdot \text{d}^{-1}$ vs. $1.06 \text{ kg} \cdot \text{kid}^{-1} \cdot \text{d}^{-1}$ for the kids consuming the Soyhull and Corn diets, respectively. No differences ($P \geq 0.44$) were observed for blood serum mineral composition between treatments. Based on these results, soybean hulls are a viable alternative feed source to corn for growing meat goats when protein requirements are met.

Key Words: meat goat, mineral, soybean hulls

055 **Technology 2-step research project: Genetic improvement made through use of DNA testing and artificial insemination to high-growth, high carcass value angus sires.** L. C. Grimes^{1,*}, L. R. Corah², T. Brink³, M. Gardiner⁴, A. K. Sexten¹, ¹*Kansas State University, Manhattan*, ²*Certified Angus Beef LLC., Manhattan, KS*, ³*Top Dollar Angus, Greeley, CO*, ⁴*Gardiner Angus Ranch, Ashland, KS.*

Through the use of breed associations and herd health databases, the beef industry has improved the recording of pedigrees and performance data. Constant evaluation of genetics and performance has allowed producers to make more informed breeding decisions that help improve herd productivity. However, as a result of recent droughts and elevated feed and grain prices, the American cowherd is at a record low, 38.5 million cattle. For the United States to continue to be the leading producer of beef in the world, the industry must adopt technologies that improve the efficiency of the cowherd and the quality beef being produced. The objective of this research project was to increase the marbling and grid premium potential in a cow base with average to below-average genetic potential in 1 generation. In April 2012, 104 yearling heifers were obtained from a single ranch source that was not expected to have a strong genetic potential for marbling. All heifers were DNA tested for predicted marbling potential, and all heifers had below average GeneSTAR DNA marker predicted marbling values. Heifers in the bottom third for marbling potential were culled. The predicted marbling values were -4.69 and -52.17 ($P < 0.01$; SEM = 3.67) units below population average for retained and culled heifers, respectively. Retained females were bred AI to 1 of 2 Angus sires selected for high growth potential and increased carcass quality. Reference sires ranked in the top 6% of the breed for calving ease and the top 1% for \$B. Resulting calves ($n = 35$) were managed traditionally, DNA tested, fed in a southwest Kansas feedyard, and harvested in June 2014. When compared with dam DNA, progeny showed predicted marbling scores 54.51 units higher ($P < 0.01$). On the rail, progeny recorded an average HCW of 373.39 kg and a 2.91 average yield grade. Progeny graded 94.6% USDA Choice or higher. Of those, 5.8% graded USDA Prime, and 35% qualified for the Certified Angus Beef brand. There were no differences in quality grade, yield grade, or price per hundredweight between sires ($P \geq 0.19$). With no carcasses taking weight discounts and an average dressing percentage of 64.92%, there was a \$113.10 grid premium per animal. The results from this study demonstrate the improvement that can be made in 1 generation by using DNA technology and proven sires simultaneously.

Key Words: beef cattle, carcass quality, genetic improvement

EXTENSION – DAIRY: STRATEGIES TO IMPROVE DAIRY CATTLE HEALTH, WELFARE, AND PERFORMANCE

056 **Colostrum: Its effect on cattle health and performance.** P. S. Erickson*, *University of New Hampshire, Durham.*

Colostrum is necessary for the development of immunity in the neonatal calf. However, 60% of the colostrum produced on U.S. dairy farms does not meet minimum quality standards (<50 g/L IgG), resulting in >40% of calves not achieving passive transfer (serum IgG < 10 g/L). This poor quality colostrum is a major contributing factor toward the U.S. calf mortality rate of 10.5%. Therefore, improving colostrum quality and uptake of IgG by calves is imperative in enhancing health, performance, and profitability. This review will focus on means of improving IgG uptake in the newborn, including: colostrum quality, time of feeding related to harvest, parity, bacterial contamination, and pasteurization. Feeding colostrum via esophageal intubation as compared with conventional feeding methods will be reviewed as intubation appears to be as efficacious as conventional (nipple bottle) feeding methods. Colostrum additives such as sodium bicarbonate, and selenium have sometimes enhanced IgG uptake. Feeding colostrum for >1 d improved local immunity in calves. Prepartum cow diets that predispose cows to hypocalcemia may reduce IgG uptake in the neonate, whereas prepartum supplementation of nicotinic acid to cows appeared to increase IgG uptake in the newborn. Behavioral changes such as artificial mothering may enhance IgG uptake. Reducing heat stress of cows during colostrumogenesis increased calf weight and uptake of IgG compared with cows that were heat stressed. Feeding at least 4 L of good quality colostrum (≥ 50 g/L IgG) has been shown to improve growth, reduce veterinary costs, and increase milk yield compared with calves fed 2 L of the same quality colostrum. Lactal-based colostrum replacers can provide adequate passive transfer of IgG. Utilization of colostrum supplements resulted in mixed outcomes in regards to passive IgG transfer. New research ideas will be presented, describing ways to improve colostrum quality and immunity in the calf, resulting in enhanced health and performance.

Key Words: calf, colostrum, immunoglobulin G

057 **Calf growth and feed intake associations with milk yield.** D. L. Beam^{1,*}, K. J. Stalder¹, A. J. Heinrichs², C. D. Dechow², ¹*Iowa State University, Ames,* ²*Pennsylvania State University, University Park.*

This study's objective was to understand the association between heifers' growth and feed intake traits with cow milk yield. Data from 197 Holstein calves from 6 trials of varying

lengths was collected at Pennsylvania State University between 2003 and 2010. Calf hip height, starter feed intake, and BW were measured for periods that ranged from 4 to 8 wk. Calves were split into high, medium, and low ranking groups according to their hip height, starter feed intake, BW, and growth rate. Heifer calf data was merged with lactation milk yield data. A total of 134,469 daily milk records were evaluated using mixed model methodology. The model fitted age at calving group, treatment within trial, parity, lactation number, and calf groups as fixed effects, and cow and calendar week by year as random effects. During lactation wk 1 to 5, cows from the intermediate weight calf classification produced 5.0 ± 2.34 kg and 5.6 ± 2.16 kg more milk than cows from the light ($P = 0.03$) or heavy ($P = 0.009$) weight calf classifications, respectively. During lactation wk 6 to 10, cows from the intermediate weight calf group produced 4.6 ± 1.99 kg and 3.8 ± 2.14 kg more milk than cows from the heavy ($P = 0.02$) and light ($P = 0.07$) weight calf classifications, respectively. Cows from the low hip height calf group tended to produce 4.2 ± 2.22 kg and 6.0 ± 2.10 kg milk less when compared with cows from the high ($P = 0.06$) and intermediate ($P = 0.004$) hip height calf groups in wk 1 to 5 of lactations, respectively. Additionally, during lactation wk 6 to 10, cows from the low hip height calf classification produced 4.2 ± 2.07 kg milk less than cows from the high hip height calf classification ($P = 0.04$). However, for lactation wk 10 to 20, there were no milk yield differences ($P > 0.10$) for cows when classified for calf hip height and BW. No significant milk yield differences were observed for starter feed intake and growth rate among cows from the different hip height and BW groupings ($P > 0.10$). Results suggest that calf hip height and rearing BW could be used as indicators for milk yield later in life.

Key Words: body weight, hip height, milk yield

058 **Serotonin: A new player in hypocalcemia.** L. L. Hernandez*, J. Laporta, *University of Wisconsin, Madison.*

Dairy cows are challenged to maintain calcium homeostasis during the early postpartum due to increased demand by the mammary gland for calcium secretion into milk. The mammary gland coordinates the cow's metabolism during lactation to ensure appropriate milk formation. Calcium is the major mineral constituent of milk. All mammals must mobilize bone tissue to maintain appropriate circulating calcium concentrations during lactation and support milk formation. Due to the high level of milk production seen in dairy cattle, approximately 47% of multiparous and 25% of primiparous cows have circulating calcium levels in the range of subclinical hypocalcemia (1.4 to 2.1 mM), approximately 5% are in the clinical range (<1.4 mM). Current therapies for the treatment and prevention and treatment of hypocalcemia include manipulation of the dietary cation-anion difference, oral calcium supplementation and intravenous calcium as a last resort. However, while these

current strategies have been helpful for the prevention of clinical hypocalcemia, subclinical hypocalcemia is still prevalent. Recently, we have demonstrated the regulation of calcium homeostasis during early lactation by the monoamine, serotonin (5-HT). Serotonin acts to increase mammary gland production of parathyroid hormone related-protein, the hormone responsible for the mobilization of calcium from bone during lactation. Concentrations of 5-HT concentrations are dynamic over the course of a lactation cycle in multiparous dairy cows and greatly fluctuate around calving in multiparous cows follow a pattern similar to that of total calcium concentrations. 5-HT concentrations are positively correlated with total calcium and PTHrP on d 1 of lactation and negatively correlated with incidence of subclinical hypocalcemia in multiparous dairy cows. Furthermore, circulating 5-HT levels are positively correlated with total calcium concentrations during the first 10 d of lactation. Using a rat model, we fed a precursor to 5-HT, 5-hydroxytryptophan (5-HTP), to rats during the transition from pregnancy to lactation in order to determine the feasibility of using 5-HT as a preventative strategy for hypocalcemia. Our results showed improved circulating calcium levels and increased calcium secretion into milk. In a preliminary acute 5-HTP dosing experiment in late lactation multiparous dairy cows, we observed that administration of 5-HTP improves calcium and glucose homeostasis. In conclusion, 5-HT is an important modulator of calcium and glucose homeostasis, and is of particular importance around the time of parturition.

Key Words: hypocalcemia, serotonin, transition cow

059 **Holistic approach for the identification, risk assessment, and mitigation of mycotoxins' impact in ruminant.**

A. Yiannikouris*, *Center for Animal Nutrigenomics and Applied Animal Nutrition, Alltech, Nicholasville, KY.*

The large number and structural diversity of mycotoxins has impeded rapid quantification owing to varying toxin extraction efficiencies and interferences from feed and food matrices. In turn, the lack of unbiased detection methods decreased the ability to identify the impact of multiple mycotoxins coming from various mold species that can contaminate feedstuffs preharvest or during storage phases, and produce mycotoxins. The complexity of ruminant feed formulations makes those uncertainties even prone to greater variation and reliability issues due to matrix complexity and lack of validated rapid methods available. We have successfully tackled these challenges by fully validating the 37+™ method that evolved into a routine analytical tool. This novel method provides simultaneous and absolute quantification for more than 37 mycotoxins in feed in a cost-effective manner. Our method sets the basis for a novel approach using nonanalogous mycotoxins to normalize classes of mycotoxins which have similar extractability and which experience similar matrix suppression and/or enhancement effect to the isotopologue during

UPLC-MSMS analysis. Four isotopically labeled standards were used to normalize 10 groups of mycotoxins, making the method applicable any feed matrices or mixture. Averaging 8 different mycotoxins per sample with a level of positive samples of 99.5% (n = 6000), the data set generated was further interpreted and normalized according to known species specific sensitivity. The latter was evaluated according to the principles of toxic equivalent factors used to perform dioxins risk assessment and adapted to mycotoxins. Specific threshold of risk related to animal performance impairment was determined, applied to dairy. The risk assessment calculates a risk equivalency quantity (REQ) expressed in ppb of AFB1-equivalent, which computes a multicontamination complex situation pertaining to feedstuffs into 1 single value. Proportions of 28.2, 36.3, and 35.5% of samples were contaminated with levels representing a high, moderate, and low risk for dairy cows, respectively. The use of REQ calculations enabled also to change the outcome of mitigation strategies. Evaluating the adsorption efficacy of yeast cell wall based product with extended carbohydrate network could now be performed by measuring REQ in 1) initial feedstuff and 2) postmycotoxins extraction and sequestering under digestive condition, and evaluating then a differential REQ. Data showed that, in realistic contamination conditions involving 12 different mycotoxins as mixture, the adsorbent enabled a decrease in risk by 70.2% in ruminants. Continuous research is carried out to further refine the methods using in situ approaches for the monitoring of mycotoxin impact and remediation strategy.

Key Words: detection, mitigation, mycotoxins, risk assessment

060 **A nutritional strategy to help control digital dermatitis in growing animals.**

A. Gomez¹, D. Dopfer², J. DeFrain¹, D. H. Kleinschmit¹, D. J. Tomlinson¹, M. Socha^{1,*}, ¹Zinpro Corporation, Eden Prairie, MN, ²School of Veterinary Medicine, University of Wisconsin, Madison, WI.

Digital dermatitis (DD) is a multifactorial disease with infectious, immune, and environmental components. This condition has been reported in intensively managed cattle in all parts of the world with higher prevalence in housed vs. grazing cattle. Previously recognized only as a disease of mature cattle, there is an increasing awareness of this condition in growing cattle. Depending on stage and severity of DD lesions, impact on cattle ranges from minor discomfort to severe and debilitating lameness. Chemical or physical trauma to the digital skin, low oxygen environment and presence of the causative agent(s) are needed for development of DD. Improving skin integrity and/or enhancing immune response in the presence of the causative agent will help reduce incidence and severity of DD. One means to enhance disease resistance of cattle is to provide them with an adequate supply of zinc, manganese, copper, cobalt, and iodine. In Study 1, a study in

which DD lesions were experimentally induced, feeding steers a strategically formulated trace mineral premix (DD Formula) reduced acute DD prevalence ($P = 0.11$) and DD lesion size ($P = 0.11$). The DD Formula was designed to supply higher levels of AA complexes Zn, Mn, and Cu (Zinpro Performance Minerals), and a higher level of iodine than is typically fed to growing cattle. In Study 2, a study in which DD lesions were naturally induced, feeding a modified version of the DD Formula to heifers had no effect ($P > 0.15$) on DD prevalence. In this study, heifers had DD lesions when enrolled in the study and feeding rate of the DD Formula per unit of BW was less than in Study 1. In Study 3, heifers began treatments prior to developing DD lesions and the dosage of the DD Formula per unit of BW was similar to feeding rate in Study 1. In this study, feeding the DD Formula to heifers in which DD lesions were naturally induced decreased ($P < 0.05$) DD prevalence. The DD Formula reduces DD prevalence when fed at the proper dose and fed prior to appearance of DD lesions.

Key Words: cattle, digital dermatitis, trace minerals

061 Chromium for dairy cattle: An essential nutrient.

K. J. Herrick*, K. E. Griswold, P. W. Rounds, A. Duffield, D. O'Connor, *Kemin Industries, Inc., Des Moines, IA.*

Although Cr research dates back to the late 19th century, it wasn't until approximately 50 yr ago it was demonstrated that Cr was an essential mineral for rats and humans. Since then, there has been a plethora of research which has helped to explain the relevance of Cr in human and production-livestock nutrition. Chromium can exist in all oxidation states; however, the most common available forms are trivalent (Cr^{+3}) and hexavalent (Cr^{+6}). Trivalent Cr is most identified with digestibility markers and commercially available forms of Cr for livestock, while Cr^{+6} is associated with carcinogenic properties of Cr. Since bioavailability of inorganic forms of Cr are generally low (0.4 to 2.0%), organic forms of Cr^{+3} are now available which improve absorption and availability of Cr to the animal. Numerous studies have shown that Cr has a strong association to both glucose and lipid metabolism through insulin potentiation. As a result, production measures affected by insulin such as growth, milk production, and immunity are areas which benefit from Cr supplementation. Because of the relationship to insulin and insulin sensitivity, metabolic disorders related to the transition and early lactation periods have previously been identified as areas of opportunity for Cr supplementation. Additional research has recently demonstrated that Cr may also have significant benefits on reproductive indices. Bryan et al. (2004) observed a tendency for improved pregnancy rate in intensively grazed cows supplemented with Cr compared with cows not provided Cr. Additionally, in research done by Kafilzadeh et al. (2012), Holstein cows supplemented with Cr had fewer days to first service and days to first estrus compared with nonsupplemented cows. It was speculated by both authors

that increased insulin sensitivity may have affected granulose cell proliferation or perhaps increased ovulation rates as observed in swine fed Cr. Part of the improved response by Kafilzadeh et al. (2012) may have been related to improved immunity. Cows fed Cr had increased neutrophil and neutrophil to lymphocyte ratio during the prepartum period. Yasui et al. (2014) observed a similar immune response. Cows fed Cr tended to have a greater percentage of neutrophils as well as a decreased incidence of cytological endometritis compared with cows not fed Cr. Because of the relationship to insulin and related metabolic pathways, Cr supplementation has the potential to positively impact numerous production measures in dairy cattle. However, additional research needs to be completed to elucidate the exact mode of action.

Key Words: chromium, dairy cattle, reproduction

062 Relationship between early lactation body condition score and midlactation feed efficiency in primiparous Holstein cows.

L. C. Hardie^{1,*}, M. J. VandeHaar², D. M. Spurlock¹, ¹*Iowa State University, Ames,* ²*Michigan State University, East Lansing.*

Feed efficiency is increasingly becoming an important trait to consider when selecting profitable dairy cows. With that comes the concern that selecting for a more feed efficient cow may inadvertently select for cows that undergo extreme body tissue loss to meet the demands of milk production. The goal of this study was to determine if residual feed intake (RFI) measured in midlactation was related to early lactation BCS in primiparous Holstein cows. Weekly BCS up to 45 days in milk (DIM) were observed on all first lactation Holstein cows at the Iowa State University dairy farm from 2012 to 2014. Beginning at approximately 50 DIM, all clinically healthy cows had daily milk production measured and feed intake recorded using a Calan Broadbent feeding system for approximately 60 d. During this time, weekly BW, BCS, and milk component data were also collected. In total, 255 cows had all of these data recorded. Early lactation BCS was predicted for days without observations. Three early lactation BCS traits were generated: average daily change in BCS during the first 25 DIM, average daily change in BCS during the first 45 DIM, and BCS at calving, measured as the average predicted BCS for DIM 3 through 5. The RFI was calculated as the error term in the regression of DMI on milk energy, change in BW, and metabolic BW. Fixed effects of replicate and DIM were included. Differences in the early lactation BCS traits were assessed for the 20 most and 20 least feed efficient cows using a mixed model. The RFI for the 20 feed efficient cows was <-1.66 and >1.69 for the feed inefficient cows. The DMI for the efficient cows averaged 18.5 and 24.2 kg/d for inefficient cows. The difference in average BCS at calving was insignificant at 3.87 for efficient cows and 3.66 for inefficient cows. Change in BCS during the first 25 DIM and during the first 45 DIM did not differ by feed effi-

ciency group. From this study, we conclude that cows differing on RFI as measured during mid-lactation do not experience significant differences in body tissue mobilization during early lactation. We appreciate the support from the USDA National Needs Graduate Fellowship Competitive Grant no. 2013-38420-20496 and the Agriculture and Food Research Initiative Competitive Grant no. 2011-68004-30340.

Key Words: body condition score, feed efficiency, residual feed intake

EXTENSION – SWINE

063 Identification of gilt development factors that impact subsequent female reproduction.

A. J. Cross^{1,*}, K. A. Gray², M. Knauer³, J. P. Cassady¹,
¹South Dakota State University, Brookings, ²Smithfield Premium Genetics, Rose Hill, NC, ³North Carolina State University, Raleigh.

The objective of this study was to identify gilt development characteristics that affect subsequent sow reproductive performance. Selection for production traits and reproductive efficiency has decreased sow longevity. Improving sow longevity can have a positive economic impact on commercial pork production. Therefore, it is important to construct management strategies that enhance gilt and sow retention. Birth and weaning information were obtained on 12,943 gilts from 2 genetic multiplication farms. After weaning, gilts were followed throughout their reproductive life on commercial sow farms (n = 10) in eastern North Carolina. Information obtained from the commercial sow farms included: age at first service, age at first farrowing, length of productive life, and lifetime prolificacy. The GLIMMIX procedure in SAS was used to examine litter birth characteristics in relation to the likelihood of a gilt farrowing a litter. A binary distribution with a logit link function was used for gilt survival to parity 1 (0 = did not farrow, 1 = farrowed). General linear models were used to evaluate age at first service and age at first farrowing. Of the 12,943 gilts that were born, 5,732 (44.3%) entered the commercial sow farms. Of the gilts that entered the sow farms, 5,262 (91.8%) farrowed a litter. An increase of 1 piglet born in a gilt's birth litter decreased the odds of her subsequently farrowing a litter by 3.3% ($P < 0.05$). Gilts with a 1 kg increase in adjusted wean weight are 1.16 times more likely to subsequently farrow a parity 1 litter ($P < 0.01$). A 1 d increase in weaning age increased age at first service by 0.83 d and age at first farrowing increases by 0.68 d ($P < 0.01$). As age at first service increased by 1 d, the odds of a gilt farrowing a parity 1 litter decreased by 1.2% ($P < 0.01$). It was concluded gilts born into smaller litters and gilts that were heavier at weaning were more likely to farrow a subsequent litter. Genetic multiplication farms

should work to maximize piglet weaning weight to improve subsequent reproduction at commercial sow farms.

Key Words: gilt, longevity, reproduction

064 Efficiency of replacement gilt production is affected by litter birth weight phenotype.

G. Foxcroft^{1,*}, J. Patterson¹, N. Holden², T. Werner², M. Allerson², E. Triemert², L. Bruner³, J. C. Pinilla⁴, ¹University of Alberta, Edmonton, Canada, ²Holden Farms Inc., Northfield, MN, ³Swine Veterinary Center, St. Peter, MN, ⁴PIC, Hendersonville, TN.

The successful selection for increased litter size has resulted in an overall decrease in litter average birth weight (LBW). However, irrespective of litter size, a genotype × environment interaction has also been reported to result in a repeatable low LBW phenotype in a subpopulation of mature sows. In the preliminary phase of a National Pork Board-funded project to investigate links between LBW phenotype and sow lifetime productivity (SLP), conducted in collaboration with Holden Farms Inc., individual piglet weights were used to determine LBW in parity 2 to 4 PIC Line 3 sows in a commercial genetic nucleus population (n = 1150). Excluding sows with a total born (TB) of < 7 and > 20, TB was negatively correlated ($P < 0.0001$) to LBW [LBW = -0.037 (TB) + 1.87, $R^2 = 0.20$], representing a 500 g difference between the smallest and largest litters. In contrast, the variation in LBW among litters with the same TB was greater (mean = 950 g, range 600 to 1400 g). Sows with 2 consecutive parity records (n = 183, to date) were classified as having a repeatable low (LLBW, n = 24) or high (HLBW, n = 28) LBW phenotype, if LBW fell 1 standard deviation below or above the population mean, respectively, and a repeatable medium (MLBW, n = 131) phenotype for intermediate weight litters. Overall, there was a significant correlation between LBW measured at consecutive farrowings ($r = 0.4$; $P < 0.0001$). Furthermore, supporting previous results, no sows first giving birth to a LLBW litter produced a HLBW litter at the next farrowing. An extreme LLBW phenotype is, therefore, repeatable and predictable within sows. Considering L3 sows bred to produce replacement L3 gilts in the nucleus population, preliminary analyses identify entire sets of littermate gilts that are already subjectively designated “nonselect” at weaning or the preselection stage on the basis of being “small” or “thin”, suggesting that a LLBW phenotype has a major impact on the efficiency of replacement gilt production. Further evidence to substantiate the hypothesis that “a repeatable low LBW phenotype will negatively impact the production of selectable replacement gilts at nucleus and multiplication level” will continue to be a major component of this ongoing collaborative study.

Key Words: birth weight, gilt, selection

065 **“Select” gilts have superior lifetime productivity.**

J. Patterson^{1*}, G. Foxcroft¹, N. Holden², T. Werner², E. Triemert², B. Gustafson², J. C. Pinilla³, ¹*University of Alberta, Edmonton, Canada*, ²*Holden Farms Inc., Northfield, MN*, ³*PIC, Hendersonville, TN*.

Establishing effective gilt development unit (GDU) protocols was considered pivotal to the success of a long-term National Pork Board funded project designed to link gilt litter of origin traits to sow lifetime productivity (SLP). In collaboration with Holden Farms Inc., prepubertal Camborough gilts (n = 6082) were delivered to a designated GDU over a 21-mo period, with the goal of delivering known cyclic (Select) gilts to the sow breeding farm. A purpose built boar exposure area (BEAR) was designed to facilitate stimulation and detection of puberty (full standing heat in the presence of a boar) by providing fenceline and direct contact (15 min daily) with at least 6 mature boars over a 28-d period, starting at approximately 170 d of age. At D14, nonpubertal gilts were mixed in new pen groups. At D23, noncyclic gilts with no record of vulval development were eligible for treatment with PG600 to induce puberty in these “opportunity” females. Gilts without a record of puberty at D28 were deemed “Nonselect”. At the end of the GDU phase, 75% of the gilts were considered “Select” (4561/6082). In practice, 4980 gilts were delivered to the sow farm and retrospectively classified as: “Select” gilts expressed a pubertal estrus and either exhibited standing heat without intervention (SEL, n = 3276), or exhibited estrus after PG600 treatment (SELPG, n = 1137). A number of “Nonselect” gilts transferred to the sow farm either did not spontaneously show estrus (NOSEL, n = 417), or did not exhibit puberty immediately after PG600 treatment (NOSELPG, n = 150). More SEL gilts ($P \leq 0.05$) were served (SEL: 97.9, SELPG: 96.6, NOSEL: 94.3, NOSELPG: 88.9%) and farrowed to first service (SEL: 94.3, SELPG: 91.0, NOSEL: 89.2, NOSELPG: 86.0%) than the other classifications. However, once gilts were successfully bred, the percentage that farrowed at Parity 4 (SEL: 73.0, SELPG: 70.2, NOSEL: 70.0, NOSELPG: 70.4%), and total numbers born (SEL: 55.2, SELPG: 55.0, NOSEL: 54.2, NOSELPG: 55.7) and weaned (SEL: 42.9, SELPG: 42.4, NOSEL: 43.7, NOSELPG: 43.0) were not different ($P > 0.05$) among gilt classifications. Therefore, effective gilt selection, linked to successful introduction to the breeding herd, is a critical driver of SLP. These GDU/BEAR protocols will now be used to study more complex associations among gilt litter of origin, rate of selection in the GDU and SLP.

Key Words: gilts, puberty, selection

066 **Relationship of Minolta color scores at birth with piglet weights and survival.**

T. L. Carolan^{*}, T. J. Safranski, M. R. Eilersieck, *University of Missouri, Columbia*.

Subjective viability scores at birth have been shown to correlate with piglet growth and survival. Viability score

includes the skin color of a piglet, which could be measured objectively. The objective of this study was to measure relationship of Minolta color scores of piglets at birth with piglet growth and survival. Minolta scores (from low values to high values; L*, white to black, a*, green to red, and b*, blue to yellow) were taken immediately after birth. Each piglet’s side was wiped off and the Minolta camera was pressed against their side to get the scores. Each Minolta score was divided into quartiles increasing in value from Q1, Q2, Q3, to Q4. Piglets were weighed at birth (n = 660), and a random sample again 24 h postparturition (n = 310), 11 wk of age (n = 304), and 21 wk of age (n = 312). At birth, piglets with L* in Q4 compared with Q3 were heavier ($P = 0.0309$). Piglets with birth b* in Q4 were heavier than Q1, Q2, and Q3 ($P < 0.0001$, $P = 0.0005$, and $P = 0.0006$). Week 11 weights were significantly higher if L* was either in Q1 or Q2 compared with both Q3 ($P = 0.0248$, $P = 0.0306$) and Q4 ($P = 0.0140$, $P = 0.0175$). Piglets at wk 11 with a* in Q4 were heavier compared with Q2 ($P = 0.0255$). Heavier piglets had more red pigmentation at birth, and b* in Q4 compared with Q2 ($P = 0.0428$). Week 21 weights tended to be higher when L* was in Q1 compared with Q2 ($P = 0.0908$), and when a* was in Q1 or Q4 compared with Q2 ($P = 0.1170$ and $P = 0.1295$). Piglets were more likely to survive to 17 d of age if their b* was in Q2 compared with Q3 and Q4 ($P = 0.0321$ and $P = 0.0088$). There is significant evidence to suggest that certain Minolta scores at birth correlate with higher weights in early piglet growth, and there are some tendencies for birth Minolta scores to correlate with heavier weights later in piglet growth.

Key Words: growth, piglet, survival

067 **Development of a mobile phone application to predict live body weight in Ugandan village pigs without the use of a scale using various body measurements.**

M. Walugembe^{*}, Y. Liu, V. Sukhwai, D. M. Weiss, K. J. Stalder, M. F. Rothschild, *Iowa State University, Ames*.

In Uganda, very few pig producers own scales, thereby making fair sale of pigs based on weight quite difficult. To remedy this situation, a study to develop pig BW prediction equations based on various body measurements was conducted in the rural Kamuli district, Uganda. Body weight (kg) and body measurement data (cm) were collected from 411 pigs between 15 kg and 127 kg from both local and exotic (mainly cross-bred) pigs. Five body measurements; body length, heart girth, height, body width (over the shoulders), and flank-to-flank were taken from each pig. Prediction models were developed by regression analysis where BW was the dependent variable and the various body measures were the independent variables. The data were organized into 3 categories for modeling: pigs categorized as < 40 kg, ≥ 40 kg, and all pigs. Mean weights in the < 40 kg and ≥ 40 kg categories were 27 ± 6.5 kg and 63 ± 19.6 kg, respectively. Body length and heart girth were used to

predict ($R^2 = 0.89$) weight for the <40 kg pigs with the prediction equation: $\text{Weight} = -41.814 + 0.296(\text{body length}) + 0.654(\text{heart girth})$. Four body measurements; body length, heart girth, height, and body width were strongly predictive ($R^2 = 0.92$) of live BW for the ≥ 40 kg pigs with the prediction equation: $\text{Weight} = -108.198 + 0.228(\text{body length}) + 1.094(\text{heart girth}) + 0.267(\text{height}) + 0.922(\text{body width})$. The flank-to-flank measurement did not affect model prediction ($P > 0.05$) and quadratic terms also did not improve accuracy. Because local Ugandan farmers are not likely to use prediction equations to compute pig weights, an android-based mobile app was developed using the appropriate body measurements. The app is designed to be used with English or Luganda, a Uganda native language spoken by most of the people in the country. We concluded that this weight estimation tool would empower Ugandan small scale pig farmers by providing them with an accurate estimate for the animal's live weight and giving them better bargaining power when selling their pigs.

Key Words: body measurements, mobile app, weight prediction model

068 Relationship between feeding behavior and performance traits in boars. C. E. Abell*, A. Steuer, T. Rathje, *DNA Genetics, Columbus, NE.*

Feed accounts for over 60% of the cost of producing a market pig. Genetic variation exists for feed efficiency and it can be improved through selection. Feed efficiency or feed intake and growth are included in most selection programs; however, there is little known about how feeding behaviors can influence performance. Individual feed intake records from 895 Yorkshire, 685 Landrace, and 1588 Duroc boars were collected at a single finishing site using Osborne Feed Intake Recording Equipment (FIRE™). Pigs were tested for 12 wk from 75.7 (± 2.8) d old to 158.5 (± 3.0) d old. During the testing period, feed intake was recorded every other week on each pig, with the first 2 d discarded as the acclimation period and the other 5 d used to predict daily feed intake. While not on the FIRE feeders, pigs ate from a fence line feeder. For all 3 breeds, a greater amount of time spent in the feeder per day was correlated with poorer feed efficiency; the correlations (\pm SD) were 0.24 ± 0.06 , 0.29 ± 0.07 , and 0.26 ± 0.05 for Yorkshire, Landrace, and Duroc boars, respectively. The phenotypic correlations between feed intake per visit and feed efficiency ranged from 0.17 to 0.22 ($P < 0.05$) for the 3 breeds. There was a positive correlation between ADG during the testing period and time spent in the feeder for all 3 breeds (0.08–0.12, $P < 0.05$), but the magnitude was small. The amount of time spent in the feeder per day increased for the first 3 wk after the pigs started the test, then declined for the remaining test period for all 3 breeds. Yorkshire boars spent the most time in the feeder at the beginning of the testing period, but spent the least time in the feeder after 2 wk on-test compared with the other 2 breeds. The number of visits per day decreased throughout the testing period for Landrace and Duroc boars,

while Yorkshire boars had a maximum number of visits per day half way through the testing period. Feed consumed per visit for all 3 breeds increased throughout the testing period. It was observed that Yorkshire boars had more visits per day to the feeder, but consumed less feed per day compared with Landrace and Duroc boars. Establishing how feeding behaviors influence boar performance can result in improved response in feed efficiency through both selection and feeding strategies.

Key Words: feed intake, growth rate, swine

069 The effect of DDGS particle size and pellet quality on grower-finisher pig performance.

W. J. Pacheco^{1,*}, M. Knauer¹, E. van Heugten¹, A. C. Fahrenholz¹, C. E. Phillips², C. R. Stark³, ¹North Carolina State University, Raleigh, ²Murphy-Brown LLC, Rose Hill, NC, ³Kansas State University, Manhattan.

The objective of the study was to evaluate the effect of further grinding distillers dried grains with solubles (DDGS) and the percentage feed fines on grower-finisher pig performance. A total of 760 mixed sex pigs (28.8 ± 3.1 kg) were housed in a curtain-sided barn with mechanical ventilation and totally slatted flooring. The experimental design consisted of a 2×2 factorial design with 2 particle sizes of DDGS (640 vs. 450 μm) and 2 levels of fines (0 vs. 25%). The 4 treatments were randomly distributed among 40 pens with 10 replicates per treatment. Pigs were fed a common diet containing 30% DDGS and 6.5% supplemental fat in 3 dietary phases grower (1 to 40 d), developer (41 to 83 d), and finisher (84 to 116 d). Of the 6.5% supplemental fat in each diet, 1.5% was added in the mixer and 5.0% was added postpelleting. Diets were conditioned at 77°C for 45 seconds and then pelleted using a pellet mill equipped with a 3.5×36 mm die. The fines produced during the pelleting process were separated using a pellet screener and then mixed back with the whole pellets to obtain the desired percentage fines in the final feed. Feeds were delivered and pen feed intake recorded using an automatic feed delivery system (FeedPro). Feed consumption and BW were determined at 1, 18, 40, 83, and 116 d on test and gain to feed (G:F) calculated. Data were analyzed using PROC GLM in SAS. Pen was the experimental unit. Fixed effects included DDGS particle size, percentage fines, and their interaction. The particle size of DDGS did not impact ($P > 0.05$) overall ADG (836 vs. 842 g; $P = 0.65$), ADFI (2205 vs. 2222 g; $P = 0.66$), or G:F (0.379 vs. 0.379; $P = 0.95$). Diets with 0% fines did not improve ($P > 0.05$) ADG (843 vs. 835 g; $P = 0.48$), ADFI (2224 vs. 2204 g; $P = 0.59$), or G:F (0.379 vs. 0.379; $P = 0.97$) in comparison to diets with 25% fines. Results indicated that DDGS does not need to be further ground at the feed mill and that up to 25% feed fines could be fed without adverse effects on pig performance.

Key Words: DDGS, fines, grinding, particle size

**GARY ALLEE SYMPOSIUM:
IMPACT OF FDA GUIDANCE'S 209
AND 213 ON THE SWINE INDUSTRY**

070 **Use it and lose it: The dilemma of antibiotic resistance development.** E. Topp*, *Agriculture and Agri-Food Canada, London, ON, Canada.*

Amid concerns that the loss of antibiotic efficacy will have dire consequences for human morbidity and mortality, there is an urgent need for a comprehensive and global strategy to forestall the development of resistance to antibiotics by bacterial pathogens. Action must include steps to promote the judicious use of antibiotics in human medicine and in animal production, and to mitigate terrestrial and aquatic exposure to antibiotic residues and antibiotic resistance genes carried in agricultural wastes, and effluents from municipal wastewater treatment. It is important that in mixed agriculture, livestock and crop production systems be tightly coupled with respect to nutrient flow. Manures typically carry antibiotic-resistant bacteria, and numerous genes associated with antibiotic resistance determinants have been detected in molecular inventories of manure microbial populations, and in the environment in proximity to land fertilized with manure. In field experiments in London, ON, Canada, we have been evaluating the dynamics of antibiotic resistance genes (ARGs) and bacteria following the land application of dairy or swine manure, or sewage sludge, and whether the use of these materials as soil amendments in normal farming practice increases the abundance of ARGs on crops at harvest. Following a general introduction to antibiotic resistance, this presentation will present recent search results (e.g., *Applied and Environmental Microbiology* 79:5701-9; 80:3258-65; 80:6898-6907) and discuss their potential significance within the broad context of antibiotic resistance development. Key findings are that soils become enriched with DNA carried in amendments including genes associated with antibiotic resistance and gene mobility. Antibiotic resistance genes persisted for months following soil amendment with seasonally variable and complex dynamics. Vegetable crops harvested in the fall following a spring amendment application carried an additional burden of ARGs, compared with crops grown in unamended soil. Further knowledge concerning the origin and dynamics of ARGs in animal and crop production systems is needed to inform agricultural policies and practices that mitigate human exposure to antibiotic resistant bacteria entrained on food crops.

Key Words: antibiotic resistance, manure, soil

071 **Antibiotic resistance in the swine industry.**
P. R. Davies*, *University of Minnesota, St. Paul.*

Antimicrobials are important tools for ensuring the health,

welfare, and productivity of food animals. Societal concerns about the use of antimicrobials in food animals increased greatly in recent years, and substantial regulatory changes to oversight of antimicrobial use are underway in the United States. Even greater restrictions are likely in the future. These changes are likely to impact animal health, welfare, and productivity of swine production, and the economic viability of some farms, particularly smaller farmers. From a scientific perspective, 2 important unanswered questions are: 1) to what extent does antimicrobial use in food animals contribute to problems of clinical treatment failure in humans resulting from resistance; and 2) Which patterns of antimicrobial use in animals are of greatest concern with respect to selection of resistant bacteria? Without this knowledge, arguments that restricted use of antimicrobials in food animals will measurably benefit public health, and that particular modes of use are more harmful, rest more on belief than evidence. Momentum for regulatory changes in the United States has been inherited from changes implemented in the EU over the last 15 yr. Most notably, banning of antimicrobial growth promoters in Denmark in 2000, and across the EU in 2006, gave great impetus to the recent changes in FDA regulations. The changes in the EU were initially motivated by specific concerns about antimicrobial resistance in foodborne pathogens (e.g., *Salmonella*, *Campylobacter*), where the link between animal antimicrobial use and human health is most direct. However, any resultant reduction in resistance in these organisms has been questionable. As we traverse the spectrum of treatment-control-prevention-growth promotion uses, societal support for antimicrobial use in animals will understandably decline. Assuming any reduction of antimicrobial use is desirable (i.e., less is better), it seems logical to eliminate uses that are less necessary or less justifiable in terms of benefits to animal health and welfare. However, it is ominous that recent developments to reduce antimicrobial use in food animals in the EU are almost completely divorced from any assessment of trends of resistance in bacteria or in clinical antimicrobial resistance in humans. An EU directive for mandatory recording and analysis of antimicrobial use in food animals is now being implemented, and better systems for accurately quantifying use in the United States are to be expected. Of greater concern are calls to eliminate preventive uses of antimicrobials, which appear to pay no heed to likely impact on animal health and well-being.

Key Words: antimicrobial, resistance, use

072 **What FDA Guidance 213 and the veterinary feed directive mean on the farm.** E. A. Wagstrom*,
National Pork Producers Council, Washington, DC.

The FDA has published final Guidance for Industry No. 213 and a proposed Veterinary Feed Directive (VFD) rule. Guidance for Industry No. 213 asks sponsors to relinquish their claims for production uses (growth promotion or improvement

of nutritional efficiency) for antimicrobials in classes that are used in human medicine. The VFD Rule will require all therapeutic uses of these same antimicrobials in feed or water to be under a veterinary order or prescription. Farmers in the United States are allowed to utilize a range of antimicrobials to improve growth or nutritional efficiency without veterinary oversight. Some of these antimicrobials are also in classes used in human medicine. The fluoroquinolone and cephalosporin classes have never been used for production purposes in the United States. Certain feed antimicrobials have required a VFD. The current regulations require that the veterinarian state not only the indication and dose, but also an amount of feed that will be consumed during treatment. These requirements have been problematic. Antimicrobials administered in feed can only be used as labeled. Since administering an antimicrobial for a different indication is considered extra-label, after the production claims are discontinued it will be illegal to use these antibiotics to promote growth. The implementation of Guidance 213 and the revised VFD rule will change how antimicrobials are used in food animal production. Simplistically, many feel that the success of these changes should be measured by a decrease in the amount of antimicrobials sold. However, it is uncertain how much clinical disease is being prevented by the current uses of antimicrobials that will require treatment following the removal of growth promotion antibiotics. The requirement for the therapeutic uses of antimicrobials in feed and water to be under veterinary oversight will also impact farmers of all sizes. It is expected that the revisions to the VFD rule will make the process more user friendly. However, it is expected these changes will impose a burden on farmers and veterinarians. Since there are relatively few veterinarians practicing food animal medicine in the United States, the burden to provide and document the veterinary orders may be substantial. The FDA Guidance for Industry No. 213 and the changes to the VFD rule will have substantial impact on antimicrobial use decisions on farm and add to the burden to document judicious use of therapeutic antimicrobials by producers who utilize them on their farms.

Key Words: antimicrobial use, FDA, veterinary feed directive

073 **Identifying potential alternatives to antibiotics.**

H. K. Allen*, T. Looft, J. Trachsel, T. A. Casey, T. B. Stanton, *USDA National Animal Disease Center, Ames, IA.*

The greatest challenges to identifying antibiotic alternatives in animal agriculture are the numerous different uses of antibiotics: disease treatment, disease prevention, and improved feed efficiency. These various uses are achieved by administering antibiotics at either high or low concentrations, which beget different effects on both pathogenic and commensal gut bacteria. Selecting an appropriate alternative is therefore dependent on the intended use of the antibiotic. Three promising

alternatives that address the different goals of antibiotic use will be discussed here: phage therapy, vaccination, and modulation of gut bacteria (e.g., probiotics, prebiotics, synbiotics, or competitive exclusion). Benefits and shortcomings of each of these strategies will be described. Vaccination targets specific pathogens, which is an advantage because few collateral effects will be experienced, but is limited by knowledge of the etiological agent. Phage therapy also benefits from being a targeted approach, but is akin to antibiotics because of the potential for resistance to develop when used imprudently. Probiotic and similar modulators of the gut bacterial community are often reported as promising but lack experimental reproducibility, likely due to unknown principles governing the complex relationship between a host and its gut bacterial consortium. The goal of research in our lab is to understand how growth-promoting antibiotics alter the intestinal bacterial community to enhance animal performance, and perhaps this information will inform efficacious antibiotic alternatives. One avenue has been to define the effects of the growth-promoting antibiotic carbadox on the swine bacterial community. Our results show that carbadox has an immediate (within 7 d of initial administration) effect on the gut bacterial community, but that the community recovers even in the continued presence of carbadox. Notably, the abundance of some bacteria (members of the *Prevotella* genus) remain constant during carbadox exposure, while other bacterial populations temporarily decrease. Further work is required to determine the potential of these bacteria as modulation targets. As tightening regulations continue to limit antibiotic use, these and other alternatives to antibiotics merit continued exploration to improve animal health and food safety.

Key Words: antibiotic alternatives, antibiotics, carbadox, phage therapy, probiotics, vaccines

074 **The paradigm of restricted antimicrobial use:**

Swine production in the EU. T. van Kempen*, *North Carolina State University, Raleigh; Nutreco R&D, Boxmeer, the Netherlands.*

Instilled by fears for unmanageable bacterial infections in humans, the use of antimicrobials as growth promoters is under dispute in many countries, and already banned in the European Union. On paper, it is possible to produce livestock without the use of antimicrobials by practicing perfect biosecurity. Indeed, some farmers in affected regions have rebuilt their production system in order to achieve much better biosecurity, but also to align better with increasing environmental and welfare demands. For farms unable to do so, but also for farms where biosecurity has been improved, practical means for better managing health are needed. Likely, the 2 most critical points are birth and weaning. The birth process is stressful for the piglet, especially when the sows lack stamina to sustain parturition. Better preparation of the sow for parturition is key. Once born, piglets should be provided with an optimum

climate to facilitate colostrum intake; supplemental milk can be a beneficial source of additional nutrients and health factors, especially for weaker animals. This supplemental milk is ideally made available on the day of birth and offered warm and frequently as to stimulate intake. Later-on, during lactation, creep feed should be offered in order to facilitate the transition to solid feed after weaning. The feed after weaning should not be perceived as novel to the piglet, as this can delay intakes, resulting in opportunities for infections. *Escherichia coli* infection trials demonstrated that feed intake was the key protectant for newly weaned piglets, not the composition of the diet (ZnO provides an exception to this rule). The time of day of weaning should be optimized for intake while diet composition should focus on intake above anything else. Plasma, colostrum powder, and hyperimmunized eggs provide precious immunological support to the newly weaned. There is also a host of organic acid and plant-extract based products that can aid in maintaining intestinal health. These products should first of all not hurt palatability; second, they should aid in maintaining a stable gut environment. For the latter, in vitro data for selecting products is only a first stab; products should be proven and tried under field conditions. Smart combinations, however, can certainly aid in maintaining piglet health during stress periods. In conclusion, swine production without antimicrobials is tough; with high quality management, high quality diets, and proven additives that aid in stabilizing the gut, the pain can be lessened.

Key Words: additives, antimicrobials, swine

075 Use of antibiotics in swine production in the light of new FDA guidelines. C. J. Rademacher*, Murphy-Brown, LLC, Ames, IA.

Group sow housing has been the predominant industry social issue in regards to modern swine production, and the regulation of antibiotics usage in the swine industry is quickly becoming the next issue with societal implications. Although there is no definitive link between use of antibiotics in production animal medicine and the increase in resistance in human medicine, there has been strong societal pressures for the government to intervene. The FDA has responded by releasing 2 guidances for the U.S. swine industry designed to limit the amount of antibiotics used, as well as enacting more veterinary oversight into the use of antibiotics, particularly for growth promotion. FDA Guidance No. 209 and 213 are designed to limit the use of medically important (human) antibiotics in animal agriculture. The scope of the limitation was to prohibit the use of medically important antibiotics for growth promotion or for improvement in feed efficiency. It states that, under veterinary guidance, the use of medically important antibiotics are allowed for treatment and control. It is also allowed for prevention as long as certain criteria are met, such as evidence of efficacy, it is an accepted veterinary practice, no practical alternatives are available, and it targets a specific

etiologic agent. The guidance also states the importance for veterinary consultation for the use of any medically important antibiotics in modern agriculture. Essentially, it will eliminate the over-the-counter use of medically important antibiotics, thereby requiring veterinary oversight to be able to use them. With both of these regulations, there is a 3 yr grace period before they are officially enacted, which means 2016 will be when these guidances become law. In preparation to meet these new regulations, our company has begun the process of updating our production practices. The focus of this presentation will be on discussing the antibiotic program changes that have been implemented to meet the criteria of the guidance documents. Examples from our nursery and grow-finish production system evaluations will be shared with the audience.

Key Words: antibiotics, FDA guidelines, swine production

GROWTH, DEVELOPMENT, MUSCLE BIOLOGY, AND MEAT SCIENCE: GROWTH, DEVELOPMENT, MEAT SCIENCE, & MUSCLE BIOLOGY

076 Effects of in utero heat stress on muscle development of barrows. T. A. Wilmoth^{1,*}, Z. D. Callahan², T. J. Safranski², B. R. Wiegand², ¹Clemson University, Clemson, SC, ²University of Missouri, Columbia.

Muscle development occurs between d 25 to 90 of gestation and can be influenced by environmental factors such as in utero heat stress during fetal development and postnatal growth. Changes in muscle development can alter the quality of the meat product. Therefore, the objectives of this work were to determine the effects of in utero heat stress, excess dietary lysine, and Paylean on muscle development of barrows. At 25 kg, barrows of control ($n = 40$) or heat stressed (HS; $n = 40$) dams were individually housed and fed a corn-soybean meal diet. At this time, barrows were equally and randomly assigned to receive a diet that met (100% NRC; $n = 20$) or exceeded (110% NRC; $n = 20$) NRC lysine requirements. In the last 30 days of finishing, barrows were again equally and randomly assigned to a diet containing 0 ($n = 10$) or 7.4 mg/kg Paylean (PAY; $n = 10$). Diets were fed until 121 kg of weight was attained. At slaughter, muscle samples were collected from the longissimus dorsi (LD) and semitendinosus (ST) and used for the adenosinetriphosphatase assay. In the LD, the number of primary muscle fibers (PCLD), the number of secondary fibers (SCLD), the size of primary fibers (PDL) and the size of secondary fibers (SDL) were determined. The same variables (PCST, SCST, SPST, PDST, and SDST) were determined for ST. The ratio of secondary to primary fibers (SPLD and SPST) was also determined for each LD and ST. Heat stressed treatment increased (58.17 ± 1.17 vs. 60.90

± 1.06 µm; $P = 0.09$) SDLD. Heat stressed × PAY interactions increased SDLD ($P = 0.02$) and decreased SPLD ($P = 0.04$). There was a decrease for an interaction between lysine by HS for SCLD ($P = 0.08$). Heat stressed × lysine × PAY interactions increased SCLD ($P = 0.03$) and decreased SPLD ($P = 0.009$). In ST muscle, HS treatment increased PDST (57.74 ± 1.09 vs. 63.78 ± 1.13 µm; $P = 0.0003$) and SDST (67.70 ± 1.36 vs. 72.74 ± 1.40 µm; $P = 0.01$). A lysine × PAY interaction increased PDST ($P = 0.04$) and trends for this interactions reduced PCST ($P = 0.07$) and SCST ($P = 0.10$). There were also positive correlations between shear force and PDL ($r = 0.31$, $P = 0.01$), SDLD ($r = 0.27$, $P = 0.04$), and PDST ($r = 0.30$, $P = 0.03$) and a tendency for SDST ($r = 0.25$, $P = 0.06$). Heat stress during gestation alters muscle development, resulting in increased muscle fiber size at harvest and, ultimately, a tougher product.

Key Words: heat stress, muscle development, ractopamine

077 **Integrative responses of pig adipose tissues to a high-fat, high-fiber diet: Towards key regulators of energy flexibility.** F. Gondret^{1,2,*}, A. Vincent^{1,2}, M. Houee³, S. Lagarrigue^{1,2}, A. Siegel⁴, D. Causeur³, I. Louveau^{1,2}, ¹INRA UMR1348 PEGASE, Saint Gilles, France, ²AgroCampus-Ouest UMR1348 PEGASE, Rennes, France, ³AgroCampus-Ouest UMR6625 IRMAR, Rennes, France, ⁴CNRS-Université de Rennes 1-INRIA, UMR6074 IRISA, Rennes, France.

The competition between food and feed challenges the use of alternative resources such as fibrous feedstuffs in diets for pigs. Adding fat to high-fiber diets appears as a relevant strategy to improve dietary energy value and feed efficiency, but this changes the nutrients and energy source compared to a standard low-fat diet. This study aimed to elucidate the transcriptional mechanisms involved in variations of adiposity when pigs were fed a high-fat, high-fiber diet. Growing barrows (Large White; $n = 48$) divergently selected for feed efficiency were offered during 10 wk either a low-fat, low-fiber diet (LF) or a high-fat, high-fiber diet (HF) where oils and wheat straw were used to partially substitute cereals ($n = 24$ per diet). At 132 days of age, HF pigs displayed lower ($P < 0.001$) proportions of perirenal (PRAT; -16%) and subcutaneous (SCAT; -28%) fat tissues than LF pigs. Analyses using a porcine microarray showed that diet had pronounced effects on adipose tissue transcriptomes. The number of differentially expressed genes (DEG) was greater in PRAT than in SCAT, with 1,251 and 825 unique genes being upregulated and 2,440 and 1,279 unique genes being downregulated by the HF diet in PRAT and SCAT, respectively (cutoffs for P -corrected BH were <0.10 and raw $P < 0.01$ and fold changes between conditions were >1.1 or <0.9). A multiple factor analysis revealed large similarities between the 2 adipose tissues in response to diets. Notably, different genes related to protein catabo-

lism (33 DEG), protein transport (33 DEG), apoptosis (31 DEG), phosphate metabolic process including ATP synthesis (34 DEG), response to stress (26 DEG), and glucose metabolism (13 DEG) were commonly downregulated in HF pigs. Conversely, IGF1R participating to the negative regulation of apoptotic process was upregulated by the HF diet in the 2 adipose tissues. Correlation modules also stressed the upregulation by the HF diet of genes related to immunity and defense response specifically in PRAT. Causality graph analysis highlighted MLXIPL, SREBF1, peroxisome proliferator-activated receptors (PPARG and PPAR α), and their heterodimer partner RXRA as candidate upstream regulators of these processes. The qPCR analyses confirmed dietary-related differences in expression levels of these regulators in the 2 adipose tissues. Altogether, high fiber intake in growing pigs was associated with lower body fatness, which was related to lower glucose metabolism in adipose tissues; its effect on immune factors in the perirenal fat deserves further studies.

Key Words: adipose tissue, fiber diet, pig

078 **Correlation of fresh muscle firmness with sensory characteristics of pork loins destined for export to a quality focused market.** E. K. Arkfeld^{1,*}, S. Mancini^{1,2}, B. Fields³, A. C. Dilger⁴, D. D. Boler⁴, ¹University of Illinois, Urbana, ²University of Pisa, Pisa, Italy, ³Genus PIC, Hendersonville, TN, ⁴University of Illinois at Urbana-Champaign, Urbana.

Because pork processors use subjective firmness at 1 d post-mortem to sort loins for quality-driven export markets, the objective was to correlate firmness at either 1 or 28 d post-mortem with sensory characteristics. Boneless loins ($N = 154$; 2.86 to 5.58 kg) were aged for 28 days at 1.7°C. Firmness was assessed at 1 d postmortem using a 5-point subjective scale at the 10th rib. On d 28, subjective firmness scores were assigned using the same scale on the ventral side of the loin at 3 locations: the area of the 10th rib, the anterior half, and the posterior half. Durometer readings were collected at the 10th rib on both dorsal and ventral sides of the loin and then averaged for average loin objective firmness. Loin flop and circumference were measured. Chops were cut and frozen on 28 d to assess sensory, quality, and mechanistic characteristics. Data were analyzed using the correlation procedure of SAS with Spearman correlation coefficients to account for the non-normality of data. Subjective firmness measures on 1 and 28 d postmortem were correlated to 28-d loin flop distance and loin circumference ($P < 0.01$). Dorsal and ventral durometer readings at 28 d postmortem were not correlated to these traits ($P > 0.30$). Day 28 subjective loin firmness was negatively correlated with purge loss and accounted for between 7.3 (10th rib) and 12.0% (anterior portion) of the total variation in purge ($P < 0.01$). Although 1-d subjective firmness accounted for 3.0% of the variation in 28-d Warner-Bratzler shear force (WBSF; $P = 0.03$), 28-d subjective firmness measures were

not correlated to WBSF ($P > 0.36$). Sensory tenderness was weakly correlated with subjective anterior firmness ($P = 0.03$, $r = 0.17$) but no other firmness measures. Sensory chewiness was weakly correlated with 28-d 10th rib and anterior firmness ($P < 0.05$, $r = -0.18$ and $r = -0.19$, respectively). Day 28 loin dorsal durometer readings accounted for 3.6% of the total variation in sensory juiciness ($P = 0.02$), and 1- and 28-d subjective anterior firmness tended to correlate with juiciness ($P \leq 0.10$, $r = 0.14$ and $r = 0.13$, respectively). Averaged 28-d loin durometer readings and 1-d subjective firmness measures did not correlate with sensory characteristics ($P \geq 0.10$). Initial (1 d) firmness accounted for 4.0% of the variation in intramuscular fat iodine value ($P = 0.02$). No firmness measures were correlated with soluble or insoluble collagen content ($P > 0.05$). These results suggest that 1-d postmortem firmness measures do not correlate to pork quality or sensory characteristics at 28 d. Although a small amount of variation in sensory attributes can be explained by 28-d firmness measures, results are not consistent throughout the loin.

Key Words: firmness, quality, sensory

079 Dietary hydrolysable tannins from chestnut have the potential to reduce the risk of boar tainted carcasses. G. Bee*, S. Ampuero Kragten, *Agroscope Institute for Livestock Sciences, Posieux, Switzerland.*

Recent in vitro incubation studies of swine cecal inoculum with different concentrations of hydrolysable tannins (HT) suggested an inhibitory effect of HT on the total activity of cecal bacteria. These findings are of interest especially in the production of entire males where the synthesis of skatole and indole, 2 compounds responsible for boar taint, could be reduced in the colon by dietary means. Results of a recent in vivo study revealed the potential of HT to reduce the incidence of boar taint. Therefore, the goal of the present study was to determine possible threshold levels of supplemented dietary HT on skatole and indole tissue deposition. For the study, 44 Swiss Large White entire males from 11 litters were selected at 59.4 kg BW and assigned within litter to 1 of 4 treatments: an unsupplemented control finisher diet (T0) and a finisher diet supplemented with 1.5 (T15), 3.0 (T30), or 4.5% (T45) chestnut powder. All pigs were reared in 1 pen equipped with 4 automatic feeders. They had ad libitum access to the assigned diets. The animals were weighed weekly and individual feed intake was monitored daily. At 103.5 kg BW, pigs were slaughtered and organ weights as well as carcass characteristics were assessed. In addition, concentrations of androstenone, skatole, and indole levels were measured in the backfat using HPLC. Despite similar feed intake, T45 pigs tended ($P < 0.10$) to grow slower than T15 pigs, with intermediate values for T0 and T30 pigs (0.80, 0.92, 0.88, and 0.83 kg/d, respectively). The T45 and T30 pigs were less (0.34 kg/kg each; $P < 0.05$) feed efficient than T0 and T15 pigs (0.38 and 0.37 kg/kg, respectively). Compared to the T0 group, lean

meat percentage was lower ($P < 0.05$) in carcasses of boars from the T15 group (56.7 vs. 58.4%), with intermediate values for the T30 and T45 group (57.3 and 57.5%, respectively). Weight of the liver, kidney, and salivary gland was less ($P < 0.10$) in the T45 group compared to all other groups. Due to large variability in the androstenone, skatole, and indole levels in the backfat, no significant ($P > 0.27$) dietary effects were observed. However, taking into account the suggested boar taint thresholds for androstenone (<1 mg/kg) and/or skatole (<0.25 mg/kg), fewer T45 than T0, T15, and T30 pigs were above these thresholds (2 vs. 5, 6, and 5, respectively). In conclusion, the current data show that despite the slight negative effect of the highest dietary HT supply on growth performance incidence of boar taint could be lowered at the highest HT inclusion level.

Key Words: boar taint, hydrolysable tannin, pig

080 The effects of maternal energy restriction during midgestation on growth performance, gene expression, and immune function in the resultant beef offspring. A. R. Taylor^{1,*}, D. A. Mohrhauser¹, K. R. Underwood¹, R. H. Pritchard¹, A. E. Wertz-Lutz², A. D. Blair³, ¹South Dakota State University, Brookings, ²ADM Alliance Nutrition, Quincy, IL, ³South Dakota State University, Rapid City.

Fetal or developmental programming evaluates the effects of maternal alterations on the developing fetus and the potential adverse effects later in life. To understand these potential consequences in beef cattle, the objectives of this research were to determine the effects of maternal nutrient restriction during midgestation on offspring growth performance, subcutaneous adipose tissue gene expression, and the humoral immune response in the resultant beef offspring. Pregnant beef cows (84 ± 11 d of gestation, 4 ± 1 yr, 495 ± 58 kg, and 4.9 ± 0.5 BCS) were allotted to 1 of 2 dietary treatments: 1) Control ($n = 76$), fed to achieve and/or maintain BCS 5.0 to 5.5, or 2) Restricted ($n = 75$), fed to lose 1 BCS over the ensuing 91-d treatment period of midgestation. Following treatment, cows were commingled and managed as a common group through weaning. Cow data was analyzed using PROC GLM (SAS). Progeny data were analyzed as a completely randomized design using PROC GLM and Repeated Measures in PROC MIXED (SAS) for growth performance and immune response, respectively. Fold differences in progeny gene expression were determined using Relative Expression Software Tool (REST). A subsample of weaned calves was used to measure humoral immune response. Two additional subsamples were sampled at weaning and harvest to evaluate gene expression. Control cows maintained or gained condition whereas Restricted cows lost condition ($P < 0.05$) during the midgestation treatment period. Midgestation treatment did not affect ($P > 0.05$) birth weight, weaning weight, or adjusted 205-d weaning weight of progeny. Expected gender differences occurred with steers

having heavier ($P < 0.05$) birth weights, weaning weights, and adjusted 205-d weaning weights compared to heifers. No differences ($P > 0.05$) were observed between treatments during the feeding period on live cattle performance variables including ADG, DMI and G:F. No differences were detected ($P > 0.05$) in subcutaneous adipose tissue gene expression in the weaning or final subsample. Calves from Restricted cows had lower antibody titers ($P < 0.05$) in response to a novel antigen during the receiving period. These results suggest a mild loss in body condition encountered by a cow during midgestation will not affect adipose differentiation or growth throughout the postnatal period in beef cattle offspring. However, these conditions imposed on the cow during midgestation may have an adverse impact on antibody production during the receiving period in the resultant calf.

Key Words: cattle, fetal programming, growth

081 **Effects of maternal plane of nutrition during midgestation on beef calf postweaning growth and feed efficiency, methane production, insulin sensitivity, and carcass characteristics.** T. B. Wilson*, B. C. Ramirez, L. F. Rodriguez, A. R. Green, D. D. Boler, A. C. Dilger, T. L. Felix, D. W. Shike, *University of Illinois at Urbana-Champaign, Urbana.*

Objectives were to investigate the effects of maternal plane of nutrition, during midgestation, on calf postweaning growth and feed efficiency, methane production, insulin sensitivity, and carcass characteristics. Calves ($n = 27$; steers, $n = 14$, and heifers, $n = 13$; initial BW = 239 ± 22 kg) used for this experiment were born to beef cows limit-fed for 3 planes of nutrition from 195 ± 14 to 112 ± 14 d prepartum: 100% NRC energy and protein requirement (REQ), 70% NRC requirement (70%REQ), or 130% NRC requirement (130%REQ). Calves were weaned at 198 ± 14 d of age and transitioned over 30 d to a common finishing diet. Individual DMI was recorded using GrowSafe (Airdrie, AB, Canada). At 304 ± 14 d of age, methane was collected, beginning at 3 h postfeeding, for 24 h. An indwelling venous catheter was inserted at 316 ± 14 d of age to conduct a glucose tolerance test. Plasma glucose and insulin concentrations were analyzed preinfusion and 5, 10, 15, 20, 30, 60, 90, and 120 min postinfusion. All calves were slaughtered at 404 ± 14 d of age at an average backfat of 1.24 cm. Transition period initial BW, ADG, and DMI were not different ($P \geq 0.39$). However, G:F was greatest ($P = 0.01$) for calves from cows fed 70%REQ and least for calves from REQ cows; calves from 130%REQ cows were intermediate and different from both. In the finishing phase, treatment did not affect ($P \geq 0.11$) final BW, DMI, ADG, G:F, or residual feed intake. Residual gain tended ($P = 0.06$) to be greater in calves from 130%REQ cows when compared to calves from 70%REQ and REQ cows. Ultrasound backfat at 299 ± 14 d postweaning tended ($P = 0.06$) to be greatest for calves from REQ cows and lowest for calves from 70%REQ

cows, with calves from 130%REQ cows being intermediate. Maternal treatments did not affect ($P = 0.66$) calves' methane production. There were no effects ($P > 0.15$) of maternal treatment on calf postinfusion glucose and insulin concentrations, glucose and insulin area under curve, or insulin to glucose ratio. Calves from REQ cows tended ($P = 0.08$) to have greater HCW than calves from 70%REQ and 130%REQ cows. Treatment did not affect ($P \geq 0.18$) carcass backfat, yield grade, LM area, marbling score, KPH, shear force, or intramuscular fat percentage. Differing maternal plane of nutrition during midgestation affected transition period gain efficiency yet did not dramatically impact calf growth performance, feed efficiency measures, methane production, insulin sensitivity, or carcass characteristics during the finishing phase.

Key Words: carcass characteristics, feed efficiency, fetal programming

082 **Evaluation of the effects of zilpaterol hydrochloride supplementation on catecholamine response and other blood metabolites following a combined corticotropin releasing hormone and vasopressin challenge.** J. O. Buntyn^{1,*}, N. C. Burdick Sanchez², T. B. Schmidt¹, S. E. Sieren¹, G. E. Erickson¹, S. J. Jones¹, J. A. Carroll², ¹University of Nebraska, Lincoln, ²USDA-ARS, Livestock Issues Research Unit, Lubbock, TX.

The stress response of cattle supplemented with zilpaterol hydrochloride (ZH) has become an issue due to claims of cattle responding poorly to stress. This study was designed to determine if differences exist in the catecholamine and blood metabolite response of ZH-supplemented cattle when exposed to a metabolic stress challenge. Crossbred heifers ($n = 18$; 596 ± 39 kg BW) were randomized into 2 treatment groups and individually fed daily with heifer serving as the experimental unit: 1) Control (CON), the finishing diet with no ZH, and 2) Zilpaterol (ZIL), the finishing diet with ZH (7.56 g/t DM basis). Zilpaterol heifers were supplemented ZH for 20 d, with a 3-d withdraw period. On d 20 of supplementation, all heifers were fitted with indwelling jugular catheters. On d 24, starting at 0400 (6 h before) and 0800 h (2 h before) and continuing until 1600 h (8 h after), blood samples were collected at 60-min intervals for plasma and serum, respectively. At 1000 h (d 24), heifers received an intravenous bolus of corticotropin releasing hormone (CRH; $0.3 \mu\text{g}/\text{kg}$ BW) and vasopressin (VP; $1.0 \mu\text{g}/\text{kg}$ BW) to activate the stress axis. Serum was separated and stored at -80°C until analyzed for creatine phosphokinase (CPK), creatine, Ca, P, Na, K, and liver enzymes. Blood samples were collected in EDTA vacutainers; plasma was separated, flash frozen, and stored at -80°C until analyzed for catecholamines. Data were analyzed using the MIXED procedure with hour as a repeated measure and compound symmetry covariance structure. There was a treatment effect ($P < 0.02$) only for Ca and K; ZIL heifers had decreased

concentrations during the CRH/VP challenge. Heifers for ZIL had increased concentrations of CPK ($P = 0.05$) and creatine ($P < 0.01$) during CRH/VP challenge. A treatment \times time effect ($P = 0.02$) was observed for P. Concentrations of P were similar -2 h before to 6 h after challenge. At 7 h postchallenge, CON heifers had less P compared to ZIL heifers. There were no differences observed ($P \geq 0.22$) for the liver enzymes aspartate transaminase and gamma glutamyltransferase. Heifers fed CON had greater concentrations of alkaline phosphatase and sorbitol dehydrogenase ($P < 0.05$) compared to ZIL heifers. Heifers for ZIL had decreased concentrations of epinephrine ($P = 0.04$). There was no difference ($P = 0.94$) for norepinephrine. Whereas some variations were observed between ZIL and CON heifers in terms of response to the CRH/VP challenge, these alterations appear to be minor. In this experimental setting, supplementation of ZH did not dramatically alter the ability of cattle to respond to stress stimuli.

Key Words: beta-agonist, stress response, Zilmax

083 **Supplementation of zilpaterol hydrochloride does not significantly alter the serum metabolic profile and metabolic enzyme profile of finishing heifers.**

S. E. Sieren^{1,*}, S. J. Jones¹, J. O. Buntyn¹, J. A. Carroll², N. C. Burdick Sanchez², T. B. Schmidt¹, ¹University of Nebraska, Lincoln, ²USDA-ARS, Livestock Issues Research Unit, Lubbock, TX.

Supplementation of zilpaterol hydrochloride (ZH; Zilmax) to cattle has been implicated as having a negative impact on the well-being of cattle. However, there is limited data to support or refute these claims. This study was designed to determine if differences exist in the serum metabolic profile and metabolic enzymes of heifers supplemented ZH. Heifers ($n = 20$; 556 ± 7 kg BW) were separated into 2 groups: Control (CON), with no ZH, or 2) ZIL, supplemented with ZH at 7.56 g/t (DM basis). The trial was conducted over a 25-d period (-2 to 22 d), with 3 serum collection periods (-2 to 3 d [ZH supplementation started on d 0], 12 to 15 d, and 20 to 22 d [withdrawal period]). For each day of the collection periods, 2 blood samples were collected for serum profile analysis (0800 and 2000 h). Serum was separated and stored at -80°C until analyzed for blood urea nitrogen (BUN), total protein, albumin, globulin, P, K, Na, anion gap, serum total Ca (TCa), creatinine (CREAT), creatine phosphokinase (CPK), and the enzymes aspartate transaminase (AT), alkaline phosphatase (AP), gamma glutamyltransferase (GG), and sorbitol dehydrogenase (SDH). Data were analyzed using the MIXED procedure of SAS with hour as a repeated measure and compound symmetry covariance structure (liver enzymes AT, AP, GG, and SDH were analyzed as change from baseline [-2 to 0 d]). A treatment \times time interaction was observed for BUN; concentrations were similar ($P > 0.13$) prior to ZH supplementation; however, from 12 to 22 d after supplementation, BUN concentrations in ZIL heifers were decreased ($P < 0.01$) compared to CON

heifers. No differences ($P = 0.58$) were observed for serum total protein, albumin, globulin, P, K, Na, and anion gap. For TCa, only a treatment effect ($P = 0.008$) was observed; CON heifers had greater concentrations of TCa compared to ZIL (9.8 vs. 9.5 mg/dL, respectively). A treatment \times time interaction ($P < 0.001$) was observed for CREAT and CPK. Prior to ZH supplementation, CREAT and CPK concentrations were similar ($P \geq 0.18$); after ZH supplementation (4 to 22 d), CREAT and CPK concentrations were greater ($P < 0.04$) in ZIL supplemented heifers. No differences ($P > 0.16$) were observed for the liver enzymes AT, AP, GG, and SDH in terms of change from baseline concentrations. Whereas some variation was observed between ZIL and CON heifers (primarily in terms of protein accretion), all variables of interest were within normal biological ranges for cattle.

Key Words: beta-agonist, serum profile, Zilmax

084 **A comparison of performance, carcass characteristics, and meat quality from intact male beef cattle relative to castrated male beef cattle administered growth promotion technology.**

M. E. Stephens^{1,*}, S. J. Bartle¹, D. N. Rethorst¹, C. D. Reinhardt¹, M. G. Siemens², D. U. Thomson¹, ¹Kansas State University, Manhattan, ²Cargill, Wichita, KS.

Castration is a surgical procedure in male beef cattle that has raised animal welfare concerns. Steroid implants and beta-adrenergic agonists are fed to steers after castration to improve feed efficiency and growth rates but can have a negative impact on carcass quality. Yearling bulls that are raised for breeding purposes that fail the breeding soundness exam are castrated and administered growth promotion technology and then fed for beef. The purpose of this study was to compare the effects on performance, carcass characteristics, and meat quality of intact male cattle not administered any growth promotion technology versus castrated male yearling cattle that are administered growth promotion technology. Angus bulls ($n = 24$; 605 ± 37 kg) averaging 16 mo of age were stratified by weight and randomly assigned to 1 of 2 treatments: uncastrated control (BULL) and castrated with growth promotion technology (STR) treatment. Cattle assigned to STR treatment were implanted with 120 mg trenbolone acetate and 24 mg estradiol on d 0 and fed ractopamine hydrochloride (300 mg/d) the last 28 d of feeding. Cattle were fed a rolled corn-based finishing ration with a NEg of 0.64 Mcal/lb for 62 d (final weight = 680 ± 37 kg). Carcass samples and data were collected at a commercial abattoir. The BULL treatment had a higher ADG (1.40 vs. 1.05 kg; $P < 0.05$) and tended to have increased G:F (0.09 vs. 0.07 kg; $P < 0.10$). Feed intake for BULL and STR (14.87 vs. 15.05 kg; $P > 0.20$) was not different. There was no difference between treatments for quality grade, yield grade, HCW, back fat thickness, and dressing percent. Longissimus muscle area was greater in BULL compared to STR (100.1 vs. 89.3 cm²; $P < 0.05$). There was no difference in tender-

ness for BULL and STR based on Warner–Bratzler shear force (WBSF) measures (4.82 and 4.32 kg of force; $P < 0.05$). There was no difference between BULL and STR cattle for myofibrillar tenderness (5.24 vs. 5.43), juiciness (5.18 vs. 4.98), beef flavor intensity (5.29 vs. 5.27), connective tissue amount (5.97 vs. 6.26), overall tenderness (5.34 vs. 5.58), and off flavor intensity (7.73 vs. 7.70). The castration of yearling bulls administered metabolic modifier technology did not improve performance, carcass characteristics, WBSF, or sensory panel items. Eliminating an animal welfare concern along with removing the cost and management of metabolic modifiers while maintaining meat quality and improving performance, castration is unnecessary for this age of bulls.

Key Words: castration

447 **Effects of dietary narasin inclusion level on the growth performance, incidence and severity of diarrhea, and viral shedding in nursery pigs infected with porcine epidemic diarrhea virus.**

C. L. Puls^{1*}, K. S. Rosenkrans¹, J. A. King¹, T. E. Weber¹, M. J. Ritter¹, C. T. Herr¹, J. G. Owens¹, K. K. Keffaber¹, L. Kesl², T. A. Marsteller¹, ¹*Elanco Animal Health, Greenfield, IN*, ²*Veterinary Resources, Inc., Ames, IA*.

This study was conducted to determine the effects of narasin on the growth performance, incidence and severity of diarrhea, and viral shedding in nursery pigs infected with porcine epidemic diarrhea virus (PEDV). The study was carried out over a fixed time period of 14 d from 29 to 43 d of age (7.6 ± 0.64 to 12.1 ± 0.96 kg BW, respectively). A randomized complete block design (blocking factor = weight) was used with 3 narasin inclusion levels (0, 30, and 60 mg/kg). Diets were formulated to meet or exceed NRC (2012) recommendations for nursery pigs. A total of 75 barrows ($n = 36$) and gilts ($n = 39$) were used and were housed in mixed-gender pens of 5 pigs (5 groups/treatment). Pigs were allocated to pens and treatments at weaning (22 d of age) and started on dietary treatments 7 d prior to being challenged with PEDV. Pigs were weighed on day -7, 0 (start; challenge), 5, and 14 (end) of the study; all feed additions to the feeders were recorded. Diarrhea scores (1 = normal, 2 = pasty, 3 = semisolid, and 4 = loose) were recorded and fecal swab samples were taken each day following the challenge to determine viral shedding values. No pigs died or were removed while on the study. Compared to the control, feeding narasin from d 0 to 5 increased ($P \leq 0.05$) ADG (0.11, 0.17, and 0.22 kg for 0, 30, and 60 mg/kg, respectively; SEM = 0.025) and G:F (0.375, 0.551, and 0.670; SEM = 0.0767, respectively), but there was no effect ($P > 0.10$) on overall growth performance from d 0 to 14. Diarrhea scores decreased with increasing narasin level (1.49, 1.45, and 1.37, respectively), although these differences were not statistically significant ($P > 0.10$). Compared to the control (0 mg/kg), pigs fed 30 mg/kg narasin had lower ($P < 0.10$) viral shedding

on d 2 and 3 of the study; pigs fed 60 mg/kg narasin had lower ($P < 0.10$) viral shedding on d 2, 3, 4, 5, and 6 of the study compared to the control. The results of this study suggest that feeding narasin lowers viral shedding levels of PEDV in nursery pigs, but further research is needed to understand the impacts of narasin on growth performance and incidence of morbidity and mortality in pigs infected with PEDV.

Key Words: growth, pigs, porcine epidemic diarrhea virus, viral shedding

**HARLAN RITCHIE SYMPOSIUM:
HAVE WE ENTERED A NEW ERA
IN BEEF PRODUCTION?**

085 **Trends to watch in cattle nutrition.** G. P. Lardy*,
North Dakota State University, Fargo.

The beef cattle industry has evolved continuously since the first cattle arrived in North America over 500 yr ago. One way to predict the future is to evaluate current trends and extrapolate what will happen. Industry-wide trends, a changing consumer demographic, as well as rapidly changing agricultural science and technology, will impact various segments of the beef industry at fundamental levels. Here are 7 trends that will impact cattle nutrition in the future: 1) cost pressures will drive continued industry consolidation, 2) rapidly growing world population and more people achieving middle class incomes will result in greater demand for animal protein products, 3) feed price volatility will necessitate flexible production systems, 4) heightened consumer and corporate interest in how and what cattle are fed, 5) continued development of crops and feedstuffs with enhanced nutrient qualities, 6) better understanding of how the microbial population and cattle genetics interact will affect nutrition supply and nutrient requirements, and 7) the nexus of food, water, and energy security will drive changes in the geography of where and what cattle are fed. These changes are occurring on the local, regional, national, and global scale. Some of these trends may not seem intuitively linked to cattle nutrition, but they are all driving change in beef cattle production systems and, as a consequence, cattle nutrition programs. In order to provide producers with sound advice for the future, beef cattle nutritionists need to embrace available technologies and develop multidisciplinary research which addresses the changing landscape of the industry. They need to be innovative and creative in how they develop their research programs. Research programs need to become more interdisciplinary in order to address changes and provide sound research-based recommendations. Scientists training the next generation of nutritionists must prepare students to deal with current and future changes which will impact cattle nutrition. In light of the fact that feed costs make up over 60% of the cost of production in beef cattle enterprises, Extension programs need to position producers to adapt to a constantly

changing industry landscape. Change in the beef cattle industry is certain, how we respond and adapt is up to us.

Key Words: beef cattle, nutrition, trends

086 Cow herd investment opportunities during a period of prosperity. W. J. Sexten*, *Division of Animal Sciences, University of Missouri, Columbia.*

Record high cattle prices, coupled with abundant supplies of relatively inexpensive feed and forage, have contributed to prosperity for most Midwestern beef cattle operations. Prosperity provides the opportunity to pay down debt and make operational improvements in preparation for more challenging financial times. Ideally, herd investments should provide for short- and long-term returns by reducing costs, increasing productivity, or enhancing efficiency. Debt service offers the immediate opportunity to reduce interest cost while increasing management decision flexibility. Handling facility investments can improve genetic, reproductive, health, and nutritional management, in addition to reducing operator and cattle stress at processing. Implementation of nearly every cattle management decision begins at the handling facility. Genetic improvements will prepare cow herds to increase performance, expand market options, or enhance efficiency. Even with recent technology improvements, the selection of superior genetics still requires scales and sorting capabilities. With handling facility investments, producers may expand reproductive management to narrow the calving window, increase AI use, or diagnose nonproductive cows, offering labor and nutrient efficiency savings. Preventative health management should focus on reducing calving and weaning losses. Herd health management using a scale equipped handling facility ensures accurate antimicrobial and anthelmintic dosing, reducing drug costs, enhancing animal performance, and protecting product efficacy. Cow nutrient demand grouping represents a management opportunity to optimize supplement cost relative to production efficiency. Developing facilities to enable nutrient need determination while expanding the ability to sort and house these groups prepares herds to weather higher feed and forage prices. Facilities designed to minimize weaning stress while providing short-term feeding infrastructure expands market opportunities while reducing shrink. Midwest pasture acres are increasingly viewed as potential row crop acres, suggesting investments increasing carrying capacity or harvest efficiency prepare operations for future land use challenges. Pasture improvements increasing forage yield, nutritional quality, weed competition, and antiquality factors offer long-term investment for an increasingly shrinking resource. Investments to reduce forage losses during harvest, storage, and feeding represent an opportunity to reduce hay acres and forage cost. Numerous investment opportunities exist to improve the cow herd; short- and long-term returns on these investments are dependent on current productivity and future resource limitations. With increasing competition for land, resource investments designed to

reduce cost, increase productivity, or enhance efficiency when evaluated on a per-acre basis offer the greatest opportunity to maintain profitability.

Key Words: beef cattle, efficiency, profitability

087 New innovations in how we sell beef. B. E. Wasser*, *National Cattlemen's Beef Association, Centennial, CO.*

In today's highly competitive protein marketplace, it is critical for the beef industry to improve product performance over time and to offer innovative, relevant products to consumers. Through a series of related checkoff-funded programs set in motion in the late 1990s, the industry responded to depressed prices for the beef chuck and round by developing innovative, value-added cuts that meet consumer needs in retail and foodservice. A research study called muscle profiling evaluated individual muscles in the chuck and round to identify those with marketable value beyond their traditional uses. The results of this study have made it possible for the industry to capture higher values for beef carcasses. New knowledge of individual muscle performance has prompted technical exploration to find optimal uses for muscles in the ends of the carcass, ultimately increasing demand for underutilized cuts and decreasing price pressures on middle meats. For example, the volume of the Flat Iron Steak has grown significantly since its widespread introduction in 2002, and now more than 31.8 million kilograms are sold annually, making it the 6th most popular cut on restaurant menus, where it outpaces more traditional cuts like the T-Bone and Porterhouse. This session will highlight these and other checkoff-funded innovative fabrication methods and state-of-the-art education tools intended to create positive eating experiences for consumers and spur value creation for the beef carcass. Moreover, the session will cover recent checkoff research related to improving the consistency of beef's eating experience by targeting beef's palatability drivers: tenderness, flavor, and juiciness.

Key Words: chuck, innovative cuts, palatability

088 Tracking beef industry dollars. N. Speer*, *Bowling Green, KY.*

The wave of higher prices within the beef complex during the past several years is unprecedented. Historically, amidst uneven economic recovery, beef expenditures would typically have been flat-to-negative as consumers traded down within the beef category and/or traded across to less expensive competitive proteins. Nevertheless, despite persistent drag on the economy since the financial crisis, beef and cattle prices have surged higher. That occurrence, though, has invoked concerns around consumer resistance and potential for demand destruction. Those questions have been especially prevalent during 2014 as beef prices surge ahead of competitive proteins. Additionally, considering that cattle prices have doubled in just

5 yr since, some observers express further concern about the market being overstretched and poised for a sharp pullback—consistent with the behavior of most commodity markets. The upshot being discussion about the need for renewed analysis of current production systems, industry value incentives, and their subsequent impact upon consumer prices. Ground beef is the industry's volume leader, representing upwards of 50 to 60% of all beef consumed in the United States, and often positioned as the primary price-category offering for beef directly comparable with pork and poultry. Given those considerations, dialogue has arisen around the prudence of tilting the production emphasis towards ground beef. However, beginning in 2014, new USDA boxed beef reports indicate ground beef and trimmings comprise only about 20% of the cutout value. Moreover, the industry's move away from a less-commoditized perspective have paid significant dividends during the past several years and served to underpin beef's competitiveness. Primarily, high-quality, differentiated beef products are accounting for an ever-larger portion of the beef industry's total revenue. The sales mix of Prime and Branded categories have gained market share during the past 5 yr. That results in customers buying more beef at higher prices on a consistent basis. That occurrence inherently helps to break free from a more traditional commodity business and buffer it against quality shortfalls that historically hampered the beef business.

Key Words: beef industry, beef prices, cattle prices

NONRUMINANT NUTRITION: FEED ADDITIVES

089 **Salmonella surrogate mitigation in poultry feed using a dry acid powder.** R. A. Cochrane^{1,*}, C. R. Stark¹, A. R. Huss¹, G. Aldrich¹, C. J. Knueven², C. K. Jones¹, J. S. Pitts³, ¹Kansas State University, Manhattan, ²Jones-Hamilton Co., Walbridge, OH, ³Jones-Hamilton Co., Weatherford, TX.

Salmonella contamination is a prevalent concern for the feed industry. Heat treatment is commonly used to mitigate pathogens, but it is a point-in-time strategy that does not prevent recontamination. Chemical alternatives may limit recontamination, but are often difficult to mix effectively or corrode equipment. A dry acid powder, such as sodium bisulfate (SBS; Jones-Hamilton, Co., Walbridge, OH), may be a practical option for pathogen mitigation. Therefore, the objective of this experiment was to evaluate the effectiveness of SBS to mitigate postprocessing contamination of a *Salmonella* surrogate, *Enterococcus faecium* ATCC 8459, in poultry feeds. Treatments were arranged in a 2 × 6 factorial with 2 feed forms (nonprocessed mash vs. pelleted feed) and 6 levels of SBS (0, 0.175, 0.35, 0.70, 1.4, and 2.8% w/w). A standard, broiler grower feed was inoculated with *E. faecium*, treatments

mixed with SBS, and pelleted at 70°C on a pilot scale (California Pellet Mill, Crawfordsville, IN). Pellet production test was the experimental unit and there were 3 pellet production replicates. Treatments were randomized prior to pelleting and a noninoculated flush was utilized between each treatment to prevent crossover contamination. Mash samples before thermal processing and corresponding pelleted samples were collected. Samples were analyzed for *E. faecium* on d 0, 2, 4, 7, and 14. All main effects and interactions were significant ($P < 0.0001$). Specifically, pelleting resulted in a 3-log reduction in *E. faecium* ($P < 0.0001$; 6.6×10^5 vs. 2.3×10^2 CFU/g for mash vs. pelleted, respectively). In both pelleted and mash feeds, there was a linear decline in *E. faecium* with increasing SBS inclusion ($P < 0.0001$; 1.3×10^4 , 9.8×10^3 , 8.5×10^3 , 7.7×10^3 , 7.6×10^3 , 2.5×10^3 CFU/g for 0, 0.175, 0.35, 0.70, 1.4, and 2.8% SBS, respectively for mash feeds on d 14). There was also a linear decrease in *E. faecium* over time ($P < 0.0001$, 6.7×10^5 , 6.9×10^4 , 6.0×10^4 , 5.0×10^3 , and 1.3×10^3 CFU/g for the negative control on d 0, 2, 4, 7, and 14, respectively). In summary, this research suggests that thermal processing, time, and SBS concentration all impact pathogen levels in poultry feeds, and that including a dry acid powder may be an effective pathogen mitigation strategy.

Key Words: *Enterococcus faecium*, feed safety, pathogen, poultry, *Salmonella*, sodium bisulfate

090 Evaluating chemical mitigation of porcine epidemic diarrhea virus in swine feed and ingredients.

R. A. Cochrane^{*}, J. C. Woodworth, S. S. Dritz, A. R. Huss, C. R. Stark, R. A. Hesse, M. D. Tokach, J. F. Bai, C. K. Jones, Kansas State University, Manhattan.

Porcine epidemic diarrhea virus (PEDv) is transmitted by fecal-oral contamination. Research has confirmed swine feed or ingredients as potential vectors of transmission, so strategies need to be developed to mitigate PEDv presence in feed. Therefore, the objective of this experiment was to evaluate the effectiveness of various chemicals to mitigate PEDv in swine feed and ingredients. Treatments were arranged in a 5 × 4 factorial with 5 chemical treatments and 4 feed matrices. The chemical treatments included: 1) negative control with no chemical addition, 2) 0.003% commercial formaldehyde, 3) 1% sodium bisulfate, 4) 1% sodium chlorate, and 5) 3% organic acid blend. The 4 matrices included: 1) complete swine diet, 2) blood meal, 3) meat and bone meal, and 4) spray-dried animal plasma. Matrices were first chemically treated, then inoculated with 5.6×10^4 TCID₅₀/g PEDv, stored at room temperature, and analyzed by real-time PCR on d 0, 1, 3, 7, 14, 21, and 42. Data were analyzed by the GLIMMIX procedure of SAS with day as a repeated measure. The analyzed values represent threshold cycle (CT) at which the virus was detected, and thus lower values indicate greater nucleic acid presence, not infectivity. All main effects and interactions were

significant; however, only main effects are discussed in this abstract due to space limitations ($P < 0.0001$). Both commercial formaldehyde treatment and organic acid addition decreased RNA concentration of PEDv compared with the control ($P < 0.05$), with the commercial formaldehyde treatment being the most effective on d 0 by decreasing the CT by 1.4 to 2.8 CT compared with the control. Feed matrix appears important in retention of PEDv as RNA concentrations were 1.2 to 3.8 CT higher in the complete swine diet and blood meal than meat and bone meal or spray-dried animal plasma on d 0 ($P < 0.05$). Additionally, PEDv stability over time was influenced by matrix as RNA concentrations only improved 0.7 and 2.9 CT by d 42 for spray-dried animal plasma and meat and bone meal, respectively, compared with 4.1 and 5.6 CT for the complete swine diet and blood meal. In summary, time, formaldehyde, and organic acid treatments all enhance the RNA degradation of PEDv in swine feed and ingredients, but their effectiveness varies within matrix. More research is needed to relate RNA concentration to infectivity and to elucidate the appropriate chemical concentration for each feed ingredient or diet.

Key Words: chemical treatment, feed matrix, PEDv, swine

091 Effects of dietary inclusion of direct-fed microbials on gut health and growth of nursery pigs orally challenged with F18-positive enterotoxigenic *Escherichia coli*. Y. Sun, I. Park*, C. H. Stahl, S. W. Kim, *North Carolina State University, Raleigh.*

This study was to determine the effect of direct-fed microbials (DFM, PrimaLac, Star Labs, Clarksdale, MO) on the growth performance and gut health on newly weaned pigs with an oral challenge of F18+ enterotoxigenic *Escherichia coli* (ETEC). PrimaLac includes *Lactobacillus acidophilus* (2.5×10^7 cfu/gram), *L. casei* (2.5×10^7 cfu/gram), *Bifidobacterium thermophilum* (2.5×10^7 cfu/gram), and *Enterococcus faecium* (2.5×10^7 cfu/gram). Thirty-two pigs (16 barrows and 16 gilts at 6.99 ± 0.33 kg BW) in individual pens were randomly allotted to 4 treatments (2×2 factorial arrangement: first factor was DFM and the second factor was ETEC). Pigs were fed experimental diets based on 2 phases (10 and 15 d, respectively). Direct-fed microbials were supplemented in the feed for Phase 1 (0 or 0.15%) and Phase 2 (0 or 0.10%). Pigs were challenged with ETEC (0 or 2×10^9 CFU) on d 13 of the study. Body weight and feed intake were measured on d 5, 9, 13, 19, and 25. Fecal scores were measured based on the 0 to 3 scale (0 = normal, to 3 = severe diarrhea) on d 2, 3, 5, 9, 12, and daily from d 13. Blood samples were taken on d 19 and 24 to measure tumor necrosis factor-alpha (TNF- α) and malonaldehyde (MDA). On d 25, all pigs were euthanized to obtain tissues (jejunum and ileum) to measure TNF- α , MDA, and morphological evaluation. Digesta (jejunum, ileum, and colon) were also obtained to measure pH. Data were analyzed using the Mixed procedure in SAS except for occurrence of

diarrhea, which was analyzed by Chi-square. Overall, DFM increased ($P < 0.05$) ADG (193 to 308 g/d) and ADFI (354 to 491 g/d). Fecal scores were increased ($P < 0.05$) by ETEC (0.45 to 1.03). The number of pigs with diarrhea was increased ($P < 0.05$) by ETEC (1 to 6 pigs) from d 13 to 25. The crypt depth (255 to 284 μ m) in ileum was increased ($P < 0.05$) by ETEC. There were interactions ($P < 0.05$) between DFM and ETEC on villus height and villus height: crypt depth, indicating that DFM increased villus height and villus height: crypt depth when pigs had ETEC. There was an interaction ($P < 0.05$) on serum TNF- α concentration on d 19 indicating that DFM decreased TNF- α when pigs had ETEC. Collectively, ETEC increased occurrence of diarrhea and caused mild issues on gut health, whereas DFM improved growth performance without affecting gut health.

Key Words: direct-fed microbials, *Escherichia coli*, growth performance, gut health, nursery pigs

092 Effect of standardized ileal digestible tryptophan : lysine ratio on growth performance of 11 to 20 kg nursery pigs. M. A. Goncalves^{1,*}, M. D. Tokach¹, S. S. Dritz¹, N. M. Bello¹, K. J. Touchette², J. M. DeRouche¹, J. C. Woodworth¹, R. D. Goodband¹, ¹*Kansas State University, Manhattan,* ²*Ajinomoto Heartland, Inc., Chicago, IL.*

Two experiments were conducted to determine the standardized ileal digestible (SID) Trp:Lys ratio requirement for 11 to 20 kg pigs. Experiment 1 was conducted to validate the dietary approach, and Exp. 2 was a dose titration. Both experiments used corn-soybean meal based diets with 30% DDGS. Experiments 1 and 2 used 1,188 and 1,088 pigs (PIC 337 \times 1050; initially 13.0 ± 0.16 and 11.2 ± 0.55 kg BW), were 21 d in duration, and had 11 and 6 pens/treatment with 24 to 27 pigs/pen, respectively. In Exp. 1, different SID Trp:Lys ratios (14.5 vs. 20%), CP (26.1 vs. 22.9%), and SID Lys levels (0.97 vs. 1.29%) combined into the following dietary treatments: High CP, High Lys, and High Trp:Lys (HHH); Low CP, High Lys, and High Trp:Lys (LHH); Low CP, Low Lys, and High Trp:Lys (LLH); and Low CP, Low Lys, and Low Trp:Lys (LLL). Lowering CP (HHH vs. LHH) did not significantly influence ($P > 0.05$) ADG, but G:F was greater in HHH compared with LHH. Decreasing lysine (LHH vs. LLH) and Trp:Lys (LLH vs. LLL) reduced ($P < 0.05$) ADG and G:F, respectively. Thus, low-CP diets formulated at 0.97% SID Lys appear to ensure pigs are below their Lys requirement when determining the optimal SID Trp:Lys ratio. In Exp. 2, dietary treatments consisted of SID Trp:Lys ratios of 14.5, 16.5, 18.0, 19.5, 21.0, 22.5, and 24.5% formulated to 0.97% SID Lys and 18.1% CP. Response variables, ADG and G:F, were each fitted using general linear and nonlinear mixed models with heterogeneous residual variances and pen as the experimental unit. Competing models included quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ).

Table 092.

	SID Trp:Lys, %						
	14.5	16.5	18.0	19.5	21.0	22.5	24.5
ADG, g	369 ± 20.2	428 ± 20.2	442 ± 20.2	432 ± 20.2	453 ± 17.6	451 ± 17.6	435 ± 17.6
G:F	0.543 ± 0.008	0.582 ± 0.005	0.582 ± 0.005	0.578 ± 0.008	0.590 ± 0.005	0.584 ± 0.005	0.580 ± 0.008

For each response, the best fitting models were selected using Bayesian information criterion. Increasing Trp:Lys increased ($P < 0.004$) ADG and G:F in a quadratic manner. For ADG, the best fitting model was a QP $[-317 + 7259 \times (\text{Trp:Lys}) - 17,110 \times (\text{Trp:Lys})^2]$ with maximum ADG at 21.2% SID Trp:Lys and 99% of maximum ADG achieved at 19.5% SID Trp:Lys. For G:F, BLL, and BLQ models had comparable fit and estimated SID Trp:Lys requirements of 16.6 (95% CI: 16.0 to 17.3) and 17.1% (95% CI: 16.6 to 17.7), respectively. In conclusion, the SID Trp:Lys requirement for 11 to 20 kg pigs ranged from 16.6% for G:F to 21.2% for maximum ADG, with 99% of maximum ADG at 19.5% SID Trp:Lys.

Key Words: amino acids, pigs, tryptophan

093 **Withdrawn.**

094 **Effects of an essential oils blend on growth performance of nursery pigs.**

N. Lu^{1,*}, M. D. Lindemann¹, J. R. Bergstrom², C. W. Parks², H. J. Monegue¹, J. H. Cho¹,
¹University of Kentucky, Lexington, ²DSM Nutritional Products, Parsippany, NJ.

Three experiments were conducted to evaluate the effects of a proprietary blend of essential oils (CRINA Piglets, DSM Nutritional Products, Parsippany, NJ) on growth performance of nursery pigs. A total of 96, 48, and 48 crossbred nursery pigs with initial BW of 6.62, 7.17, and 7.10 kg were used, respectively. Pigs were blocked by initial BW and sex before randomly allotted to 4 dietary treatments in each of the 3 experiments that were conducted for 35 d using 3 diet phases (7, 14, and 14 d). The dietary treatments were: 1) basal diets with no additive [CON]; 2) CON plus carbadox at 55 ppm [MEC]; 3) CON plus CRINA Piglets at 200 ppm [CRI]; and 4) CON plus carbadox at 55 ppm and CRINA Piglets at 200 ppm [MEC + CRI]. Basal diets were formulated to contain 3335, 3344, and 3329 kcal/kg ME, and 1.62, 1.51, and 1.41% total lysine, for the 3 phases, respectively. Data were checked for normality and pooled for statistical analysis. In total, 12 replicates (pens) were used per treatment, and no experiment × treatment interactions were detected ($P > 0.26$). The 35-d ADG was 493, 514, 510, and 495 g/d for Diet 1 to 4, respectively ($P = 0.25$); the 35-d ADFI was 741, 757, 752, and 741 g/d, respectively ($P = 0.80$); and the 35-d G:F was 0.666, 0.680, 0.678, and 0.667, respectively ($P = 0.55$). The 35-d ADG response demonstrated a significant MEC × CRI interaction ($P = 0.05$), which indicated the numerical improvement of MEC and CRI

might be negated by their combination. The response to both products decreased across the 3 diet phases. Compared with CON, MEC and CRI numerically increased ADG in Phase 1 by 10.43 and 12.27%, respectively (180 and 183 vs. 163 g/d); in Phase 2 by 6.28 and 3.14%, respectively (508 and 493 vs. 478 g/d); and in Phase 3 by 1.93 and 2.37%, respectively (687 and 690 vs. 674 g/d). Likewise, when comparing MEC and CRI to CON, the numerical differences in G:F were 12.40 and 4.75% in Phase 1, respectively (0.734 and 0.684 vs. 0.653); 3.00 and 0.46% in Phase 2, respectively (0.762 and 0.743 vs. 0.740); and -0.16% and 2.11% in Phase 3, respectively (0.624 and 0.639 vs. 0.625). In this study, CRI and MEC numerically improved the growth of nursery pigs in a similar manner, but the responses to each were not additive.

Key Words: essential oils, growth performance, nursery pigs

095 **Comparative effects of dietary Cu, Zn, essential oil, and chlortetracycline on nursery pig growth performance.**

J. A. Feldpausch^{1,*}, J. A. De Jong¹, M. D. Tokach¹, S. S. Dritz¹, J. C. Woodworth¹, R. G. Amachawadi¹, H. M. Scott^{1,2}, J. L. Nelssen¹, R. D. Goodband¹,
¹Kansas State University, Manhattan, ²Texas A&M University, College Station.

Weaned pigs (n = 350; PIC 1050; initially 6.05 kg) were used in a 47-d study to compare the effects of feeding antibiotic alternatives (Cu, Zn, and essential oil), alone or in combination, on nursery pig performance. Pigs were allotted to pens at weaning (d 0) and fed a common starter diet with no antimicrobial for 5 d prior to diet treatments. On d 5, pens of 5 pigs were allotted to 1 of 10 dietary treatments balanced on average pen weight in a randomized block design with 7 replications/treatment. Dietary treatments were arranged in a 2 × 2 × 2 + 2 factorial with main effects of added Cu from CuSO₄ (0 vs. 125 ppm Cu), added Zn from ZnO (0 vs. 3,000 ppm Zn from d 5 to 12 and 2,000 ppm Zn from d 12 to 33), and essential oil (0 vs. 0.1% Regano EX containing origanum oil; Ralco Animal Nutrition, Marshall, MN). The 2 additional treatments were sub-therapeutic and therapeutic levels of chlortetracycline (CTC; 55 or 441 mg/kg). All diets contained 16.5 ppm Cu and 165 ppm of Zn from the trace mineral premix. Pigs were fed experimental diets from d 5 to 33 after weaning followed by a common corn-soybean meal based diet without any antimicrobial, essential oil, or pharmacological levels of Cu or Zn from d 33 to 47. To comply with FDA guidelines, CTC was removed on d 19 from the diet of pigs fed 441 mg/kg CTC, then added again from d 20 to 33. During the treatment period, essential oil had

no effect ($P > 0.05$) on ADG or ADFI, whereas pharmacological levels of Cu, Zn, and CTC increased ($P = 0.003, 0.001, \text{linear } 0.028$, respectively) ADG with coinciding increases ($P = 0.055, 0.006$, and linear 0.079 , respectively) in ADFI. Copper, Zn, and CTC had no effect ($P > 0.05$) on G:F. Essential oil decreased ($P = 0.009$) G:F and a Cu \times essential oil interaction ($P = 0.024$) was observed due to poorer-than-expected G:F of pigs when Cu was fed in combination with essential oil. The dietary treatments had minimal carryover effects on subsequent nursery pig growth performance. Overall, from d 5 to 47, Cu increased ($P = 0.018$) ADG, Zn increased ($P < 0.05$) ADG and ADFI, and essential oil tended to decrease ($P = 0.086$) overall G:F. In conclusion, increased levels of dietary Cu, Zn, or CTC improved weanling pig performance while essential oil elicited no growth performance benefits.

Key Words: antibiotic, essential oil, nursery pig

096 Effect of ractopamine and enzyme supplementation 28 days prior to marketing on growth performance of finishing pigs. M. D. Asmus*, A. M. Jones, E. R. Otto-Tice, C. E. Vonderohe, F. A. Cabezon, A. P. Schinckel, B. T. Richert, *Purdue University, West Lafayette, IN.*

One-hundred eighty pigs (initial BW = 105.4 ± 1.29 kg) were used to evaluate the effects of 2 enzymes individually and in combination in a corn-soybean meal-cDDGS based diet on pig growth performance and feed efficiency during late finishing. Pigs were allocated in a randomized complete block design of mixed gender pens, stratified by ancestry, gender, and initial BW to 5 treatments with 6 pens/treatment and 6 pigs/pen. Dietary treatments included: 1) negative control (0.75% standardized ileal digestible [SID] Lys; NC); 2) NC + ractopamine (RAC); 3) RAC + enzyme (0.08 MU/kg β -mannanase; RENZ1); 4) RAC + enzyme (0.08 MU/kg β -glucanase + 0.10 MU/kg β -mannanase; RENZ2); 5) RAC + enzyme (0.08 MU/kg β -glucanase, 0.18 MU/kg β -mannanase; RENZ1 + 2). Treatments 2 through 5 contained 5 ppm ractopamine from d 0 to 14 and 10 ppm ractopamine from d 14 to 28. For d 0 to 14, pigs fed the RAC diet had increased ($P < 0.001$) ADG, improved feed efficiency and tended ($P < 0.06$) to have increased ADFI when compared with pigs fed the NC diet. Pigs fed RENZ1 had increased ($P < 0.05$) ADG, and improved ($P < 0.02$) G:F, while pigs fed RENZ2 tended ($P < 0.08$) to have reduced G:F compared with pigs fed RAC. Pigs fed RAC from d 14 to 28 had increased ($P < 0.05$) ADG, ADFI, and improved G:F compared with NC. Feeding RENZ1 or RENZ2 had no impact ($P > 0.61$) on ADG, ADFI, or G:F from d 14 to 28 compared with RAC fed pigs. For the overall period d 0 to 28, pigs fed RAC diets had increased ($P < 0.04$) ADG and ADFI with improved ($P < 0.001$) feed efficiency compared with NC. Pigs fed RENZ1 had increased ($P < 0.01$) ADG and improved ($P < 0.02$) feed efficiency while pigs fed RENZ2 had no improvement ($P > 0.21$) in measured response criteria compared with pigs fed

Table 096.

	Treatment					SEM	¹ P <
	NC	RAC	RENZ1	RENZ2	RENZ1+2		
d 0 to 28							
ADG ² , kg	0.81	0.99	1.04	0.97	1.02	0.020	0.001
ADFI, kg	3.10	3.24	3.25	3.26	3.25	0.053	0.04
G/F ²	0.26	0.31	0.32	0.30	0.32	0.007	0.001

¹Main effect of Ractopamine (NC vs. RAC).

²RENZ1 improved ($P < 0.02$) ADG and G:F.

RAC. In conclusion, pigs fed the RAC diet had increased ADG and ADFI with improved feed efficiency throughout the trial. Pigs fed RENZ1 had increased ADG driven by improved feed efficiency compared with pigs fed RAC. This study indicates the combination of RAC and β -mannanase has the potential to improve late finishing performance.

Key Words: glucanase, mannanase, ractopamine

097 The effects of feeding narasin on growth and harvest performance of pigs during the grow-finish period. R. A. Arentson^{1,*}, J. J. Chewning², ¹Elanco, *Greenfield, IN*, ²Swine Research Services, *Inc., Springdale, AR.*

The purpose of this study was to determine the effects of narasin (NAR; Skycis, Elanco Animal Health, Greenfield, IN) on the growth and harvest performance of pigs during the grow-finish period. On d -8 or -9, 74 pens each containing 8 pigs were blocked by gender and weight within each of 4 barns, resulting in 18 blocks containing 2 pens of gilts and 2 pens of barrows and 1 block containing 2 pens of gilts. On d 0 (initial BW 26.34 kg), diet treatments control (CON) or NAR 15 ppm were randomly assigned to pens within gender of each block. Pigs were fed a series of 5 corn-soybean meal diet phases with or without NAR premix. Pigs were weighed on d 0, 26, 54, 74, 95 or 96, and 109 or 110 to determine initial weight, phase weights, and ADG. Feed issuance and weigh backs were recorded in order to determine ADFI and G:F. On d 95 or 96, the heaviest 3 barrows and 1 gilt from appropriate pens and on d 109 or 110 the remaining pigs were transported to a food company for harvest. Fat depth, loin depth, and HCW were measured on each carcass. Data were analyzed using the PROC MIXED procedure of SAS. Pigs fed NAR had a greater BW on d 54 ($P < 0.01$), 74 ($P < 0.001$), and 95.5 ($P < 0.001$) and tended to be greater at the end of the study ($P < 0.1$) than pigs fed CON. Pigs fed NAR had a faster ADG during d 0 to 26 ($P < 0.05$), 26 to 54 ($P < 0.01$), and 54 to 74 ($P < 0.001$), and tended to be faster during d 0 to 109.5 ($P < 0.10$) than pigs fed CON. Feed intake by pigs fed NAR was greater during d 26 to 54 ($P < 0.05$) and d 54 to 74 ($P < 0.05$), but was less than CON from d 95.5 to 109.5 ($P < 0.05$). The G:F of pigs fed NAR was greater than CON on d 54 to 74 ($P < 0.01$) and d 0 to 109.5 ($P < 0.05$). On d 95.5 and 109.5, HCW ($P < 0.01$) and loin depth ($P < 0.01$) of pigs fed NAR was greater than pigs fed CON. Data from this study demonstrates that NAR improves growth

Table 097.

Item	CON	NAR	SE	P
Overall ADG, kg	0.950	0.967	0.010	<0.1
Overall ADFI, kg	2.440	2.455	0.018	>0.1
Overall G:F	0.404	0.410	0.004	<0.05
Carcass wt., kg	96.46	98.25	0.542	<0.01
Loin depth, mm	65.82	67.40	0.408	<0.01

performance and carcass characteristics of grow-finish pigs.

Key Words: grow-finish, narasin, pig

098 The effects of feeding narasin (Skycis) or virginiamycin (Stafac) on summer finishing pig performance. M. Knauer^{1,*}, P. J. Rincker², S. Fry³,

¹North Carolina State University, Raleigh, ²Elanco Animal Health, Greenfield, IN, ³Elanco, Greenfield, IN.

The purpose of this study was to determine the effects of narasin (NAR; Skycis, Elanco Animal Health, Greenfield, IN) or virginiamycin (VIR; Stafac, Phibro Animal Health, Teaneck, NJ) on the summer growth and harvest performance of grower-finisher pigs. Upon arrival (May 23, 2014), 360 barrows (Smithfield Premium Genetics, Rose Hill, NC) were weighed (initial BW 23.0 kg) and randomly allocated to 1 of 3 treatments: Control (CON), NAR 15 ppm, or VIR 11 ppm. Each treatment had 15 pens containing 8 pigs per pen (0.87 m² per pig). Housing consisted of slatted flooring, mechanical ventilation, and sprinklers activating at 28.9°C. Each treatment consisted of a sequence of 4 corn-soybean meal diets fed from d 0 to 90, and the CON diet fed to all treatments d 90 to harvest. Pigs were weighed on d 0, 28, 56, 77, 90, and at harvest to determine start weight, phase weights, harvest weight, and ADG. Feed issuance and weigh backs were recorded in order to determine ADFI and G:F. At d 96, pigs were individually tattooed and transported to a commercial packer for harvest and collection of HCW. Data were analyzed in SAS using PROC GLM. Fixed effects included treatment and room. Pen was the experimental unit. From d 0 to 28, pigs fed NAR had greater ($P < 0.01$) ADG than CON and VIR and greater ($P < 0.01$) ADFI than CON and VIR. From d 28 to 56, pigs fed NAR had greater ($P = 0.01$) ADG than CON and tended ($P = 0.07$) to have greater ADG than VIR. Pigs fed NAR and VIR had greater ($P < 0.05$) G:F from d 56 to 77 vs. their CON fed counterparts. Overall ADG was greater ($P < 0.05$) for pigs fed NAR than for pigs fed the CON and VIR diets. Pigs fed NAR had greater ($P < 0.05$) overall G:F than CON and numerically better G:F than pigs fed VIR. The percentage of pigs completing the study and mortality did not differ ($P > 0.05$ between treatments). At harvest, pigs fed NAR had greater ($P < 0.01$) carcass weight and yield than CON and VIR, while BW CV was lower ($P < 0.05$) for pigs fed NAR vs. CON and VIR diets. Results showed that supplementing diets with NAR during the summer significantly improved growth performance and carcass characteristics of finishing pigs.

Key Words: narasin, pig, virginiamycin

**NONRUMINANT NUTRITION:
GROW-FINISH NUTRITION
AND MANAGEMENT**

099 Effects of reduced oil distillers dried grains with solubles and soybean oil on dietary lysine, fat, and fiber digestibility in corn based diets fed to growing pigs. N. A. Gutierrez*, N. V. L. Serão, J. F. Patience, Iowa State University, Ames.

The use of corn co-products increases the concentration of fiber and often the use of supplemental fat in swine diets, which may affect energy and nutrient digestibility. An experiment was conducted to determine the effects of reduced oil distillers dried grains with solubles (DDGS-RO) and soybean oil (SBO) on dietary Lys, acid hydrolyzed ether extract (AEE), and neutral detergent fiber (NDF) digestibility in corn-based diets fed to growing pigs. Eighteen growing pigs (BW = 33.8 ± 0.5 kg) were surgically fitted with a T-cannula in the distal ileum and allocated to 1 of 6 treatment groups (TG) in a 3-period incomplete latin-square design, with 9 observations per treatment. Six dietary treatments were obtained by adding 0, 20, and 40% DDGS-RO to corn-casein diets formulated with 2 and 6% SBO. Ileal digesta and fecal samples were collected, and the apparent ileal (AID) and total tract digestibility (ATTD) of AEE and NDF and the AID of Lys were determined. Data were analyzed with a model including the fixed effects of DDGS-RO, SBO, their interaction, and initial BW (covariate), and the random effects of TG and Period. Results showed that the AID of Lys was not affected by SBO concentration ($P > 0.05$), but DDGS-RO inclusion showed a quadratic effect ($P < 0.001$). The AID of Lys was highly predictable ($R^2 = 0.69$) from the DDGS-RO and dietary SBO level. An interaction between DDGS-RO and SBO on the AID ($P = 0.003$; $R^2 = 0.68$) and ATTD ($P = 0.004$; $R^2 = 0.79$) of AEE was observed, where the AID and ATTD of AEE increased with SBO. The AID (72.5 to 79.1%) and ATTD (62.6 to 71.6%) of AEE increased with DDGS-RO at 2% SBO, but no effect was observed at 6% SBO. An interaction between DDGS-RO and SBO on the AID ($P = 0.037$; $R^2 = 0.53$) and ATTD ($P = 0.004$; $R^2 = 0.36$) of NDF was observed, where the AID (46.4 to 22.4%) and ATTD (52.0 to 40.9%) of NDF decreased with DDGS-RO at 6% SBO, but no effect was observed at 2% SBO. The AID of NDF increased (72.5 to 79.1%) with SBO at 0% DDGS-RO, but no effect was observed at other DDGS-RO levels. In conclusion, DDGS-RO increased the digestibility of AEE, and decreased the digestibility of NDF, but the effect was modulated by SBO. Soybean oil increased the digestibility of AEE, but the effect was modulated by DDGS-RO, and increased the AID of NDF in diets without DDGS-RO. The AID of Lys decreased with DDGS-RO and was not affected by addition of SBO.

Key Words: digestibility, fat, fiber

100 **The effect of divergent selection for residual feed intake on digestibility of control and low energy, high fiber diets.** E. D. Mauch^{1,*}, N. K. Gabler¹, T. E. Weber¹, J. F. Patience¹, B. J. Kerr², J. C. M. Dekkers¹, ¹Iowa State University, Ames, ²USDA-ARS, Ames, IA.

Since 2001, Residual Feed Intake (RFI) lines of Yorkshire swine at Iowa State University have been selected for increased (low RFI) or decreased (high RFI) feed efficiency under a standard corn-soybean meal based diet. Group-penned pigs from Generation 8 of these lines were fed 2 diets varying in energy and fiber content. Diets consisted of a high energy, low fiber diet (Control), similar to the diet fed during genetic selection, and a low energy, high fiber diet (Fiber), which served as a dietary challenge. The Fiber diet contained 2.03 Mcal NE/kg and 25.9% NDF compared with 2.47 Mcal NE/kg and 9.4% NDF for the Control diet, resulting in an 18% NE and 175% fiber difference per kg diet. Both diets met NRC (1998) requirements and contained titanium dioxide (TiO₂) as a digestibility marker. Therefore, our objective was to evaluate potential interactions between genetic line (low RFI: n = 59, high RFI: n = 58) and diet composition (Control: n = 47, Fiber: n = 70). Fecal grab samples (n = 117) were collected from barrows and gilts during the first growing phase (30 to 60 kg BW) and were then analyzed for TiO₂, DM, GE, and N to calculate apparent total tract digestibility (ATTD, %) of DM, GE, and N. There was a significant interaction between RFI line and diet for ATTD of DM, GE, and N ($P < 0.05$). When fed the Control diet, both RFI lines had a similar DM ATTD coefficients (mean 85.2%), but when the Fiber diet was fed, the low RFI line had a DM digestibility of 59.0% compared with 55.5% for the high RFI line. The average ATTD of GE was 84.4% for both lines when fed the Control diet, but was 58.0 and 54.7% for low vs. high RFI pigs, respectively, when fed the Fiber diet. When fed the Control diet, ATTD of N was similar between the lines (mean 79.5%), but when fed the Fiber diet, dropped to 61.6 and 56.2% for the low and high RFI lines, respectively. In conclusion, both RFI lines had similar DM, GE, and N ATTD when fed the Control diet. However, when fed a more fibrous diet, the low RFI line had greater ATTD coefficients for DM, GE, and N compared with the high RFI line. Funding provided by AFRI-NIFA grant No. 2011-68004-30336.

Key Words: apparent total tract digestibility, residual feed intake, swine

101 **Effect of precision feeding strategy on feeding behavior of growing-finishing pigs.** I. Andretta¹, C. Pomar², J. Rivest³, J. Pomar⁴, L. Hauschild⁵, M. Kipper⁶, ¹Universidade Estadual Paulista, Jaboticabal, Brazil, ²Agriculture and Agri-Food Canada, Sherbrooke, QC, Canada, ³Centre de Développement du Porc du Québec Inc., Québec, Canada, ⁴Universitat de Lleida, Lleida, Spain, ⁵FCAV/UNESP, Jaboticabal, Brazil, ⁶Universidade Federal de Santa Maria, Santa Maria, Brazil.

The impact of switching from conventional (3-phase/group) to precision feeding programs (daily-phase/individuals) on feeding behavior of 35 females and 35 barrows (30.4 ± 2.2 kg) was evaluated in an 84 d trial. Pigs were housed in the same pen but fed individually according to 1 of 5 feeding programs (treatments). Five automatic feeders registered individual feeding information (feeder entry and exit times, and the consumed feed per visit) totaling 59,701 feeder visits. Daily standardized ileal digestible (SID) lysine requirements were estimated with a mathematical model using individual daily feed intake and weekly BW data. Pigs assigned to the 3-phase feeding program (3P) received within each 28-d feeding phase the same fixed blend of feeds A (high lysine density) and B (low lysine density) whose lysine concentration corresponded to the requirement of the 80th centile pig of the population at the beginning of the phase. Pigs assigned to 1 of 4 precision feeding programs received feeds A and B blends adjusted daily to match 110, 100, 90, or 80% of the estimated lysine requirements of each individual pig. Lean and fat body composition were assessed every 28 d by dual-energy x-ray absorptiometry (DXA). Nitrogen excretion was estimated as the difference between intake and retention values. The pig was the experimental unit in variance analysis (MIXED procedure, SAS). Average daily SID lysine intake and N excretion of 3P pigs were 22.4 and 31.7 g, respectively. Average daily feed intake and weight gain were 2.44 and 1.05 kg in 3P pigs. Feeding pigs individually providing 90, 100, and 110% of the daily lysine requirements resulted in the same ($P > 0.05$) feed intake, feed efficiency, and growth performance than the 3P program. Compared with 3P pigs, those fed to daily requirements ate 26% less SID lysine ($P < 0.05$) and excreted 30% less N ($P < 0.05$). The number of visits, duration, interval between visits, consumption per meal, and intake rate were not affected ($P > 0.05$) by treatments. Feeding behavior responses were not correlated with diet composition ($P > 0.05$). However, feed intake rate was negatively correlated with feed ($r = -0.74$; $P < 0.05$) and protein efficiencies ($r = -0.55$; $P < 0.05$). Feeding growing pigs individually with daily tailored diets is an effective approach to reduce lysine supply and nutrient excretion without affecting pig performance or feeding behavior.

Key Words: nutrient requirements, nutrition, precision farming

Table 102. Antibiotic and antibiotic alternative rotations.

Phase	Duration	Antibiotic program	Antibiotic free program
Nursery 1	1.36 kg/pig	Carbadox + 3,000 mg/kg Zn	water acidification + 3,000 mg/kg Zn
Nursery 2	2.5 kg/pig	Carbadox + 2,500 mg/kg Zn	water acidification (13 d total) + 2,500mg/kg Zn
Nursery 3	8.18 kg/pig	Carbadox + 2,000 mg/kg Zn	Direct-fed microbial (DFM) + 2,000 mg/kg Zn
Nursery 4	ad lib to d 42	Carbadox + 189 mg/kg Cu	DFM + 250 mg/kg Cu
Grower 1	21 d	Chlortetracycline, 50 g/t	DFM + 126 mg/kg Cu
Grower 2	21 d	Lincomix, 100 g/t	DFM + water acidification
Grower 3	21 d	Lincomix, 40 g/t	DFM
Finisher 1	21 d	Tylan, 20 g/t	oregano
Finisher 2	21 d	Tylan, 10 g/t	oregano

102 Comparison of the effects of antibiotic-free and conventional management on growth performance in swine. C. E. Vonderohe*, A. M. Jones, B. T. Richert, J. S. Radcliffe, *Purdue University, West Lafayette, IN.*

Seven-hundred-twenty-four mixed sex pigs were placed in 11 rooms at the Purdue Swine Environmental Research Building to determine the effects of rearing pigs without antibiotics on growth performance. Pigs were blocked by BW and gender and allotted to room and pen with 10 or 11 mixed-sex pigs/pen. Control pigs consumed diets (Table 102) containing antibiotics and were treated with injectable antibiotics when deemed necessary. Antibiotic-free animals consumed diets with alternatives to antibiotics and received no injectable antibiotics. If sick animals did not respond to antibiotic alternatives, they were removed from the experiment. Pigs were weighed at the start and end of each dietary phase, and mortality and morbidity were recorded daily. Data were analyzed using the GLM procedure in SAS. During the nursery phase, control pigs grew faster ($P < 0.02$; 0.449 vs. 0.426 kg/d), and consumed more feed ($P < 0.05$; 0.694 vs. 0.660 kg/d) than antibiotic-free animals, resulting in similar G:F. Similar ADG, ADFI, and G:F were observed throughout the grower phases, and therefore the increased BW of control-fed pigs was maintained, and tended to be heavier ($P = 0.06$) at the start of the finisher phases (86.0 vs. 84.5 kg). However, antibiotic-free animals grew 3% faster ($P < 0.01$) and had 6% better G:F ($P < 0.001$) in the finisher phases. As a result, there was no overall effect ($P > 0.10$) of treatment on ADG, but there was a trend ($P = 0.08$) for increased ADFI (2.11 vs. 2.07 kg) and reduced ($P < 0.05$) G:F (0.518 vs. 0.527) in control pigs compared with antibiotic-free. Thirty antibiotic-free animals (8.3%) were removed from the study compared with 11 control (3.0%). In conclusion, antibiotic-free management can yield a similar growth performance to conventional systems, but the limited disease treatment options may limit the number of pigs marketed under this management system.

Key Words: antibiotic, performance, swine

103 A PRRS-PED virus co-infection reduces total tract digestibility in grower pigs. W. P. Schweer*, K. Schwartz, K. J. Yoon, N. K. Gabler, *Iowa State University, Ames.*

Porcine reproductive and respiratory syndrome (PRRS) and porcine epidemic diarrhea (PED) are 2 costly diseases to the swine industry. Therefore, our objective was to determine the impact PRRSv and PEDv, alone or combination, had on apparent total tract digestibility (ATTD) and apparent ileal digestibility (AID) coefficients in early grower pigs. Forty-two Choice Genetics gilts (16.8 ± 0.6 kg BW), naive for PRRS and PED, were selected and randomly assigned to 1 of 4 treatments: 1) Control (n = 6), 2) PRRS only (n = 12), 3) PED only (n = 12), 4) PRRS + PED (n = 12). Treatments 2 and 4 were inoculated with live PRRSv on d 0 and euthanized on d 21. Treatments 3 and 4 were inoculated with PEDv on d 14, 7 d prior to euthanasia on d 21. PRRSv infection was determined by serum QPCR and seroconversion. PEDv infection was confirmed by fecal PCR. Feces were collected on d 18 to 20 and ileal digesta was collected at euthanasia (d 21). Feed, feces, and digesta were analyzed for DM, OM, and N. Feed and feces were analyzed for energy, and digesta and feed were analyzed for AA. Feed intake was used as a covariate for statistical analysis of ATTD and AID. By design, Control pigs remained PRRS and PED negative throughout the study. Compared with control pigs, PRRSv infection did not reduce ATTD or AID of nutrients and energy ($P > 0.05$). However, PED infection, alone or in combination with PRRS, decreased ATTD of DM and energy by 8 and 12%, respectively ($P < 0.05$). Although PED alone decreased N and OM ATTD (7 and 2.5%, respectively), they were not significantly different ($P = 0.24$ and 0.35, respectively). Compared with controls, the PRRS + PED group had N and OM ATTD reduced by 13 and 3%, respectively ($P < 0.05$). PED alone or in combination reduced AID DM (14 to 18%) and OM (6 to 8%), but not significantly ($P > 0.05$). The AID of Met, Leu, Phe, Arg, and Trp did not differ between virus challenges. However, lysine AID tended to be reduced in PED and PRRS + PED treatments compared with the control (10 to 12%, $P = 0.095$). Altogether, the controls and PRRS treatment have similar digestibility coefficients, while the 2 PEDv challenges reduced ATTD of nutrients and energy. Surprisingly, AID of AA was not affected by PEDv or PRRSv challenges in this model.

Key Words: digestibility, PED, PRRS

104 Withdrawn.

105 The importance of implementing a by-product withdraw strategy prior to slaughter in finishing pigs: A review of strategies that mitigate the negative impact on carcass yield. K. F. Coble*, J. M. DeRouchey, M. D. Tokach, S. S. Dritz, R. D. Goodband, J. C. Woodworth, *Kansas State University, Manhattan.*

Ingredients such as dried distillers grains with solubles (DDGS) and wheat middlings (midds) contain higher amounts of fiber and are lower in energy than their originating grain sources. Previous research has shown that feeding high-fiber diets to pigs throughout the finishing period has negative effects on carcass yield and HCW. Also, dietary therapies, such as ractopamine HCl, pelleting the diet, or increasing energy through fat addition prior to marketing, has not been successful to negate fiber's effect on carcass yield. Limited research suggests that removal of high-fiber ingredients approximately 20 to 30 d prior to slaughter can restore carcass yield. However, the optimal time period for withdrawing high-fiber ingredients prior to marketing has only recently been more closely researched. Two trials were conducted to determine the number of days prior to slaughter that high-fiber ingredients (30% DDGS and 19% midds; 19% NDF) should be removed from finishing pig diets to optimize growth performance, carcass characteristics, and digestive tract weights. First a university setting trial demonstrated that withdrawal strategy did not significantly influence growth performance, but carcass yield decreased ($P < 0.01$) in pigs fed the high-fiber diet compared with those fed the corn-soybean meal control (9.3% NDF) and increased (quadratic; $P < 0.03$) as days of withdrawal increased from 0 to 15 d. Pigs continuously fed the high-fiber diet had heavier ($P < 0.01$) full large intestine weight than pigs fed the control. A second study in a commercial setting demonstrated that pigs fed the high-fiber diet throughout had decreased ($P < 0.01$) HCW compared with those fed the control diet. Percentage yield was not significantly influenced by high-fiber diet withdrawal period; however, HCW increased linearly ($P < 0.05$) as withdrawal period increased up to 19 d. In summary, pigs fed high-fiber diets have decreased carcass yield but yield can be restored by switching pigs to a corn-soybean meal diet 15 to 19 d prior to marketing.

Key Words: fiber, finishing pigs, yield

106 Evaluation of the precision and accuracy of equations to predict backfat iodine value in pork carcasses of pigs fed diets containing distillers dried grains with solubles (DDGS). F. Wu^{1,*}, L. J. Johnston², P. E. Urriola¹, G. C. Shurson³, ¹*Department of Animal Science, University of Minnesota, St. Paul,* ²*West Central Research and Outreach Center, University of Minnesota, Morris.*

Iodine value (IV) is a common measurement of fat quality

Table 106.

Reference	Equation	PE	Bias
Benz et al., 2011			
Equation 1	$35.458 + 14.324 \times \text{Diet 18:2n6, \%}$	8.18	0.42
Equation 2	$51.946 + 0.2715 \times \text{Diet IVP}^1$	6.46	-5.07
Bergstrom et al., 2010	$57.89 + 0.18 \times \text{Diet IVP}$	6.18	-4.24
Boyd et al., 1997	$52.4 + 0.315 \times \text{Diet IVP}$	4.60	-2.18
Madsen et al., 1992	$47.1 + 0.14 \times \text{IVP/d, kg}$	6.44	-4.98
Cromwell et al., 2011	$64.5 + 0.432 \times \% \text{ DDGS in diet}$	8.26	7.10
Restrepo et al., 2013			
Equation 1	$70.06 + 0.29 \times \% \text{ DDGS in diet}$	9.19	8.00
Equation 2	$60.13 + 0.27 \times \text{Diet IVP}$	5.03	3.03

¹IVP = dietary IV \times % dietary lipids \times 0.10.

that determines the concentration of unsaturated fatty acids in pork carcass fat depots. Equations have been developed to predict backfat IV based on the amount and composition of dietary lipids fed to growing-finishing pigs. The objective of this study was to evaluate 8 published equations for predicting backfat IV of pigs using dietary fatty acid composition and intake of 8 diets fed in 2 similar experiments. Pigs ($n = 432$ /experiment, initial BW = 23.9 ± 4.1 kg, 9 pigs/pen, 12 pens/treatment) were fed diets consisting of corn and soybean meal or corn-soybean meal diets containing 40% distillers dried grains with solubles (DDGS) from 7 different sources (ether extract content ranged from 5.6 to 16.0%) in a 4-phase feeding program. The IV product (IVP) of diets ranged from 24.0 to 82.1 g/100g. Pigs were harvested (BW = 114.6 ± 7.9 kg), and backfat at the midline of the last rib were sampled from 2 pigs in each pen (24 pigs/treatment), with BW closest to the pen mean. Backfat samples were analyzed for fatty acid composition, and IV was calculated from the AOAC (1998) equation and analyzed using Proc Mixed of SAS with pen as the experimental unit. Calculated backfat IV ranged from 57.7 to 82.3 g/100g. Precision (low prediction error; PE) and accuracy (deviation of predicted means from observed means; bias) were calculated for each equation using predicted backfat IV compared with calculated backfat IV of pigs fed the 8 dietary treatments. Backfat IV was predicted poorly using equations based on percentage of DDGS in the diet, but using equation: $52.4 + (0.315 \times \text{diet IVP})$ resulted in the best estimates for backfat IV due to the least PE and low bias.

Key Words: backfat iodine value, distillers dried grains with solubles, growing-finishing pigs, prediction equations

107 Effect of standardized ileal digestible tryptophan:lysine ratio on growth performance of finishing pigs. M. A. Goncalves^{1,*}, M. D. Tokach¹, S. S. Dritz¹, N. M. Bello¹, K. J. Touchette², J. M. DeRouchey¹, J. C. Woodworth¹, R. D. Goodband¹, ¹*Kansas State University, Manhattan,* ²*Ajinomoto Heartland, Inc., Chicago, IL.*

Four experiments were conducted to estimate the standardized ileal digestible (SID) Trp:Lys ratio requirement for finishing

pigs. Dietary treatments consisted of SID Trp:Lys ratios of 14.5, 16.5, 18.0, 19.5, 21.0, 22.5, and 24.5%. All experiments were 21 d in duration and used corn-soybean meal-based diets with 30% DDGS formulated to be deficient in Lys at the end of each experiment. A total of 1,166, 1,099, 1,132, and 975 gilts (PIC 337 × 1050, initially 29.9 ± 2.0, 55.5 ± 4.8, 71.2 ± 3.4, and 106.2 ± 3.1 kg BW ± SD) were used in Exp. 1 to 4, respectively. Within each experiment, pens of pigs were blocked by weight and assigned to 1 of the 7 dietary treatments in a randomized complete block design. Each experiment consisted of 6 pens/treatment with 20 to 28 pigs/pen. Data from all experiments were combined for analysis using general linear and nonlinear mixed models with random clustering effects of experiment and weight block within experiment and also with pen as the experimental unit. Competing models included quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ). Best fitting models were selected using Bayesian information criterion. Increasing Trp:Lys increased ADG and G:F in a quadratic manner ($P < 0.001$). For ADG, QP [Prediction equation: $189.5 + 6084 \times (\text{Trp:Lys}) - 12878 \times (\text{Trp:Lys})^2$] and BLQ [if SID Trp:Lys < 22.9%, prediction equation: $900 - 15,000 \times (0.229 - \text{Trp:Lys})^2$] had comparable fit and estimated SID Trp:Lys requirements at 23.6 (95% CI: 21.2 to 26.1%) and 22.9% (95% CI: 22.0 to 23.7%), respectively. For G:F, BLL [if SID Trp:Lys < 16.9%, prediction equation: $0.4036 + 1.0 \times (0.169 - \text{Trp:Lys})$] and BLQ [if SID Trp:Lys < 18.7%, prediction equation: $0.403 + 15.0 \times (0.187 - \text{Trp:Lys})^2$] had comparable fit and estimated SID Trp:Lys requirements at 16.9 (95% CI: 16.0 to 17.9) and 18.7% (95% CI: 18.1 to 19.3%). Thus, the estimated mean requirements for SID Trp:Lys for 30 to 125 kg pigs ranged from 16.9% for G:F to 23.6% for maximum ADG. Furthermore, 95% of the maximum estimated ADG was obtained feeding 17.5% SID Trp:Lys and 98% of the maximum estimated ADG was obtained feeding 19.5% SID Trp:Lys.

Key Words: amino acids, finishing pigs, tryptophan

108 Effects of increasing crystalline amino acids in sorghum- or corn-based diets on finishing pig growth performance. K. E. Jordan*, J. Nemecek, M. A. Goncalves, R. D. Goodband, M. D. Tokach, S. S. Dritz, J. M. DeRouchey, J. C. Woodworth, Kansas State University, Manhattan.

A total of 288 pigs (PIC 327 × 1050; initially 45.9 kg) were used in a 90 d study to compare the effects of increasing crystalline AA in sorghum- and corn-based diets on grow-finish pig growth performance. Treatments with 8 pigs per pen and 6 pens per treatment were arranged in a 2 × 3 factorial with main effects of grain source (sorghum vs. corn) and crystalline AA supplementation (low, medium, or high). Because replacing increasing amounts of soybean meal with crystalline AA changes the NE of the diet, all diets were formulated to the same standardized ileal digestible (SID) Lys:NE ratio. The Lys

Table 108.

Crystalline AA:	Grain source					
	Sorghum			Corn		
	Low	Medium	High	Low	Medium	High
d 0 to 90						
ADG, kg	0.90	0.91	0.87	0.92	0.93	0.90
ADFI, kg	2.66	2.63	2.55	2.62	2.63	2.54
G:F	0.340	0.347	0.342	0.350	0.353	0.353
Jowl IV	67.9	67.9	67.3	68.8	68.9	69.6

SEM was 0.013, 0.037, 0.003, and 0.59 for ADG, ADFI, G:F, and Jowl IV, respectively.

concentration in the diets was formulated at 95% of the pig's estimated requirement based on the NRC (2012) to ensure that the other AA, as a ratio to Lys, would not be underestimated. The grain sources and soybean meal were analyzed for AA profile and diets formulated from these concentrations. Suggested AA ratios to Lys as well as SID coefficients used were obtained from the NRC (2012). The low AA fortification contained L-lysine HCl and DL-methionine. The medium AA fortification contained L-lysine HCl, DL-methionine, and L-threonine, and the high AA fortification contained L-lysine HCl, DL-methionine, L-threonine, and L-valine to sorghum- or L-tryptophan to corn-based diets as Val was 5th limiting in sorghum-based diets and Trp 5th limiting in corn-based diets. Overall, no grain source × crystalline AA interactions were observed. Pigs fed corn-based diets tended to have greater ADG ($P < 0.072$) and had greater G:F ($P < 0.01$) than those fed sorghum-based diets. As crystalline AA concentrations increased, ADG tended to increase then decrease (quadratic; $P = 0.057$), and ADFI decreased (linear; $P = 0.019$). Pigs fed sorghum had decreased ($P < 0.01$) jowl iodine value (IV) in comparison with pigs fed corn. In conclusion, balancing to the 5th limiting AA using NRC (2012) suggested AA ratios in corn- or sorghum-based diets resulted in decreased ADG and G:F and pigs fed corn-based diets had greater G:F and IV than those fed sorghum.

Key Words: corn, grow-finish pig, sorghum

109 Growing pigs' simulated amino acid requirements differs between actual factorial methods.

A. Remus^{1*}, C. Pomar², L. Hauschild³, ¹Department of Animal Science - FCAV/UNESP, Jaboticabal/SP, Brazil, ²Agriculture and Agri-Food Canada, Sherbrooke, QC, Canada, ³FCAV/UNESP, Jaboticabal, Brazil.

The objective of this study was to compare actual factorial methods used to estimate phase-feeding growing pigs' lysine requirements with the method developed for precision feeding (PF) which provides individual pigs with daily tailored diets. Data from 36 high-performance pigs (25 kg initial BW, mean SE = 2.23) were used in a 28 d trial. Observed individual daily NE intake and BW gain were smoothed by linear regression and used to estimate individual and population standardized ileal digestible lysine (SIDLys) requirements. Body weight gain was assumed constant (regression slope) for every pig

within the trial. The PF individual SIDLys requirements were calculated daily assuming 16% protein in daily gain, 7% lysine in protein, and 72% SIDLys retention efficiency plus the maintenance (Hauschild et al., 2012). Phase-feeding SIDLys population requirements were estimated with the Brazilian (BT, Rostagno et al., 2011), NRC (2012), and PF factorial methods. These requirements were estimated as recommended using the average pig in the middle of the phase in BT and NRC methods, and the 80 centile pig of the population at the beginning of the phase in the PF method. Between-animal variation in SIDLys requirements varied from 22% at the beginning to 8% at the end of the trial. Daily population BT and NRC SIDLys requirements were respectively 15 and 13% higher than the average daily PF model requirements. When using these models to estimate the optimal population SIDLys concentration to be served in the studied 28 d feeding phase, BT and NRC methods (i.e., average pig in the middle of the phase) yielded similar recommendations (3.48 and 3.44 SIDLys g/Kcal NE, respectively), but were, in average, 22% lower than the estimated by the PF method (i.e., 80 centile pig at the beginning of the phase). In the first day, 64, 69 and 25% of pigs were underfed with the BT, NRC, and PF methods, respectively, for a total period, in the same order, of 16, 18, and 2% of the 1008 pig-day estimations. The BT and NRC methods were calibrated for maximum population responses, this explaining why they overestimate the daily average animal requirements by more than 13%, and yield a value close to the 80 centile pig of the population. The average pig in the middle of the feeding phase has to be used with caution to estimate requirements of this phase given the large variation in nutrient requirements that exist between and across pigs over time.

Key Words: lysine, NRC, precision nutrition, swine

110 The tryptophan:lysine requirement of grow-finish

pigs. L. Greiner^{1,*}, A. Graham¹, K. J. Touchette²,
¹Carthage Innovative Swine Solutions, LLC, Carthage,
IL, ²Ajinomoto Heartland, Inc., Chicago, IL.

Twelve-hundred grow-finish pigs (PIC 337 × 1050) were evaluated to determine the optimum Trp:Lys ratio for gain and feed conversion. The study was conducted in 3 phases: 23 to 41 kg, 55 to 77 kg, and 98 to 114 kg. Pigs were blocked by gender and weight starting at 23 kg and randomly assigned within block to 1 of 6 treatments (14, 16, 18, 20, 22, and 24 standardized ileal digestible [SID] Trp:Lys ratio) with 13 pens per treatment. Blocks either had 24 or 25 pigs per pen. Pigs were returned to a common diet that maintained a Trp:Lys ratio of 18 between each trial phase. The first phase diet consisted of corn/soybean meal/dried distiller's grains with solubles and was formulated to 2549 kcal/kg NE. The other 2 phases consisted of corn/soybean meal and were formulated to 2666 and 2692 kcal/kg NE respectively. In all phases, soybean meal and fat was held constant and feed-grade Trp was added to alter the Trp:Lys ratio. The SID Lys content was formulated

Table 110.

	BLL	BLQ
Phase 1		
ADG	19.8	21.4
G:F	15.1	23.8
Phase 2		
ADG	18.0	19.7
G:F	14.7	30.6
Phase 3		
ADG	18.4	20.8
G:F	15.1	19.5

0.05% lower than the expected requirement for the heaviest weight of each phase across the study, and all other nutrients met or exceeded the NRC requirements. Data were analyzed using Proc Mixed with linear (L) and quadratic (Q) contrasts. Data were reported as LSMEANS. Broken line linear (BLL) and broken line quadratic (BLQ) analyses were conducted to determine the SID Trp:Lys requirement for growth parameters. In Phase 1, pig ADG increased (0.76, 0.79, 0.79, 0.82, 0.83, 0.81 kg/d; $L P < 0.01$, $Q P < 0.04$) as the Trp:Lys ratio increased. In addition, there was a linear improvement in feed conversion (0.49, 0.49, 0.50, 0.50, 0.50, 0.50; $P < 0.08$). In Phase 2, pig ADG was not influenced by Trp:Lys ratio (0.96, 0.91, 0.98, 1.01, 0.98, 0.96; $P = 0.31$), while feed conversion was improved linearly (0.38, 0.38, 0.39, 0.39, 0.39; $P < 0.03$). In phase 3, pig ADG increased linearly (0.91, 0.93, 0.99, 1.00, 1.02, 0.97; $P < 0.05$) and feed conversion was improved (0.32, 0.33, 0.34, 0.34, 0.32; $P < 0.05$) quadratically as the Trp:Lys ratio increased. Based on the data, the optimal ratio for ADG in grow-finish pigs is between 18.0 and 21.4. The optimal ratio for feed conversion is less consistent at about 15 for BLL and 19.5 or greater for BLQ.

Key Words: grow-finish, pig, tryptophan

NONRUMINANT NUTRITION: MINERALS AND VITAMINS

111 A survey of added trace mineral concentrations

used in the U.S. swine industry. M. D. Tokach,
J. C. Woodworth, J. M. DeRouchey, R. D. Goodband,
S. S. Dritz, J. R. Flohr*, Kansas State University,
Manhattan.

Swine producers and nutritionists representing production systems across the United States were surveyed about added trace mineral concentrations in swine diets used from March to June of 2014. Respondents were asked to provide trace mineral premix concentrations, and inclusion rates to calculate complete diet added trace mineral concentrations. Additionally, weight ranges associated with feeding phases were collected. In total, 18 production systems participated in the survey representing approximately 2.3 million sows (40% of the U.S. industry). Data were compiled into weight ranges that

Table 111.

Trace minerals, ppm	Nursery Phase 1		Late finishing		Lactation	
	Mean	SD	Mean	SD	Mean	SD
Cu	111.4	96.9	65.9	71.0	16.1	6.0
I	0.52	0.21	0.34	0.24	0.53	0.30
Fe	103.5	15.9	66.5	25.2	102.2	28.8
Mn	36.6	7.7	18.6	9.8	37.6	13.2
Se	0.30	0.004	0.22	0.08	0.29	0.04
Zn	3,032	599.5	73.8	26.8	123.0	28.3

were relatively consistent across all producers who participated in the survey. There were 3 nursery phases (Phase 1, 5 to 7 kg; Phase 2, 7 to 11 kg; and Phase 3, 11 to 25 kg), 4 finishing phases (early, 25 to 50 kg; mid, 50 to 100 kg; late, 100 to 135 kg; and late with ractopamine, 100 to 135 kg), and 4 breeding herd dietary phases (gilt development, gestation, lactation, and boar). Descriptive statistics were used to summarize survey results including: mean, median, minimum, maximum, 25th percentile (lowest quartile), and 75th percentile (highest quartile) and standard deviation. In phase 1 nursery diets, supplementation rates were 18.6, 3.7, 1.0, 9.1, 1.0, and 30.3 times the 2012 NRC requirement for Cu, I, Fe, Mn, Se, and Zn, respectively. The elevated Zn and Cu in Phase 1 diets indicate pharmacological concentrations added for growth promotion. Meanwhile, for late finishing pigs, supplementation rates were 22.0, 2.4, 1.7, 9.3, 1.5, and 1.5 times the NRC requirement for Cu, I, Fe, Mn, Se, and Zn, respectively. On average, producers supplemented high concentrations of Cu in late finishing, but there was variability in the concentration added (SD, 71.0 mg/kg). One respondent indicated Co supplementation in late finishing diets. In lactation diets, supplementation rates were 0.8, 3.8, 1.3, 1.5, 1.9, and 1.2 times the NRC requirement for Cu, I, Fe, Mn, Se, and Zn, respectively. Additionally, 5 respondents supplied partial or complete added levels of Cu, Mn, and Zn from organic sources. Ultimately, evaluating current supplementation practices can be used to develop future experimental designs to test trace mineral supplementation practices.

Key Words: survey, swine industry, trace minerals

112 Quantitative relationships between standardized total tract digestible phosphorus and calcium intake and its retention and excretion in growing pigs fed corn-soybean meal diets. N. A. Gutierrez^{1,*}, N. V. L. Serão¹, A. J. Elsbernd¹, S. L. Hansen¹, C. L. Walk², M. R. Bedford², J. F. Patience¹, ¹Iowa State University, Ames, ²AB Vista Feed Ingredients, Marlborough, UK.

An experiment was conducted to determine the quantitative relationships between standardized total tract digestible (STTD) P and Ca intake with their retention and excretion by growing pigs fed corn-soybean meal diets. Forty-eight barrows (BW = 22.7 ± 0.2 kg) were allotted to 1 of 8 diets, housed individually in pens for 3 wk, then moved to metabo-

lism crates and allowed 4 d adaptation and 5 d for collection of urine and fecal samples. Eight corn-soybean meal diets were formulated for similar NE, fat, and AA concentrations, but with increasing STTD P from 0.16 to 0.62% using mono-calcium phosphate. The Ca:STTD P ratios were maintained constant among treatments. The STTD P intake increased ($P < 0.001$) from 64 to 242% of the daily requirement (4.59 g/d of STTD P). Basal urinary P excretion of 0.03 g P/d was observed up to 4.96 g of STTD P intake/d, after which the urinary P excretion increased ($P < 0.001$). Excretion of Ca in urine decreased ($P < 0.001$) with intake, reaching a basal urinary excretion of 0.40 g/d at 17.97 g/d of Ca intake. The daily intake of STTD P and Ca moderately explained the variation in urinary excretion of P ($R^2 = 0.41$) and Ca ($R^2 = 0.64$). The absorption and retention of P increased linearly ($P < 0.001$) with dietary P intake, whereas absorption and retention of Ca increased quadratically ($P < 0.001$). Absorption and retention of P and Ca were highly predictable from the STTD P and Ca intake, with R^2 of 0.87 and 0.90, respectively. The femur mineral content (FMC, g) increased by 2.71 g of FMC per g/d of STTD P intake, but reached a plateau (29.54 g) at 8.84 g/d of STTD P intake. The FMC was highly predictable from the STTD P intake ($R^2 = 0.89$). The FMC affected the urinary P excretion ($P < 0.01$), but moderately explained ($R^2 = 0.19$) the variation in urinary P. In conclusion, constant excretion of P in urine was observed, but increased linearly at STTD P intake levels above the requirement for maximum growth. The FMC increased with STTD P intake, but reached a plateau at a greater STTD P intake level than the requirement for maximum growth. Dietary STTD P was therefore absorbed and used for growth, but excess P was accumulated in bones, until a plateau was reached, and excreted in urine. The predictability of P and Ca excretion in urine from the dietary STTD P and Ca intake was moderate.

Key Words: phosphorus, calcium, urine

113 Digestible calcium requirements and calcium and phosphorus balance for weaning pigs.

J. C. González-Vega^{1,*}, C. L. Walk², H. H. Stein¹, ¹University of Illinois, Urbana, ²AB Vista Feed Ingredients, Marlborough, UK.

Two experiments were conducted to determine the standardized total tract digestible (STTD) Ca requirement of 11 to 25 kg pigs based on growth performance, bone ash, or bone Ca retention. Diets were based on corn, soybean meal, and lactose. Six diets were formulated to contain 0.36% STTD P, which is 10% above the NRC requirement to make sure that P was not limiting Ca deposition. These diets were formulated to contain 0.32, 0.40, 0.48, 0.56, 0.64, or 0.72% STTD Ca, by including increasing amounts of calcium carbonate at the expense of cornstarch. Two additional diets were formulated to contain 0.72% STTD Ca and 0.33 or 0.40% STTD P to determine if 0.36% STTD P had negative effects on the Ca requirement.

The same batch of diets were used in both experiments. In Exp. 1, 256 pigs (initial BW: 11.39 ± 1.21 kg) were randomly allotted to the 8 diets, with 8 replicate pens per diet in a randomized complete block design. Pen was the experimental unit and each pen had 4 pigs. On the last day of the experiment, 1 barrow per pen was euthanized to collect the femurs. Results indicated that ADG and G:F ratio started to decline at 0.56 and 0.43% STTD Ca, respectively. However, the requirement for STTD Ca to maximize bone ash, bone Ca, and bone P were 0.48, 0.48, and 0.56%, respectively. Growth performance was not affected by the level of P in the diets; however, bone ash increased linearly ($P < 0.05$) as the STTD P increased. In Exp. 2, eighty pigs (initial BW: 13.12 ± 1.79 kg) were randomly allotted to the 8 diets, with 10 replicate pigs per diet in a randomized complete block design. Pig was the experimental unit. Fecal and urine samples were collected using the marker-to-marker approach. Results indicated that the amount of Ca retained (g/d) increased linearly ($P < 0.001$) and quadratically ($P < 0.05$) as the level of dietary STTD Ca increased. Increasing dietary STTD P increased linearly ($P < 0.01$) the retention of Ca (g/d). The requirement for STTD Ca to maximize Ca retention (g/d) was 0.52%. In conclusion, the STTD Ca requirement by 11 to 25 kg to maximize bone ash under these experimental conditions was 0.48%, however, ADG and G:F ratio declined at 0.56 and 0.43% STTD Ca, respectively.

Key Words: calcium requirements, digestible calcium, retention

114 **Effect of particle size in calcium carbonate on apparent and standardized total tract digestibility and retention of calcium by growing pigs.** L. A.

Merriman*, H. H. Stein, *University of Illinois at Urbana-Champaign, Urbana.*

An experiment was conducted to determine apparent total tract digestibility (ATTD), standardized total tract digestibility (STTD), and retention of Ca among diets containing calcium carbonate produced to different particle sizes. Four corn-potato protein isolate-based diets were formulated to contain identical concentrations of Ca and P, but calcium carbonate (ILC Resources, Alden, IA) used in these diets was ground to 4 different particle sizes (approximately 200, 500, 700, and 1125 microns). Diets were formulated to contain 0.70% Ca and 0.33% standardized digestible P. A Ca-free diet was also formulated to determine basal endogenous losses of Ca. Forty growing barrows (average initial BW of 15.42 ± 0.70 kg) were allotted to a randomized complete block design with 5 dietary treatments and 8 replicate pigs per treatment. Experimental diets were provided for 12 d with initial 5 d adaptation period. Feces were collected for 5 d using marker-to-marker approach. Data were analyzed using MIXED procedure of SAS with fixed effect, diet, and random effect, block. Basal endogenous losses of Ca were 0.329 g/kg DMI. Results indicate particle size did not influence ($P > 0.05$) ATTD, STTD, or retention of Ca. The

ATTD of Ca was 69.98 ± 3.24 , 74.28 ± 2.71 , 69.96 ± 2.93 , and $72.07 \pm 2.66\%$ for diets containing 200, 500, 700, and 1125 micron particle sizes of limestone, respectively. The STTD of Ca was 74.15 ± 3.24 , 78.45 ± 2.71 , 74.13 ± 2.93 , and $76.24 \pm 2.66\%$ for diets containing 200, 500, 700, and 1125 micron particle size of limestone, respectively. Retention of Ca was 67.39 ± 3.08 , 70.40 ± 2.63 , 63.93 ± 2.79 , and $67.18 \pm 2.16\%$ for diets containing 200, 500, 700, and 1125 micron particle size of limestone, respectively. Similarly, particle size had no effect ($P > 0.05$) on ATTD and retention of P. The ATTD P was 64.46 ± 1.71 , 66.78 ± 2.65 , 64.18 ± 2.98 , and $63.18 \pm 1.69\%$ and retention of P was 61.38 ± 1.39 , 63.83 ± 2.82 , 61.90 ± 2.76 , and $60.94 \pm 1.53\%$ for diets containing 200, 500, 700 and 1125 micron particle size of calcium carbonate, respectively. In conclusion, particle size of calcium carbonate did not affect ATTD and STTD of Ca, or retention of Ca by pigs.

Key Words: calcium, particle size, pigs

115 **Withdrawn.**

116 **Effect of diets formulated based on standardized total tract digestible phosphorus fed to growing pigs.** J. J. Abelilla^{1,*}, R. C. Sulabo¹, H. H. Stein²,

S. P. Acda¹, A. A. Angeles¹, M. C. R. Oliveros¹, F. E. Merca³, ¹*Animal and Dairy Sciences Cluster, University of the Philippines, Los Baños, the Philippines*, ²*University of Illinois, Urbana*, ³*Institute of Chemistry, University of the Philippines, Los Baños, the Philippines.*

The standardized total tract digestibility (STTD) of P was determined in corn (53 and 73%), soybean meal (SBM; 46 and 73%), and full fat rice bran (FFRB; 50 and 64%) without and with phytase in our previous experiment. An experiment was conducted to validate the STTD of P for these ingredients by analyzing growth performance of pigs. A total of 36 barrows (PIC L337 × C24, initial BW = 33.0 ± 2.7 kg) were individually housed and randomly allotted to 4 corn-SBM based diets following a 2×2 factorial arrangement in a randomized complete block design. Factors were 2 levels of phytase (0 and 500 units/kg; Optiphos 2000, Enzyvia, Sheridan, IN) and 2 levels of full fat rice bran (0 and 10%), with initial BW as a blocking factor. All diets were formulated with same batches of corn, SBM, and FFRB and to contain 0.31% STTD P, same ME and standardized ileal digestible (SID) AA. Vitamins and minerals were included in the diets to meet or exceed the requirements for growing pigs (NRC, 2012). The diets were fed ad libitum to growing pigs for 28 d. Monocalcium phosphate (MCP) was included in corn-SBM diets at 0.86 and 0.50% (without and with phytase, respectively) and in corn-SBM-full fat rice bran diets at 0.48 and 0% inclusion rate (without and with phytase, respectively). There was no phytase × FFRB interaction in any of the growth parameters measured.

Table 116. Effect of full fat rice bran and phytase on growth performance of growing pigs.¹

Diet:	Corn-SBM		Corn-SBM-FFRB		SEM
	0	500	0	500	
Item Phytase, FTU/kg:					
Initial BW, kg	32.7	33.4	32.9	33.1	0.94
Final BW, kg	58.8	62.0	60.1	61.2	1.59
ADG, kg	0.93	1.02	0.97	1.00	0.05
ADFI, kg	2.22	2.22	2.26	2.27	0.03
G:F	0.42	0.46	0.43	0.44	0.02

¹FTU, phytase units.

There was also no difference in ADG, ADFI, G:F or final BW between pigs fed diets without and with phytase and diets with 0 or 10% FFRB. In conclusion, the values for STTD of P in corn, SBM, and FFRB were accurately analyzed in previous experiment. If rice bran and/or phytase are used, the inclusion of MCP can be reduced or removed in corn and SBM based diets for growing pigs.

Key Words: phosphorus, phytase, rice bran

117 Creating a Zn deficient model to understand the impact of different Zn sources on performance and oxidative status in pigs. J. Zhao*, M. Vazquez-Anon, G. Bowman, *Novus International, Inc., St. Charles, MO.*

The objective of this study was to create a Zn-deficient model and to investigate the impact of 3 different Zn sources on growth performance, immunity, and oxidative status in pigs. A total of 128 nursery male pigs were used. All pigs were fed a common Zn-deficient semipurified diet (corn grit, soy concentrate) for 21 d, and started the dietary treatments on d 22 for 3 wk (42 d of age, BW 12.2 kg). There were 4 treatments with 8 replicates per treatment and 4 pigs per pen. The 4 treatments included: a negative control without Zn supplementation, 3 Zn groups supplemented with 40 ppm Zn from Zn(HMTBa)₂ (Novus International Inc., St. Charles, MO), ZnO, or glycine-Zn. One pig per pen, close to average pen weight, was killed at the end of study for tibia weight, tibia Zn (dry weight basis), plasma TBARS, free carbonyl, and hepatic vitamin E measurement. Data were analyzed with PROC GLM 1-way ANOVA. After the 21 d period of Zn depletion, typical Zn-deficient symptoms were observed in most pigs including parakeratosis (skin lesion), hair overgrowth, and anorexia. Five days after repletion, Zn supplementation groups had better ADFI ($P < 0.01$), ADG ($P < 0.01$), and feed conversion ratio (FCR; $P < 0.01$) than the nonsupplemented control. Among the 3 different Zn sources, pigs fed Zn(HMTBa)₂ gain more than pigs fed ZnO (21%, $P < 0.05$), and had better FCR (11%, $P < 0.05$). The pigs fed Zn-glycine were intermediate. Tibia weight (both tibiae) was increased with Zn(HMTBa)₂ supplementation compared with the control ($P < 0.05$), while ZnO supplemented pigs were intermediate. Compared with the control, tibia Zn (dry basis) was increased 34, 56, and

112% with ZnO, Zn-glycine, and Zn(HMTBa)₂, respectively ($P < 0.01$). Pigs fed Zn(HMTBa)₂ had significantly higher tibia Zn concentrations than pigs fed ZnO ($P < 0.05$). No difference was observed in immunity and oxidative status ($P > 0.10$). In summary, Zn deficiency (parakeratosis) was observed in pigs fed Zn-deficient semipurified diet for 21 d. Pigs fed Zn deficient diet had reduced feed intake and retarded growth. Among the 3 Zn sources, both organic Zn [Zn(HMTBa)₂ and Zn-glycine] are more bioavailable than ZnO, based on performance and tibia Zn levels.

Key Words: organic Zn, parakeratosis, swine, zinc

118 Effects of heat stress and zinc supplementation on swine metabolome. L. Wang^{1,*}, P. E. Urriola², Z. J. Rambo³, M. E. Wilson³, J. L. Torrison³, G. C. Shurson², C. Chen¹, ¹*Department of Food Science and Nutrition, University of Minnesota, St. Paul,* ²*Department of Animal Science, University of Minnesota, St. Paul,* ³*Zinpro Corporation, Eden Prairie, MN.*

Heat stress (HS) greatly affects energy metabolism, but the impact of HS on the swine metabolome is not well characterized. In this study, metabolic effects of HS and Zn supplementation were evaluated using 3 diets: ZnNeg (no Zn supplementation), ZnIO (120 ppm ZnSO₄), and ZnAA (60 ppm ZnSO₄ + 60 ppm AvailaZn zinc AA complex). Diets were formulated based on NRC (2012) requirements and fed to crossbred gilts (71 ± 9 kg BW, $n = 8/\text{trt}$). Following a 3 × 2 factorial design, pigs were acclimated to experimental diets for 2 wk, then challenged with a diurnal HS treatment (12 h at 37°C and 12 h at 25°C per day) or maintained in a thermal-neutral (TN) environment (21°C) for 7 d. Blood samples were collected on d 1, 2, 5, and 7 during HS treatment, while tissue, cecal fluid, and feces were harvested after sacrifice on d 7. The metabolic changes associated with HS and Zn supplementation were evaluated by growth performance, blood chemistry, and untargeted metabolomics. Compared with the TN environment, HS greatly decreased ADG (1.17 vs. 0.44 kg; $P < 0.01$), ADFI (3.36 vs. 2.06 kg; $P < 0.01$), and G:F ratio (0.35 vs. 0.20; $P < 0.01$). However, Zn supplementation did not affect growth performance under either TN or HS conditions. Results from blood chemistry showed that HS and Zn supplementation did not alter serum level of glucose, triglycerides, cholesterol, Fe, and Zn. However, HS led to higher creatinine (1.08 vs. 0.88 mg/dL; $P < 0.01$) and lower BUN (12.79 vs. 16.06 mg/dL; $P < 0.01$) serum level vs. TN. This was likely caused by elevated muscle degradation and reduced renal reabsorption in HS. Untargeted metabolomic analysis of serum, liver, fecal, and cecal extracts revealed clear separations of HS and TN samples in the multivariate models, suggesting that HS greatly affected chemical composition of the metabolome. Subsequent structural and quantitative analyses identified diverse HS-induced changes in AA, lipid, and bacterial metabolism, such as the

decrease of free lysine in serum (172.47 vs. 249.03 μM ; $P < 0.01$) and increase of acetic acid in cecal fluid (1.69 vs. 1.24 mM; $P < 0.01$). Overall, metabolomic analysis provided novel and comprehensive information on the metabolic events associated with HS and Zn supplementation, which warrant further investigation into the roles of these metabolic events in growth and stress response.

Key Words: heat stress, metabolomics, zinc supplementation

119 **A survey of added vitamin concentrations used in the U.S. swine industry.** J. R. Flohr*, M. D. Tokach, J. C. Woodworth, J. M. DeRouchey, R. D. Goodband, S. S. Dritz, *Kansas State University, Manhattan.*

Swine producers and nutritionists representing production systems in the United States were surveyed about added dietary vitamin concentrations in swine diets used from March to June of 2014. In total, 18 respondents participated representing approximately 2.3 million sows (~40% of the U.S. industry). Respondents were asked to provide vitamin premix concentrations, inclusion rates, and weight ranges associated with feeding phases. Data were compiled into weight ranges that were relatively consistent across participants. There were 3 nursery phases (Phase 1, 5 to 7 kg; Phase 2, 7 to 11 kg; and Phase 3, 11 to 25 kg), 4 finishing phases (early, 25 to 50 kg; mid, 50 to 100 kg; late, 100 to 135 kg; and late with ractopamine, 100 to 135 kg), and 4 breeding herd dietary phases (gilt development, gestation, lactation, and boar). In Phase 1 nursery diets, supplementation rates were 4.8, 11.6, 4.6, 7.7, 2.3, 1.6, 2.5, and 2.0 times the 2012 NRC requirement for A, D, E, K, riboflavin, niacin, pantothenic acid, and vitamin B₁₂ (cobalamin), respectively. Vitamin D supplementation rates were the most variable among participants with a standard deviation of 2,306 IU/kg. Meanwhile, for late finishing pigs, supplementation rates were 3.2, 5.0, 1.8, 3.6, 1.8, 0.7, 1.8, and 3.3 times the NRC requirement for A, D, E, K, riboflavin, niacin, pantothenic acid, and vitamin B₁₂, respectively. The average niacin supplementation was below the NRC requirement, likely due to the recent increase in requirement from the 1998 to 2012 publication. Supplementation rates in lactation diets were 5.2, 2.2, 1.6, 7.3, 2.2, 4.6, 2.3, and 2.4 times the NRC requirement for A, D, E, K, riboflavin, niacin, pantothenic acid, and vitamin B₁₂, respectively. Lactation diets also contained on average added thiamin, 2.2 mg/kg (5 respondents); pyridoxine, 3.5 mg/kg (13 respondents); biotin, 0.29 mg/kg; and folacin 1.68 mg/kg. Understanding current supplementation practices may help develop experimental designs to test future alternative vitamin supplementation practices.

Key Words: survey, swine industry, vitamins

Table 119.

Vitamins	Nursery Phase 1		Late finishing		Lactation	
	Mean	SD	Mean	SD	Mean	SD
A, IU/kg	10,622	833	4,194	1,001	10,425	922
D, IU/kg	2,561	2,306	747.0	209.4	1,793	349.4
E, IU/kg	74.1	27.8	20.1	6.6	70.3	70.3
K, mg/kg	3.9	0.4	1.8	0.4	3.8	1.1
Riboflavin, mg/kg	9.1	1.1	3.6	0.9	8.2	1.3
Niacin, mg/kg	49.1	11.5	20.2	4.9	45.9	11.7
Pantothenic acid, mg/kg	30.2	3.7	12.6	3.1	27.6	3.7
Vitamin B ₁₂ , $\mu\text{g}/\text{kg}$	39.1	2.4	16.6	3.5	35.5	4.6

NONRUMINANT NUTRITION: EXOGENOUS ENZYMES

120 **Effects of phytase on phosphorus digestibility of rice co-products fed to growing pigs.**

G. A. Casas*, H. H. Stein, *University of Illinois at Urbana-Champaign, Urbana.*

The objectives of this experiment were to determine the apparent total tract digestibility (ATTD) and the standardized total tract digestibility (STTD) of P, and the effect of microbial phytase on ATTD and STTD of P in full fat rice bran (FFRB), defatted rice bran (DFRB), brown rice, broken rice, and rice mill feed when fed to pigs. Ninety-six barrows (initial BW 19.4 \pm 1.4 kg) were allotted to 12 diets, with 8 replicate pigs per diet in a randomized complete block design. A basal diet based on corn and soybean meal was formulated, and 5 diets were formulated by adding each of the 5 rice co-products to the basal diet. Six additional diets that were similar to the initial 6 diets, with the exception that 500 units of microbial phytase (Optiphos; Enzyvia, Sheridan, IN) were included were also formulated. The ATTD of P was calculated for each diet using the direct procedure. The STTD of P was calculated for each diet by correcting the ATTD of P for the endogenous P losses. The ATTD and STTD of P in each rice co-product were calculated using the difference procedure. The concentration of P in feces was reduced ($P < 0.05$) from pigs fed diets containing microbial phytase compared with pigs fed diets without phytase. The total daily P output in feces from pigs fed diets with phytase was also less ($P < 0.05$) than in feces from pigs fed diets without microbial phytase, except for diets containing broken rice. Among the rice co-products, the greatest ($P < 0.05$) ATTD and STTD of P were observed for broken rice regardless of inclusion of phytase. The ATTD of P was greater ($P < 0.05$) for all ingredients except DFRB if microbial phytase was used than if no microbial phytase was used, and the STTD of P in brown rice, FFRB, rice mill feed was also greater ($P < 0.05$) if microbial phytase was used than if no microbial phytase was used. In conclusion, the STTD of

Table 121. Effect of phytase on apparent total tract digestibility (ATTD), and standardized total tract digestibility (STTD) of P in corn, soybean meal (SBM), and full fat rice bran.¹

Item	Corn				SBM				Full fat rice bran			
	Phytase, FTU/kg		SEM	P-value	Phytase, FTU/kg		SEM	P-value	Phytase, FTU/kg		SEM	P-value
	0	500			0	500			0	500		
ATTD of P, %	47	66	4	0.005	38	68	8	0.018	47	62	4	0.012
Basal EPL, mg/d	136	147	10	0.478	149	134	4	0.030	159	159	9	0.994
STTD of P, %	53	73	4	0.004	46	73	8	0.035	50	64	4	0.015

¹FTU, phytase units.

Table 122.

	HiP0	HiP1	HiP2	HiP3	HiInP	SE	P-value
ADG, kg							Treatment
Phase 2	0.43 ^a	0.51 ^b	0.50 ^b	0.54 ^b	0.51 ^b	0.01	<0.01
Phase 3	0.64 ^c	0.59 ^{ab}	0.68 ^d	0.62 ^{bc}	0.57 ^a	0.02	<0.01
Overall	0.43 ^a	0.44 ^a	0.48 ^b	0.47 ^b	0.43 ^a	0.01	<0.01
ADFI, kg							
Phase 2	0.56 ^a	0.62 ^b	0.62 ^b	0.63 ^b	0.62 ^b	0.02	<0.03
Feed Efficiency							
Phase 2	0.77 ^a	0.82 ^b	0.81 ^{ab}	0.87 ^c	0.82 ^b	0.02	<0.01
Overall	0.68 ^a	0.69 ^{ab}	0.72 ^{bc}	0.73 ^c	0.70 ^{abc}	0.01	<0.03

^{a,b,c}Means within row with different superscript differ ($P < 0.05$).

P is greater in broken rice than in all other rice co-products. The STTD of P in brown rice, FFRB, DFRB, and rice mill feed is relatively low due to the high concentration of phytate in these ingredients, but addition of microbial phytase will increase the STTD of P in most rice co-products.

Key Words: phosphorus digestibility, phytase, pig

121 Effect of microbial phytase on the standardized total tract digestibility and in vitro release of phosphorus in corn, soybean meal, and rice bran fed to growing pigs. J. J. Abelilla^{1,*}, R. C. Sulabo¹, H. H. Stein², S. P. Acda¹, A. A. Angeles¹, M. C. R. Oliveros¹, F. E. Merca³, ¹*Animal and Dairy Sciences Cluster, University of the Philippines, Los Baños, the Philippines*, ²*University of Illinois, Urbana*, ³*Institute of Chemistry, University of the Philippines, Los Baños, the Philippines*.

Two experiments were conducted to determine the effect of microbial phytase on the standardized total tract digestibility (% STTD) of P in corn, soybean meal, and full fat rice bran when fed to growing pigs, and to determine if in vitro P release measured using procedures adapted from Liu et al. (1997) may be used to predict STTD of P. Each raw material was used as the sole source of P in semipurified diets (without or with microbial phytase, 500 units/kg of Optiphos 2000, Enzyvia, Sheridan, IN) that also contained sucrose, vitamins and minerals except P. In Exp. 1, 36 barrows (PIC L337 × C24, initial BW = 22.3 ± 1.4 kg) were fed semipurified diets for 10 d, with a 5 d adaptation period and 5 d for collection of feces. Each pig was housed in metabolism cages that allowed for total collection of feces. Basal endogenous P loss (EPL) was assumed to be 200 mg/kg DMI. Addition of phytase increased ($P < 0.05$) the STTD of P in corn from 53.38 to 73.35%, in SBM from 46.12

to 73.05%, and in rice bran from 49.76 to 64.43%. In Exp. 2, 1.0 g of each diet was incubated with 3000 units of pepsin at pH 2.5 for 75 min. The pepsin digesta was then mixed with 2.4 mg of pancreatin and then incubated at pH 6.0 for 240 min. The in vitro release of P was highly correlated ($r = 0.94$) with the in vivo P digestibility. In conclusion, microbial phytase improved the STTD of P in corn, SBM, and full fat rice bran, and the in vitro procedure may be used to predict the STTD of P in corn, SBM, and full fat rice bran fed to growing pigs.

Key Words: phosphorus digestibility, pigs, rice bran

122 Effects of increasing dietary levels of *Aspergillus oryzae*-derived phytase (Ronozyme) on the growth performance of nursery pigs fed an adequate phosphorous diet. T. C. Tsai^{1,*}, H. J. Kim¹, J. R. Bergstrom², J. J. Chewning³, J. K. Apple¹, C. V. Maxwell¹, ¹*Department of Animal Science, University of Arkansas Division of Agriculture, Fayetteville*, ²*DSM Nutritional Products, Inc., Parsippany, NJ*, ³*Swine Research Services, Inc., Springdale, AR*.

Pigs (PIC 29 × 380, n = 270) were blocked by initial BW (6.89 ± 0.29 kg) at weaning (21 ± 3 d) and allotted to 1 of 5 pens within each of 9 blocks. Pens within blocks were randomly assigned to 1 of 5 dietary treatments: HiP0 (devoid of phytase with available phosphorus [aP] = 0.55, 0.40, and 0.33% for Phases 1, 2, and 3), HiP1, HiP2, HiP3 (HiP0 + 0.015, 0.037, and 0.059% of Ronozyme HiPhos 2700 GT), and HiInP (HiP0 + monocalcium-phosphate to meet the estimated-aP-level in HiP3). Nutrients in all diets were formulated to meet or exceed the NRC 2012 requirement throughout the 3-diet-phases fed during the 37 d experiment. For Phase 1 (d 0 to 9); ADG and ADFI were improved ($P < 0.03$) for HiP1-, 2-, and 3-fed-pigs

compared with those fed HiP0. HiP3- and HInP-fed-pigs had similar ($P > 0.70$) ADG, ADFI, and G:F. During Phase 2 (d 9 to 23); HiP1-, 2-, and 3-fed-pigs had greater ADG (Cubic, $P < 0.03$), ADFI (Quadratic, $P < 0.05$), and G:F (Cubic, $P < 0.04$) compared with those fed HiP0. HiP3-fed-pigs had similar ADG ($P = 0.09$) and ADFI ($P = 0.66$), but improved G:F ($P < 0.05$), compared with those fed HInP. In Phase 3 (d 23 to 37); ADG was improved (Cubic, $P < 0.05$) in HiP2-fed-pigs compared with those fed HiP0, and HiP2- and 3-fed-pigs had increased ($P < 0.03$) ADG compared with those HInP-fed. Overall, ADG (Quadratic, $P < 0.05$), and G:F (linear, $P < 0.01$) of HiP1-, 2-, and 3-fed-pigs were higher than those fed HiP0, but ADFI was similar ($P = 0.23$). HiP3-fed-pigs had greater ($P < 0.01$) ADG, and a tendency ($P = 0.07$) for higher G:F than those fed HInP. The results of this study demonstrate that adding phytase to nursery diets believed-to-be P adequate improved ADG, and G:F; which indicates that the P requirement may be underestimated or that phytase provides benefits beyond releasing P.

Key Words: adequate phosphorus, nursery pigs, phytase

123 Super-dosed phytase improves rate and efficiency of gain in nursery pigs. D. D. Koehler^{1,*}, B. Corrigan¹, A. J. Elsbernd², S. A. Gould², C. L. Holloway², J. F. Patience², ¹VitaPlus Corporation, Madison, WI, ²Iowa State University, Ames.

Previous studies have shown that phytase fed at super-dosed levels may improve pig performance. However, the level of phytase used for super-dosing and the performance responses have been inconsistent. An experiment was conducted with newly weaned nursery pigs to determine if rate and efficiency of gain could be improved with a super-dose level of phytase and whether this response would be greater when energy and AA were limiting. Four hundred forty pigs (6.27 ± 0.29 kg) were assigned to pens on the basis of BW, providing 11 pens of 10 pigs each per treatment. Pens were assigned to treatment according to a randomized complete block design. Treatments were arranged in a factorial design comparing the main effects of diet (positive control [PC] vs. a negative control: 10% lower standardized ileal digestible [SID] lysine with relative lowering of all other essential AA and 1% reduced fat [NC]) and phytase levels (0 vs. 2,500 phytase units [FTU] Quantum Blue). Feed and water were provided ad libitum across 4 dietary phases: 3×1 wk plus 1×2 wk. Data were analyzed using the PROC MIXED procedure of SAS. For the overall experiment (Table 123), both diet and phytase were significant for ADG and G:F. However, ADFI was unaffected. There were no interactions. Not shown in the table, NC with 2500 FTU phytase resulted in ADG (0.459 vs. 0.468) and G:F (0.691 vs. 0.701) that were not different from that of the PC with no phytase ($P < 0.05$). In conclusion, feeding phytase at super-dosed levels in the nursery phase improves growth performance, irrespective of diet adequacy.

Key Words: lysine, phytase, superdose

Table 123.

Item	Main effect of diet ¹		Main effect of phytase		P-values		
	PC	NC	0	2,500 FTU	Diet	Phytase	D×P
BW, kg							
d 0	6.28	6.26	6.27	6.27	0.10	0.72	0.72
d 35	22.45	21.68	21.89	22.23	<0.01	0.14	0.34
ADG, kg/d	0.477	0.456	0.461	0.472	<0.001	0.043	0.520
ADFI, kg/d	0.676	0.685	0.681	0.681	0.186	1.000	0.893
G:F	0.706	0.667	0.678	0.695	<0.001	0.006	0.239

¹PC = positive control; NC = negative control.

124 Improving nutrient utilization through the use of super-dosing of phytase in growing pig diets.

C. L. Holloway^{1,*}, R. D. Boyd², J. F. Patience¹, ¹Iowa State University, Ames, ²The Hanor Company, Inc., Franklin, KY.

Previous research has provided evidence that super-dosing phytase may improve pig performance through so-called *nutrient uplift*. This experiment was conducted to investigate this possibility by determining if super-dosing of phytase improves the apparent total tract digestibility (ATTD) of energy, N, and DM. Thirty-two pigs were placed on test at an average initial BW of 39.7 ± 0.69 kg, after being blocked by initial BW. Diets were fed in 3 phases and were based on corn and soybean meal with chromic oxide added at 0.4% as an indigestible marker. There were 4 treatments containing increasing levels of Quantum Blue phytase. A control diet contained 250 phytase units (FTU) of phytase/kg diet which released the equivalent of 0.08% standardized total tract digestible P from phytate; to this base diet, 3 super-dose levels were added above that of the control: 1000, 1750, and 2500 FTU. Pigs were fed at 3.2 times maintenance and water was provided ad libitum. Feces and urine were collected at 40, 60, and 80 kg, respectively. Samples were analyzed for GE, DM, N, and chromic oxide. Data were analyzed using the MIXED procedure of SAS (9.4) with treatment and collection weight being fixed effects, and weight block as a random effect. The ATTD of GE was not affected by phytase level: 89.0, 88.2, 89.2, and 89.2% for the control, 1000, 1750, and 2500 FTU treatments, respectively ($P = 0.1345$). The ATTD of DM was not affected by phytase level: 90.1, 89.6, 90.5, and 90.6% for the control, 1000, 1750, and 2500 FTU treatments, respectively ($P = 0.1533$). Similarly, ATTD of N was not affected by phytase level ($P = 0.6181$). Overall, ATTD of CP was higher at 40 kg compared with 60 and 80 kg (90.3 vs. 89.1 and 89.3%, respectively, $P < 0.01$). The ATTD of GE was lower at 60 kg than 40 kg or 80 kg (88.6 vs. 89.0 and 89.2%, respectively, $P = 0.04$), and ATTD of DM was lower at 60 kg than 40 kg or 80 kg (89.9 vs. 90.2 and 90.6%, respectively, $P = 0.04$). In conclusion, under the conditions of this study, no evidence was observed to suggest that super-dosing of phytase provided a benefit in terms of ATTD of energy, CP, or DM.

Key Words: digestibility, phytase, superdose

125 **The effect of superdosing phytase with or without the addition of live yeast in diets void of spray dried plasma in pigs from weaning to 21 days postweaning.** C. L. Bradley*, C. L. Walk, N. D. Walker, P. Wilcock, *AB Vista Feed Ingredients, Marlborough, UK.*

A 21 d starter feed trial was designed to determine if adding 2000 phytase units (FTU)/kg of phytase (Quantum Blue) to a simple diet (SD; no plasma/high soybean meal, SBM) with or without a live yeast (Vistacell) would improve pig performance and be comparable to pigs fed a complex diet (CD; plasma/low SBM). Weaned pigs (n = 360; 6.0 ± 0.01 kg) were assigned to 1 of 4 dietary treatments with 9 replicate pens per treatment and 10 pigs per pen (mixed sex). Treatments were as follows. Treatment CD: 6% spray dried plasma (SDP; 15% SBM in Phase 1 [P1], and 3% SDP [20% SBM in P2]); Treatment SD: negative control (NC) with plasma replaced by SBM (P1, 25%; P2, 30%); Treatment SD1: NC + 2000 FTU/kg phytase; Treatment SD2: NC + 2000 FTU/kg phytase and 1 kg/t of live yeast. All pigs were fed a 2-phase feed program (P1 = 1 to 7 d and P2 = 7 to 21 d) postweaning, with each diet in each phase formulated to be iso-nutrient including available P (0.50 and 0.45% for P1 and P2, respectively) regardless of the inclusion of phytase. Data were analyzed using the Fit Model platform in JMP v. 11.0. In P1, pigs fed the CD had higher ADG ($P < 0.05$) and ADFI ($P < 0.05$) and better FCR (feed conversion rate, $P < 0.05$) than all other treatments. There were no other performance differences between treatments in P1. In P2, pigs fed the SD1 and SD2 had higher ADG ($P < 0.05$) and ADFI ($P < 0.05$) and better FCR ($P < 0.05$) compared with pigs fed the SD, while there was no significant difference between CD and SD. Overall (21 d), there was no significant differences in ADG between CD, SD1, and SD2; and all 3 treatments were significantly ($P < 0.05$) better than the SD. The use of SD negatively impacted FCR when compared with the CD diet (1.21 v. 1.14; $P < 0.05$); however, the addition of high phytase (SD1) improved the FCR ($P < 0.05$) of the SD to that level of the CD fed pigs. The combination of live yeast and superdosing phytase (SD2) improved ($P < 0.05$) FCR of the SD to a level that was better (1.07; SD2 v. 1.14; CD; $P < 0.05$) than the CD fed pigs. In conclusion, SDP in starter diets may be replaced with diets containing higher levels of SBM without negatively impacting overall growth performance or efficiency, when dietary phytase is added at 2000 FTU/kg. Further FCR benefits can be achieved by the addition of live yeast with superdosing phytase.

Key Words: phytase, starter, superdose

126 **Withdrawn.**

127 **Response of protease supplementation on growth performance of weanling pigs.** F. N. Almeida*, J. Zhao, J. Escobar, M. Vazquez-Anon, *Novus International, Inc., St. Charles, MO.*

A previous study demonstrated the efficacy of dietary supplementation of a protease (CIBENZA DP100; Novus International Inc., St. Charles, MO) in reducing diet cost while maintaining growth performance in weanling pigs. The objective of this study was to investigate the effects of DP100 on growth performance of nursery pigs under commercial conditions. A total of 968 pigs (initial BW = 6.5 kg, mixed gender) were allotted to 4 treatments in a complete randomized block design with 11 replicates (22 pigs/pen) per treatment. A positive (POS) and a negative (NEG) control diet were formulated. The POS diets were formulated to contain 1.32 and 1.19% standardized ileal digestible (SID) Lys (Phases 2 and 3, respectively). The NEG diets were formulated by subtracting the matrix value provided by supplementation of 500 ppm of DP100, from the POS. Two additional diets were formulated by supplementing NEG with 250 or 500 ppm of DP100 (NEG + 250 or NEG + 500, respectively). Pigs were fed the treatments in a 2-phase program (Phase 2, d 7 to 21; Phase 3, d 21 to 42). Data were analyzed using the Mixed Procedure (SAS Inst. Inc., Cary, NC). During Phase 2, no differences were observed for ADG. The ADFI was lower ($P < 0.05$) for pigs fed the NEG (0.376 kg) and NEG + 250 (0.383 kg) than for pigs fed POS diet (0.409 kg). As a result, feed efficiency was greater ($P < 0.01$) for pigs fed either the NEG or NEG + DP100 supplemented diets than pigs fed the POS diet. In Phase 3, however, both ADG and FG were improved by supplementation of DP100 to the NEG. The ADG was not different between NEG + 500 (0.480 kg) and POS (0.483 kg). Feed efficiency was not different among POS, NEG + 250, and NEG + 500. Overall, 500 ppm DP100 tended to improved ADG ($P = 0.07$; 0.399 and 0.402 kg, respectively) and ADFI ($P = 0.06$; 0.627 and 0.633 kg, respectively) to the same level of pigs fed the POS diet. Feed cost (\$/kg BW gain) was reduced in the NEG+500 (\$0.58) compared with the POS (\$0.64). In conclusion, supplementation of weanling pig diets with 500 ppm of CIBENZA DP100 resulted in reduction of diet cost without detrimental effects on growth performance.

Key Words: growth performance, pigs, protease

128 **Efficacy of protease on growth, gut health, and nutrient digestibility in nursery pigs fed diets with different levels of soybean meal.** I. Park^{1,*}, P. Biggs², S. W. Kim¹, ¹North Carolina State University, Raleigh, ²BioResource International, Inc., Durham, NC.

This study was to determine the effect of supplemental protease (Versazyme, BRI, Durham, NC) on the growth performance, gut health, and digestibility of newly weaned pigs fed diets with different levels of soybean meal (SBM). One-

hundred twenty pigs (60 barrows and 60 gilts) were weaned at 21 d of age and fed a common early wean feed for 4 d. On 25 d of age (7.77 ± 0.63 kg BW), pigs were randomly allotted to 4 treatments (2×2 factorial arrangement) with 10 pens (3 pigs per pen, 5 barrow and 5 gilt pens) per treatment, and fed experimental diets for 3 wk. Factors were SBM levels (22 and 29%) and protease (0 and 0.05%). All diets were calculated to meet or exceed the NRC nutrient requirements. Body weight and feed intake were measured weekly. Titanium dioxide (0.3%) was added to experimental diets from d 18 to 21 as an indigestible marker. Blood samples were taken on d 20 to measure tumor necrosis factor alpha (TNF- α) and malondialdehyde (MDA). On d 21, 24 pigs (1 from each pen and 6 pens per treatment) were euthanized to obtain the duodenal and jejunal mucosa to measure TNF- α , MDA, and morphology. The jejunal and ileal digesta were obtained to measure viscosity and nutrient digestibility, respectively. Data were analyzed using PROC MIXED procedure in SAS with pen as the experimental unit. Overall, G:F was increased ($P < 0.05$) as SBM levels increased from 22 to 29% (0.742 vs. 0.770, respectively) or protease was supplemented (0.744 vs. 0.768, respectively). There was no difference in ADG and ADFI among treatments. Viscosity and nutrient digestibility were not affected by SBM and protease. Supplemental protease decreased ($P < 0.05$) concentration of TNF- α in the duodenal (2.49 vs. 3.06 pg/mg) and jejunal (2.11 vs. 2.99 pg/mg) mucosa. Increased use of SBM decreased ($P < 0.05$) villus height (627 to 564 μm) whereas the use of protease increased ($P < 0.05$) villus height (573 to 617 μm) without interaction between 2 factors. Collectively, dietary supplementation of protease enhanced feed efficiency and gut health as measured by decreased TNF- α and increased villus height.

Key Words: growth performance, gut health, nursery pigs, protease, soybean meal

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- 129 **Effects of xylanase supplementation and feeding method on nutrient digestibility in pigs fed diets containing corn dried distillers grains with solubles or wheat middlings.** K. Moran^{1,*}, E. van Heugten¹, R. D. Boyd^{1,2}, P. Wilcock³, C. F. de Lange⁴, ¹North Carolina State University, Raleigh, ²The Hanor Company, Inc., Franklin, KY, ³AB Vista Feed Ingredients, Marlborough, UK, ⁴Department of Animal and Poultry Science, University of Guelph, Guelph, ON, Canada.

The objective was to determine the effect of endo-1,4- β -xylanase supplementation (Xyl; with or without) and feeding method (dry or liquid) on apparent total tract digestibility (ATTD) and apparent ileal digestibility (AID) of nutrients in growing pigs fed diets containing 30% of corn dried distillers grains with solubles (DDGS) or 30% of wheat middlings (Midds). Sixty-four pigs (BW 25.9 ± 0.38 kg) were blocked by BW and sex, placed in individual pens, and randomly as-

signed to 8 dietary treatments. Within each feedstuff, diets were fed either liquid or dry, without or with Xyl (24,000 BXU/kg feed). Diets contained 3.25 Mcal/kg ME and 1.05% standardized ileal digestible (SID) lysine. Pigs were fed restricted at 3 times maintenance energy requirements (197 kcal ME/kg BW^{0.60}) in 2 equal meals. Liquid diets were prepared by steeping DDGS or Midds with water (1:3 w:v) with or without Xyl for 24 h, followed by mixing with the respective basal diet and water to achieve a final DM concentration of 25%. Following a 13 d adaptation, fecal samples were collected for 3 d. When DDGS was included, Xyl increased AID of NDF in liquid diets (48.4 vs. 31.6%), but not in dry diets (interaction, $P = 0.03$). Pigs fed liquid diets with DDGS had decreased ($P < 0.05$) ATTD of GE (81.1 vs. 83.0%) and NDF (64.8 vs. 72.1%) compared with pigs fed dry diets. When Midds were included, Xyl increased AID of NDF in pigs fed dry diets (52.9 vs. 31.7%) but not in pigs fed liquid diets (interaction, $P = 0.09$). Pigs fed liquid diets with Midds had greater AID of N ($P = 0.01$) than pigs fed dry diets (77.7 vs. 72.0%). The AID of GE tended to be greater ($P = 0.09$) for pigs fed Midds with Xyl (63.7 vs. 57.3%). Pigs fed dry diets with Midds and Xyl had increased ATTD of NDF; however it was reduced when pigs were fed liquid diets with Xyl (interaction, $P < 0.01$). The ATTD of GE (80.4 vs. 78.1%) and N (80.2 vs. 78.0%) was improved ($P < 0.05$) in pigs fed Midds with Xyl compared with diets without Xyl. This study indicates that Midds based diets with Xyl in liquid feeding did not improve nutrient digestibility. However, addition of Xyl improved ATTD of GE, N and NDF in dry diets with Midds. Furthermore, DDGS based diets with Xyl in liquid feeding improved only AID of NDF. Results suggest that the addition of Xyl appears to be more beneficial in Midds than DDGS based diets.

Key Words: enzyme, nutrient digestibility, pigs

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- 130 **The effect of xylanase in grower-finisher pigs fed low or high fat diets.** P. Wilcock^{1,*}, C. L. Bradley¹, H. V. Masey O'Neill¹, G. Gourley², ¹AB Vista Feed Ingredients, Marlborough, UK, ²Gourley Research Group LLC, Webster City, IA.

This trial was designed to determine if the use of a xylanase (Econase XT) would improve pig performance in low (3% added fat) or high (6% added fat) fat diets. At 21 d postweaning, 1,680 pigs were selected (840 gilts and 840 barrows), weighed, and randomly (within sex) allocated to 1 of 4 treatments: 1) low fat, LF; 2) LF + 16,000 BXU/kg xylanase; 3) high fat, HF; and 4) HF + 16,000 BXU/kg. Each treatment had 20 pen replicates (10 pens of barrows and 10 pens of gilts) with 21 pigs per pen. From 21 d of age, pigs were fed an 8 phase feeding regimen with each phase allocated on a kg/pig feed budget basis. When the treatment group had consumed the delivered budget all pens within that treatment were switched to the next phase of the feeding regime. Diets were

based on corn/soybean meal/corn distillers and added fat (AV blend). All pigs were weighed at 21 d postweaning and then every 21 d until d 146. Data (d 21 to 146) were analyzed as a simple ANOVA using JMP v.10 with pen as the experimental unit. Data were analyzed as a 2 (xylanase level) \times 2 (added fat level) \times 2 (sex) factorial. There were no interactions between main effects, thus only the main effect means are reported. Barrows had a significantly greater ADG (910 v. 840 g/d; $P < 0.01$) and ADFI (2.04 v. 1.84 kg/d; $P < 0.01$) than gilts, with gilts having an improved feed conversion rate (FCR; 2.15 v. 2.24; $P < 0.01$). The addition of added fat from 3 to 6% significantly increased ADG (880 v. 870 g/d; $P < 0.05$) and ADFI (1.98 v. 1.88 kg/d; $P < 0.01$) while improving FCR (2.13 v. 2.27; $P < 0.01$). The addition of xylanase at 16,000 BXU/kg had no significant effect on ADFI or ADG but improved FCR (2.18 v. 2.21; $P < 0.01$). In conclusion, the use of xylanase in corn/soybean meal/corn distillers based grower-finisher diets improved FCR irrespective of added fat level (3 or 6%).

Key Words: finisher, pig, xylanase

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- 131 **Effects of dietary β -mannanase on the growth performance of growing pigs.** O. F. Mendoza^{1,*}, A. M. Gaines¹, B. A. Peterson¹, P. J. Rincker², C. M. Shull¹, ¹*The Maschhoffs, LLC, Carlyle, IL*, ²*Elanco Animal Health, Greenfield, IN*.

The effects of dietary inclusion of β -mannanase (Hemicell HT 1.5X) on the growth performance of growing pigs was evaluated in a study using a RCBD with 3 dietary treatments fed in 3 phases as follows: 1) Negative Control (NC; 3,307, 3,217, and 3,219 dietary ME [kcal/kg], for Phase 1, 2, and 3, respectively); 2) Positive Control (PC; As NC + supplemental fat to increase the ME of the diet by approximately 100 kcal/kg), and 3) Hemicell (HEM; As NC + Hemicell HT 1.5X at 0.025%, or 0.08 MU/kg). Experimental diets were corn-soybean meal based with corn co-products, and were fed in meal form. Diets were formulated to contain the same level of standardized ileal digestible lysine across dietary phases and to meet or exceed NRC (2012) nutrient requirements. Pigs had ad libitum access to feed and water throughout the study, which was carried out from weaning (initial BW 5.91 \pm 0.38 kg) to wk 8 postweaning (BW 33.98 \pm 2.35 kg) using 1,383 pigs housed in groups of 21 or 22, with 21 replicates per treatment for a total of 63 pens. Growth performance for the PC and HEM treatments were similar ($P > 0.05$) for all traits evaluated. Compared to pigs fed the NC diet, pigs fed the HEM diet were 5.5% heavier ($P < 0.001$) at the end of test (32.8, 34.5, and 34.6 kg, respectively, for NC, PC and HEM; SEM = 0.49) and had 7.1% greater ($P < 0.001$) overall ADG (476, 507, and 510 g for NC, PC and HEM, respectively; SEM = 5.9). In addition, pigs fed the HEM diet consumed 4.9% more ($P = 0.003$) feed (793, 817, and 832 g for NC, PC, and HEM, respectively; SEM = 14.0) and had 2.8% greater ($P < 0.001$) G:F (0.602, 0.622, and 0.619 for NC,

PC, and HEM, respectively; SEM = 0.0052). The results of this study suggest that nursery pigs fed Hemicell HT 1.5X have a greater growth rate, feed intake, and feed efficiency compared with pigs fed a diet without it, which is explained by the enzyme's energy sparing effect.

Key Words: enzyme, growth, pigs

NONRUMINANT NUTRITION: FEED INGREDIENTS AND PROCESSING

- 132 **Energy digestibility in 23 sources of distillers dried grains with solubles fed to pigs.** S. M. Curry*, H. H. Stein, *University of Illinois, Urbana*.

In the United States, the primary feedstock for ethanol production is corn. Illinois is one of the major corn producers in the nation, and much of that corn is used to produce ethanol. The resulting co-product is distillers dried grains with solubles (DDGS). In recent years, ethanol plants have been centrifuging solubles and the resulting DDGS contains more protein and fiber, but less fat. Therefore, the purpose of this experiment was to determine if the concentration of DE and ME in DDGS produced in and around Illinois varied among plants. Twenty-four barrows (average initial BW: 28.1 \pm 1.8 kg) were randomly allotted to 1 of 24 dietary treatments in a 24 \times 8 Youden square design with 24 diets and 8 periods. Approximately 250 kg of DDGS were procured from 11 ethanol plants in Illinois, 4 ethanol plants in Indiana, 4 ethanol plants in Iowa, 2 ethanol plants in Missouri, and 2 ethanol plants in Wisconsin. Twenty-four diets were formulated: 1 diet containing 97.8% corn and 23 diets containing 40% of each source of DDGS. Each period consisted of a 7 d diet adaptation period, and feces and urine were collected during the following 5 d based on the marker to marker approach. Results indicated that DDGS had high variability in concentration of ADF, NDF, and lignin (CV = 18.01, 10.09, and 34.74%, respectively). There was a wide range of particle size (266 to 930 μ m) and bulk density (368 to 548 g/L) observed among the 23 sources of DDGS. The acid hydrolyzed ether extract ranged from 5.3 to 10.6% indicating that some ethanol plants were centrifuging solubles to remove the corn oil from the solubles. The DE, ME, ATTD of GE, and ATTD of N in DDGS were different ($P < 0.05$) among sources. Correlation coefficients among and between chemical and physical components and DE and ME were determined. Prediction equations for DE and ME in DDGS were generated, but the accuracy with which DE and ME could be predicted was relatively low. In conclusion, DDGS procured from Illinois and surrounding states vary in concentration of ether extract, but more research is needed to generate prediction equations that can accurately predict DE and ME in DDGS.

Key Words: distillers dried grains with solubles, energy, pigs

Table 133.

Item	LOW	ML	MH	HIGH	SEM
ADFI, kg	2.57 ^a	2.70 ^b	2.47 ^c	2.45 ^c	0.033
ADG, kg	0.89	0.92	0.91	0.90	0.014
G:F	0.362 ^a	0.353 ^a	0.385 ^b	0.385 ^b	0.004
DDGS NE ¹ , kcal/ kg (as-fed)	2,377	1,924	2,612	2,513	

^{a,b,c}Within a row, means without a common superscript differ ($P < 0.05$).

¹Calculated NE of DDGS using NRC (2012) model.

133 Impact of feeding diets containing corn distillers dried grains with solubles with variable predicted net energy content on growth performance and carcass characteristics of growing-finishing pigs. F. Wu^{1,*}, L. J. Johnston², P. E. Urriola³, A. M. Hilbrands², G. C. Shurson³, ¹Department of Animal Science, University of Minnesota, St. Paul, ²West Central Research and Outreach Center, University of Minnesota, Morris, ³Department of Animal Science, University of Minnesota, St. Paul.

The NE system is increasingly being adopted in the United States because of increased use of high-fiber feed ingredients such as distillers dried grains with solubles (DDGS). However, limited data are available on the NE content of corn DDGS for swine. Illuminate provides NE estimates based on chemical composition for various DDGS sources, but these values require validation. The objective of this study was to determine growth and carcass responses of growing-finishing pigs fed 4 DDGS sources with increasing NE (as-fed) content estimated by Illuminate. Pigs ($n = 432$) were blocked by initial BW (22.0 ± 4.3 kg) and pens were allotted randomly to 1 of 4 dietary treatments (9 pigs/pen, 12 replicates/treatment). Treatments consisted of corn-soybean meal diets containing 40% DDGS from: 1) low NE (2,083 kcal/kg; LOW), 2) medium-low NE (2,255 kcal/kg; ML), 3) medium-high NE (2,469 kcal/kg; MH), and 4) high NE (2,743 kcal/kg; HIGH), and were fed using a 4-phase feeding program. Diets met or exceeded NRC (2012) nutrient requirements and were calculated to contain the same standardized ileal digestible Lys:NE within phases. Growth performance and carcass data were analyzed using the MIXED procedure of SAS. Overall, ADFI of pigs fed LOW was less than ML, but greater than MH and HIGH. No differences were observed in ADG among treatments. Gain:feed was reduced in pigs fed LOW and ML compared with MH and HIGH. No treatment differences ($P > 0.40$) were observed in HCW, dressing percentage, backfat depth, LM area, and carcass percent fat-free lean. Assuming NE content of corn and soybean meal based on NRC (2012), NE estimates were calculated for each DDGS source using the NRC (2012) model to match the model-predicted G:F with the observed G:F. In conclusion, G:F responses of pigs did not correspond to the increasing NE estimates of the 4 DDGS sources and suggest that NE may have been overestimated for ML and HIGH DDGS sources, and underestimated for the LOW and MH DDGS

sources. However, variable NE content of DDGS sources had no impact on carcass composition of growing-finishing pigs.

Key Words: carcass composition, distillers dried grains with solubles, growing-finishing pigs, growth performance, net energy prediction

134 Digestibility of energy and concentrations of digestible and metabolizable energy in processed soybean and rapeseed products fed to growing pigs. D. M. D. L. Navarro^{1,*}, Y. Liu¹, T. S. Bruun², H. H. Stein¹, ¹University of Illinois at Urbana-Champaign, Urbana, ²Danish Pig Research Centre, Danish Agriculture and Food Council, Copenhagen, Denmark.

An experiment was conducted to determine the digestibility of energy and the concentrations of DE and ME in 2 sources of enzyme-treated soybean meal (ESBM-1 and ESBM-2), extruded soybean meal (SBM-EX), soy protein concentrate (SPC), conventional dehulled soybean meal (SBM-CV), conventional 00-rapeseed expellers (RSE), and in a fermented co-product mixture (FCM) fed to growing pigs. Sixty-four barrows (initial BW: 19.81 ± 0.90 kg) were placed in metabolism cages and were allotted into a randomized complete block design with 8 diets and 8 pigs per diet. A corn-based diet and 7 diets containing corn and each of the experimental ingredients were formulated. Feces and urine were collected for 5 d after a 5 d adaptation period. The ATTD of GE in corn was not different from SBM-CV, but was greater ($P < 0.05$) than in the other ingredients. The concentration of DE in ESBM-1, ESBM-2, SBM-EX, SPC, SBM-CV, RSE, and FCM was 4,349, 4,121, 4,432, 4,460, 4,303, 3,793 and 3,610 kcal/kg DM, respectively, with a pooled SEM of 91 kcal/kg. The DE in corn (3,864 kcal/kg DM) was greater ($P < 0.05$) than in FCM, but less ($P < 0.05$) than in SBM-EX, SPC, ESBM-1, and SBM-CV. The DE in SBM-EX was greater ($P < 0.05$) than in SBM-CV, ESBM-2, RSE, and FCM, but not different from SPC and ESBM-1. The concentration of ME in ESBM-1, ESBM-2, SBM-EX, SPC, SBM-CV, RSE, and FCM was 4,158, 3,782, 4,240, 4,226, 4,044, 3,522, and 3,364 kcal/kg DM, respectively, with a pooled SEM of 135 kcal/kg. The ME of ESBM-2 was less ($P < 0.05$) than in all other soybean products, but greater ($P < 0.05$) than in RSE and FCM. The ME of corn (3,780 kcal/kg DM) was less ($P < 0.05$) than in all soybean products except ESBM-2, but greater ($P < 0.05$) than in the rapeseed products. There was no difference in DE and ME between RSE and FCM, but the DE and ME for both ingredients were less ($P < 0.05$) than in all soybean products. It is concluded that there are differences among processed soybean products, with some having greater concentrations of DE and ME than others. However, the concentrations of DE and ME in all soybean products used in this experiment were greater than in rapeseed expellers and the fermented co-product mixture.

Key Words: energy, rapeseed products, soybean products

135 **Evaluation of a microbially-converted soybean meal as a substitute for fishmeal in weaned pig diets.** S. M. Sinn^{1,*}, W. Gibbons¹, M. Brown¹, J. M. DeRouchey², C. L. Levesque¹, ¹South Dakota State University, Brookings, ²Kansas State University, Manhattan.

Standard ileal digestibility (SID) values, determined previously in our laboratory, were similar between fish meal (FM) and microbially-converted soybean meal (MCSBM). A performance trial was conducted to evaluate MCSBM as a replacement for FM in weaned pig diets. A total of 184 barrows and 152 gilts were weaned at 21d of age and assigned to 1 of 6 experimental diets (8 pens/diet with 7 pigs/pen; barrows and gilts were balanced across treatments) fed in Phase I (d 0 to 7) and Phase II (d 8 to 21) of a 3-phase feeding program. All pigs received a common Phase III (d 22 to 35) diet. Experimental diets included: 1) negative control (NEG) containing corn, soybean meal and whey; 2) NEG + acidifier; 3) NEG + fishmeal (FISH); 4) FISH + acidifier; 5) NEG + MCSBM; and 6) MCSBM + acidifier. Fish meal and MCSBM were included at 7.5 and 5.0% in Phase I and II, respectively. Diets were formulated to meet the NRC (2012) SID lysine:MEg/Mcal requirement for weaned pigs. Pig BW and feed disappearance was measured weekly. Tissue and digesta samples were collected on d 7 and 21 from stomach, duodenum, ileum, cecum, and feces (1 mean pig/pen based on ADG and balanced for gender across treatment). Digesta pH was measured at the stomach, duodenum, jejunum, ileum, cecum, and colon. Mean initial BW was 6.1 ± 0.83 kg and final BW was 20.1 ± 2.0 kg. Data was analyzed by the MIXED model of SAS. Daily gain, BW, and G:F from d 0 to 7, 8 to 21, and 22 to 35 were not different between treatments. Daily feed intake tended to be greater ($P = 0.09$) in pigs fed FISH compared with NEG (954 vs. 769g/d, respectively), similarly for FISH compared with MCSBM + acid (954 vs. 756 g/d) from d 22 to 28. There was no difference in pH across the digestive tract between treatments at d 7 (mean pH across treatments was 3.85, 5.25, 6.34, 6.95, 6.04, and 6.27 in the stomach, duodenum, jejunum, ileum, cecum, and colon, respectively). On d 21, pH in the ileum was lower in pigs fed MCSBM than pigs fed NEG, MCSBM + acid, FISH + acid, and NEG + acid (5.60 vs. 6.90, 6.92, 7.04, and 7.21, respectively). MCSBM affected digesta pH in the distal small intestine. Performance was similar for pigs fed FM or MCSBM, thus MCSBM may be an alternative to FM in nursery diets; however, it is important to note neither FM nor MCSBM provided additional benefit over solvent extracted soybean meal (i.e., NEG diet).

Key Words: growth performance, microbially-converted soybean meal, weaned pig

136 **Use of feed technology to improve the nutritional value of feed ingredients feed to pigs.** O. J. Rojas*, H. H. Stein, *University of Illinois, Urbana.*

Seven experiments were conducted to investigate the effects of using feed technologies to improve the nutritional value of diets fed to pigs. Results of 2 digestibility experiments indicated that the concentration of DE and ME linearly increased ($P < 0.05$) as the particle size of corn was reduced from 865 to 677, 485, or 339 μ m. Results of a subsequent experiment indicated that by using corn ground to a smaller particle size, the amount of added fat may be reduced in diets fed to growing-finishing pigs without affecting animal growth performance or carcass composition, except that dressing percentage is increased ($P < 0.05$). Results of 2 additional experiments indicated that G:F of weaning pigs is improved ($P < 0.05$) if diets contain corn ground to a particle size of 339 μ m rather than a greater particle size, which confirmed that the ME of finely ground corn is greater than the ME of coarsely ground corn. Thus, less expensive diets may be formulated if corn is ground to a smaller particle size. Results of a subsequent experiment indicated that extrusion of distillers dried grains with solubles (DDGS) or treatment with sodium hydroxide, calcium oxide, or an enzyme mixture of hemicellulase and xylanase did not improve ME or increase digestibility of GE, OM, NDF, or ADF. However, treatment of DDGS with a mixture of cellulase and xylanase resulted in an increase ($P < 0.05$) in digestibility of GE and OM and increased ($P < 0.05$) ME compared with untreated DDGS. The last experiment was conducted to test the hypothesis that pelleting and extrusion of diets, either alone or in combination, will improve nutrient and energy digestibility. Results indicated that energy utilization may be improved ($P < 0.05$) by pelleting or extrusion or by the combination of the 2 technologies. The response to extrusion seems to be greater in high-fiber diets than in corn-soybean meal diets, but regardless of the level of fiber in the diet, the combination of extrusion and pelleting always increased ($P < 0.05$) the utilization of energy in the diet. In conclusion, use of fine grinding, enzyme addition, or extrusion and pelleting positively influence energy and nutrient digestibility in diets fed to pigs.

Key Words: particle size, pig, processing

137 **Withdrawn.**

138 **Diet nutrient digestibility and growth performance of weaned pigs fed sugar beet pulp.** L. F. Wang^{1,*}, E. Beltranena^{1,2}, R. T. Zijlstra¹, ¹Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, Canada, ²Alberta Agriculture and Rural Development, Edmonton, Canada.

Using alternative feedstuffs to replace cereal grains in swine

diets is economically important for pork producers. To explore biological limits for young pigs to ingest high-fiber feedstuffs, effects of increasing inclusion of sugar beet pulp (SBP) by substituting wheat grain on diet nutrient digestibility and growth performance of young pigs were evaluated. In total, 220 pigs (initial BW = 7.5 kg) starting 1 wk after weaning at 19 d of age were fed Phase 1 diets for 2 wk (d 1 to 14) and, sequentially, Phase 2 diets for 3 wk (d 15 to 35). Five pelleted wheat-based diets including 0, 6, 12, 18, and 24% SBP in substitution of wheat were fed. The SBP contained (as-fed) 10.0% CP, 27.1% ADF, and 40.9% NDF. Phase 1 and 2 diets were formulated to provide 2.29 and 2.24 Mcal NE/kg, and 5.26 and 5.12 g standardized ileal digestible (SID) Lys/Mcal NE, respectively. Diets were balanced for NE by increasing canola oil from 0.5 to 5% for Phase 1 and 2 diets, and for AA by increasing crystalline AA. Increasing inclusion of SBP up to 24% linearly reduced ($P < 0.001$) apparent total tract digestibility (ATTD) of GE by 4.4 percentage units and of CP by 7.7 percentage units in Phase 1 diets, and linearly decreased the ATTD of GE by 1.3 percentage units ($P < 0.001$) and of CP by 6.0 percentage units ($P < 0.001$) in Phase 2 diets. Increasing inclusion of SBP up to 24% linearly reduced ($P < 0.001$) calculated diet NE values by 0.12 Mcal/kg in Phase 1, and quadratically increased ($P < 0.0001$) calculated diet NE values by 0.02 Mcal/kg in Phase 2. Increasing inclusion of SBP tended to reduce ($P < 0.06$) ADFI for d 1 to 7 and linearly reduced ADFI ($P < 0.05$) for d 8 to 14 and 22 to 28. The ADG for d 15 to 35 was linearly decreased ($P < 0.01$) from 711 to 647 g/d. The G:F was linearly increased ($P < 0.01$) for d 1 to 7, but was quadratically reduced ($P < 0.05$) for d 15 to 28. Overall (d 1 to 35), increasing dietary inclusion of SBP linearly reduced ($P < 0.01$) ADFI by 50.7 g/d and ADG by 46.1 g/d, and quadratically reduced ($P = 0.02$) G:F by 0.03. Increasing inclusion of SBP up to 24% linearly reduced ($P < 0.001$) final BW at d 35 by 1.6 kg. In conclusion, young pigs had difficulty to digest SBP and pigs fed increasing inclusion of SBP had a reduced growth performance.

Key Words: growth performance, pig, sugar beet pulp

139 Use of spectroscopy to predict nutrient digestibility in pigs and to identify in vitro digestion limits.

L. F. Wang^{1,*}, M. L. Swift^{1,2}, E. Beltranena^{1,3}, R. T. Zijlstra¹, ¹Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, Canada, ²Alberta Agriculture and Rural Development, Lethbridge, Canada, ³Alberta Agriculture and Rural Development, Edmonton, Canada.

Co-products are increasingly used as alternative feedstuffs for pigs, but their quality varies widely. Rapid evaluation of apparent total tract digestibility (ATTD) of energy of co-products using, for example, near-infrared spectroscopy (NIRS) is thus important; however, digestibility data are required for its calibration. In vitro digestion (IVD) models may predict ATTD of

energy, but have not been tested rigorously for co-products. In Exp. 1, we predicted ATTD of energy of canola meal, corn dried distillers grain with solubles (DDGS), soybean meal, and wheat millrun using an IVD model and chemical analyses. Unlike for cereal grains ($R^2 > 0.90$), the IVD model predicted variation in ATTD of energy among co-products not accurately ($R^2 = 0.69$) while chemical analyses had greater accuracy. The IVD model underestimated ATTD of energy in corn DDGS and wheat millrun, poorly described variation of ATTD of energy within the other co-products, and must be improved. The small quantity of IVD residues restricts using chemical analyses or NIRS to identify IVD limits. Mid-infrared spectroscopy can obtain accurate scans of 200-mg IVD residues, but has not been calibrated for ATTD of energy. In Exp. 2, a novel approach of using functional group digestibility (FGD) predicted apparent ileal digestibility (AID) of CP of wheat accurately ($R^2 = 0.99$). Absorbance in the amide I region (1,689 to 1,631 cm^{-1}) of mid-infrared spectra and ratio of inorganic indigestible marker in diet and digesta was used. In Exp. 3, the FGD predicted fat digestibility. The AID of total fatty acids ($R^2 = 0.75$) and ATTD of ether extract ($R^2 = 0.90$) of flaxseed and field pea were estimated with FGD at 2,923 cm^{-1} and 1,766 to 1,695 cm^{-1} of mid-infrared spectra, respectively. Using spectroscopic methods, evidence of poor enzymatic digestion of fat and fiber for co-products in IVD models was identified. Our findings will assist further development of IVD models to predict ATTD of energy of co-products.

Key Words: energy digestibility, in vitro, spectroscopy

140 Formation of fines during the pelleted feed manufacturing process and the resulting differences in nutrient composition of fines and pellets.

J. A. De Jong^{1,*}, J. M. DeRouchey¹, M. D. Tokach¹, R. D. Goodband¹, J. C. Woodworth¹, C. K. Jones¹, C. R. Stark¹, L. McKinney², G. Smith², J. A. Erceg¹, ¹Kansas State University, Manhattan, ²DFS, Newell, IA.

A 3-wk study was conducted at a commercial feed mill to determine where the formation of fines occurred during pelleted feed manufacturing and if differences in nutrient composition exist between fines and pellets. During the study, 1,781 pelleted feed samples representing 4,203 metric tonnes were collected from 4 swine and 2 turkey diet formulations. Progression of fines formation during the manufacturing process was determined by collecting samples immediately after the pellet mill, pellet cooler, fat coater, and at load-out. Samples were taken on 7 to 10 different runs of feed for each diet. Pellet durability index (PDI) and percentage fines were determined for all samples, and nutrient analysis was determined on a pooled sample from each run within diet. Overall, PDI was different ($P < 0.05$; SEM = 0.82) between mill sampling locations. Pellet durability index was similar between the pellet mill (77.0%) and pellet cooler exit (78.3%). From the pellet cooler exit, PDI increased ($P < 0.05$) to the fat coater exit

Table 140.

Item, % ¹	Fines	Pellets	SEM	<i>P</i> <
DM	88.83	88.32	0.16	0.031
CP	13.58	15.24	0.48	0.021
ADF	4.09	3.59	0.20	0.087
Ca	0.74	0.74	0.07	0.975
P	0.50	0.53	0.02	0.354
Fat	9.00	7.71	0.42	0.039

¹Values represent the mean of 32 samples.

(84.6%) but then decreased between the fat coater exit and load-out (84.6 vs. 81.9%). The largest increase in PDI was observed between the pellet cooler exit and fat coater exit (78.3 vs. 84.6%). Percentage fines decreased ($P < 0.05$; SEM = 0.76) from the pellet mill to cooler exit (9.44 vs. 8.54%), but then increased ($P < 0.05$; SEM = 0.77) after the fat coater and from the fat coater to load-out (14.20 vs. 20.46%). The largest increase in fines was observed between pellet cooler and fat coater exits and between the fat coater exit and load out (5.6 and 6.5%). For nutrient composition, DM and fat were greater ($P < 0.05$) and ADF tended to be greater ($P < 0.08$) in fines than in pellets. However, CP was lower ($P < 0.05$) in fines than in pellets. In conclusion, fines increased from the pellet mill to load-out and PDI improved from the pellet mill to the fat coater but then was poorer at load-out. Fines were higher in fiber and fat, but lower in CP when compared with pellets.

Key Words: feed mill, fines, pellet durability index, pellets

141 Impact of particle size and grinding method (roller or hammermill) on apparent total tract digestibility of energy in growing pigs. J. A. Acosta Camargo^{1,*}, S. A. Gould¹, C. K. Jones², C. R. Stark², J. F. Patience¹, ¹Iowa State University, Ames, ²Kansas State University, Manhattan.

The objective of this study was to determine the impact of mean particle size (PS) of corn and wheat with 2 different grinding technologies on the apparent total tract digestibility (ATTD) of GE in growing pigs (GP) and in finishing pigs (FP). Ninety-six growing barrows (BW = 54.6 ± 0.4 kg) and 96 finishing barrows (BW = 110.2 ± 0.8; PIC 337 sires × C22 or C29), providing 8 observations per dietary treatment, were housed in individual pens and randomly assigned to 1 of 12 treatments. Corn and wheat were ground to 3 different PS (300, 500, and 700 microns), using either a roller mill (RM) or a hammermill (HM). Fecal samples were collected for the last 3 d of an 11 d feeding period. Titanium dioxide was used as an indigestible marker. Data were analyzed using the MIXED procedure of SAS. Particle size interacted with growth stage ($P < 0.01$); ATTD of GE increased in GP by lowering PS (81.4, 84.7, and 85.6% for 700, 500, and 300 microns respectively; $P < 0.05$); in FP, ATTD of GE increased from 700 to 500 microns ($P < 0.05$) and remained constant at 300 microns (83.65, 86.50, and 86.20% respectively). Particle size interact-

Table 142.

Item	Mash	45 s		Extruded	SEM	<i>P</i> =
		Pellet	Pellet			
ADG, kg	0.95	0.99	1.01	0.98	0.012	<0.001
ADFI, kg	2.78	2.73	2.78	2.68	0.038	0.140
G:F	0.341	0.362	0.363	0.368	0.003	<0.001
HCW, kg	91.5	95.1	95.5	94.9	1.20	0.046
Yield, %	72.1	72.7	72.4	72.6	0.19	0.092
Backfat, mm	20.5	19.7	20.9	20.6	0.56	0.524
Loin depth, mm	60.9	62.7	62.5	62.7	0.83	0.353
Jowl iodine value	75.7	77.0	77.1	77.5	0.40	0.008

ed with ingredient ($P < 0.01$); ATTD of GE improved in pigs fed corn by lowering PS (81.55, 84.44, and 85.94% for 700, 500, and 300 microns, respectively); in pigs fed wheat, ATTD of GE increased from 700 to 500 microns, but was similar at 300 microns (83.49, 86.75, and 85.87%, respectively). Particle size interacted with grinding technique ($P < 0.01$); ATTD of GE increased by lowering PS with RM (82.42, 85.40, and 86.68% for 700, 500, and 300 microns, respectively; $P < 0.05$); for HM, ATTD of GE increased ($P < 0.05$) from 700 to 500 microns but was similar ($P > 0.05$) at 300 microns (82.62, 85.79, and 85.14%, respectively). In conclusion, lowering PS improved ATTD of GE. This improvement was accentuated more in growing pigs than finishing pigs, in corn more than in wheat and when using the RM than the HM.

Key Words: hammermill, particle size, roller mill

142 Using extreme thermal processing to improve nutrient utilization of diets for finishing pigs. G. E. Bokelman^{1,*}, K. F. Coble², C. R. Stark¹, J. C. Woodworth¹, M. D. Tokach¹, S. Alavi¹, C. K. Jones¹, ¹Kansas State University, Manhattan, ²New Fashion Pork, Jackson, MN.

A total of 270 pigs (PIC 337 × 1050; initially 52.2 kg BW) were utilized in a 79-d experiment to determine the effects of feed processing methods (long-term conditioning or extrusion) on finishing pig growth performance and carcass characteristics. There were 7 or 8 pigs per pen and 9 pens per treatment. Treatments included 1) negative control: nonprocessed mash, 2) positive control: pelleted with 45 s conditioner retention time, 3) pelleted with 95 s conditioner retention time, and 4) extruded. Diets were fed in 3 phases with the same low energy formulation across treatments containing 30% corn dried distillers grains with solubles and 19% wheat middlings. Thermal processing, regardless of length or type, affected ADG and G:F ($P < 0.05$), but not ADFI ($P > 0.10$). Extruded diets tended to improve G:F compared with pelleted diets ($P < 0.10$). Interestingly, HCW was greater when pigs were fed pelleted diets compared with extruded diets, regardless of conditioning time ($P < 0.05$). However, pigs fed any thermally-processed treatment had greater HCW compared with those fed the negative control mash ($P < 0.05$). Thermal processing did not influence percentage yield, backfat, or loin depth when HCW was used as a covariate ($P > 0.10$).

However, pigs fed thermally-processed diets had greater jowl iodine value compared with those fed mash diets ($P < 0.05$). This experiment again confirms the benefits of thermally processing feeds to improve ADG and G:F, but neither extended conditioning nor extrusion extracted additional nutrients from low energy feedstuffs compared with traditional pelleting. However, this research suggests that more extreme thermal processing conditions may be used for feed safety purposes without hindering nutrient utilization.

Key Words: extrude, pellet, pig

143 Effects of seaweed β -1,3-glucan (Algamune™) on growth performance of weaned piglets.

Z. Cheng^{1,*}, Y. Wang¹, D. Hou¹, H. Zhang¹, Y. Chen¹, H. Lei¹, B. Wang¹, R. Levine², ¹*Animal Nutrition & Feed Center, COFCO Nutrition and Health Institute, Beijing, China*, ²*Algal Scientific Corporation, Northville, MI*.

The experiment was designed to investigate Algamune™ (dried algae containing about 50% β -1,3-glucan) effects on growth performance. Healthy weaned piglets ($n = 192$), aged 35 d, were selected and divided into 4 treatment groups, with each group comprising 4 replicates of 12 pigs each. Pigs were fed ad libitum and given free access to water. The feeding trial ran for 22 d from the start of the nursery period. The experiment comprised 4 treatment groups: a control group (no Algamune™), the feed formula in control group contained soybean meal, extruded soybeans, corn, fish meal and premix, and 3 test groups, the feed formula in test groups were similar to that of control group, except that they also contained 0.05%, 0.1, or 0.15 Algamune™ (equivalent to 500, 1000, 1500 g/MT, respectively). All dietary AA and nutrients met or exceeded NRC (1998) standards. Data were processed using software SPSS16.0 significant difference analysis. Compared with the control group, the test groups showed a trend towards an increase in ADG with the 0.05% β -glucan group showing a 5.1% increase, but the groups were not significantly different ($P = 0.945$, Table 143). Also, ADFI for the 0.05% β -glucan treatment group was numerically higher than the control while higher doses of β -glucan showed numerically lower ADFI ($P = 0.599$, Table 143). Compared with the control group, the 0.1% β -glucan group demonstrated a 4.5% decrease in FCR and the 0.15% β -glucan group a decrease of 7.8% ($P = 0.383$, Table 1). Overall, this experiment suggests a trend that diets supplemented with Algamune™ may improve piglet ADG and FCR, but more work is required to determine the optimal dose and validate any performance enhancements.

Key Words: β -glucan, growth performance, nursery pigs

Table 143. Effect of beta glucan on nursery pigs (mean \pm standard error)

Group	Control	0.05% Algamune™	0.1% Algamune™	0.15% Algamune™
Initial WT, kg	12.21 \pm 1.11	12.12 \pm 2.32	12.18 \pm 2.22	12.17 \pm 1.96
ADG, g	478 \pm 7.5	503 \pm 45.3	487 \pm 76.2	490 \pm 76.2
ADFI, g	738 \pm 87.8	778 \pm 58.0	715 \pm 101.9	692 \pm 104.3
FCR	1.54 \pm 0.17	1.55 \pm 0.09	1.47 \pm 0.05	1.42 \pm 0.13

NONRUMINANT NUTRITION: SOW NUTRITION AND MANAGEMENT

144 Effects of lysine and energy intake during late gestation on weight gain and reproductive performance of gilts and sows under commercial conditions.

M. A. Goncalves*, K. M. Gourley, S. S. Dritz, M. D. Tokach, N. M. Bello, J. M. DeRouchey, J. C. Woodworth, R. D. Goodband, *Kansas State University, Manhattan.*

This experiment was conducted to evaluate the effects of Lys and energy intake during late gestation on reproductive performance of gilts and sows. A total of 1,105 females (PIC 1050) were used from d 90 of gestation until farrowing. Treatments were a $2 \times 2 \times 2$ factorial having 2 parity groups (P1 or P2+), 2 standardized ileal digestible (SID) Lys intakes (10.7 or 20.0 g/d), and 2 energy intakes (4,503 or 6,704 kcal/d intake of NE). Females were housed in pens by parity level, blocked by weight, and individually assigned to the dietary treatments within each weight block. Diets were corn-soybean meal based. Data were analyzed using generalized linear mixed models consisting with pen as the experimental unit for parity, and the individual female as the experimental unit for dietary treatments. Bonferroni adjustment was used to adjust multiple comparisons. Dietary treatments were Low Lys, Low Energy (LL), High Lys, Low Energy (HL), Low Lys, High Energy (LH), and High Lys, High Energy (HH). There were Lys \times Energy ($P < 0.001$) and Parity \times Energy ($P < 0.001$) interactions for BW gain. Increasing Lys or energy increased ($P < 0.001$) BW gain of both gilts and sows; however, the magnitude of response was greater when Lys and energy were increased together (LL: 11.94 \pm 0.40, HL: 14.90 \pm 0.40, LH: 18.45 \pm 0.40, HH: 23.75 \pm 0.40 kg \pm SEM). Further, under high energy intake, there was no evidence for differences ($P = 0.996$) in BW gain between gilts (21.44 \pm 0.39 kg) and sows (20.76 \pm 0.60 kg). However, sows fed low energy intake had less ($P < 0.001$) BW gain (11.95 \pm 0.60 kg) than gilts (14.89 \pm 0.39 kg). There was no evidence for differences between dietary treatments in total pigs born ($P > 0.17$; LL: 15.1 \pm 0.02; HL: 14.7 \pm 0.02; LH: 14.9 \pm 0.02; HH: 14.9 \pm 0.02) or born alive ($P > 0.215$; LL: 14.1 \pm 0.02; HL: 13.8 \pm 0.02; LH: 13.7 \pm 0.02; HH: 13.9 \pm 0.02). There was no evidence for differences between dietary treatments in total litter birth weight ($P > 0.19$; LL: 19.3 \pm 0.21; HL: 19.1 \pm 0.21; LH: 19.2

± 0.21 ; HH: 19.5 ± 0.21 kg). In conclusion, even though the dietary treatments caused large differences in BW gain among gilts and sows, 10.7 g of SID Lys and 4,503 kcal of NE/d was enough to maintain total litter birth weight.

Key Words: energy, lysine, sows

145 **Impact of feeding level postweaning on wean to estrus interval, conception and farrowing rates, and subsequent farrowing performance.**

A. Graham^{1*}, K. J. Touchette², S. Jungst³, M. Tegtmeyer¹, J. Connor⁴, L. Greiner¹, ¹*Carthage Innovative Swine Solutions, LLC, Carthage, IL*, ²*Ajinomoto Heartland, Inc., Chicago, IL*, ³*Genus PIC, Hendersonville, TN*, ⁴*Carthage Veterinary Service, Ltd., Carthage, IL*.

Previous research has demonstrated that increasing postweaning feed intake of sows with poor body condition can improve reproductive performance. The objective of this study was to determine the effect of feeding level from weaning to breeding of sows with good body condition on subsequent reproductive performance. Six-hundred-thirty-eight sows (PIC 1050, C29, and C22) were randomly allotted within parity block (P1, P2, P3+) to 1 of 3 treatments after being weaned and moved into the wean sow room to evaluate the effect postweaning feed intake on sow reproductive performance. Treatments were as follows: 2.7 kg of feed daily, 3.6 kg of feed daily, and 5.5 kg of feed daily. Sows in the study had a BCS of 2.75 or greater based on a 5 point scale, with 3 being ideal condition, and had a standard lactation length between 18 to 23 d. At weaning, sows were blocked based on parity and day of weaning and then randomly assigned within block to 1 of the 3 treatments. Diets for the study were corn-soybean meal based with dried distillers grains with solubles and were formulated to contain 0.55% standardized ileal digestible (SID) Lys and 3.2 Mcal Mod ME/kg. All other nutrients met or exceeded NRC requirements for gestating sows. All sows were fed twice daily, with their daily allotment equally divided between the 2 feedings. Sows were provided free access to water. Treatments were maintained until the day the sow was first bred. At breeding, sows were provided 1.8 kg/d ration throughout the gestation period. Data were analyzed using Proc Mixed with LSMEANS reported. Main effects of parity and treatment and the interactions were evaluated. Sow feed intake differed between treatments (2.68, 3.54, 5.18 kg/d; $P < 0.01$). Average wean to estrus (5.13, 4.98, and 4.97 d; $P > 0.10$), conception rates (95.63, 95.58, 94.67%; $P > 0.10$), and subsequent total born (14.33, 13.93, 13.92 pigs/sow; $P > 0.10$) were not significantly different between treatments (2.7, 3.6, or 5.5 kg, respectively). There were no parity by treatment interactions. In conclusion, when sows are in good body condition at weaning, there was no benefit on conception rates or subsequent born alive when feeding above 2.75 kg/d.

Key Words: feed intake, sow, wean to estrus

146 **Understanding the impact on performance and the costs associated with increasing gestation feed allowance to sows classified as thin body condition.**

E. K. Weber^{1*}, J. A. Calderón Diaz², K. J. Stalder², M. A. FitzSimmons³, G. Gourley⁴, ¹*Gourley Premium Pork LC, Long Prairie, MN*, ²*Iowa State University, Ames*, ³*MAF Veterinary Services, Mapleton, MN*, ⁴*Gourley Research Group LLC, Webster City, IA*.

The objective of this study was to determine if increased daily feed allowance during gestation leads to increased weight gain, feed costs, and improved body condition of sows. Fifty-six sows classified as thin body condition (BCS = 2.2 ± 0.07) were randomly allotted by gestation week (wk 5 to 10) and parity (2 to 4; 3.7 ± 0.09) to 1 of 2 daily feed allowance treatments (3.2 vs. 4.5 kg). Additionally, 24 sows (BCS = 3.4 ± 0.08 ; parity = 3.6 ± 0.11) considered to be in “ideal” body condition were fed 3.2 kg of feed daily and served as controls. Feed was pre-weighed and delivered to sows individually and remaining feed weights were estimated daily. Sows were individually weighed and BCS evaluated at the start (d 0) and end of study (d 30). Two experienced herds people visually scored BCS on a scale of 1 to 5 on sows individually. Data were analyzed using the MIXED procedure of SAS, with sow as the experimental unit and fixed effects of daily feed allowance and gestation week. Body weight at d 0 was included as a continuous variable. For all sows, BCS improved over the 30 d period (control = 3.68, 4.5 kg/d = 2.94, 3.2 kg/d = 2.91) with the control sows maintaining a significantly higher ($P < 0.0001$) BCS when compared with sows that were classified thin at d 0. Overall sows fed 4.5 kg of feed daily had greater BW gain (36.9 vs. 27.7 kg; $P = 0.0006$) when compared with sows initially classified as thin body condition that were fed 3.2 kg daily. Furthermore, when economically evaluating the treatments, the cost per kg of gain was not significantly different (\$1.08 vs. \$1.09/kg gain) when feeding either 3.2 or 4.5 kg/d to sows classified as thin. However, sows on the 4.5 kg/d treatment had the greatest total feed cost per sow when compared with sows from the control group and treatment sows that were fed 3.2 kg daily (\$37.36, \$25.22, and \$26.43, respectively; $P < 0.0001$). In conclusion, increasing daily feed allowance for sows classified with a thin BCS during gestation improved gain and BCS, while not significantly increasing the feed cost per kg of gain for these animals over the 30 d trial.

Key Words: body condition, gestation feed, sows

147 **Feeding an activated animal protein improves sow and offspring performance.**

R. E. Musser^{*}, R. Song, K. W. Purser, C. D. Hagen, *NUTRIQUEST, Mason City, IA*.

This experiment evaluated the effects of feeding an activated animal protein (betaGRO™) on reproductive performance of sows and growth performance of their piglets. A total of

254 sows (PIC 1050) selected from a commercial herd were allotted randomly to diets containing 0 (CON) or 1.0 g/kg betaGRO™ (bG) in gestation and lactation, resulting in approximately 127 sows per treatment. Offspring (n = 1,242) were blocked by weaning BW within sow diet and split to feed CON or bG (3.0, 1.5, 1.0, 1.0 g/kg for Phases 1, 2, 3, and 4, respectively) resulting in 11 or 12 pens/treatment for 54 d postweaning. Data were analyzed using the MIXED procedure of SAS for a 2 × 2 split-plot design with fixed effects of sow diet, nursery diet, and their interactions. Compared with CON, feeding bG to sows significantly reduced percentage of small pigs at birth (BW ≤ 1.13 kg; 29.6 vs. 33.3%, *P* = 0.05), improved pig weaning weight by 4.3% (5.75 vs. 5.51 kg, *P* = 0.005), and reduced sow wean-estrus intervals by 1.1 d (4.5 vs. 5.6 d, *P* = 0.05). In the early nursery phase (d 0 to 22), pigs from sows fed bG showed 16.6% greater ADG (*P* < 0.001), 12.2% greater ADFI (*P* < 0.001), and 5.0% greater G:F (*P* = 0.04) than those from sows fed CON. In the late nursery phase (d 22 to 54), ADG and ADFI were both increased (*P* = 0.01) in pigs from sows fed bG, but G:F was not affected by sow diet. During the overall nursery period (d 0 to 54), feeding bG to sows resulted in greater ADG (371.4 vs. 348.6 g/d, *P* < 0.001) and ADFI (545.5 vs. 510.5 g/d, *P* < 0.001) in their offspring. The final BW of pigs from sows fed bG was 4.7% greater than those from sows fed CON (25.8 vs. 24.6 kg, *P* = 0.001). Feeding bG in nursery diets improved ADG (*P* = 0.04) and tended to improve ADFI (*P* = 0.07) and G:F (*P* = 0.08) compared with feeding CON in the early nursery phase, but did not show effects in the late nursery or overall phases. These results indicate that feeding an activated animal protein to sows in gestation and lactation positively affects sow and litter performance and also improves growth performance of their offspring in the nursery phase.

Key Words: activated animal protein, growth performance, reproductive performance

148 **Essential nature of fatty acids for the modern lactating sow.** D. S. Rosero^{1,2,*}, J. Odle¹, R. D. Boyd^{1,2}, E. van Heugten¹, ¹North Carolina State University, Raleigh, ²The Hanor Company, Inc., Franklin, KY.

Supplemental lipids are of keen importance in sow nutrition due to their high energy density and provision of essential fatty acids (EFA, linoleic and α-linolenic acid). In previous research, we demonstrated that lipid supplementation during lactation moderately improved (choice white grease) or decreased (animal-vegetable blend) sow performance, but greatly improved subsequent reproduction. We hypothesized that this benefit was due to EFA from supplemented lipids, because they are precursors of hormones important for reproduction. The objective of the present study was to determine the impact of supplemental EFA during lactation on the subsequent reproduction of sows. In Exp. 1, 50 lactating sows were assigned randomly to a 2 × 2 factorial arrangement of diets plus a control diet without added lipid. Fac-

tors included linoleic (2.1 and 3.3%) and α-linolenic acid (0.15 and 0.45%), obtained by adding 4% of mixtures of canola, corn, and flaxseed oils to diets. The balance of EFA was estimated by subtracting the amount secreted in milk from the calculated absorbed dietary EFA. For sows consuming low levels of EFA, the balance of EFA was relatively low (15.1 and 1.0 g/d, for linoleic and α-linolenic acid, respectively). Supplemental EFA greatly increased the balance of EFA (*P* < 0.05; 33.6 and 8.6 g/d), which had a positive effect in the subsequent reproduction, as demonstrated in Exp. 2. In this experiment, a total of 480 lactating sows (equally balanced by Parity 1, and 3 to 5, P3+) were used to define the minimum levels of EFA for optimal subsequent reproduction. Sows were assigned randomly to a 3 × 3 factorial arrangement plus a control diet without added lipid. Factors included linoleic (2.1, 2.7, and 3.3%) and α-linolenic acid (0.15, 0.30, and 0.45%), obtained as in Exp. 1. The effects of linoleic acid on P3+ sows were influenced by level of α-linolenic acid. For diets containing <0.45% α-linolenic acid, increasing linoleic acid tended to improve farrowing rate (*P* = 0.07; 75, 85, and 85% for 2.1, 2.7, and 3.3% linoleic acid, respectively). Increasing linoleic acid linearly increased the subsequent litter size for Parity 1 and P3+ sows (*P* = 0.03; 13.2, 14.1, and 14.0 pigs). These results demonstrate that EFA supplementation during lactation directly affects subsequent reproduction, and that this phenomenon is increasingly important with advancing sow age. We estimate that provision of 100 g/d of linoleic acid to lactating sows will ensure adequate consumption of this fatty acid and prevent a potential negative balance.

Key Words: essential fatty acids, lactating sows, subsequent reproduction

150 **Sow performance in response to dietary betaine fed in lactation and weaning-to-35 d postinsemination during moderate heat stress.** S. M. Mendoza^{1,*}, G. Martinez¹, M. Knauer¹, E. van Heugten¹, P. Wilcock², R. D. Boyd^{1,3}, ¹North Carolina State University, Raleigh, ²AB Vista Feed Ingredients, Marlborough, UK, ³The Hanor Company, Inc., Franklin, KY.

This study was conducted to evaluate the effect of feeding dietary betaine during lactation and weaning-to-35 d postinsemination on sow reproductive performance during summer months. A total of 649 sows were balanced by parity (169, 153, and 327 sows representing parity 1, 2, and 3 to 6, respectively) and assigned within parity to a 2 × 2 factorial arrangement of treatments. Factors included betaine concentration: 1) in lactation (0 or 0.2%) and 2) from weaning through early gestation (0 or 0.2%). Lactation diets were corn-soybean meal based with 10% rice bran and 6.0% wheat middlings, and formulated to contain 651 ppm of choline, 3.31 g standardized ileal digestible (SID) Lys/Mcal ME and a SID Met + Cys:Lys ratio of 0.56. Gestation diets were corn-soybean meal based with 30% wheat middlings, 15% rice bran, and formulated to contain 651 ppm choline, 1.82 g SID Lys/Mcal

Table 151.

Item	Thermoneutral		Heat stress		SEM	Diet	Environment
	Control	Low	Control	Low		<i>P</i> -value	<i>P</i> -value
Sow FI, kg/d	5.20	5.56	4.28	4.28	0.26	0.299	0.011
Sow DBW, kg/d	-0.30	-0.63	-0.84	-0.84	0.19	0.368	0.044
Piglet ADG, g	263.3	279.2	236.7	235.2	9.70	0.426	0.001
Sow DBF, mm	-1.46	-2.74	-3.22	-2.17	1.01	0.680	0.445
WtE, d	7.68	7.22	7.00	5.67	1.13	0.777	0.971
HR, beats/min	69.38	69.87	89.98	91.00	7.23	0.960	0.042
RR, breaths/min	71.74	69.37	93.81	93.27	6.37	0.951	0.014
BT, °C	36.83	37.66	37.77	38.02	0.86	0.830	0.420
MUN, mg/dL	9.46	2.35	9.83	1.92	0.72	<0.0001	0.979
TMP, %	4.47	4.29	4.64	4.55	4.30	0.184	0.028
Ammonia, g/d	34.2	11.2	26.8	12.9	2.9	<0.0001	0.351

ME, and a SID Met + Cys:Lys ratio of 0.69. Sows were started on lactation diets the day they farrowed. Sows that did not return to estrus within 14 d after weaning were removed from further study. Data were analyzed using the MIXED procedure of SAS and GLIMMIX was used for dichotomous variables using the logit link function. Lactation length was used as a covariate for percentage of sows that returned to estrus. Average room temperature was $25.2 \pm 2^\circ\text{C}$ during lactation and $24.1 \pm 3^\circ\text{C}$ during the weaning-to-35 d postinsemination period. Betaine fed in lactation tended to reduce feed intake ($P = 0.07$; 3.52 vs. 3.72 kg/d), and reduced litter gain weight ($P = 0.03$; 48.9 vs. 51.2 kg) and rectal temperature ($P = 0.04$; 39.35 vs. 39.70°C) in Parity 1 and 2 sows, but not Parity 3 or older sows. Feeding betaine after weaning tended to increase ($P = 0.08$) the percentage of sows returning to estrus within 14 d (87.0 vs. 81.7%). Wean-to-estrus interval tended ($P = 0.07$) to be reduced for parity 1 sows fed betaine (4.53 vs. 4.91 d). Conception rate was numerically reduced for Parity 1 sows when betaine was fed during lactation ($P = 0.17$; 71.9 vs. 80.7%). When betaine was fed to Parity 3 and older sows from weaning-to-35 d postinsemination, conception rate was numerically increased ($P = 0.14$; 87.0 vs. 80.8%). Results suggest that the use of 0.2% betaine during lactation did not benefit sow performance and conception. However, feeding betaine after weaning to Parity 3 or older sows may increase the number of sows that conceived.

Key Words: betaine, conception rate, sow performance

151 Impact of reduced dietary crude protein concentration with crystalline amino acid supplementation on lactation performance and ammonia emission of sows housed under thermo-neutral and thermal-heat stress environments.

D. Chamberlin^{1,*}, W. J. Powers¹, D. W. Rozeboom¹, T. M. Brown-Brandl², S. Erwin¹, C. Walker¹, N. L. Trottier¹, ¹Michigan State University, East Lansing, ²USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE.

The objective of this study was to test the hypothesis that feeding a diet containing lower dietary CP and supplemental crystalline amino acid (CAA) compared with a diet meeting

Lys requirement without supplemental AA, reduces ammonia emission, and maintains lactation performance in sows housed under thermo-neutral and thermal-heat stress environments. Thirty-six multiparous sows were allocated to a 2×2 factorial arrangement of 2 temperatures, thermo-neutral (21°C; TN) and heat stress (31.5°C; HS), and 2 diets, 17.16 (Control) and 11.82% CP (Low), in a randomized complete block design. The HS sows were acclimated during late gestation to increasing temperature from 21 to 31.5 °C. During lactation, temperature for HS sows were incrementally changed (24 to 31.5°C and 31.5 to 24°C) from 0500 to 1500 and 1800 to 0500, respectively. Control diet met standardized ileal digestible (SID) Lys requirement with no added CAA and Low diet contained added crystalline Lys, Thr, Trp, Val, and Phe. Compared with Control, piglet ADG, sow feed intake (FI), true milk protein (TMP), weight loss (DBW), heart rate (HR), and respiration rate (RR) of Low sows did not differ. Compared with Control, MUN and ammonia emissions decreased for sows fed Low ($P < 0.0001$). Change in back fat (DBF), body temp (BT), and days postweaning to estrus (WtE) did not differ between diets. Compared with TN, DBW, HR, and RR of HS sows were greater ($P < 0.05$). Compared with TN, piglet ADG of HS sows were less ($P < 0.05$). In conclusion, feeding reduced CP diet to lactating sows improved N utilization and did not impact lactation performance of sows under either thermo-neutral or thermal-heat stress environments. These results indicate that reduction of dietary CP, in conjunction with aggressive CAA supplementation, may be implemented for lactating sows to mitigate ammonia emissions while maintaining lactation performance.

Key Words: amino acid, ammonia emission, sow

152 **Growth and body composition, feed intake, and carcass composition traits of developing gilts fed different dietary lysine and metabolizable energy levels.** J. A. Calderón Díaz^{1,*}, J. L. Vallet², T. J. Prince³, C. E. Phillips⁴, A. E. DeDecker⁴, K. Stalder¹, ¹Department of Animal Science, Iowa State University, Ames, ²USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE, ³Prince Nutrition Service LLC, Auburn, AL, ⁴Murphy-Brown LLC, Rose Hill, NC.

The objective of this study was to manipulate the lean:fat ratio of replacement gilts by feeding diets differing in lysine and ME content. Crossbred Large White × Landrace gilts (n = 1221) were housed in groups of 17 to 18 gilts and randomly allotted at 100 d of age to receive 1 of 6 corn-soybean diets formulated to provide 2 standardized ileal digestible (SID) lysine and 3 ME levels. Gilts received grower diets formulated to provide 0.86 or 1.02% SID lysine and 2.94 (Low), 3.25 (Medium), or 3.57 (High) Mcal of ME/kg from 100 d of age until approximately 90 kg BW. Then, gilts were fed finisher diets containing 0.73% or 0.85% SID lysine and 2.94 (Low), 3.26 (Medium) or 3.59 Mcal (High) of ME/kg until 260 d of age. Gilts were weighed and backfat thickness and loin area were recorded at the beginning of the trial and then every 28 d. Feed intake was recorded as feed disappearance within the pen at 2 wk intervals. Lysine (g) and ME (Mcal) consumed were calculated based on diet formulations. Pen was considered the experimental unit (12 pens per diet; 72 pens on trial). Data were analyzed using a mixed model, which included lysine and ME content, data recording day, and their interactions as fixed effects. Body weight at 100 d of age was used as a linear covariate. Pen within lysine × ME level × barn was included as a random effect. There were no differences between lysine or ME levels or their interaction for growth and body composition, except for backfat, which was greater for gilts fed a High ME (~2 mm; $P < 0.05$). Gilts fed High ME diets consumed 14.7 and 7.6 kg less ($P < 0.05$) feed than gilts fed the Low ME and Medium ME diets, respectively. Gilts fed the High ME diet consumed 0.72 and 0.38 kg of feed and 5.7 and 3 g of lysine less per kg of BW gain ($P < 0.05$) than gilts fed Low ME or Medium ME diets, respectively. Gilts consumed approximately 13 Mcal of ME/kg of BW gain, irrespective of dietary treatment. Growth and body composition was not altered when provided with ad libitum access to diets differing in lysine and ME content as gilts displayed compensatory feed intake. These data suggest that SID lysine and ME requirements were met even for the lowest SID lysine and ME level provided. USDA is an equal opportunity provider and employer.

Key Words: body composition, lysine, metabolizable energy

153 **The determination of amount of feed grade lysine usage in lactating sows.** L. Greiner^{1,*}, A. Graham¹, M. Tegtmeyer¹, K. J. Touchette², S. Jungst³, ¹Carthage Innovative Swine Solutions, LLC, Carthage, IL, ²Ajinomoto Heartland, Inc., Chicago, IL, ³Genus PIC, Hendersonville, TN.

Two studies were conducted to evaluate optimal levels of feed grade lysine usage in lactating sows. Data were analyzed with Proc Mixed and reported as LSMEANS. In Exp. 1, 290 PIC 1050 sows were blocked by parity and allotted to 1 of 4 experimental diets containing 20% dried distillers grain with solubles and different levels of L-Lys HCl (0.30, 0.40, 0.50, and 0.60%, respectively) replacing intact lysine from soybean meal. L-Thr and Met (Alimet™) were included in the diets as necessary. All diets contained 1.12% standardized ileal digestible (SID) lysine and 3.45 Mcal ME/kg. Each treatment was represented in a 4 × 2 factorial where sows were fed once or twice a day. Parity 1, 2, and 3+ sows were allowed a maximum ADFI of 5.2, 5.5, and 5.7 kg/d, respectively. Data were analyzed with lysine level, feeding time, and parity as main effects, along with 2-factor interactions. There were no significant interactions. Percentage sow weight loss did not differ between the 2 feeding treatments (-4.08 vs. -4.72, respectively, $P = 0.71$). Piglet litter gain (2.35, 2.50, 2.50, 2.41 kg, $P = 0.27$) and sow weight loss (-2.82, -4.76, -3.07, -6.69 kg, $P = 0.31$) were not affected by L-Lys.HCL level. However, sow backfat loss increased linearly as percentage of L-Lys.HCL increased (-3.88, -4.55, -4.54, -5.68 mm, $P < 0.10$). In Exp. 1, the higher L-Lys.HCL diets had SID Trp:Lys levels below 16. A second study (Exp. 2) was conducted to evaluate increased levels of L-Lys.HCL when SID Trp:Lys was above 17. L-Lys.HCL was added in replacement of soybean meal at levels of 0.30, 0.45, and 0.60%. All 257 sows were allowed a maximum intake of 5.9 kg/d and water ad libitum. Diets were formulated at 1.05% SID lysine. The study was designed as a randomized complete block design with the block being parity (P1, P2, and P3+). Data were analyzed as main effects and respective interactions of lysine level and parity with linear contrast and treatment comparisons. As L-Lys.HCL increased, piglet ADG did not change (0.230, 0.230, 0.230 kg, $P = 0.49$), nor did sow weight loss (-2.35, -3.52, -2.74%, $P = 0.70$) or wean to estrus interval (4.64, 5.43, 5.00 d, $P = 0.47$). In conclusion, feeding 0.06% synthetic Lys does not appear to influence sow lactation criteria when the SID Trp:Lys level is above the minimum requirement.

Key Words: lactation, lysine, sow

154 **Increasing dietary valine-to-lysine ratio did not affect litter and sow performance during lactation.**

A. V. Strathe^{1,*}, T. S. Bruun², J. E. Zehrann³,
C. F. Hansen¹, ¹*Department of Large Animal Sciences, University of Copenhagen, Copenhagen, Denmark,*
²*Danish Pig Research Centre, Danish Agriculture and Food Council, Copenhagen, Denmark,* ³*Evonik Degussa International AG, Vejle, Denmark.*

The aim of the current study was to determine the valine requirement of lactating sows weaning more than 12 piglets. A total of 565 sows were randomly allocated to 1 of 6 diets with analyzed total Val:Lys at 81.7, 84.4, 87.4, 89.5, 93.7, and 97.0% (calculated standardized ileal digestible [SID] Val:Lys at 77.6, 80.2, 83.0, 85.0, and 92.2%, and 7.1 g SID Lys pr. kg in all diets) from d 2 postpartum when litters were standardized to 14 piglets per sow. The sows were fed 2 times per day until d 10 where after feeding was increased to 3 times per day. Sow BW, backfat (BF) thickness, and litter weight were recorded at d 2 and at weaning (d 26). On a subsample of 12 sows per dietary group, blood samples were collected and litter weight recorded weekly. Blood samples were centrifuged for 10 min (1,560 × g) at room temperature before the plasma was analyzed for glucose, lactate, NEFA, creatinine, and urea N. A milk sample was obtained and sows BW and BF registered at d 17. Prior to milk sampling, the litter was removed from the sow for 45 min after an intramuscular injection with 2 mL oxytocin was given. Milk samples were analyzed for DM, lactose, fat, and protein. Statistical analysis was performed using R. Milk composition, feed intake, ADG, BW loss, and BF loss was analyzed in a model testing effects of Val:Lys ratio, random effect of block and with BW, BF, or litter weight at d 2 as covariate. In the model for blood concentrations, effects of day, diet × day, and random effects of sow was also included. Sow feed intake was similar across treatments and averaged 6.1 ± 0.8 kg/d ($P = 0.66$). Milk concentrations of DM (17.4 ± 1.5%, $P = 0.33$), lactose (5.6 ± 0.4%, $P = 0.05$), protein (4.7 ± 0.4%, $P = 0.90$) and fat (7.2 ± 1.3%, $P = 0.37$) were not affected by Val:Lys. On average, the sows weaned 12.8 ± 1.2 piglets ($P = 0.25$) with an ADG of the litter from d 2 to weaning of 2.8 ± 1.9 kg/d ($P = 0.61$) with no influence of the dietary treatment. Total loss of BF (3.3 ± 1.9 mm, $P = 0.80$) and BW (25.9 ± 13.9, $P = 0.35$) was also not affected by dietary Val:Lys. Plasma concentrations of glucose ($P = 0.33$), lactate ($P = 0.37$), NEFA ($P = 0.89$), urea N ($P = 0.20$), and creatinine ($P = 0.42$) was not impacted by Val:Lys. In conclusion, there was no effects of increasing total dietary Val:Lys above 81.7% on litter growth and sow metabolism in the current study.

Key Words: lactation, sow, valine

155 **Lactation performance in sows fed diets with graded levels of crystalline amino acids as substitute for crude protein at lysine requirement.**

D. Chamberlin*, D. W. Rozeboom, S. Erwin,
N. L. Trottier, *Michigan State University, East Lansing.*

The objective of this study was to test the hypothesis that lactation performance of sows fed diets containing 3 and 6% less CP will not differ, when supplemented with crystalline amino acid (CAA) to meet standardized ileal digestible (SID) requirement, compared with a diet solely based on protein-bound AA. Multiparous purebred Yorkshire sows ($n = 48$) were allocated to 1 of 3 dietary treatments: 17.16% (Control), 14.48% (MCP), and 11.82% (LCP) CP, in a randomized complete block design. Diets were formulated to meet the SID Lys requirement. Control diet did not contain CAA and exceeded SID requirements of all other AA. The MCP and LCP diets contained the following CAA: Lys, Thr, Trp, and Val, in addition to Phe for LCP diet only. Voluntary feed intake was measured daily. Sow and piglet BW were measured on d 0, 3, 6, 9, 12, 15, 18, and 21, and milk samples collected on d 4 and 16. Data were analyzed as a randomized complete block design with parity, day, and diets as fixed classification effects, and sow as random effect. Compared with Control, voluntary feed intake (kg) of sows fed MCP and LCP did not differ ($P = 0.373$) and was 5.85, 5.64, 5.66 (±0.1150) for Control, MCP, and LCP, respectively. Compared with Control, piglet ADG of sows fed MCP and LCP did not differ ($P = 0.757$) and were (g/d) 263.5, 277.2, and 274.0 (±13.9), respectively. Compared with Control, milk urea nitrogen (MUN, mg/dL) decreased ($P < 0.001$) for MCP and LCP, and was 8.57, 6.85, and 2.94 mg/dL (±0.93), respectively. In conclusion, feeding reduced CP diets with CAA supplementation did not impact lactation performance and reduced MUN. These results are the first to suggest that aggressive CAA supplementation can be implemented in lactating sow diets to optimize N utilization.

Key Words: amino acid, lactation, sow

**NONRUMINANT NUTRITION:
FEED INGREDIENT BIOSAFETY**

156 **Biosecurity in the global feed industry.**

W. H. Turlington*, R. S. Sellers, J. G. Newman,
American Feed Industry Association, Arlington, VA.

Biosecurity refers to the implementation of measures to prevent the introduction of disease into a healthy population of animals or limit the spread of the disease once introduced. The foundation of biosecurity is based upon the knowledge of disease epidemiology, the duration of pathogen excretion in infected animals, the routes of excretion, survival in the envi-

ronment, and vectors for infection. Based on factual information, actions can be taken to control the spread of a disease. The basic principles of biosecurity may be classified into 3 areas: isolation, sanitation, and traffic control. Isolation is the first and most important element of biosecurity, as it involves keeping potentially infected animals and materials away from uninfected animals. Sanitation is critical, as most pathogen contamination is contained in fecal material, urine, or secretions that adhere to surfaces. Traffic control minimizes the risk of potential exposure or contamination. Behavior changes and actions by people are required for biosecurity measures that reduce the risk of the introduction and spread of disease to be effective. Unfortunately, inconsistency in implementation of practices or the lack of knowledge about a disease leads to failure of many biosecurity programs. Keeping the U.S. livestock industry healthy and free from an infectious disease requires an interdisciplinary effort involving the cooperation of USDA and other countries around the world to prevent foreign animal diseases from spreading across borders. In 2011, the National Animal Health Reporting System listed 21 reportable diseases for swine, which did not include Porcine epidemic diarrhea virus (PEDv). Although the 2013 source of the infection of the most recent form of PEDv in the United States is unclear and may never be found, recent research indicates feed and feed ingredients may be carriers of the virus, though not the cause. Serious interest by the feed industry for science-based guidelines caused the American Feed Industry Association to look at recent research and revise its *Biosecurity Awareness Guidelines*. The update takes into account new information developed by the National Pork Board, universities, and industry firms, and provides recommendations to prevent the spread of the virus by a feed manufacturing facility. It also provides decontamination procedures for facilities and for trucks that may enter a farm with a disease. The guide can be found at www.afia.org.

Key Words: biosecurity, feed, Porcine epidemic diarrhea virus

157 Food Safety Modernization Act partnership in animal feed safety. K. E. Klommmhaus*, *US FDA CVM, Des Moines, IA*.

In the United States, animal food is regulated by both federal and state agencies. The U.S. Food and Drug Administration (FDA) is the primary federal agency responsible for animal food regulation. FDA's oversight of animal food is found in various federal laws and regulations. The most extensive change to the manner in which FDA regulates animal food was brought about by the passage of the Food Safety Modernization Act (FSMA), which was signed into law on January 4, 2011. FSMA enables FDA to better protect public health by strengthening the food safety system. The main themes in FSMA are prevention, inspection and compliance, imports, and enhanced partnerships. FSMA requires a shift in focus to

preventing food safety problems rather than relying primarily on reacting to problems after they occur. Under FSMA, FDA will require comprehensive, science-based preventive controls across the food supply, including preventive controls for human and animal food and produce safety regulations. FSMA recognizes that preventive control standards improve food safety only to the extent that producers and processors comply with them. To ensure compliance, FSMA provides FDA with a mandatory inspection frequency and new enforcement authorities designed to achieve higher rates of compliance such as mandatory recall authority, access to food safety records, suspension of registration, and administrative detention. FSMA granted FDA unprecedented authority to ensure that imported products meet U.S. standards and are safe for U.S. consumers. For the first time, importers have an explicit responsibility to verify that their foreign suppliers have adequate preventive controls in place to ensure that the food they produce is safe. Lastly, FSMA recognizes that FDA cannot and should not be responsible for food safety oversight alone by recognizing the need for enhanced partnerships and collaboration with other government agencies. Food safety agencies need to work together in an integrated way to achieve our public health goals. One of the main FSMA provisions of interest to the animal food industry is the proposed rule for Current Good Manufacturing Practice and Hazard Analysis and Risk-Based Preventive Controls for Food for Animals. The proposed rule applies to all animal food, including pet food. The proposed rule would require all domestic and foreign facilities required to register under the FDCA to implement current Good Manufacturing Practices for the manufacture, processing, packing, and holding of animal food, to conduct a hazard analysis and implement risk-based preventive controls.

Key Words: feed safety, Food Safety Modernization Act

158 Safety of feed ingredients derived from animal by-products. D. L. Meeker*, *National Renderers Association, Alexandria, VA*.

The rendering industry collects and safely processes approximately 25.4 billion kilograms of animal by-products each year in the United States and Canada. Rendering plants process a variety of raw materials from animal agriculture, principally offal from slaughterhouses, but including whole animals that die on farms or in transit and other materials such as bone, feathers, and blood. By recycling these by-products into various protein, fat, and mineral products, including meat and bone meal, hydrolyzed feather meal, blood meal, and various types of animal fats and greases, the sustainability of animal agriculture is greatly enhanced. The rendering industry is conscious of its role in the prevention of disease and microbiological control while providing safe feed ingredients for livestock, poultry, aquaculture, and pets. There are 117 rendering plants representing more than 95% of the total tonnage of rendered

products produced in the United States and Canada that are certified in the voluntary Rendering Industry Code of Practice. In this program, plants determine whether physical, biological, and/or chemical hazards exist, and establish ways to monitor and control them within appropriate standards for animal feed ingredients. Preventive controls and good manufacturing practices (GMP) ensure that cooking controls pathogenic microbial contamination and that recontamination does not occur after the rendering process. Testing is used to spot check, and verifies that rendering processes are correctly managed and operated. Each rendering plant develops a feed safety plan based on the raw materials processed and the products manufactured. Accurate records, product traceability, and documentation are also required. The program involves employee training and record keeping, and is followed up by independent third-party audits to make certain that plants are following their plans to ensure product safety. The Rendering Industry Code of Practice is updated as needed to reflect new regulations or new information on how to best produce safe rendered products. Rendering industry research continues to support the program and update documentation available to renderers on cooking temperatures and other important manufacturing practices to ensure product safety. The U.S. Food and Drug Administration recently proposed animal feed safety regulations to implement the Food Safety Modernization Act (FSMA) passed by Congress. The rendering industry has updated its certification program to meet all expected FSMA requirements which including hazard analysis and prevention concepts similar to those renderers have used for several years.

Key Words: by-products, feed safety, rendering

159 Current technologies to control pathogens in feed.

K. E. Richardson*, *Anitox, Lawrenceville, GA.*

Animal feed has been identified as a vector for bacteria that are harmful to human and animal health. A majority of the research has been focused on *Salmonella* and human food safety. However, other species of bacteria in feed, such as *E. coli* and *Clostridia*, negatively affect the intestinal health of the animal. This can result in reduced animal performance and economic loss to the producer. Control measures for reducing bacterial contamination of feed include preventing contamination from entering the facility, preventing multiplication of contaminants within the facility, and implementing processes that reduce the initial level of bacteria in feed and protect the feed from recontamination. Feed ingredients continue to be a source of entry for bacteria into a facility. Implementing a routine monitoring program of incoming ingredients and vendor approval process can reduce risk. Companies should verify that detection methods for bacterial contaminants are suitable for the ingredient being evaluated. Recent research has shown that utilizing methods that have been developed for human foods can often fail to detect pathogens in feed, such as *Salmonella*. In the mill, dust and residues within the

transport system are the primary sources of contamination. Dust can contain as much as 1000 cfu/g of *Salmonella* and >100,000 cfu/g of enterobacteriaceae. Properly operating dust collection systems are considered essential in reducing persistent contamination of the facility. Residue formation within a transport system indicates moisture penetration (i.e., a leak) or condensation and promotes bacterial multiplication. Processes that have been employed to reduce bacteria involve thermal treatment, chemical preservatives, or a combination of both. However, numerous factors can influence the effectiveness of these intervention strategies. Contamination of feed by *Salmonella* subsequent to thermal treatment has been observed within transport systems, in storage bins, and in feed trucks via dust and residues. This recontamination is not limited to *Salmonella*, as it also occurs with other economically-important contaminants including *Clostridia*, *Enterobacteriaceae*, and mold. As a result, chemical preservatives such as organic acids and formaldehyde have been utilized to protect feed from this risk. Controlling pathogens in feed is a challenging, but critically important, part of feed manufacturing. It requires a multifaceted approach, as each control point has its challenges. Because the variety of organisms causing contamination can vary greatly, it is recommended that multiple methods be employed to provide the most effective level of protection.

Key Words: chemical preservatives, food and feed safety, intestinal health, pelleting

160 Determining the minimum infectious dose of Porcine epidemic diarrhea virus in a feed matrix.

L. L. Schumacher^{1,*}, J. C. Woodworth¹, J. Zhang², P. C. Gauger², Q. Chen², M. Welch², H. Salzebrenner², J. Thomas², R. Main², S. S. Dritz¹, R. A. Cochrane¹, C. K. Jones¹, ¹Kansas State University, Manhattan, ²Iowa State University, Ames.

Feed has been confirmed as a potential vehicle for Porcine epidemic diarrhea virus (PEDv) transfer. In order to determine the overall magnitude of risk and provide the necessary information for future research studies, a study was conducted to determine the minimum dose of PEDv in feed required to induce infectivity using a 10-d-old pig bioassay model. An initial source of PEDv isolate (USA/IN/2013/19338 P7) was serially diluted in 1 log increments to form 9 different PEDv doses ranging from 5.6×10^5 to 5.6×10^{-3} TCID₅₀/mL with corresponding PCR cycle thresholds (Ct) of 14.0 to >45, respectively. Aliquots (500 mL) of the PEDv dilutions were mixed in 4.5 kg of a corn-soybean meal based swine gestation diet to form 9 experimental treatments that were compared with a control that contained PEDv-negative tissue culture medium. The inoculated feed (100 g) was then mixed with 400 mL of PBS and refrigerated (4°C) overnight before extraction of the supernatant, which was subsequently used for the bioassay (10 mL of supernatant/pig and 3 pigs/dose). The 4 highest feed doses had detectable PEDv RNA (5.6×10^4 ,

10^3 , 10^2 , and 10^1 TCID₅₀/g corresponding to a Ct of 27, 30, 33, and 37, respectively) and Ct increased linearly ($P < 0.01$, R^2 0.98) as PEDv dose decreased. Every 1 log reduction in PEDv concentration resulted in an increase in 3.4 ± 0.21 Ct in feed with detectable PEDv RNA. When the PEDv was added to the feed, an increase of 9.6 ± 0.4 SEM Ct was observed compared with the tissue culture PEDv concentration for those feed samples that had detectable PEDv RNA. When the supernatant was used to inoculate 10-d-old pigs, fecal sample Ct ranged from 16 to 27 on d 4 and 6 after inoculation for pigs inoculated with the 4 highest feed doses. No detectable PEDv RNA (Ct > 45) was noted in pigs inoculated with the other doses. Infection with PEDv was further confirmed in pigs from these 4 doses by histopathology and PEDv specific immunohistochemistry. In conclusion, these data suggest that PEDv infectivity was correlated with a positive feed PEDv PCR analysis. The minimum infective dose of PEDv in a feed matrix was demonstrated to be 5.6×10^1 TCID₅₀/g and had an equivalent feed PCR Ct of 37. Overall, these data confirm that feed can be a vehicle for PEDv transfer and that a Ct of 37 can lead to infectivity in 10-d-old pigs.

Key Words: bioassay, feed, minimum infectious dose, Porcine epidemic diarrhea virus

161 Recent research into feed processing and biosafety.

C. K. Jones*, C. R. Stark, S. S. Dritz, A. R. Rigdon, J. C. Woodworth, *Kansas State University, Manhattan.*

The U.S. feed industry is under increased regulatory scrutiny as the Food Safety Modernization Act (FSMA) will soon require feed mills to have food safety plans with hazard analysis and controls. In addition to traditional physical and chemical hazards, biological hazards such as *Salmonella* and Porcine epidemic diarrhea virus (PEDv) have also been associated with feed. *Salmonella* deaths from shell eggs in 2010 were traced to unsanitary conditions in layer houses and a feed mill, and *Salmonella* illnesses in humans were traced to contaminated dry dog food in 2012. More recently, feed has been proven to be 1 of the many vectors of PEDv transmission in the swine industry. Fortunately, there are solutions to minimize these potential feed pathogens. Interventional strategies to minimize biological hazards in feed can be categorized as thermal or nonthermal. Pathogen mitigation by thermal processing is relatively practical, but the time and temperature relationship required is dependent upon the pathogen, dose, and matrix. Additionally, steps must be taken to prevent recontamination of animal feed during cooling, load out, and transportation because thermal inactivation of pathogens occurs at a point in time, but has no sustained effects to prevent recontamination. Non-thermal mitigation strategies, such as the inclusion of chemical additives, typically retain some mitigation characteristics to some level to prevent recontamination. However, chemical mitigants may have drawbacks associated with worker safety, consumer acceptance, or regulatory approval. For example,

commercial formaldehyde has been shown to be effective at mitigating PEDv in swine feed and protein meals, but it is only approved for use in animal feed for *Salmonella* control. Again, the effectiveness of various chemical mitigants depends upon matrix and inclusion level. The feed industry has advanced its understanding of feed biosafety in recent years. Nevertheless, additional research is needed to refine pathogen mitigation strategies to maximize effectiveness while simultaneously increasing practicality of implementation.

Key Words: biosafety, feed, pathogen, Porcine epidemic diarrhea virus, *Salmonella*

162 An epidemiological investigation of porcine-origin feed ingredients and the occurrence of porcine epidemic diarrhea on midwestern U.S. pork farms.

E. J. Neumann¹, M. A. Ackerman², C. Troxel³, R. L. Moser^{*3}, ¹*Epi-Insight Limited, Palmerston North, New Zealand*, ²*Swine Veterinary Services PC, Greensburg, IN*, ³*JBS United, Inc., Sheridan, IN.*

Porcine epidemic diarrhea virus (PEDv) is a virus in the family Coronaviridae, confirmed for the first time in the United States on May 16, 2013. An investigation of the Canadian outbreak by the Canadian government identified an empirical association between feeding porcine blood plasma (subsequently found to be PCR positive for PEDv genetic material) and occurrence of the disease. To investigate the association between exposure to porcine-origin feed ingredients and the occurrence of PEDv, an epidemiological investigation of midwestern U.S. pork farms was undertaken in May 2014. Feed delivery data related to pig farming clients confirmed as being infected with PEDv (case farms) were obtained from a commercial feed manufacturer's information system. All deliveries of feed in the 2 wk prior to each PEDv outbreak that contained either spray dried plasma protein (SDPP), granulated red-blood cells (SDBC), choice white grease (CWG), or hydrolyzed porcine proteins (HPEP) were identified. The batching number for each feed delivery was then back-traced through the feed manufacturer's information system to identify the lot-level detail for each of the ingredients listed above that were included in the deliveries. This list of risk-associated lot numbers was then forward-traced to identify the complete list of clients to whom feed deliveries were made that included these same ingredient lot numbers but were not infected with PEDv (control farms). The risk of PEDv that was associated with exposure to specific lots of porcine-origin feed ingredients was then determined by estimating the odd's ratio (OR) for each ingredient (at both the ingredient-level and the lot-level). Forty-three cases and 418 controls were included in the study, with the most important limiting factor being the availability of ingredient data at the lot-level. Two sources of SDPP (5 and 6 lots, respectively), and 1 source each of SDBC (3 lots), CWG (10 lots), and HPEP (1 lot) were included in the analysis of risk. No ingredients were positively associated ($OR > 1$ and $P < 0.05$) with PEDv

case farms. Significant differences in risk were identified amongst lot numbers of several ingredients and in these instances; Mantel-Haenszel adjustments to the OR were made. Amongst all ingredients, only a single-lot of CWG was significantly positively associated with PEDv cases. Inclusion of commercially manufactured porcine-origin feed ingredients in swine feed does not appear to be strongly associated with the occurrence of PEDv in pigs consuming that feed.

Key Words: epidemiology, porcine epidemic diarrhea, porcine-origin feed ingredients

NONRUMINANT NUTRITION: LIPIDS AND ENERGY

163 Calibration of net energy for fat by growth assay in early and late phases of growth in pigs.

R. D. Boyd^{1,2,*}, C. E. Zier-Rush¹, M. McGrath¹, R. Palan¹, J. Picou¹, E. van Heugten², ¹*The Hanor Company, Inc., Franklin, KY*, ²*North Carolina State University, Raleigh*.

Growth assays are required to calibrate ingredient NE values. This study was conducted to determine the NE for choice white grease (CWG) fat in 2 phases of growth for pigs fed ad libitum. Literature estimates are too variable. A total of 2344 gilts and castrates (37.9 ± 0.9 kg, PIC genetics) were used in two 28 d assays, involving 98 pens of 23 to 24 pigs each. Diets involved a corn-soybean (C-S) NE reference diet, and a C-S fat (4.50%) control to compare response by sex. Four diets were used to estimate fat NE by replacing corn with fat, AA and diluent (washed fine sand, bentonite). Fat was assumed to have 8,000, 7,000, 6,000, or 5,000 kcal NE/kg fat, with respective diets increasingly diluted to deliver equivalent NE to the C-S reference. These diets formed a standard curve with G:F ratio regressed to intersect the C-S G:F response; thereby estimating fat NE. All diets had equivalent content of soy, corn dried distillers grain with solubles, and other ingredients. Nutrients met or exceeded NRC (1998) minimums, with nutrient to calorie ratios held constant. CWG fat was chemically described: FFA, 5.9%; GE, 9,395 kcal/kg; U:S ratio, 1.60; 18:2 ω -6, 15.7%; MIU, 0.79% and peroxide. Pigs were acclimated to diets and pens were allotted by sex and weight to treatment. Both sexes responded similarly to the fat control, in both phases (sex \times diet, $P > 0.40$). G:F ratio for early growth (38 to 67 kg) was 0.439 and 0.478 for pigs fed C-S and Fat control diets ($P < 0.001$). Fat titration diets averaged 0.440, 0.443, 0.450, 0.455 (± 0.003 , $P < 0.001$), which suggests that CWG fat was approximately 8,000 kcal NE/kg; lower NE estimates (7,000 to 5,000) were increasingly incorrect. Pigs were placed on a common diet for 12 d (4.6% fat), pens were weighed and reallocated to the diet format. A total of 2250 gilts and castrates (35.6 ± 0.64 kg, in 96 pens) were used for a second assay (end

Table 164.

Item	Control		Soybean oil		Corn oil		SEM
	0%	2.5%	5%	2.5%	5%		
ADG, g	643	655	634	645	642	12.8	
ADFI, ¹ g	989	981	889	945	913	23.7	
G:F ¹	0.651	0.668	0.714	0.684	0.704	0.01	
CE, NE/kg of gain	3,686	3,757	3,668	3,674	3,717	49.0	

¹Linear effect of increasing oil ($P < 0.05$).

weight, 106.5 ± 1.2 kg). G:F ratio was 0.328 and 0.354 for pigs fed C-S and fat control diets. Productive energy use (G:F ratio) improved (linear, $P < 0.001$) with the progressive decline in assumed fat NE (0.325, 0.333, 0.342, 0.345 ± 0.003 , respectively). Assuming the C-S reference G:F ratio and that body composition was not altered, fat NE approximated 8,000 kcal/kg. Regression estimates yielded 8,059 kcal NE/kg for 38 to 67 kg and 8,502 for 79 to 107 kg phases. Approximately 85% of GE (9,395) is productively useful. Our NE estimate is 14% higher than NRC (2012) estimates of 7,148 to 7,374 kcal NE/kg (similar U:S ratio, 18:2 ω -6%).

Key Words: fat, growth, net energy

164 Evaluation of different oil sources for nursery pigs.

K. E. Jordan^{*}, M. A. Goncalves, J. A. De Jong, J. C. Woodworth, M. D. Tokach, R. D. Goodband, S. S. Dritz, J. M. DeRouche, *Kansas State University, Manhattan*.

A total of 210 pigs (PIC 327 \times 1050, initially 13.1 kg BW and 46 d of age) were used in a 21-d trial to evaluate the effect of oil source and level on nursery pig growth performance. The 2 oil sources included a commercial source of soybean oil (Grain States Soya Inc., West Point, NE), and a proprietary source of refined corn oil originating from the ethanol industry (Corn Oil ONE, LLC Pleasant Hill, IA). The 5 experimental diets included: a control diet without added oil, diets with 2.5 or 5% added soybean oil, or diets with 2.5 or 5% added corn oil. Diets were formulated with an identical standardized ileal digestible Lys:calorie ratio and were fed in meal form. There were 6 pens per treatment with 7 pigs per pen. Soybean oil and corn oil were assigned a NE value of 7,545 and 7,549 kcal/kg (NRC, 2012), respectively for diet formulation. Overall, from d 0 to 21, there were no oil source by level interactions, or differences between oil sources observed. Increasing corn or soybean oil had no effect on ADG or final BW; however, increasing corn oil or soybean oil decreased (linear; $P < 0.05$) ADFI, which resulted in improved (linear; $P < 0.01$) G:F. Caloric efficiency (CE; Mcal NE/kg of gain) was not affected by oil source or level, indicating the energy values assigned to the oil sources were accurate. This study shows the benefits of adding either corn or soybean oil in late-phase nursery diets to improve G:F.

Key Words: corn oil, nursery pig, soybean oil

165 **Effects of reducing the dietary Omega-6 to Omega-3 fatty acid ratio in low protein quality nursery diets on growth performance and immune response in starter pigs.** S. Hooda*, R. E. Fisher, N. Karrow, C. F. de Lange, *Department of Animal and Poultry Science, University of Guelph, Guelph, ON, Canada.*

We hypothesized that reducing the dietary ω -6: ω -3 fatty acid ratio in low protein quality diets will improve growth performance and immune response of starter pigs. Thus, the objective of this study was to define optimum ω -6: ω -3 in low protein quality diets for growth performance and immune response in postweaning pigs. Newly-weaned pigs (age 21 d; BW 6.43 \pm 0.33 kg) were randomly assigned to 5 dietary treatments (6 pens/treatment; 8 pigs/pen; d 0 of study): positive control diet (High; animal protein), negative control diet (Low; soybean protein), 3 Low diets with 1.25% (Low1.25), 2.5% (Low2.5), and 5% (Low5) fish oil to achieve 4:1, 2:1, and 1:1 ω -6: ω -3, respectively. Pigs were fed treatment diets in 2 phases for 7 and 14 d, respectively, followed by a common phase III diet for 21 d. On d 6 and 20, 12 pigs per treatment were sensitized with 0.5 mg ovalbumin (OVA), 0.5 mg killed *Candida albicans*, and 0.5 mg Quil A adjuvant in 1 mL saline. Blood samples were collected at d 20 and 34 for determination of anti-OVA IgG, and d 22 and 28 for haptoglobin (Hp) analysis. The dermal hypersensitivity response (DHR) was evaluated on d 40, using intradermal injection of OVA in thigh skin, and skin fold thickness (SFT) was measured at 6, 24, and 48 h postinjection. During Phase I, ADG, ADFI, and G:F were greater ($P < 0.05$) in pigs fed High diet, as compared with Low diet, and improved in pigs fed Low1.25 and Low2.5. In contrast, further reducing the ω -6: ω -3 (Low5) lowered ADFI, ADG, and G:F during Phase I (quadratic effect, $P < 0.05$; ADG for respective treatments: 109, 61.4, 87.8, 97.1, 69.8 g/d, ± 9.22). Diet did not affect growth performance after Phase I. At d 34, intake of fish oil linearly decreased ($P < 0.05$) anti-OVA IgG response. At 6 h, DHR to OVA was lower ($P < 0.05$) in pigs fed Low2.5 as compared with all other treatments. The serum Hp were influenced ($P < 0.05$) by diets on d 22. The highest ($P < 0.05$) serum Hp were in pigs fed Low and linearly attenuated ($P < 0.05$) in pigs fed fish oil diets. In conclusion, 2.5% fish oil (2:1, ω -6: ω -3) in low protein quality diets resulted in best growth performance and immune response. Thus, in this experiment, low protein quality diets with 2.5% fish oil could replace high quality protein diets in early weaned pigs.

Key Words: fish oil, protein quality, starter pigs

166 **Can omega-3 fatty acids replace antibiotics in starter feeds?** L. Eastwood*, D. A. Gillis, M. R. Deibert, D. Beaulieu, *Prairie Swine Centre, Inc., Saskatoon, SK, Canada.*

Omega-3 fatty acids (FA) have antiinflammatory properties,

and are transferred to piglets via milk when fed to sows. This experiment was conducted to determine if improving piglet health prior to weaning, by supplementing the sows lactation diet with ω -3 FA, would allow for removal of antibiotics (Ab) from nursery diets. Treatments, arranged as a $2 \times 2 \times 2$ factorial, included the main effects of sow diet, weaning age, and nursery diet. Sows weaned at 26 ± 2 d ($n = 52$) or 19 ± 2 d ($n = 51$) were fed either a control diet or a diet with 3% flaxseed beginning 1 wk preparturition. At weaning, one-half of each litter was fed a starter diet containing Ab (0.1% LS20), the other half the same diet without Ab (1181 piglets total). Litters were weaned into unwashed nurseries. All piglets exited the nursery at 54 ± 2 d of age. Performance and general health (measured by CBC and blood chemistry panels) were determined. There were no effects ($P > 0.10$) of sow diet ($\pm \omega$ -3 FA) on sow lactation ADFI (6.75 ± 0.25 kg/d), live born piglets (14.72 ± 0.62), piglet ADG (0.25 ± 0.01 kg/d) or the number weaned per litter (11.46 ± 0.29). Sows fed the ω -3 diet had greater total ω -3 in their milk relative to control sows (2.61 vs. $1.55 \pm 0.8\%$; $P < 0.01$). In the nursery, there was no impact of sow diet on ADG, ADFI, or G:F of piglets regardless of weaning age ($P > 0.10$). Diet (sow or nursery) did not affect the final BW of piglets at nursery exit (19.45 ± 0.20 kg; $P > 0.05$); however, piglets weaned at 3 wk were 1.5 kg heavier than those weaned at 4 wk (20.20 vs. 18.69 ± 0.20 kg; $P < 0.01$). Regardless of treatment, piglets weaned at 3 wk had lower creatine kinase, aspartate aminotransferase, and white blood cell counts ($P < 0.05$), indicating reduced muscle catabolism and immune responses. In this experiment, when piglets from a high health herd were raised in an unwashed nursery, neither ω -3 FA during lactation nor Ab in the nursery diets were beneficial, regardless of weaning age.

Key Words: antibiotics, nursery, omega-3 fatty acids

167 **Effects of reduced CP diets, formulated on either an ME or NE basis, on growth performance and carcass characteristics of growing-finishing swine.** J. K. Apple^{1,*}, C. V. Maxwell¹, T. C. Tsai¹, H. J. Kim¹, J. W. Yancey¹, K. J. Touchette², J. E. Thomson³, J. Less⁴, J. J. Chewning⁵, ¹*Department of Animal Science, University of Arkansas Division of Agriculture, Fayetteville*, ²*Ajinomoto Heartland, Inc., Chicago, IL*, ³*Evonik Degussa Corp, Kennesaw, GA*, ⁴*Archer Daniels Midland Co, Decatur, IL*, ⁵*Swine Research Services, Inc., Springdale, AR.*

Barrows and gilts ($n = 245$) were used to compare the effects of reduced CP (RCP) diets, formulated on an ME (3.43 Mcal/kg) or NE (2.58 Mcal/kg) basis, on performance and carcass characteristics. Pigs were blocked by initial BW, and, within blocks, pens of pigs (5 pigs/pen) were assigned randomly to 1 of 5 dietary treatments: corn-soybean meal diets formulated to meet standardized ileal digestible (SID) ideal AA ratio requirements (C; 21.1, 20.2, 17.4, 15.2, and 18.2% CP for Phases 1,

2, 3, 4, and 5, respectively); diets formulated on the same ME or same NE basis as C-diets to meet the SID Ile or Val:Lys ratio (RCP1; 19.1, 17.1, 14.6, 12.8, and 16.2% CP for phases 1 through 5, respectively); or diets formulated on the same ME or same NE basis as C to meet the SID His:Lys ratio (RCP2; 17.0, 15.1, 12.9, 11.2, and 14.7% CP for Phases 1 through 5, respectively). Paylean (10 mg/kg) was included in all diets during the last 3 wk of finishing. Individual pig BW and pen feed disappearance were recorded at the end of each phase to calculate ADG, ADFI, and G:F. At an average BW of 127 kg, all pigs were slaughtered at a commercial pork plant. Carcass data were collected before chilling, and randomly selected pork loins (3/pen) were captured for pork quality data collection. ADG increased, then decreased (quadratic, $P \leq 0.06$) with decreasing CP in ME- and NE-diets; however, neither ADFI ($P \geq 0.11$) nor G:F ($P \geq 0.14$) were affected by dietary treatments. HCW increased, then declined to C (quadratic, $P \leq 0.06$) with decreasing CP in both ME- and NE-diets, but dressing percentage increased with decreasing dietary CP (linear, $P = 0.02$) in ME-diets. LM depth decreased (quadratic, $P = 0.07$) with decreasing CP in NE-diets, but neither fat depth ($P \geq 0.16$) nor estimated lean yield ($P \geq 0.21$) differed among dietary treatments. LM drip loss percentage increased (quadratic, $P = 0.03$) with decreasing CP in NE-diets. Visual LM color scores decreased (quadratic, $P \leq 0.02$) as CP decreased in ME-diets; yet, instrumental color measures did not ($P \geq 0.12$) differ among dietary treatments. Results indicate that growth rate was reduced at the highest level of CP reduction in ME- or NE-based diets, without affecting G:F or carcass composition; however, the effects of RCP on pork quality traits were more evident when diets were formulated on a NE basis.

Key Words: metabolizable energy, net energy, reduced crude protein, swine

168 Endogenous and exogenous fat digestion in growing pigs. J. A. Acosta Camargo^{1*},

R. D. Boyd², J. F. Patience¹, ¹Iowa State University, Ames, ²The Hanor Company, Inc., Franklin, KY.

The objective of this experiment was to compare the apparent total tract digestibility (ATTD) of endogenous fat (ether extract innate in ingredients; ENEE) vs. fat added to the diet (EX) in formulations that contain increasing quantities of co-product ingredients. There were 5 dietary treatments: a corn soybean meal-based control diet (C-S) plus 2 pair of 2 diets each, with 1 of 2 levels of co-product inclusion per pair: (6% [LCP] or 12% (HCP) of each of corn DDGS, wheat middlings and corn germ meal), each with or without added soybean oil. Soybean oil was added at 1.7% to the LCP or at 3.4% the HCP, respectively, to maintain constant NE relative to the C-S. Dietary treatments were fed during early growth (40 to 70 kg; GP) and late growth (70 to 110 kg; FP) periods. Diets with no added fat provided a baseline to calculate ENEE digestion. Then, within each pair of co-product diets (LCP and HCP),

the ATTD of EX could be calculated by difference. Forty gilts (PIC 337 sires × Camborough product sows; initial BW = 38.5 ± 0.4 kg) were randomly assigned to diet, receiving feed and water ad libitum. Total fecal collection was performed when pigs were transferred to metabolism crates at the end of GP (59.4 ± 0.4 kg BW) and FP (95.8 ± 0.8 kg BW). Data were analyzed using the MIXED procedure of SAS. In GP, ATTD of ENEE increased with the addition of co-products (29.6, 36.0, and 47.5%; for C-S, LCP, and HCP, respectively; $P < 0.01$). In FP, ATTD of ENEE also increased with the addition of co-products (36.0, 47.2 and 48.2%; for C-S, LCP, and HCP, respectively; $P < 0.01$). In GP, ATTD of total fat in the diet was 56.8% in LCP with 1.7% added fat and 69.8% in HCP with 3.4% added fat ($P < 0.01$). In FP, ATTD of total fat in the diet was 59.2% in LCP, with 1.7% added fat and 69.4% in HCP with 3.4% added fat ($P < 0.01$). By difference, the ATTD of EX was 96.0% in LCP and 94.8% in HCP in the GP, and 83.2% in LCP and 93.8% in HCP in the FP. In conclusion, fat added to the diet is much more highly digested than fat which exists naturally in the tested ingredients.

Key Words: co-products, fat digestibility, soybean oil

169 Effect of added crystalized dietary fat on the energy digestibility and growth performance of fattening pigs. G. Bee*, P. Stoll, *Agroscope Institute for Livestock Sciences, Posieux, Switzerland.*

In view of the easy handling during feed preparation, crystalline fat powders (CF) are often utilized in pig diets. Their energetic value is declared to be equal to its original source. To assess the correctness of this assumption, a digestibility and growth performance study with 48 pigs (4 littermates of the same sex from 12 litters) was carried out. The pigs were offered from 25 to 105 kg BW either a diet without added fat (F-) or a diet with either 6% added palm oil (P6) or 3 or 6% added CF (CF3 and CF6). The CF was produced from the same palm oil batch used in P6. As a result of the crystallization process, the CF contained greater amounts of SFA (99.4 vs. 49.8%) and less MUFA (4.3 vs. 40.4%) and PUFA (0.1 vs. 9.8%). For the experiment, pigs were penned in grouping pens equipped with an automatic feeder system which allowed restricted feed allowance. Because diets were not isoenergetic (DE = 14:5, 15.9, 15.1, and 15.7 MJ/kg; dLys:DE = 0.61, 0.52, 0.56, 0.52 g/MJ, respectively), daily amount of feed offered was based on the DE intake for an ADG of 750 g. Energy and fat digestibility was determined at 30, 50, 70, and 90 kg BW using celite as indigestible marker. Although DE intake was similar (26.9 MJ/kg; $P > 0.05$) for all treatments, CF6 pigs grew slower ($P < 0.001$) than F-, P6, and CF3 pigs (714 vs. 780, 754, 760 g/d, respectively). This difference was mainly accumulated from 25 to 60 kg BW (616 vs. 710, 667, 666 g/d). At 30, 50, 70, and 90 kg BW, the energy digestibility coefficients amounted to 0.71, 0.72, 0.76, and 0.74 for palm oil and 0.50, 0.67, 0.65, and 0.66 for CF. These differences

were caused by on average 5% lower fat digestibility, the difference being larger in the grower than the finisher period. Based on these digestibility coefficients, the DE content of palm oil was 28.5 and 29.8 MJ/kg at 30 and >50 kg BW, respectively. The corresponding values for CF were with 20.2 and 26.4 MJ/kg markedly lower. In conclusion, these results show that the greater degree of saturation of the fat due to the crystallization process markedly reduced the DE contents compared with its original source. In addition, it appears that, compared with older pigs, younger pigs can cope less well with highly saturated dietary fat.

Key Words: energy digestibility, pig, saturated fat

170 Does heat stress alter the pig's response to dietary fat source, as it relates to carcass iodine value?

T. A. Kellner*, L. H. Baumgard, K. J. Prusa,
J. F. Patience, *Iowa State University, Ames.*

Heat stress results in major losses to the pork industry through reduced growth performance and possibly carcass fat quality. The objective was to investigate the effect of heat stress on the pig's response to dietary fat in terms of growth performance and pork fat quality over a 35 d finishing period. A total of 96 barrows (PIC 337 × C22/29) with an initial BW of 100.4 ± 1.2 kg were randomly allotted to 1 of 9 treatments arranged as a 3 × 3 factorial: (TN [thermonutral: constant 24°C; ad libitum access to feed], PFTN [pair-fed thermoneutral: constant 24°C; limit-fed based on previous HS daily feed intake], or HS [heat stress: cyclical 28°C nighttime, 33°C d 0 to 7, 33.5°C d 7 to 14, 34°C d 14 to 21, 34.5°C d 21 to 28, 35°C d 28 to 35 daytime; ad libitum access to feed]) and diet (a corn-soybean meal based diet with 0% added fat, 3% added tallow [iodine value, IV = 41.8], or 3% added corn oil [IV = 123.0]). Pigs were individually housed to track intake and undertake jowl fat biopsies. Data were analyzed using PROC MIXED with environment and dietary treatment as fixed effects, and replicate (2 replicates of 48 barrows) as a random effect. Rectal temperature (HS = 39.0, TN = 38.1, PFTN = 38.2°C) and respiration rates (HS = 78, TN = 36, PFTN = 34 bpm) increased due to HS ($P < 0.001$). HS decreased ADFI (27.8%; $P < 0.001$). ADG (HS = 0.72, TN = 1.03, PFTN = 0.78 kg/d; $P < 0.001$), and G:F (HS = 0.290, TN = 0.301, PFTN = 0.319; $P = 0.006$) also reduced by HS. G:F but not ADG or ADFI tended to be influenced by dietary treatment (0% added fat = 0.292, 3% tallow = 0.303, 3% corn oil = 0.314 g/100 g; $P \leq 0.073$). Exposure to HS did not impact IV at market (HS = 69.2, TN = 69.3, PFTN = 69.8 g/100 g; $P = 0.624$). Carcass IV increased with increasing degree of unsaturation of the dietary fat (0% added fat = 68.5, tallow = 68.2, corn oil = 71.5 g/100 g; $P < 0.001$). There was no interaction between HS and diet ($P \geq 0.191$) on carcass IV. In conclusion, HS impaired growth performance but not carcass IV or the response to dietary fat. IV was affected by dietary fat source.

Key Words: fat, heat stress, iodine value

171 Apparent balance of essential fatty acids for the prolific lactating sow. D. S. Rosero^{1,2,*}, J. Odle¹, R. D. Boyd^{1,2}, E. van Heugten¹, ¹North Carolina State University, Raleigh, ²The Hanor Company, Inc., Franklin, KY.

The objective of this study was to determine the effects of supplementing diets with EFA (linoleic, C18:2 ω -6; and α -linolenic acid, C18:3 ω -3) on sow milk composition in order to estimate the balance of EFA during lactation. Fifty sows, balanced by parity (1 vs. 3 to 5) and nursing 12 pigs, were randomly assigned to a 2 × 2 factorial arrangement of diets plus a control diet without added lipid. Factors included linoleic (2.1 and 3.3%) and α -linolenic acid (0.15 and 0.45%); resulting in 4 different ω -6: ω -3 (primarily from EFA) fatty acid ratios: 5, 7, 14, and 22. Concentration of EFA was obtained by adding 4% of different mixtures of canola, corn, and flaxseed oils to diets. Diets were corn-soybean meal based with 12% wheat middlings and contained 3.39 Mcal ME/kg and 3.29 g standardized ileal digestible (SID) Lys/Mcal ME. Milk samples were collected from each sow on d 10 of lactation. Data were analyzed using the mixed procedure of SAS. No diet by parity interactions were detected ($P > 0.05$). Supplemental EFA did not impact milk concentrations of protein ($P = 0.26$), lactose ($P = 0.48$), or Ca ($P = 0.80$). Supplemental α -linolenic acid tended to reduce milk fat content ($P = 0.07$; 6.5 and 5.9% for 0.15 and 0.45% α -linolenic acid, respectively). Supplemental EFA increased milk concentration of both α -linolenic ($P < 0.05$; 0.75 and 1.18 g/kg of milk) and linoleic acid ($P < 0.01$; 9.9 and 13.8 g/kg of milk for 2.1 and 3.3% linoleic acid, respectively) in a dose-related manner. Supplemental linoleic acid tended to increase the concentration of arachidonic acid secreted in milk ($P = 0.08$; 0.39 and 0.47 g/kg of milk), but concentration was reduced with 0.45% α -linolenic acid (linoleic × α -linolenic acid interaction, $P < 0.05$). The balance of EFA was estimated by subtracting the amount secreted in milk from the apparently absorbed dietary EFA. For sows consuming control diet, the balance of EFA was relatively low (18.1 and 1.3 g/d, for linoleic and α -linolenic acid, respectively) and similar to the balance for sows consuming diets with low levels of EFA (15.1 and 1.0 g/d, for 2.1% linoleic and 0.15% α -linolenic acid, respectively). Supplemental EFA greatly increased the balance of EFA ($P < 0.05$; 33.6 and 8.6 g/d for 3.3% linoleic and 0.45% α -linolenic acid, respectively). In conclusion, supplemental EFA alters milk fat composition and greatly increased the apparent balance of EFA during lactation. The latter may be beneficial for subsequent reproduction of prolific lactating sows because EFA are precursors of hormones important for reproduction.

Key Words: dietary lipids, essential fatty acids, lactating sows

PHYSIOLOGY: FERTILITY AND REPRODUCTIVE MANAGEMENT

172 Enhanced prediction of frozen boar sperm fertility by assessing classical and novel traits collectively.

B. W. Daigneault^{1,*}, K. A. McNamara¹, P. H. Purdy², S. L. Rodriguez Zas¹, R. L. Krisher^{1,3}, R. V. Knox¹, D. J. Miller¹, ¹University of Illinois at Urbana-Champaign, Urbana, ²USDA-ARS-National Animal Germplasm Program, Fort Collins, CO, ³National Foundation for Fertility Research, Lone Tree, CO.

Cryopreserved semen is seldom used for commercial porcine AI, despite the many advantages of frozen sperm. Compared to fresh semen, the fertility of frozen-thawed boar sperm is more variable and usually lower. Predicting the fertility of individual ejaculates to select higher quality semen for AI would increase success. Our objective was to test novel and classical laboratory analyses to identify characteristics of cryopreserved sperm that collectively predict boar fertility. Single ejaculates of sperm from 14 boars of several breeds were collected and frozen. Traditional postthaw analyses of motility, viability, and acrosome integrity were evaluated at 0, 30, and 60 min postthaw. In vitro fertilization, cleavage, and blastocyst development were also determined. Finally, a sperm-oviduct binding assay and a competitive zona binding assay were applied to calculate sperm adhesion to these 2 matrices. Fertility of the same ejaculates subjected to lab assays was determined for each boar by AI of mature gilts using 4.0×10^9 total sperm from 1 boar at 24 h and a second boar at 36 h after the onset of estrus. Boar insemination order was reversed in consecutive replicates. Reproductive tracts were harvested at 32 d after AI and fetal paternity was identified using DNA microsatellite markers. Fertility was defined as 1) the mean percentage of the litter sired and 2) the mean number of piglets sired in each litter. Means of each lab evaluation were individually modeled by boar, and those values were applied to stepwise multiple linear regression analyses to determine which sperm traits could collectively estimate fertility in the simplest model. The regression model to predict the percentage of litter sired by boar was highly effective ($P < 0.001$, $r^2 = 0.87$) and included 5 traits; acrosome compromised sperm, percentage live sperm, percentage total motility, and the number of zona-bound sperm. A second model to predict the number of piglets sired by boar was also effective ($P < 0.05$, $r^2 = 0.57$). These models indicate that the fertility of cryopreserved boar sperm can be predicted effectively by including traditional and novel laboratory assays that assess multiple functions of sperm. Inclusion of novel functional traits of sperm with classical traits was a useful approach to enhance fertility prediction and more accurately identify ejaculates of low fertility. Agriculture and Food Research Initiative Competitive

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Key Words: boar, frozen, sperm

173 Effect of numbers of sperm and timing of a single, postcervical insemination on fertility of weaned sows treated with OvuGel. K. C. Esparza-Harris^{1,*}, M. E. Johnston², S. K. Webel², R. V. Knox¹, ¹University of Illinois, Urbana, ²JBS United Inc., Sheridan, IN.

Variability in estrus and ovulation requires multiple inseminations during estrus to ensure 1 AI occurs close to ovulation. Induction of ovulation with a GnRH agonist after weaning improves synchrony of ovulation and allows for fixed time AI. However, the interaction between number of sperm in the AI dose and the timing of insemination have not been evaluated. The objective of this study was to determine the effects of sperm numbers in a single postcervical artificial insemination (PCAI) and the timing of insemination following induced ovulation in weaned sows. The experiment was performed in replicates at a 1000-sow commercial research farm during summer and fall. Multiparous PIC sows ($n = 503$) were allotted by parity (average = 2.8) and lactation length (average = 19.3 d) to receive a single PCAI using 2.5 or 1.5 billion viable sperm at either 22, 26, or 30 h following OvuGel administration at 96 h postweaning. Sows received fence-line boar contact once daily 3 to 6 d following weaning. Subpopulations of sows ($n = 427$) were assessed for follicle size and ovulation utilizing ultrasound at 8 h intervals. Data were analyzed for the effects of sperm numbers and AI timing with and without ovarian follicle measures excluding sows that were diagnosed by trans-rectal ultrasound as having corpora lutea at time of ovulation induction. Of all sows, 89% expressed estrus within 6 d of weaning. At time of OvuGel administration, >90% of sows had large (≥ 6.5 mm) follicles; with 89% of those ovulating by 48 h and 93% ovulating by 56 h. Pregnancy rate was not affected by replicate, lactation length, follicle size, or ovarian cysts, but was affected by parity, estrus expression, and ovulation ($P < 0.05$). There was a tendency for number of sperm ($P = 0.09$) to affect pregnancy with AI using 2.5 billion (87%) greater than AI with 1.5 billion sperm (80%). Pregnancy rate following insemination at 22 h post-OvuGel (89%) was greater ($P = 0.03$) than AI at 30 h (76%), while AI at 26 h (87%) did not differ. There was no interaction ($P > 0.10$) between number of sperm and timing of insemination. These preliminary data indicate that AI timing after ovulation induction affects pregnancy establishment and validates a recommended timing of insemination of 22 h following OvuGel. Future farrowing and litter data will enable determination of optimal fixed AI timing and number of sperm.

Key Words: artificial insemination, fertility, ovulation, swine

174 **Effect of time of OvuGel administration on timing of estrus and ovulation and pregnancy rates in gilts synchronized for estrus.**

L. M. Gesing^{1,*}, M. Ellis¹, R. V. Knox¹, C. F. Shipley¹, B. A. Peterson², M. E. Johnston³, S. K. Webel³, ¹University of Illinois, Champaign-Urbana, ²The Maschhoffs, Carlyle, IL, ³JBS United, Inc., Sheridan, IN.

The effect of time of OvuGel administration on timing of estrus and ovulation and pregnancy rates was evaluated in a study involving 448 gilts that had been synchronized for estrus by administering Matrix for 14 d. A RCBD with the following treatments was used: 1) Control (no OvuGel administration), 2) OvuGel administration on d 5 (118 h) after the end of Matrix administration (OV5), and 3) OvuGel administration on d 6 (142 h) after the end of Matrix administration (OV6). Control gilts were inseminated once per each morning of behavioral estrus; gilts administered OvuGel received 1 insemination 24 h after OvuGel administration. Gilts were randomly allotted to treatment within genetic line on the basis of similar live weight and stage of estrous cycle. Gilts were checked for estrus and ultrasonically scanned (trans-rectally; subsample of 250) at 12 h intervals from d 4 to 10 after Matrix administration. Gilts on the OV5 and OV6 treatments exhibited estrus earlier ($P < 0.05$) than Control gilts (140.0, 140.9, and 151.3 h after the end of Matrix administration, respectively; SEM 2.51). Ovulation occurred earlier ($P < 0.05$) for OV5 (164.8 h) than OV6 gilts (174.3 h) and earlier ($P < 0.05$) for OV6 than Control gilts (189.7 h; SEM 2.17). A greater ($P < 0.05$) percentage of Control gilts (100.0%) exhibited estrus at insemination than OV5 and OV6 gilts and more ($P < 0.05$) OV6 gilts (64.6%) exhibited estrus at insemination compared with OV5 gilts (40.4%). Gilts on the OV6 treatment had a lower ($P < 0.05$) interval from insemination to ovulation than OV5 gilts (8.2 vs. 22.8 h, respectively), and a greater ($P < 0.05$) percentage of OV6 gilts ovulated within 48 h after OvuGel administration than OV5 gilts (92.5 vs. 70.9%, respectively). Pregnancy rate (percentage of total gilts allotted to the study that were pregnant at 35 d) was greater ($P < 0.05$) for Control and OV6 than OV5 gilts (74.5, 77.6, and 56.2%, respectively). Pregnancy rate (percentage of total gilts inseminated that were pregnant at 35 d) was greater ($P < 0.05$) for Control than OV5 and OV6 gilts (91.0, 56.2 and 77.6%, respectively) and greater ($P < 0.05$) for OV6 than OV5 gilts. These results suggest that in gilts the timing of estrus and ovulation and pregnancy rates depend on the time of OvuGel administration following estrus synchronization, and in OvuGel administered gilts, single insemination with normal fertility is achievable.

Key Words: gilt, OvuGel, ovulation

175 **Reproductive performance after two different breeding protocols following intravaginal OvuGel administration in Matrix treated gilts.**

M. E. Johnston^{*}, M. E. Swanson, S. K. Webel, JBS United, Inc., Sheridan, IN.

The objective was to compare the reproductive performance of gilts using 2 breeding protocols after OvuGel (OG) treatment 126 h following the last feeding of Matrix and gilts inseminated when found in estrus. Danbred gilts ($n = 814$) were blocked by date of first estrus and BCS and allocated to 1 of 3 treatments: Control (272), OG1 (270), and OG2 (272). All gilts were fed 15 mg Matrix · gilt⁻¹ · d⁻¹ for 14 d. All gilts were observed daily for behavioral estrus starting on d 4 post-Matrix and continuing until gilts no longer expressed estrus or until d 9 after last Matrix. Controls were inseminated the first day in estrus and each day they remained in estrus. OG1 and OG2 gilts were administered OvuGel 126 h after the last feeding of Matrix. OG1 and OG2 gilts received a single insemination 24 h post-OvuGel, regardless of estrus status. OG2 gilts that were expressing estrus 24 h after the first insemination received a second insemination. Control gilts averaged 1.9 inseminations per gilt, OG1 gilts received 1 insemination per gilt, and OG2 gilts had 1.4 inseminations per gilt ($P < 0.01$). There were 11.4% of the Control gilts that did not express estrus by d 9 post-Matrix compared with 30.0 and 30.2% for the OG1 and OG2 gilts, respectively ($P < 0.01$). There was no difference ($P > 0.99$) in percentage pregnant at 30 d of gestation among Control (80.6%), OG1 (80.9%), and OG2 (81.0%) gilts. Percentage farrowed was also not different ($P > 0.78$) among Control (75.9%), OG1 (78.3%), and OG2 (77.7%) gilts. The OG2 gilts had fewer total pigs born per litter (13.4 vs. 14.4, $P < 0.01$) and fewer born alive per litter (12.6 vs. 13.4, $P < 0.05$) than Control gilts. However, total pigs born per litter was similar ($P > 0.11$) for Control and OG1 gilts (14.4 and 13.9, respectively). Likewise, number born alive per litter was not different ($P > 0.22$) among Control (13.4) and OG1 gilts (13.0). Total pigs born per semen dose was 6.6, 10.8, and 7.3 ($P < 0.01$) for Control, OG1, and OG2 gilts, respectively. These data indicate that administering OvuGel to gilts 126 h post-Matrix and inseminating a single time 24 h later, regardless of estrus status, results in farrowing rates and litter sizes comparable to gilts receiving multiple inseminations following detection of behavioral estrus. In addition, a second conditional insemination proved unnecessary and illustrated the risk of inseminating animals after ovulation.

Key Words: gilt, OvuGel, reproduction

Table 176.

	Control	ALT	SEP	SW	24HR	SEM	<i>P</i> <
WEI, d	3.5 ^b	-0.7 ^a	-0.5 ^a	-0.9 ^a	0.0 ^a	0.66	0.001
Day in estrus postfarrowing	24.5	24.3	24.5	24.1	25.0	0.66	0.250
Mated in lactation, %	—	79.3	73.3	86.7	64.3	0.17	0.060
Pregnancy rate, %	96.7 ^c	78.3 ^{abc}	75.0 ^{ab}	92.0 ^{bc}	66.3 ^a	0.13	0.020
Creep feed use, g/pig/d	14 ^a	17 ^a	34 ^c	13 ^a	26 ^b	2.3	0.001
Pig BW d 21, kg ¹	6.59 ^d	6.34 ^b	6.23 ^a	6.45 ^c	6.14 ^a	0.056	0.001
Pig BW d 25, kg ¹	7.09 ^{ab}	7.18 ^b	7.01 ^a	7.40 ^c	7.33 ^c	0.091	0.001

^{a-d}Within a row, means without a common superscript differ (*P* < 0.05).

¹Initial BW covariate.

176 Suckling reduction and boar exposure to induce estrus in lactating sows.

H. L. Frobose*, M. D. Tokach, J. M. DeRouchey, R. D. Goodband, S. S. Dritz, J. C. Woodworth, J. L. Nelssen, D. L. Davis, *Kansas State University, Manhattan.*

A total of 135 sows (PIC 1050) were used over 5 consecutive farrowing groups (February to August 2014) to determine an optimal lactational estrus induction strategy. Litter size was equalized within parity to 11.5 ± 1.1 pigs at d 2 postfarrowing. At d 18, sows were assigned to 1 of 5 treatments (n = 26 to 28) based on parity, farrowing date, and suckled litter size. Treatments were: 1) Control, 2) ALT (all but the 5 lightest BW pigs weaned on d 18, remaining pigs combined and alternated between paired sows at 12 h intervals), 3) SEP (pigs separated for 12 h/d from d 18 to 25), 4) Split-wean (SW; all but 5 lightest BW pigs weaned on d 18), or 5) 24HR (pigs removed for a 24 h period on d 18). Controls were weaned at d 21, with all other treatments weaned at d 25. From d 18 until weaning, all sows were provided daily boar exposure within the farrowing house by allowing 5 min of nose-to-nose contact with a mature boar. Creep feed access was provided from d 14 until weaning. Sow backfat and BW losses during lactation were similar across treatments. Sows in the 4 reduced suckling treatments had a decreased wean to estrus interval (WEI; -0.5 vs. 3.5 d; *P* < 0.05) vs. controls, resulting in similar postfarrowing day in estrus across treatments. A total of 80 of 106 sows (76%) subjected to reduced suckling treatments expressed lactational estrus, but SEP and 24HR reduced (*P* < 0.05) pregnancy rate vs. controls. Creep feed disappearance was greatest (*P* < 0.01) from SEP and 24HR litters, but SEP decreased (*P* < 0.05) pig BW vs. other reduced suckling treatments; whereas SW and 24HR pigs were heavier (*P* < 0.05) than controls at d 25. These data indicate that treatments altering nursing differ in their ability to induce lactational estrus and the weight gain of litters.

Key Words: altered suckling, lactational estrus, split weaning

177 Litter of origin effects on gilt development in a commercial setting.

J. L. Vallet^{1,*}, J. A. Calderon-Diaz², K. J. Stalder², C. E. Phillips³, J. R. Miles¹, E. C. Wright-Johnson¹, L. A. Rempel¹, C. A. Lents¹, D. Nonneman¹, G. A. Rohrer¹, B. A. Freking¹, R. A. Cushman¹, ¹USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE, ²Iowa State University, Ames, ³Murphy-Brown LLC, Warsaw, NC.

The preweaning litter environment of gilts can affect subsequent development. In a recent experiment designed to test the effects of dietary ME and lysine on gilt development, individual birth weights, immunocrits (related to colostrum intake), sow parity, number weaned, individual weaning weights, and litter weaning weights were collected for gilts destined for the experiment (n = 1010). Body weight, loin eye area, and back fat were measured at d 100 of age and at 28-d intervals until slaughter (d 260). From d 160 to slaughter, gilts were observed daily for estrus. At slaughter, the reproductive tract and 1 mammary gland were recovered. The reproductive tract was classified as cyclic or prepubertal and the number of corpora lutea was counted. Uterine horn lengths and ovarian dimensions were measured. Mammary gland tissue was assayed for protein and fat using proximate analysis. Day of the estrous cycle at slaughter was calculated using the day of first standing estrus (d 0) recorded within 23 d previous to slaughter. Each gilt development trait was analyzed for association with each litter of origin trait, after adjusting for effects of dietary treatments. Uterine length, mammary gland protein, and fat were also adjusted for day of the cycle at slaughter. Results indicated that body growth (d 100 to 240) was positively associated with immunocrit (*P* < 0.01), birth weight (*P* < 0.01), and preweaning ADG (*P* < 0.01). Loin eye area growth was positively associated with birth weight (*P* < 0.01) and preweaning ADG (*P* < 0.05). Back fat growth was positively associated with immunocrit (*P* < 0.01), birth weight (*P* = 0.01), and preweaning ADG (*P* < 0.01). Age at puberty was positively associated with number of piglets weaned (*P* = 0.098), birth weight (*P* < 0.01), and weight of the litter at weaning (*P* = 0.098), and negatively associated with preweaning ADG (*P* < 0.01). Total uterine length was positively associated with immunocrit (*P* = 0.0572). Ovary length (*P* < 0.05) and width (*P* = 0.082) were associated with sow parity. Prepubertal at slaughter was positively associated

with immunocrit ($P < 0.01$) and sow parity ($P < 0.01$). Mammary gland protein was negatively associated with weaning litter weight ($P = 0.066$) and preweaning ADG ($P < 0.01$). Mammary gland fat was positively associated with weaning litter weight ($P = 0.093$) and number of piglets weaned ($P > 0.05$). All other associations between litter of origin and gilt development traits were not significant. These results indicate that colostrum, birth weights, and preweaning growth are associated with gilt development traits during later life. USDA is an equal opportunity provider and employer.

Key Words: preweaning, puberty, uterus

178 Physiological characteristics of lactating sows with high milk production. C. F. Hansen^{1,*}, T. S. Bruun², A. V. Strathe¹, ¹*Department of Large Animal Sciences, University of Copenhagen, Copenhagen, Denmark*, ²*Danish Pig Research Centre, Danish Agriculture and Food Council, Copenhagen, Denmark*.

The objective of this study was to investigate if physiological characteristics of lactating sows could be used as indicators of high litter growth. The data for the current evaluation was obtained from a nutritional study of the effects of increasing dietary Val:Lys ratio on the performance of litters and sows during lactation. There were no effects ($P = 0.30$) of the dietary treatments; therefore, the data were pooled for this evaluation. In total, data from 565 sows where litters had been standardized to 14 piglets at d 2 postpartum were used. Piglets were weaned at d 26. Sow BW and backfat thickness (BF) and litter weight were registered for all sows at d 2 and at weaning. On a subsample of 72 sows, blood samples were taken and litter weight measured weekly. Additionally, a milk sample was obtained and the sow's BW and BF were registered at d 17. Blood samples were analyzed for glucose, lactate, NEFA, creatinine, and urea N (Advia 1800 Chemistry System, Siemens). The sow milk samples were analyzed for DM, lactose, fat, and protein using a MilkoScan FT2 (Foss Electric, Denmark). Pearson's correlations were calculated to test for correlations between the measured variables. Total feed intake of sows were negatively correlated with BW ($r = -0.23$, $P < 0.001$) and BF ($r = -0.24$, $P < 0.001$) loss. The ADG of the litter was positively correlated with BW ($r = 0.46$, $P < 0.001$), BF ($r = 0.50$, $P < 0.001$) loss, and total feed intake ($r = 0.20$, $P < 0.05$) during lactation. Loss of BW from d 2 to d 17 was associated with decreased plasma urea N concentrations ($r = -0.29$, $P < 0.05$) at d 2, increased plasma creatinine concentrations at d 2 ($r = 0.25$, $P < 0.05$) and d 10 ($r = 0.39$, $P < 0.05$), and NEFA ($r = 0.37$, $P < 0.05$) concentrations at d 10. The BW loss from d 17 to 26 was positively correlated with plasma NEFA ($r = 0.27$, $P < 0.05$) concentrations at d 26. Mobilization of BF in early lactation was negatively correlated with milk protein content ($r = -0.33$, $P < 0.05$), but in late lactation it was positively correlated with milk fat content ($r = 0.36$, $P < 0.05$). Sows with high BF loss in late lactation had lower

plasma lactate ($r = -0.30$, $P < 0.05$) and greater plasma creatinine ($r = 0.30$, $P < 0.05$) concentrations. In conclusion, sows with a high ADG of the litter was characterized by greater loss of BW and BF, and this was associated with higher plasma concentrations of NEFA and creatinine as measures of fat and protein mobilization, respectively.

Key Words: lactation, litter growth, sow metabolism

179 Glucuronic acid supplementation during maturation improves the zona reaction during in vitro fertilization of pig oocytes. B. D. Whitaker^{*}, K. J. Jaciuk, M. M. Dean, *University of Findlay, Findlay, OH*.

An incomplete zona reaction during in vitro fertilization (IVF) could be responsible for high incidences of polyspermic penetration in pig oocytes. The objective of this study was to evaluate the effects of supplementing perivitelline space components during oocyte maturation on the incidence of polyspermic penetration, cortical granule exocytosis, and completion of the zona reaction. Oocytes ($n = 800$) were supplemented during the last 24 h of maturation with either 0.01 mM glucuronic acid (GA), 0.01 mM N-acetylglucosamine (GlcNAc), 0.01 mM GA and GlcNAc, or 0.005 mM GA and GlcNAc and then subject to IVF and subsequent embryonic development. Oocytes were either evaluated for the presence of cortical granules using the intensity of fluorescence or zona pellucida hardness using a zona dissolution assay. Fertilization characteristics were evaluated 12 h after IVF, and rates of embryonic cleavage and blastocyst development were observed at 48 h and 144 h after IVF, respectively. There were no significant differences in the percentage of oocytes at metaphase II by the end of maturation, penetration rates, and male pronuclear formation. Oocytes supplemented with GA had a significantly less ($P < 0.05$) incidence of polyspermic penetration compared with unsupplemented ($32.61 \pm 4.80\%$) and GlcNAc only supplemented oocytes ($39.78 \pm 7.93\%$). Zona pellucida digestion times were significantly longer ($P < 0.05$) in oocytes that were supplemented with GA compared with those that were not. Fluorescent intensity of cortical granules was significantly decreased ($P < 0.05$) after IVF compared with the end of maturation for each treatment. Supplementation with GA had significantly lower ($P < 0.05$) fluorescent intensities of cortical granules after IVF compared with no supplementation and 0.01 mM GlcNAc supplementation. Supplementation of 0.005 mM GA and 0.005 mM GlcNAc to the maturation media produced a significantly higher ($P < 0.05$) percentage of embryos cleaved by 48 h after IVF ($75.33 \pm 5.14\%$) compared with the other treatment groups. Supplementation of GA during oocyte maturation produced a significant higher ($P < 0.05$) percentage of embryos reaching the blastocyst stage of development compared with no supplementation or 0.01 mM GlcNAc supplemented oocytes. The results of this study suggest that

supplementing GA during oocyte maturation improves IVF success and subsequent embryo development in pigs.

Key Words: pig, polyspermy, zona reaction

180 **Age at puberty, ovulation rate, and reproductive tract traits of developing gilts fed two lysine levels and three metabolizable energy levels from 100 to 260 d of age.** J. A. Calderón Díaz^{1,*}, J. L. Vallet², C. A. Lents², D. Nonneman³, J. R. Miles², E. C. Wright-Johnson², L. A. Rempel², R. A. Cushman², B. A. Freking², G. A. Rohrer², C. E. Phillips⁴, A. E. DeDecker⁴, G. Foxcroft⁵, K. Stalder⁶, ¹*Department of Animal Science, Iowa State University, Ames*, ²*USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE*, ³*USDA/ARS, Clay Center, NE*, ⁴*Murphy-Brown LLC, Rose Hill, NC*, ⁵*Department of Swine Reproductive Physiology, University of Alberta, Edmonton, Canada*, ⁶*Iowa State University, Ames*.

The objective of this study was to determine the effect of feeding different lysine and ME levels to developing gilts on age at puberty and reproductive tract measurements. Crossbred Large White × Landrace gilts (n = 1221) housed in groups from 100 d of age until slaughter (approximately 260 d of age) were randomly allotted to 6 corn-soybean diets formulated to provide 2 standardized ileal digestible lysine levels (100% [HL] and 85% [LL]) and 3 ME levels [90% (LME), 100% (MME), 110% (HME)] at 100 d of age. The 100% lysine and 100% ME were based on an informal survey from the U.S. commercial swine industry to obtain average levels that are currently fed to developing gilts. Gilts were weighed and backfat thickness and loin muscle area were recorded at the beginning of the trial and then every 28 d. Starting at 160 d of age, gilts were exposed daily to vasectomized boars and observed for behavioral estrus. At slaughter, reproductive tracts were collected and examined to determine whether the gilt was cyclic, estrous cycle stage, ovulation rate, uterine length, and ovary length and width. Data were analyzed using mixed model methods. Average age at puberty was 193 d of age, with a range from 160 d to 265 d. There was no difference in age at puberty among dietary treatments ($P > 0.05$). Approximately 6% of gilts were not observed in standing estrous; however, only 4% of gilts had not attained puberty when evaluated at slaughter, determined by the absence of corpora lutea or corpora albicantia. The remainder of gilts with no observed standing estrus were assumed to be behaviorally anestrous (cycling but no signs of standing estrus observed). At slaughter, there were more prepubertal gilts in the low lysine treatment when compared with high lysine treatments (33 vs. 16 gilts, respectively), thus low protein in the diet was associated with puberty failure. There were no differences between dietary treatment for ovulation rate, uterine length, and ovary length and width. Uterine length in this experiment varied with stage

of the cycle and was greater as gilt BW increased. Despite significant differences in the lysine:energy ratio in the diets, the expected differences in reproductive traits were not observed. Other factors such as BW and days of estrous had a greater effect on the traits recorded than feed provided. USDA is an equal opportunity provider and employer.

Key Words: age at puberty, gilts, lysine, metabolizable energy, reproductive tract

181 **Divergent selection for residual feed intake influences whole blood transcriptomic profile in growing pigs.** M. Jegou^{1,2}, A. Vincent^{1,2}, F. Gondret^{1,2}, I. Louveau^{1,2,*}, ¹*INRA UMR1348 PEGASE, Saint Gilles, France*, ²*AgroCampus-Ouest UMR1348 PEGASE, Rennes, France*.

With the aim to improve livestock production efficiency, there is a need to gain insights into the molecular mechanisms underlying feed efficiency. There is increasing evidence that whole blood may provide valuable insight into whole-body energy homeostasis. The current study was undertaken to determine whether pig blood transcriptome was affected by genetic selection for feed efficiency and (or) by nutrition. Large White castrated male pigs from 2 lines divergently selected for residual feed intake (RFI) were fed diets with the same ME level and the same protein content, but either rich in cereals (LF) or in crude fiber and lipids (HF) during 10 wk in the growing period (n = 12 by diet and by line). At the same slaughter age (132 d), pigs selected for low RFI had an improved G:F and were leaner than pigs selected for high RFI. Irrespective of selection line, pigs fed the LF diet were heavier and fatter at slaughter than pigs fed the HF diet. Analysis of the blood transcriptome using a porcine microarray (Agilent, GPL16524, 8 × 60K) reveals larger differences between RFI lines than between diets (2154 vs. 92 probes differentially expressed, DE, $P < 0.01$). An interaction ($P < 0.01$) between line and diet was also detected for 106 probes corresponding to 57 unique genes. Among the 2154 probes DE according to the line, 1216 exhibited a ratio of expression above 1.2 or below 0.8. This corresponds to 260 unique over-expressed genes and 310 unique down-expressed genes in low RFI pigs compared with high RFI pigs. Genes over-expressed in the low RFI pigs compared with high RFI pigs were associated to the immune response (29 unique genes, cytokine binding, chemokine binding, and receptor activity), protein catabolism (24 unique genes, protein ubiquitination, proteolysis), and cell signal (12 unique genes, regulation of signal transduction). Conversely, genes underexpressed in low RFI pigs compared with high RFI pigs were involved in the immune response (64 unique genes; inflammatory response, regulation of immune system process), nucleotide transport (49 unique genes), response to stimulus (25 unique genes), protein transport (22 unique genes), cell adhesion (21 unique genes), carbohydrate metabolism (19 unique genes), and cell organization (15 unique genes). These findings suggest differences in the immune status between pigs

divergently selected for RFI. Altogether, this study demonstrates the usefulness of the blood transcriptome investigation to identify molecular differences between genotypes.

Key Words: feed efficiency, nutrition, transcriptome

**PHYSIOLOGY SYMPOSIUM:
FOLLICLE DEVELOPMENT, SPERM,
EMBRYO MORTALITY AND MATERNAL
EFFECTS ON CARCASS QUALITY**

182 Specific sugars on oviduct cells bind porcine sperm and regulate sperm calcium and lifespan.

D. J. Miller*, S. Machado, E. Pedroso-Silva, G. Kadirvel, *University of Illinois at Champaign-Urbana, Urbana.*

Upon semen deposition in the female reproductive tract, a fraction of the sperm is transported to the isthmus and uterotubal junction to form a functional sperm reservoir. This reservoir can modulate sperm Ca^{2+} , lengthen sperm lifespan, and release sperm so that fertilization occurs, even if insemination and ovulation are not well synchronized. The function of this reservoir is often inadequate in swine, which necessitates the common practice of multiple inseminations during the course of each estrus period. Previous work testing a few small oligosaccharides suggested that oviduct sugars (glycans) bound sperm. Using an array containing hundreds of glycans, we found that each glycan that bound sperm contained 1 of 2 motifs, either biantennary 6-sialylated lactosamine or Lewis X trisaccharide. Both motifs were present in the oviduct isthmus; in some cases they were both in single large glycans. Fluoresceinated versions of these glycans bound to the sperm head very specifically. If we blocked either glycan on oviduct cells, sperm binding to these cells was reduced. Thus, oviduct glycan binding was necessary and sufficient to bind sperm. Because intracellular free Ca^{2+} is an important regulator of sperm function, we examined whether oviduct glycans affected Ca^{2+} , using a fluorescent probe. Both glycans suppressed the increase in intracellular Ca^{2+} that normally accompanies capacitation. Consistent with this, glycans also reduced the normal increase in sperm protein tyrosine phosphorylation that occurs during capacitation. As these results might be expected to prolong sperm lifespan, we examined whether glycans would improve sperm viability, *in vitro*. When coupled to beads, both glycan motifs bound sperm and lengthened sperm viability above control glycans or fibronectin, a protein that binds sperm. Initial investigations into receptor candidates have identified several sperm proteins with glycan affinity, including lactadherin/SED1, a protein also implicated in binding to the zona pellucida. After binding to the oviduct reservoir, the fertilizing sperm must be released to fertilize eggs. What triggers sperm release is controversial. We have found that progesterone activates release of half of the sperm bound

to oviduct cells, and that this release depends on Ca^{2+} influx through the major Ca^{2+} channels in sperm, the CatSper channels. Together, these results elucidate how sperm are stored and released from the oviduct. This fundamental information provides insight into methods to improve sperm lifespan in the oviduct, develop novel ways to lengthen sperm storage outside the oviduct, and improve reproductive efficiency.

Key Words: capacitation, fertility, glycans, Lewis X, Sialic acid

183 Regulation of FSH target genes in ovarian granulosa cells requires input from the WNT signaling pathway. J. Hernandez Gifford*,

Oklahoma State University, Stillwater.

Ovarian follicles develop in response to endocrine regulation by the hypothalamic-pituitary-gonadal axis, and several intraovarian factors. Pituitary derived FSH and luteinizing hormone up-regulate a specific subset of genes in ovarian follicles necessary for follicle maturation and steroid production. Follicle-stimulating hormone regulation of aromatase and consequent production of estradiol relies on input from the transcriptional co-factor, beta-catenin. Beta-catenin, which was initially identified as a cell adhesion molecule, is also a key effector of canonical wingless-type mouse mammary tumor virus integration site family (WNT) signaling by interacting with TCF transcription factors to activate gene expression. Contributions of WNT signaling to ovarian development were first demonstrated in *Wnt4* null mice, which presented with sex reversed ovaries and a paucity of oocytes at birth. Subsequent studies in postnatal rodent ovaries identified several WNT ligands and WNT downstream signaling components expressed at distinct stages of folliculogenesis and luteinization. Among the WNT family of signaling molecules found in the adult rodent ovary, *Wnt4*, *Fz-1*, and *Fz-4* appear to be hormonally regulated. Similarly, data from our lab has shown *WNT2* mRNA expression to be increased in large estrogen active bovine follicles which are likely under influence of elevated endogenous FSH. In primary cultures of granulosa cells, simultaneous stimulation of WNT and FSH pathways results in an unexpected reduction in the ability of FSH to stimulate aromatase, P450 side chain cleavage, steroidogenic acute regulatory protein, and ovarian differentiation factor transcripts. The stimulatory effect of 100 ng/mL of FSH on media concentrations of estradiol and progesterone was also reduced in a dose-dependent fashion with increasing doses of WNT. These data suggest a mechanism whereby FSH regulates WNT ligands to set up a negative feedback loop through *Axin2* in an effort to ensure beta-catenin remains controlled so that TCF responsive genes are not overexpressed. Additionally, in cultured primary bovine granulosa cells, beta-catenin and protein kinase B (AKT) are shown to be directly up-regulated by FSH. Utilization of AKT pathway activators and inhibitors unveiled a requirement for AKT activity in FSH

mediated beta-catenin accumulation. Collectively, recent data indicate that beta-catenin regulated by AKT is a fundamental component of FSH-induced estrogen production.

Key Words: beta-catenin, estradiol, follicle

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- 184 **Embryonic mortality: Novel models for predicting the loss.** K. G. Pohler^{1,*}, J. A. Green¹, M. H. Pereira², R. G. Peres², J. L. M. Vasconcelos², M. F. Smith¹,
¹University of Missouri, Columbia, ²UNESP-FMVZ, Botucatu, Brazil.

Embryonic mortality (EM) is generally considered to be the primary factor limiting conception rates in cattle, and occurs early (<d 28) or late (≥d 28) during gestation (d 0 = estrus). In cattle, the incidence of early EM is approximately 25% and the incidence of late EM is approximately 3.2 to 42.7% (Vasconcelos et al., 1997; Cartmill et al., 2001a,b; Lamb, 2002). Significant effort has been directed towards understanding the mechanisms resulting in early EM; however, relatively little is known about the causes or mechanisms associated with late EM, most of which occurs around the time of placentation (d 35 to 40). Mechanisms associated with reproductive loss around the time of placentation may be associated with inadequate placental development or function. Binucleate trophoblast cells constitute 15 to 20% of the ruminant placenta trophoblast population, appear around d 19 to 20 of gestation in cattle, and secrete bPAGs along with other products. Bovine PAGs are commonly used to diagnose pregnancy success in cattle and have recently been reported to be a potential marker of late embryonic mortality in *Bos taurus* cattle (Pohler et al., 2013). Therefore, we conducted a large experiment to examine the relationship between circulating concentrations of bPAGs in Nelore beef cows (*Bos indicus*) and late EM. Furthermore, we developed a model to identify animals that will experience EM. Based on positive and negative predicative value analysis, we have identified circulating concentrations of bPAG that are 95% accurate in predicting EM (between d 28 and 100) at d 28 of gestation. In summary, based on the experiments, bPAGs seem to be a good marker for predicting EM between d 28 to 100 of gestation, and suggest that this model could help elucidate the molecular, cellular, and physiological mechanisms responsible for late EM. Advancements in our understanding of the mechanisms associated with embryonic mortality may lead to development of strategies to overcome these reproductive losses.

Key Words: cattle, placenta, pregnancy

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- 185 **Just a walk in the park: How maternal activity may be linked to carcass quality in pigs.** K. A. Vonnahme^{1,*}, E. P. Berg², North Dakota State University, Fargo.

Developmental programming is when a stimulus or insult during gestation has long-lasting impacts on the development

of the offspring. Our objective was to determine if maternal activity would impact the fetal and placental development, umbilical blood flow, and offspring growth and performance. This project was conducted over 2 parities. Yorkshire females either remained in their individual stall from d 40 to term (CON), or were subjected to exercise for 30 min 3 times per week from mid to late gestation (EX). Exercise continued until d 104. Umbilical blood flow increased ($P < 0.01$) in EX compared with CON gilts. Moreover, gilts had greater ($P < 0.01$) umbilical blood flow in their first parity compared with their second. Indices of vascular resistance was not affected ($P \geq 0.15$) by maternal treatment; however, EX gilts reached peak pulsatility index earlier than CON gilts (56.2 vs. 64.3 ± 3.6 d). Fetal weights, piglet birth weights, placental weight, interval between piglet births, and blood lactate of newborn piglets were unaffected ($P \geq 0.15$) by maternal treatment. Growth from birth to weaning was not affected ($P > 0.1$). Offspring from CON females had greater backfat, but similar LM area compared with offspring from EX females. Although BW and HCW were similar ($P > 0.20$), carcasses of offspring from EX had reduced L*, increased pH at 45 min postmortem, and decreased drip loss compared with offspring from CON. The increased umbilical blood flow may have contributed to enhanced carcass quality later in life. Exact mechanisms for how this occurred are still under investigation.

Key Words: carcass, pigs, umbilical blood flow

PHYSIOLOGY: STRESS PHYSIOLOGY

- 186 **The role of serotonin (5-HT) in calcium and energy homeostasis during lactation.** J. Laporta*, L. L. Hernandez, University of Wisconsin-Madison, Madison.

We investigated the role of nonneuronal serotonin (5-hydroxytryptamine, 5-HT) on the regulation of maternal Ca and energy status during lactation. We demonstrated that circulating concentrations of 5-HT on d 1 of lactation in Holstein dairy cows was negatively associated with milk fever incidence and ketosis severity, and was positively associated with circulating Ca and parathyroid hormone related protein (PTHrP). To evaluate the feasibility of manipulating this pathway, we administered a 5-HT precursor, 5-hydroxy-L-tryptophan (5-HTP), through alteration of the maternal diet using rodent models. Feeding rats during their transition period (7 d pre- to 9 d postparturition) with 5-HTP improved maternal Ca homeostasis during lactation, by increasing mammary PTHrP, bone Ca mobilization, and Ca uptake by the mammary gland. In addition, feeding 5-HTP increased mRNA expression of hepatic enzymes involved in energy metabolism, and of glucose transporters within the mammary gland. A genetically modified mouse model (deficient in nonneuronal 5-HT production due

to the lack of the rate-limiting enzyme tryptophan hydroxylase, TPH1) was used to demonstrate that 5-HT is necessary for proper mammary gland structure and function, and for the maintenance of Ca homeostasis in the early postpartum period. In particular, 5-HT is critical for induction of PTHrP in the mammary gland to induce maternal calcium mobilization from bone, and for mammary epithelial cell transport of Ca during lactation. We further determined that 5-HT alters methylation status of the sonic hedgehog (SHH) gene, resulting in induction of SHH mRNA expression to induce PTHrP expression, which is necessary for bone Ca mobilization. Lastly, a 5-HTP dosing experiment was performed using nonpregnant late lactation dairy cow model. Treatment of late-lactation dairy cows with 1.0 and 1.5 mg/kg of 5-HTP improves their energy metabolism, decreases loss of Ca into urine, and increases mammary uptake of Ca resulting in increased Ca secretion into milk. The major findings of this research are that 5-HT is directly involved in the regulation of energy and Ca metabolism during lactation, and that 5-HTP can be safely administered to dairy cattle. We need to understand how manipulating the serotonergic system during the transition period in dairy cows impacts maternal Ca and glucose metabolism. Our data supports the hypothesis that 5-HT can be a therapeutic target for prevention of hypocalcemia in dairy cows and possibly other metabolic disorders during lactation.

Key Words: calcium, glucose, lactation, liver, mammary gland, sertotonin

187 Effect of high stress and low stress cattle handling on selected blood chemistry parameters in finishing steers. D. A. Frese^{1,*}, C. Reinhardt¹, S. J. Bartle¹, D. N. Rethorst¹, B. E. Depenbusch², J. P. Hutcheson³, M. E. Corrigan⁴, W. T. Nichols⁴, D. Thomson¹, ¹Kansas State University, Manhattan, ²Innovative Livestock Services, Inc., Great Bend, KS, ³Merck Animal Health, Summit, NJ, ⁴Merck Animal Health, DeSoto, KS.

Angus cross steers (n = 40; 563 ± 44 kg) were used to examine the effect of handling on blood chemistry and physiology of steers near market weight. Steers were stratified by backfat thickness and randomly assigned to treatment groups: Low stress handling (LSH) and high stress handling (HSH). Cattle were then randomly assigned to 1 of 5 blocks containing 4 steers from LSH and HSH treatments. Steers in the LSH treatment were walked a course of 1,540 m. Steers in HSH were forced to run the 1,540 m course. Blood samples were obtained via jugular venipuncture before handling (BASE), and at 770 and 1,540 m, 1 and 2 h after finishing the course. Blood samples were analyzed for plasma lactate (LAC), creatinine kinase (CK), base excess (BE), blood pH, serum cortisol (CORT) concentrations, and venous CO₂ (PCO₂) and O₂ (PO₂) pressures. Heart rate (HR), respiratory rate (RR), and rectal temperature (TEMP) were measured at the same intervals. Cattle in HSH treatment had greater (*P* < 0.05) LAC than

LSH cattle at BASE (4.1 vs. 3.0 mmol/L), 770 m (16.5 vs. 2.3 mmol/L), 1,540 m (22.3L vs. 2.4 mmol/L), at 1 h (7.2 vs. 2.7 mmol/L), and 2 h (4.0 vs. 2.5 mmol/L), respectively. Creatinine kinase and RR were not different (*P* > 0.14) at any sample time. Blood pH in HSH cattle was lower compared with LSH cattle (*P* < 0.05) at 770 m (7.25 vs. 7.45) and 1,540 m (7.19 vs. 7.48), but was not different (*P* > 0.13) at BASE, 1 h, or 2 h. Heart rate and TEMP were increased in HSH cattle compared with LSH (*P* > 0.01) at all sampling times. Serum cortisol was increased (*P* < 0.05) in HSH compared with LSH cattle at 770 m (87.5 vs. 58.9 nmol/L), 1,540 m (144.4 vs. 93.1 nmol/L), and 1 h (113.5 vs. 53.1 nmol/L). Although RR was not different between LSH and HSH, PCO₂ was decreased in HSH compared with LSH (*P* < 0.05) at 1,540 m (30.6 vs. 39.3 mm Hg), and PO₂ was increased at 770 m (42.7 vs. 33.5 mm Hg) and 1,540 m (51.5 vs. 36.6 mm Hg). Results of this study show that high stress handling can cause physiologic and blood chemistry changes in steers. These changes could be potentially detrimental to cattle, emphasizing the need for low stress handling practices for promotion of welfare in cattle.

Key Words: cattle-handling, finishing cattle, lactate

188 Serum insulin-like growth factor-I, growth hormone, insulin, and glucose in first parity sows exposed to heat stress during gestation. M. C. Lucy^{1,*}, T. J. Safranski¹, J. N. Rhoades¹, D. H. Keisler¹, J. W. Ross², N. K. Gabler², R. P. Rhoads³, L. H. Baumgard², ¹University of Missouri, Columbia, ²Iowa State University, Ames, ³Virginia Tech, Blacksburg.

Objectives were to examine the effects of gestational heat stress (HS) on metabolic and hormonal profiles. Gilts (n = 54) in environmental chambers were assigned to cyclical HS (n = 27, 27 to 37°C, relative humidity, RH = 85 to 55%) or thermo-neutral (TN: n = 27, 15 to 20°C, RH = 60 to 50%) treatments that were applied from wk 1 to 16 of gestation. Gilts were moved to a TN farrowing room during wk 17. Blood was collected during gestation [wk 1, 5, 9, 13, and 17; samples S1 to S5], after farrowing (lactation wk 1 to 3; S6 to S8), and 9 d after weaning (S9). Body weight, back fat (BF), and loin eye area (LEA) of sows were measured monthly. There was an effect of treatment (*P* < 0.001) on rectal temperature (38.44 ± 0.02 vs. 38.26 ± 0.02°C; *P* < 0.001) and respiration rate (50 ± 1 vs. 31 ± 1 bpm; *P* < 0.001; HS vs. TN, respectively). HS and TN gilts had similar starting BW (138 ± 2 kg), BF (2.7 ± 1 cm), and LEA (42.6 ± 0.7 cm²), but HS gilts were heavier (186 ± 3 vs. 178 ± 2 kg; *P* < 0.001), had more BF (2.7 ± 0.1 vs. 2.4 ± 0.1 cm; *P* < 0.05), and greater LEA (45.2 ± 1.1 vs. 41.4 ± 1.0 cm²; *P* < 0.01) at end of gestation. Blood glucose increased from late gestation and early lactation (70, 73, 69, 76, 88, 87, 83, 79, and 70 mg/dL; S1 to S9; SEM = 1; *P* < 0.001). Pattern for serum insulin was similar to glucose (0.13, 0.11, 0.20, 0.25, 0.19, 0.41, 0.40, 0.40, and 0.24 ng/mL; S1 to S9; SEM = 0.03; *P* < 0.001). HS decreased (*P* < 0.001) blood

glucose during wk 9 and 13. IGF1 progressively decreased during gestation and then increased after farrowing (106, 88, 61, 51, 52, 121, 119, 105, 122 ng/mL; S1 to S9; SEM = 4; $P < 0.001$). Changes in IGF1 were associated with changes in GH (38, 32, 28, 38, 38, 37, 39, 36, 36 ng/mL; S1 to S9; SEM = 2; $P < 0.001$) during early gestation. HS did not affect insulin, IGF1, or GH. There were large changes in hormonal and metabolic profiles during gestation and lactation. HS elevated glucose during late gestation. Changes in IGF1 were not explained by changes in GH, perhaps suggesting an uncoupling (during gestation) and then recoupling (during lactation) of the somatotrophic axis. This project was supported by USDA NIFA 2011-67003-30007.

Key Words: endocrinology, heat stress, sow

189 Reproductive performance of gilts having developed in heat stressed dams. T. Safranski^{1,*}, M. C. Lucy¹, J. N. Rhoades¹, M. Estienne², J. G. Wiegert³, M. Rhoads³, R. P. Rhoads³, L. H. Baumgard⁴, J. W. Ross⁴, ¹University of Missouri, Columbia, ²Virginia Tech, Suffolk, ³Virginia Tech, Blacksburg, ⁴Iowa State University, Ames.

First parity Large White × Landrace gilts (Choice Genetics USA) were artificially inseminated and housed under either cyclical thermoneutral (GTN; 18 to 22°C) or heat stress (GHS; 28 to 34°C) conditions throughout gestation at the University of Missouri (MU) Brody Environmental Chambers. Gilts farrowed in March 2013 and lactated for ~21 d under TN conditions, after which piglets were weaned to a mechanically ventilated wean-finish barn at the MU South Farm and raised under commercial conditions with GHS and GTN gilts housed together in pens of 22 to 25 gilts per pen. On October 7, 123 gilts aged 193 to 198 d were transported to Virginia Tech's Tidewater Agricultural Research and Extension Center (TAREC). Estrus was recorded and synchronized to facilitate 68 litters born in 4 farrowing groups. Data were analyzed using ANOVA including treatment, season (March and April vs. July and September), and their interaction where appropriate. Gilts were managed together at TAREC, and though anticipated seasonal effects were seen, neither treatment nor treatment × season interaction affected breeding weight, gestation weight gain, nor gestation length. GHS gilts tended to eat more during lactation (5.42 ± 0.115 vs. 5.12 ± 0.114 kg/d; $P = 0.07$), with no effect on lactation weight loss. Numbers born, born alive, or stillborn did not differ significantly by treatment, though numerically all favored GTN gilts (12.06 ± 0.72 vs. 12.94 ± 0.72 ; 11.32 ± 0.67 vs. 11.76 ± 0.67 ; 0.53 ± 0.15 vs. 0.47 ± 0.15 for GHS vs. GTN, respectively). GHS gilts tended to have lower piglet survival than GTN gilts ($88.9 \pm 0.02\%$ vs. $93.9 \pm 0.02\%$; $P = 0.08$). A numerical nonsignificant difference of almost 1 piglet was observed, favoring GTN gilts for total piglets weaned per litter (9.91 ± 0.53 vs. 10.85 ± 0.53). Further research is needed to quantify reproductive status of

gilts developing in utero under heat stress conditions.

Key Words: gestational heat stress, gilt, reproduction

190 Effects of heat stress and antioxidants (selenium or vitamin E) supplementation on oxidative status in growing pigs. F. Liu^{1,*}, P. Celi^{1,2}, S. Chauhan¹, J. J. Cottrell¹, A. Abrasaldo¹, S. Talukder², B. J. Leury¹, F. R. Dunshea¹, ¹Faculty of Veterinary and Agricultural Sciences, the University of Melbourne, Parkville, Australia, ²Faculty of Veterinary Science, the University of Sydney, Camden, Australia.

Heat stress (HS) results in poor performance in growing pigs, and is associated with increased oxidative stress (OS) due to imbalances between free radicals production and antioxidants system. Therefore, the aims of this experiment were to investigate the effects of supplementation with antioxidants (Se and vitamin E, VE) on OS status and HS amelioration in growing pigs. Thirty-six gilts (Large White × Landrace, 28 ± 3 kg) were fed control (0.24 ppm Se, 17 IU VE/kg, NRC 2012 recommended), or control plus Se (1.0 ppm Se yeast) or VE (200 IU VE/kg) diet for 14 d, then housed in either thermoneutral (20°C, humidity 40%; TN) or HS (35°C from 0900 to 1700 h/28°C from 1700 to 0900 h, humidity 35%) conditions for 7 d. Feeding was restricted and equalized at 2.5 times of maintenance requirement. Blood samples were collected at d 1 and 7 during thermal exposure to evaluate OS by quantifying 1) derived reactive oxygen metabolites (d-ROM, Carratelli Unit/mL); 2) antioxidants markers: biological antioxidant potential (BAP, μM), oxy-absorbent capacity (OXY-abs, μM), thiols (SHp, μM), erythrocyte glutathione peroxidase activity (GPx, $\mu mol \cdot min^{-1} \cdot mL^{-1}$); 3) oxidative damage marker: advanced oxidized protein products (AOPP, μM). Leukocyte *HSP70*, *HIF-1 α* , *GPx-1*, and *GPx-4* mRNA expression was quantified by real-time RT-PCR. Results were analyzed using REML in Genstat 16th with diet, temperature, and day as fixed effects, and pigs as random model. *HSP70* and *HIF-1 α* expression are the markers of hyperthermia and hypoxia, and both were up-regulated by HS ($P < 0.04$). However, against our expectation, free radicals production, as assessed by d-ROM decreased during HS (616 vs. 593, $P = 0.04$). GPx activity and SHp levels were not affected by HS, but BAP (2865 vs. 2770, $P = 0.02$) and OXY-abs (300 vs. 287, $P = 0.03$) were reduced, indicating HS compromised the antioxidant defense system. Oxidative damage occurred during HS, as evidenced by increased AOPP (24.6 vs. 32.4, $P = 0.008$). Selenium supplementation tended to increase GPx activity during HS (12.2, 12.4, and 15.4 for Control, VE, and Se, $P = 0.07$) independently of *GPx* gene expressions. Selenium also lowered d-ROM under TN conditions (656, 606, and 599, for Control, VE, and Se, $P < 0.05$), but not during HS. Overall, VE did not influence any of the parameters measured, and Se did not affect BAP, OXY-abs, or AOPP. In conclusion, HS triggered OS by compromising the antioxidant defense system,

but Se or VE supplementation did not mitigate HS-induced OS, although GPx activity was improved by Se.

Key Words: antioxidants, heat stress, oxidative stress

- 191 **Effect of high ambient temperature and genotype on thermoregulatory responses and gene expression in various tissues in growing pigs.** D. Renaudeau^{1,*}, J. L. Gourdine², L. Liaubet³, H. Gilbert⁴, J. Riquet⁵, ¹INRA 1348 UMR PEGASE, F-35590 Saint Gilles, France, ²INRA UR 143 URZ, F-97170 Petit Bourg, France, ³INRA UMR 1372 GenPhySe, Castanet Tolosan, France, ⁴INRA UMR1388 GenPhySE, F-31326 Castanet-Tolosan, France, ⁵INRA UMR 1372 GenPhySe, F-31326 Castanet-Tolosan, France.

Heat stress (HS) in pig production is a critical problem in temperate countries during summer but also in tropical areas where pig production dramatically increased over the past 2 decades. Physiological and metabolic adjustments resulting from the thermoregulatory responses to HS have negative consequences on pig productivity and health. The objectives of this experiment were to improve knowledge on the mechanisms underlining heat tolerance by comparing thermoregulatory responses in 3 different pig genotypes (G). This experiment was performed on a total of 36 castrated male pigs: 1 genotype sensitive to HS (Large White [LW]), 1 genotype tolerant to HS (Créole [CR]), and a cross between LW and CR pigs. Pigs were housed at 24°C for 10 d and thereafter at 32°C for 5 d. The temperature (T) transition from 24 to 32°C occurred on d 0 at a constant rate of 2°C/h. Pigs had free access to water and feed. Body T and respiratory rate were measured on d -7, -4, and -3 at 24°C and on d 1, 2, 3, 4, and 5 at 32°C. Eighteen pigs (6 per G) were slaughtered on d -2 (before the T transition) and on d 5. At slaughter, blood and 3 tissue samples (backfat [BF], longissimus dorsi [LD], and liver [LI]) were collected. A transcriptome analysis was performed on blood and tissues using a semicustom 60K microarray (GPL16524). Blood hormones and metabolites were also measured. The T × G interaction was not significant ($P > 0.05$) for feed intake and thermoregulatory responses (except for skin T). Whatever the G, HS had a significant negative effect on voluntary feed intake (-200 g/d on average). The T increase resulted in an increased rectal and skin T and respiratory rate within the first 24 to 72 h of exposure and in a subsequent recovery phase characterized by a rapid decrease of these thermoregulatory responses. Plasma glucose, lactate, glycerol, and albumin concentrations were significantly reduced under HS but creatine concentration increased at 32°C. Thyroid hormone (triiodothyronine and thyroxine) concentrations were reduced at 32°C. Irrespective to the G, a considerable number of differentially expressed genes (false discovery rate < 0.05) were found by comparing blood (13,807), LD (6,261), BF (5,236), and LI (435) samples collected at 24°C with those collected at 32°C. A first functional analysis revealed that most of the significantly differentially

expressed genes especially in BF and LD were involved in the regulation of the oxidative phosphorylation pathway.

Key Words: gene expression, genotype, heat stress, pig, thermoregulatory responses

RUMINANT NUTRITION: FEED EFFICIENCY AND RESIDUAL FEED INTAKE IN RUMINANT NUTRITION

- 193 **Using residual feed intake as a tool to improve dairy feed efficiency.** M. J. VandeHaar^{1,*}, D. M. Spurlock², ¹Michigan State University, East Lansing, ²Iowa State University, Ames.

The efficiency of converting feed to milk has more than doubled over the past century largely as the indirect result of increased milk per cow. In the future, we must begin to focus directly on increased milk per unit feed. Feed inputs are not routinely measured in individuals, so the feed efficiency phenotype for most cows is not known. Genomic selection should help overcome this problem as a reference population of animals with both phenotypic and genotypic data can be used to develop models of predicting genetic merit from genotype. Residual feed intake (RFI) is a tool to quantify feed efficiency independent of production level, BW, or BW change. A cow with negative RFI is more efficient than her cohorts because she has lower maintenance requirements, digests feed more efficiently, or uses digested feed more efficiently for maintenance, gain, or milk. Recent work in our USDA National Institute of Food and Agriculture project suggests the heritability of RFI in lactating cows is approximately 15%. Moreover, we have found some genetic loci that seem related to the efficiency trait and may help explain differences in efficiency. We also found that RFI of cows when fed high-starch vs. high-soy hull diets is highly correlated, indicating that efficiency for a cow is repeatable across diets. Others have reported that RFI is a repeatable trait across stage of lactation. Moreover, differences in digestibility might account for as much as 30% of the change in RFI amongst cows. Body temperature also seems correlated to RFI. Future efforts to find efficient cows and examine genomic relationships should help us achieve continued improvements of feed efficiency. We appreciate support from the Agriculture and Food Research Initiative Competitive Grant number 2011-68004-30340.

Key Words: dairy cattle, feed efficiency, genomics

- 194 **The role of the rumen and its microbial population in feed efficiency.** K. A. Johnson^{*}, Washington State University, Pullman.

The biological basis of feed efficiency has been attributed to processes such as protein turnover, tissue metabolism, activ-

ity, body composition, heat increment, and digestibility. Much of the work that has been and currently is being conducted investigates the role of the ruminal microbial population as part of the explanation of the feed efficiency phenotype. Specific attention has been paid to the methanogenic bacteria and opportunities to simultaneously reduce greenhouse gas emissions from animals through selection for feed efficiency. The research available for review includes whole animal methane emissions measurements, by several techniques, and molecular characterization of the ruminal microbiome with specific attention to the Archaea. Additional work has identified differences in other populations of the rumen, specifically Bacteroidales and *Prevotella*, that may be associated with the efficiency phenotype. The data available do not provide a simple relationship in which selection for feed efficiency has a concurrent reduction in methane emissions or other specific bacterial populations. Rather, the data identifies complex relationships between diet composition, feed intake patterns, level of intake, rumen size, and physiology and many other factors associated with the animal and the ruminal fermentation.

Key Words: feed efficiency, methane

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- 195 **Relationship of residual feed intake (metabolic efficiency) to postruminal metabolism in beef cattle.** M. S. Kerley^{1,*}, W. J. Sexten², A. M. Meyer²,
¹University of Missouri, Columbia, ²Division of Animal Sciences, University of Missouri, Columbia.

Residual feed intake (RFI) is a proposed energetic efficiency measurement for cattle not confounded by mature size or growth rate. Postruminal metabolism and cellular functions appear to contribute to observed animal RFI phenotypes based on data from our group and others. To date, one research emphasis of our group has been on energy metabolism in feedlot cattle with divergent RFI phenotypes. Mitochondria function, responsible for most cellular energy, was correlated with RFI phenotype where efficient calves exhibited faster oxygen uptake, greater complex I:III, and greater complex I subunit concentration. No differences in electron leak or ADP:O₂ ratio were measured among RFI phenotypes. Differences in ATP synthesis rate have accounted for most of the 1.4-fold DMI range among animals, suggesting that phosphorylation ratio influences satiety. Variation in DMI led us to hypothesize that diet nutrient density should be altered to most efficiently meet nutrient requirements of animals based on known RFI. We altered diet absorbable AA relative to energy concentration to test growth performance of calves with different RFI phenotypes. Efficiency of BW gain responded to absorbable AA supply and was dependent on RFI phenotype. In other research areas within our group, carcass fat depot differences may be explained by variable DMI among RFI phenotypes. Additionally, differences in the size and function of the gastrointestinal tract, specifically the small intestine, may influence RFI. For example, more efficient steers had less small

intestinal mass but denser intestinal mucosa. High- and low-efficiency steers had similar mRNA expression of several nutrient transporters, despite differences in DMI. Recent data suggest metabolic efficiency influences milk production with daily milk production increasing as metabolic efficiency improves, implying that efficient females have more nutrients available to partition to milk. Lastly, multigeneration RFI selection appears to be able to challenge the limits of biological efficiency. A current example is calves requiring 68% of the predicted maintenance and growth energy after several generations of selection for improved efficiency. As cellular energetic efficiency in the beef cattle population increases through selection pressure, diet nutrient density will need to be adjusted to maximize growth performance potential.

Key Words: beef, efficiency, residual feed intake

RUMINANT NUTRITION: MINERALS AND FEED ADDITIVES IN FEEDLOT

- 196 **Effect of production system on mineral retention within serially slaughtered cattle.** A. K. Watson^{1,*}, T. McEvers², M. J. Hersom³, M. P. McCurdy⁴, L. J. Walter², N. D. May², J. A. Reed², N. A. Cole⁵, K. E. Hales⁶, G. W. Horn⁷, J. P. Hutcheson⁸, T. J. Klopfenstein¹, C. R. Krehbiel⁹, T. Lawrence², J. C. MacDonald¹, G. E. Erickson¹,
¹University of Nebraska, Lincoln, ²West Texas A&M University, Canyon, ³University of Florida, Gainesville, ⁴Nutrition Service Associates, Amarillo, TX, ⁵USDA-ARS, Bushland, TX, ⁶USDA-ARS-MARC, Clay Center, NE, ⁷Oklahoma Agricultural Experiment Station, Stillwater, ⁸Merck Animal Health, Summit, NJ, ⁹Oklahoma State University, Stillwater.

Data from 3 serial harvest experiments were used to calculate mineral (Ca, P, Mg, K, and S) retention in cattle. Experiment 1 evaluated 3 rates of gain during a growing period (grazing wheat pasture at a high or low rate of gain and grazing dormant native range) followed by a common finishing diet using British crossbred steers ($n = 48$; 244 ± 23 kg). Serial harvest consisted of 4 steers per treatment following the growing period (120 d) and 6 steers per treatment following the finishing period (89–163 d). Experiment 2 used British crossbred steers ($n = 46$; 237 ± 34 kg) fed 3 growing diets (sorghum silage, program fed a high-concentrate diet, and grazing wheat pasture) or placed directly into the feedlot as calf-feds. Serial harvest included 4 steers prior to the growing phase at d 0, 6 steers from each of 3 growing treatments at d 112, and 6 steers from all 4 treatments at the end of the finishing period (104–196 d). Experiment 3 evaluated zilpaterol hydrochloride inclusion in a finishing cattle diet using calf-fed Holstein steers ($n = 115$; 449 ± 20 kg). A baseline group of 5 steers was harvested after

226 d on feed. Remaining cattle were assigned to 11 harvest groups, with slaughter every 28 d. At harvest, carcasses were broken down into lean, bone, internal cavity, hide, and fat trim tissues. Retention of minerals during the growing phase was not affected by diet fed to cattle ($P \geq 0.20$; Exp. 2). Finishing beef cattle, gaining 1.63 to 2.02 kg/d, retained 7.9 to 17.3 g Ca, 3.2 to 6.2 g P, -0.03 to 0.4 g Mg, 0.5 to 2.9 g K, and 0.3 to 1.9 g S per 100 g protein gain (Exp. 1 and 2). Retention of Mg, K, and S during the finishing period was greater ($P \leq 0.02$; Exp. 1) for cattle grown slowly (<0.6 kg/d) during the growing phase. Mineral retention was not affected by zilpaterol hydrochloride inclusion in the finishing ration when retention was expressed relative to protein gain ($P \geq 0.14$; Exp. 3). Expressing retention relative to protein gain resulted in no differences across days on feed ($P \geq 0.11$; Exp. 3), averaging 14.4 g Ca, 7.5 g P, 0.45 g Mg, 1.3 g K, and 1.0 g S per 100 g protein gain. In all experiments, expressing mineral retention on a protein gain basis minimized differences due to BW or rate of gain.

Key Words: cattle, mineral, retention

197 **Injectable trace minerals in beef cattle.**

O. N. Genter-Schroeder*, S. L. Hansen, *Iowa State University, Ames.*

Trace minerals (TM) support cattle growth, and mildly TM-deficient cattle lose more weight during transit and have lesser ADG and marbling scores. Trace mineral injection is a unique supplementation strategy, bypassing the gastrointestinal tract and rapidly improving TM stores. Ninety-eight weaned steers (256 ± 11.5 kg) were used to evaluate the impact of a multi-element TM injection prior to transit on performance, markers of the inflammatory and stress responses, and postshipping growth performance. On d 0 of a 28-d preconditioning program, steers ($n = 48$ per treatment) received an injection (1 mL/45 kg BW) of TM (MM) or physiological saline (SAL). On d 28, all steers were weighed and divided within injection treatment ($n = 24$ per injection treatment) to be trucked for a 20-h transit stress period (SHIP) or returned to their pens without access to feed or water for 20 h (NS). The SHIP steers were unloaded on d 29 and all steers (SHIP and NS) were immediately weighed and sorted into new pens ($n = 4$ steers per pen) for the growing period. At the start of finishing (d 113), steers were assigned within treatments to receive a second injection (MM or SAL; 1 mL/68 kg BW), resulting in a $2 \times 2 \times 2$ factorial design ($n = 12$ steers per treatment combination). The initial TM injection increased liver Cu, Se, and Zn concentrations ($P \leq 0.02$) but did not affect ADG during preconditioning ($P = 0.89$), BW shrink as a result of transit ($P \geq 0.52$), or plasma TM and inflammatory markers ($P \geq 0.18$). Improving TM status through TM injection caused steers to have lesser ADG ($P = 0.03$) during the 14-d period after transit (d 29 through 43), but this was short lived and did not affect growth during the growing period (d 5 through 112; $P \geq 0.40$). Trace mineral injection had minimal effects on finishing performance and carcass

characteristics. Unlike previous work, improving TM stores prior to a stressor did not improve subsequent cattle performance, likely because of the excellent TM status of the steers prior to the start of this study. As TM status of incoming feedlot cattle is generally unknown, TM injection may be a useful risk management tool to prevent lost performance due to TM deficiency. The greatest benefit of injectable TM is likely in cattle with less than adequate TM status.

Key Words: cattle, trace mineral, transit

198 **Effect of a trace mineral injection on pregnancy rate of purebred and commercial Black Angus heifers synchronized using a 14-day controlled internal drug releasing device–prostaglandin protocol.** C. J. Brasche^{1,*}, J. B. Hall², S. Harrison³, M. E. Drewnoski¹, ¹*University of Nebraska–Lincoln, Lincoln*, ²*University of Idaho, Carmen*, ³*Riverbend Ranch, Idaho Falls, ID.*

Purebred Black Angus heifers (PBA; $n = 207$; BW = 347 ± 3.0 kg) and commercial Black Angus heifers (CBA; $n = 529$; BW = 335 ± 2.3 kg) were used to examine the effect of a trace mineral injection (TMI), Multimin 90, on reproductive performance. Heifers were fed a hay and barley silage–based ration that contained selenium (0.7 mg/kg), zinc (151 mg/kg), copper (36 mg/kg), and manganese (108 mg/kg). Thirty-three days prior to the start of breeding, a controlled internal drug releasing device (CIDR) was inserted into each heifer, and alternate heifers were injected with 4 mL TMI (0.53/45 kg BW) or no injection (CON). Fourteen days later, the CIDR was removed, and 16 d after CIDR removal, heat patches were placed on heifers' tail heads and PG was injected. Heifers with fully activated heat patches 72 h after PG were inseminated and injected with GnRH. Nonresponding PBA were injected with GnRH 72 h after PG and inseminated 3 h later. Nonresponding CBA with activated heat patches at 76 h after PG were inseminated at 82 h after PG and given GnRH. All remaining CBA were injected with GnRH at 76 h and inseminated at 93 h after PG. Ten days after insemination, all CBA were given an injection of GnRH and inserted with a CIDR. The CIDR was removed 7 d later, estrus was monitored for 5 d, and heifers in estrus were inseminated. Twenty-three days after the start of breeding, CBA were transported 160 km to native range and commingled with 14 fertile bulls. Conception was determined at 33 d for PBA and 76 d for CBA after start of breeding using ultrasonography. For PBA, there was no difference ($P = 0.67$) in overall AI conception between CON (52%) and TMI (52%). Conception of CBA to first service AI did not differ ($P = 0.52$) between the CON (55%) and TMI (50%) and there was no difference in the proportion of CBA (21 vs. 22% for CON and TMI, respectively) that received second service AI (SSA). However, conception to SSA was greater ($P = 0.05$) for TMI (68%; 40/59) than CON (50%; 27/54). Overall pregnancy rate of CBA after AI and exposure to bulls for 27 d did not differ ($P = 0.53$) between the

CON (87%) and TMI (85%). These data suggest that TMI has limited impact on reproductive performance of heifers being fed adequate concentrations of trace mineral.

Key Words: beef heifers, conception, trace mineral injection

199 **Withdrawn.**

200 **Withdrawn.**

201 **Withdrawn.**

202 **Effects of shade and feeding zilpaterol hydrochloride to finishing steers on performance, carcass quality, mobility, and body temperature.**

B. M. Boyd^{1*}, S. D. Shackelford², K. E. Hales³, T. M. Brown-Brandl², M. L. Bremer⁴, M. L. Spangler⁴, G. E. Erickson⁴, ¹University of Nebraska–Lincoln, Lincoln, ²USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE, ³USDA-ARS-MARC, Clay Center, NE, ⁴University of Nebraska, Lincoln.

Crossbred steers ($n = 480$) were used to study the effects of shade and feeding zilpaterol hydrochloride (ZH) on performance, carcass quality, mobility, and body temperature (BT). A randomized block design with a 2×2 factorial arrangement of treatments was conducted with 4 replicates per treatment. Factors included housing type (HT; open lot or shaded pens) and the use or not of ZH during the last 21 d of the finishing period. Cattle were blocked into heavy or light BW and assigned randomly to pens within block. Boluses to record BT were inserted prior to initiation of ZH feeding. Respiration rates were taken daily during the ZH feeding period. Mobility scores were collected at various time points from before ZH feeding through harvest. For carcass and performance data, the model included fixed effects of block, dietary treatment, HT, and their interaction. For mobility, respiration, and BT, day was included as a repeated measure using either simple (mobility and BT) or autoregressive (respiration) covariance structure. Mobility included a covariate of mobility score prior to treatment. Interactions between ZH and HT were not significant ($P > 0.26$). No differences ($P > 0.44$) were observed for DMI, ADG, or G:F on a live basis due to ZH but cattle fed in open lots tended ($P = 0.11$) to gain more than cattle with shade. Carcasses were 14 kg heavier with larger LM area ($P < 0.01$) for cattle fed ZH. Respiration rates for cattle fed ZH were greater ($P = 0.05$) with no differences ($P = 0.88$) due to HT. Mobility scores tended ($P = 0.08$) to be greater (worse mobility) for cattle fed ZH and time was significant ($P < 0.01$) with observations taken the morning of harvest at the abattoir

being the worst for all cattle. An interaction ($P < 0.01$) was observed between ZH and HT for BT. Control cattle in shade had lower ($P < 0.05$) average and maximum BT than control cattle in open pens. Cattle in shade fed ZH had greater ($P < 0.05$) average and maximum BT than cattle fed ZH in open pens. In open pens, cattle fed ZH had lower ($P < 0.05$) area under the curve (AUC) BT than the control. In shaded pens, no difference ($P > 0.05$) was observed in AUC due to ZH but average and maximum BT was greater ($P < 0.05$) for cattle fed ZH. Feeding ZH increased respiration rate and slightly increased BT. Feeding ZH also increased carcass weight with a minor impact on mobility. The USDA is an equal opportunity provider and employer.

Key Words: mobility, temperature, zilpaterol hydrochloride

203 **Effects of supplementation of OmniGen-AF and ractopamine hydrochloride on feedlot performance and carcass characteristics.**

K. M. Sudbeck^{1*}, G. E. Erickson¹, M. K. Luebbe², K. H. Jenkins², R. G. Bondurant¹, T. Wistuba³, K. DeHaan³, J. C. MacDonald¹, ¹University of Nebraska, Lincoln, ²University of Nebraska, Scottsbluff, ³Prince Agriproducts, Quincy, IL.

Crossbred steers ($n = 336$; initial BW = 309 ± 22 kg) were used in a feedlot finishing trial in a 3×2 factorial complete randomized block design with the objective of identifying any possible interaction between OmniGen-AF (OM), a commercial feed additive containing B-complex vitamins and live yeast cells, and ractopamine hydrochloride (RAC). Factors were duration of OM supplementation (0, 28, or 56 d) during the final stage of feedlot production at 4 g/45.5 kg BW and supplementation of RAC at 300 mg-steer⁻¹·d⁻¹ for the last 28 d of finishing or no beta agonist supplementation (NORAC). Steers were blocked by BW, stratified, and assigned randomly within block to pen ($n = 42$; 8 steers/pen). Ultrasound data measurements of rump fat thickness, 12th rib fat thickness, LM area, and intramuscular fat were collected on each steer 56 and 1 d prior to harvest and the difference between these time points was calculated. The day of harvest HCW were recorded. After a 48-h chill, 12th rib fat depth, LM area, and marbling score were recorded. Data were analyzed using the GLIMMIX procedure of SAS as a completely randomized block design with pen was the experimental unit and block treated as a random effect. There were no OM \times RAC interactions observed in this study for any of the feedlot performance, carcass characteristics, or ultrasound variables measured ($P > 0.42$). There was no significant effect of OM supplementation on any feedlot performance or carcass characteristics ($P \geq 0.10$). Over the entire feeding period, steers with supplemented RAC experienced a 0.5 kg/d increase in ADG (1.81 and 1.76 kg/d; $P = 0.02$), resulting in 10.0 kg greater final BW (625 and 615 kg; $P < 0.01$) and a 7.0 kg heavier carcass

(394 and 387 kg; $P < 0.01$) compared to steers that received NORAC. Analysis of ultrasound time point differences reveals steers with supplemented RAC experienced a 2.1 cm² greater increase in steer's LM area (6.6 and 4.6 cm², respectively; $P \leq 0.01$) and reduction in the increase of intramuscular fat percentage (0.26 and 0.48%, respectively; $P = 0.02$) compared to NORAC. These data would suggest that there is no effect on overall steer feedlot performance or carcass characteristics due to OM supplementation during the final 56 d of feedlot finishing.

Key Words: beef, OmniGen-AF, ractopamine hydrochloride

204 Effect of bacterial inoculation on feedlot performance with or without the addition of yeast product. C. A. Row^{1,*}, C. J. Bittner², J. L. Harding¹, D. B. Burken¹, J. C. MacDonald², T. J. Klopfenstein², A. Aguilar³, R. Schmidt⁴, G. E. Erickson², ¹University of Nebraska–Lincoln, Lincoln, ²University of Nebraska, Lincoln, ³Lallemand, Martinsville, IN, ⁴Lallemand Animal Nutrition, Milwaukee, WI.

A finishing study using 320 yearling steers (initial BW = 417 kg \pm 22.7) evaluated the effect of using a silage inoculant or not on performance and carcass characteristics. Treatments were designed as a 2 \times 2 \times 2 factorial arrangement with factors being no inoculant (CON) or use of inoculant (*buchnerii* spp.; B500) at silage harvest, silage fed at 15 or 40% of diet DM, and presence (LevSC) or absence (noLevSC) of Levucell SC yeast product fed at 14.2 g/d. Performance data were analyzed with pen as the experimental unit. The feeding experiment started 236 d after silage harvest. Steers were blocked by BW into light, middle, and heavy blocks and randomly assigned to 1 of 40 pens within block (8 steers/pen). Pens were randomly assigned to 1 of 8 dietary treatments (5 replications/treatment). Steers were limit fed for 5 d at approximately 2% BW and 2-d weights were collected and averaged for initial BW. There were very little numeric differences in DM, CP, pH, or organic acids between the CON and B500; however, no statistical analysis was performed due to only 1 silage bunker per treatment. There was a 3-way interaction for final live BW, HCW, ADG, and G:F ($P < 0.05$). Greater inclusion of silage in the diet increased DMI ($P < 0.01$). At 15% silage inclusion, the B500 LevSC treatment had the lowest ADG, 1.79 kg/d, similar to both CON treatments ($P \geq 0.55$) and less than the B500 noLevSC treatment, 1.90 kg/d ($P = 0.05$). At 40% silage inclusion, the CON LevSC and B500 noLevSC treatments had the numerically least ADG, but all treatments were similar ($P \geq 0.06$), averaging 1.79 kg/d. At 15% silage inclusion, the B500 LevSC treatment had the lowest G:F, 0.147 ($P = 0.04$); all other treatments were similar, averaging 0.152 ($P \geq 0.16$). At 40% silage inclusion, all treatments had similar G:F, averaging 0.141 ($P \geq 0.07$). At 15% silage inclusion, the CON LevSC treatment had the numerically greatest HCW, 402 kg,

similar to the B500 noLevSC and CON noLevSC treatments ($P \geq 0.07$) and greater than the B500 LevSC treatment, 394 kg ($P < 0.01$). At 40% silage inclusion, the greatest difference between treatments was observed with the CON LevSC and B500 LevSC treatments, 389 and 397 kg, respectively ($P = 0.05$). Although there were numerical differences between treatments, there were no clear statistical advantages for any one treatment for all performance measurements.

Key Words: corn silage, inoculant, yeast

205 Effects of backgrounding rate of gain on carcass characteristics. A. R. Taylor^{1,*}, R. H. Pritchard¹, K. W. Bruns², ¹South Dakota State University, Brookings, ²University of Nebraska–Lincoln, West Central Research & Extension Center, North Platte.

Different rates of gain during the backgrounding phase have been shown to impact subsequent live cattle performance, but less is known about the impact of backgrounding ADG on carcass characteristics. The objective of this study was to evaluate rate of gain during the backgrounding phase on HCW and marbling in steers harvested at a common fatness. Steers were randomly allotted to 1 of 3 backgrounding growth rates (BGR) of 1) 1.36 kg ADG for 63 d, 2) 1.14 kg ADG for 79 d, and 3) 0.91 kg ADG for 93 d from 316 to 398 kg BW. Steers on treatment 2 and 3 were limit fed the basal corn silage diet to achieve the targeted ADG while maintaining similar profiles of fermentable carbohydrates. At the end of backgrounding, steers were switched to a common finishing diet. Steers were harvested, as a treatment, at a common 12th rib fat thickness. Pen basis data were analyzed as a completely randomized design using PROC GLM (SAS) with 10 pens/BGR and 8 steers/pen. Cold stress corrected backgrounding ADG were 1.38, 1.15, and 1.00 kg ($P < 0.001$) among BGR 1 to 3, respectively, and G:F decreased (0.153, 0.138, and 0.135; $P < 0.001$) as BGR decreased due to treatment. Total days required to reach common fatness and 12th rib fat were 187 (1.39 cm), 201 (1.39 cm), and 212 d (1.36 cm) for BGR 1 to 3, respectively. During the finishing phase, ADG (1.63, 1.77, and 1.86 kg) linearly increased ($P < 0.05$) and the DMI (10.26, 10.49, and 11.10 kg) response was quadratic ($P < 0.05$) as BGR decreased. The finishing G:F response was quadratic (0.159, 0.169, and 0.167; $P < 0.001$) as BGR decreased. Hot carcass weight (373, 385, and 389 kg) linearly increased ($P < 0.05$) as BGR decreased. Marbling score response to BGR was quadratic (Sm70, Sm85, and Sm54; $P < 0.05$) for BGR 1 to 3, respectively. Other carcass characteristics were similar ($P > 0.05$) among treatments. The linear response in HCW and quadratic response of marbling suggest that for a given frame size of a calf, there is an ideal backgrounding rate to optimize carcass quality and value. An excessive BGR caused the accumulation of total body fatness to exceed intramuscular fat accretion. Consequently, steers finished prematurely with no advantage in marbling. Conversely, if the BGR was too low,

marbling was lower, even though steers were fed to a common fat end point at a heavier BW.

Key Words: backgrounding, cattle, marbling

206 **Changes in leptin and metabolite concentrations over time in finishing beef steers and heifers.**

A. P. Foote^{1,*}, D. H. Keisler², K. E. Hales³, R. G. Tait Jr.⁴, H. C. Freetly⁴, ¹USDA, ARS, US Meat Animal Research Center, Clay Center, NE, ²University of Missouri, Columbia, ³USDA-ARS-MARC, Clay Center, NE, ⁴USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE.

Leptin is a hormone produced in adipocytes that is involved in the control of feed intake, growth, and carcass composition. The objective of this experiment was to determine if the changes in plasma leptin and metabolites over a feeding period differed between steers and heifers. Composite breed cows were bred to working ranch bulls representing Angus, Charolais, Gelbvieh, Limousin, Red Angus, and Simmental breeds to produce calves with a wide range in DMI and growth. Steer ($n = 127$) and heifer ($n = 109$) progeny individually were fed a finishing ration for 84 d with BW recorded every 21 d. Blood samples were collected on d 1, 42, and 83 via jugular venipuncture and plasma was analyzed for leptin, glucose, and lactate concentrations. Body composition was evaluated by ultrasound between d 93 and 97. Data were analyzed using the MIXED procedure of SAS. Fixed effects included breed, sex, and time, and sire was included as a random effect. All 2-way interactions were tested and removed if not significant ($P > 0.05$). Time was treated as a repeated measure with animal as the subject. There was a time \times sex interaction ($P < 0.001$) for leptin concentration, indicating that heifers had greater leptin concentrations than steers on d 1 and 42, but concentrations were not different on d 84. Heifers had greater plasma glucose concentrations than steers ($P < 0.001$), but both sexes decreased from d 1 to 42 ($P = 0.013$) and reached a nadir, not changing on d 83. Heifers also had greater lactate concentrations ($P < 0.001$), and both sexes tended to have greater lactate concentrations on d 42 than d 1 ($P = 0.059$), and d 83 was intermediate. A mixed model was also used to determine the effect of sex on body composition and carcass characteristics. Breed and sex were included as fixed effects and sire was a random effect. Heifers had slightly more back fat than steers ($P = 0.017$) but had larger LM area as measured by ultrasound ($P < 0.001$) and at slaughter ($P = 0.014$). Leptin concentrations increase over the finishing period in both steers and heifers but at a greater rate in steers, which could be due to heifers reaching a fatness endpoint earlier than steers. The USDA is an equal opportunity provider and employer.

Key Words: efficiency, feedlot cattle, growth, leptin

**RUMINANT NUTRITION:
BYPRODUCT FEEDS**

207 **Starch inclusion in beef cattle finishing diets.**

A. K. Watson^{1,*}, M. K. Luebbe², G. E. Erickson¹,
¹University of Nebraska, Lincoln, ²University of Nebraska, Scottsbluff.

In both the dry and wet corn milling industries, starch is removed from corn and further processed to make a number of products. Feed byproducts from these industries contain low concentrations of starch (<5%). Cattle have the ability to use fiber, fat, protein, or starch for energy. A meta-analysis of 20 cattle feeding experiments evaluated if cattle benefit from starch in the diet or if the energy requirement can be met using other energy sources. Within these experiments, 117 diets were fed to 708 pens of cattle. Diets contained distillers grains plus solubles (DGS; 353 pens), wet corn gluten feed (WCGF; 5 pens), solubles (20 pens), a blend of DGS and WCGF (184 pens), or no byproduct (146 pens). Cattle were fed as calf-feds (255 pens) or yearlings after being backgrounded with forage-based diets (453 pens). Cattle performance was measured on each pen of cattle; therefore, pen means were used in the meta-analysis. Performance measurements included DMI, ADG, G:F, marbling score, and fat depth. Experiment was included in the model as a random effect and type of byproduct in the diet was included as a covariate. Data were analyzed using 5 subclasses of corn inclusion: 0% corn (69 pens), 1 to 25.9% corn (28 pens), 26 to 50.9% corn (238 pens), 51 to 75.9% corn (270 pens), and $\geq 76\%$ corn (103 pens). Amount of starch, or corn, in the diet had no effect ($P = 0.63$) on yearling DMI, but a quadratic response ($P < 0.01$) was observed for calf-feds, with maximum DMI at 64% corn inclusion. Yearling and calf-fed ADG quadratically responded to corn inclusion ($P < 0.01$). Maximum ADG was at 43.8% corn inclusion for yearlings (1.74 kg/d) and 56.4% for calf-feds (1.78 kg/d). Yearling and calf-fed G:F quadratically responded ($P < 0.01$). Maximum G:F was at 49.8% corn inclusion for yearlings (0.159) and 53.4% for calf-feds (0.185). Marbling score and fat depth were not affected by cattle age ($P \geq 0.13$) and quadratically responded to corn inclusion ($P < 0.01$). Maximum marbling score was at 82.1% corn inclusion while maximum fat depth was at 56.7% corn inclusion. Maximum ADG and G:F were observed with approximately 50% corn inclusion, reflecting improved performance when byproducts replace a portion of corn. Complete removal of corn reduced performance, although it is not clear if this is due to lack of starch or negative effects of high-byproduct diets, such as fat or sulfur levels.

Key Words: byproducts, feedlot cattle, starch

208 **Effect of corn residue harvest method and monensin inclusion on performance of growing cattle.** J. J. Updike^{1,*}, A. C. Pesta², R. G. Bondurant¹, S. C. Fernando¹, G. E. Erickson¹, J. C. MacDonald¹, T. J. Klopfenstein¹, ¹*University of Nebraska, Lincoln*, ²*University of Nebraska–Lincoln, Lincoln*.

An 89-d growing study using 60 crossbred steers (initial BW = 309 ± 27 kg) was conducted to evaluate the impact of alternative corn residue harvesting methods on cattle performance. Steers were individually fed in a Calan gate system and were limit fed a common diet of 50% alfalfa and 50% wet corn gluten feed at 2% of BW for 5 d followed by 3-d weights at the beginning and end of the experiment. Steers were implanted on d 1 with Ralgro. Steers were blocked by initial BW into 10 blocks and were assigned randomly to 1 of 6 treatments within block. Diets consisted of 1 of 4 forages: sorghum silage, corn stalks, husklage, or ensiled husklage. Stalks were harvested by raking and baling after grain harvest. The husklage was collected and baled directly behind the combine and contained 27% leaf, 17% husk, 14% upper stem, and 42% cob. Two additional ensiled husklage diets were fed either with or without monensin on a 3-wk rotation. All diets included 3% SoyPass and 30% wet corn gluten feed. Feed refusals were collected and weighed weekly. Steers fed sorghum silage had the greatest DMI at 9.55 kg/d and the greatest ADG at 1.48 kg ($P < 0.01$) compared to other forages. Steers fed husklage had greater ADG and DMI and an improved G:F ratio compared to cornstalks ($P < 0.01$). Steers fed cornstalks had the lowest DMI, ADG, and G:F ratio ($P < 0.01$). Ensiling husklage resulted in an increase in DMI and ADG ($P < 0.05$) but did not change G:F ratio ($P = 0.13$) compared to husklage that was not ensiled. Steers consuming husklage and ensiled husklage refused 5 to 8% of their daily feed offering vs. 2% for the cornstalks. Steers receiving monensin for 89 d had the greatest ADG ($P < 0.01$), while there was no difference between no monensin and rotating monensin. Steers not fed monensin had the lowest DMI (6.79 kg) with steers fed monensin having the greatest (7.70 kg; $P = 0.04$) and steers rotating monensin being intermediate (7.05 kg). No effect of monensin inclusion on G:F was observed ($P > 0.12$). Changing the harvest method of the corn residue may improve forage quality compared to conventional stalks.

Key Words: corn residue, growing cattle, harvest method

209 **Effect of harvest method of corn residue on digestibility.** J. J. Updike^{1,*}, L. J. McPhillips², M. L. Jolly², J. L. Harding², J. C. MacDonald¹, T. J. Klopfenstein¹, ¹*University of Nebraska, Lincoln*, ²*University of Nebraska–Lincoln, Lincoln*.

A 64-d metabolism study using 18 crossbred wethers (BW = 26.1 kg; SD = 4.5) was conducted to determine if the harvest method of corn residue impacts digestibility and qual-

ity of the bale produced. Wethers were blocked into 3 blocks based on previous DMI. Five forage-based diets were used containing 1 of the following forages: brome, husk, husklage, ensiled husklage, or stalklage. Husks were obtained from a seed corn plant and then sifted through a 0.91 by 1.52 m metal screen by hand to remove any remaining corn. The husklage was baled directly behind the combine at the time of grain harvest. Husklage bales contained 27% leaf, 17% husk, 14% upper stem, and 42% cob. Ensiled husklage was produced by adding water to the husklage to obtain a DM content of 35% and bagging for a minimum of 30 d. Stalklage was harvested and had a composition similar to baled stalks, containing the stem, leaf, cob, and husk. Diets were 70:30 forage:wet corn gluten feed (DM basis). Four periods of 16 d contained 9 d for adaptation and 7 d for total fecal collection. In the fourth period, wet corn gluten feed was fed to determine forage digestibility by difference. Husk had the greatest DM digestibility (DMD; 68.11%), OM digestibility (OMD; 70.49%), and NDF digestibility (NDFD; 75.28%; $P < 0.01$). There was no differences in DMD ($P = 0.26$) and OMD ($P = 0.31$) of husklage and ensiled husklage, although NDFD tended to be greater for husklage ($P = 0.10$). Husklage had a DMD, OMD, and NDFD of 54.07, 56.4, and 62.4%, respectively. The ensiled husklage resulted in a DMD of 50.9%, an OMD of 53.3%, and an NDFD of 57.52%. Stalklage had a DMD, OMD, and NDFD of 49.37, 57.58, and 57.94%, respectively. There was no difference between the husklage and stalklage in OMD ($P = 0.68$); however, the NDFD ($P = 0.11$) and DMD ($P = 0.09$) tended to be greater for the husklage. The brome had the lowest DMD at 45.11%, OMD at 47.77%, and NDFD at 46.92% ($P < 0.01$). The husklage, ensiled husklage, and stalklage were intermediate to the husk and brome. Forage quality of the residue may be improved by changing the harvest method compared to conventional harvesting.

Key Words: corn residue, digestibility, harvest method

210 **Effect of the addition of calcium oxide in soybean hull and nonsoybean hull based beef diets on feedlot performance and carcass characteristics.**

C. R. Muegge*, J. P. Schoonmaker, *Purdue University, West Lafayette, IN*.

The acidic nature of dried distillers grains with solubles (DDGS) is a key determinant in depressing fiber and protein digestibility and plays a primary role in decreased intake and growth rate when DDGS concentrations exceed 30% of the diet DM. We hypothesized that addition of soybean hulls (SBH) and/or CaO to rations containing DDGS would increase rumen pH, enhance fiber digestibility, and improve steer performance. Angus × Simmental steers ($n = 112$; BW = 364.4 kg, SD = 7.87) were allotted to 1 of 4 diets arranged as a 2 × 2 factorial to determine the effect of SBH and CaO on performance of steers fed 20% corn stover and 30% DDGS. Soybean hull diets contained 30% SBH and 14.1 or 15.0%

corn, whereas corn diets contained 43.9 or 44.8% corn. Calcium oxide diets contained 1% CaO and non-CaO diets contained 1.9% limestone. Diets were fed once daily at 0800 h until steers achieved a target BW of 628 kg. Statistical analyses were conducted using the MIXED procedure of SAS. Weights did not differ among treatments throughout the study ($P \geq 0.46$). Overall carcass-adjusted gain did not differ due to SBH or CaO inclusion ($P \geq 0.13$), but there was an interaction ($P = 0.01$) where CaO improved gain of steers fed corn but not steers fed SBH. Steers fed SBH consumed more than steers fed corn ($P = 0.02$) and an interaction tended to occur ($P = 0.06$) where CaO increased DMI of steers fed corn but not steers fed SBH. An interaction occurred for G:F during the last 62 d of the study, where CaO increased G:F in steers fed corn ($P = 0.02$) but not in steers fed SBH. Overall, G:F did not differ among treatments ($P = 0.36$). Calcium oxide increased HCW and yield grade (interaction, $P \leq 0.04$) and tended to increase backfat (interaction, $P = 0.08$) in steers fed corn but not in steers fed SBH. Dressing percentage, longissimus dorsi area, percent KPH, and marbling score did not differ among treatments ($P \geq 0.14$). Steers fed SBH tended to have a greater percentage of carcasses grade select ($P = 0.09$) and fewer grade choice average ($P = 0.02$) compared to steers fed corn. In conclusion, CaO appears to enhance performance of cattle fed DDGS + corn stover diets when corn is a primary component of the diet but not when corn is partially replaced by a fiber-based energy feed.

Key Words: calcium oxide, performance, steer

211 **Effect of pelleted byproducts on performance when fed to growing cattle.** C. A. Welchons^{1,*}, C. J. Bittner¹, D. B. Burken¹, J. C. MacDonald², G. E. Erickson², ¹University of Nebraska–Lincoln, Lincoln, ²University of Nebraska, Lincoln.

An 84-d growing trial was conducted using 300 heifers (initial BW = 279 kg, SD = 22) to determine the effects of supplementing a pellet consisting of 54% corn stover treated with calcium oxide, 32% dried distillers grains, 14% solubles, and 1% urea on the performance of growing cattle fed either a high-quality (HQ; brome silage, sorghum silage, and alfalfa hay blend) or low-quality (LQ; bromegrass hay) forage. The experiment was arranged in a 2 × 3 factorial with LQ or HQ forage as one factor and level of supplement (0, 0.5, or 1.0% of BW) as the other. Heifers were blocked by BW ($n = 3$) and stratified by BW within block. Heifers were limit fed 5 d and weighed on 2 consecutive days at beginning and end of trial. A forage × supplement interaction existed for final BW (FBW), ADG, and G:F ($P < 0.01$). For the HQ forage diet, there was a linear increase in BW, ADG, and G:F as supplement level increased ($P < 0.01$), while for the LQ forage diet, there was a quadratic response ($P < 0.04$) as supplement level increased; FBW, ADG, and G:F increased at a decreasing rate. In the LQ diet, as supplement level increased from 0 to 0.5%,

there was a 96% increase in ADG and a 77% increase in G:F. As supplement increased from 0.5 to 1%, ADG and G:F increased by only 24 and 15%, respectively. The ADG and G:F response between 0.5 and 1% in LQ forage was similar to relative increases in HQ diet between 0.5 and 1% levels of supplementation (19 and 7% for ADG and G:F, respectively). The larger increase in the LQ diet from 0 to 0.5% of BW supplementation suggests a protein response, while the rate of increase from 0.05 to 1% of BW is more in concert with the response seen in the HQ forage diets suggesting an energy response as supplement level increased further. Forage DMI and total DMI had linear responses as supplement increased, with forage DMI decreasing and total DMI increasing ($P < 0.01$). However, forage quality did not affect either forage or total DMI ($P > 0.17$). These data suggest that use of a corn residue-based pellet increases performance in growing animals when fed either a LQ or HQ roughage diet, although there is a greater response when fed in a LQ forage diet.

Key Words: byproducts, growing, pellet

212 **Effects of replacing corn with a pellet consisting of treated corn stover and distillers byproducts on performance of finishing cattle.** J. L. Harding^{1,*}, J. C. MacDonald², C. J. Bittner¹, G. E. Erickson², D. B. Burken¹, ¹University of Nebraska–Lincoln, Lincoln, ²University of Nebraska, Lincoln.

A 183-d finishing study using 336 crossbred steer calves (initial BW = 301 ± 25 kg) evaluated the effects of replacing corn with a pellet consisting of alkaline-treated corn stover, dry distillers grains, and solubles in diets containing modified distillers grains plus solubles (MDGS) on finishing cattle performance. Treatments were designed as a 2 × 3 plus 1 factorial. The 2 factors were inclusion of MDGS (20 or 40%, DM basis) and inclusion of the pellet (10, 20, or 30%, DM basis). The control diet (CON) consisted of a 50:50 blend of dry-rolled corn and high-moisture corn and 40% MDGS. All diets contained 5% wheat straw and 4% dry meal supplement. Linear and quadratic effects of the pellet within 20 and 40% MDGS were evaluated. A linear increase ($P = 0.05$) in DMI was observed as pellet inclusion increased from 0% in the CON (10.58 ± 0.41 kg/d) to 30% (10.97 ± 0.62 kg/d) in diets containing 40% MDGS. A quadratic response ($P = 0.03$) in DMI was observed as pellet inclusion increased from 10 (10.91 ± 0.72 kg/d) to 30% (10.95 ± 0.51 kg/d) in diets containing 20% MDGS due to greater DMI of 20% pellet (11.28 ± 0.33 kg/d). No differences in ADG were observed ($P = 0.21$) as pellet inclusion increased in either 20 or 40% MDGS. A linear decrease ($P = 0.04$) in G:F was observed as level of pellet increased from 0 (0.181 ± 0.006) to 30% (0.175 ± 0.005) in diets containing 40% MDGS. In diets containing 20% MDGS, no difference ($P \geq 0.22$) in G:F was observed as pellet inclusion increased from 10 (0.175 ± 0.007) to 30% (0.164 ± 0.005). When fed with 40% MDGS, the pellet was 100% the feeding value of corn at 10% inclusion, 94% the

value of corn at 20% inclusion, and 88% at 30% inclusion of the diet. Using an estimated G:F of 0.177 for a CON containing 20% MDGS and 0% pellet, the pellet is 83% the feeding value of corn when fed at 10%, 69% the feeding value of corn when fed at 20% of the diet, and 77% the feeding value of corn when fed at 30% of the diet.

Key Words: finishing, pellet, treated corn stover

214 **Impact of feeding distillers grains or isolated components in distillers grains on feedlot performance and carcass traits.** B. B. Conroy^{1,*}, J. A. Hansen¹, G. E. Erickson², M. K. Luebke¹, ¹University of Nebraska, Scottsbluff, ²University of Nebraska, Lincoln.

The ethanol industry is partially removing corn oil to produce deoiled distillers grains with solubles. Additional processing changes (i.e., corn oil, fiber, and protein) are underway that will change the nutrient composition and, potentially, the energy value of distillers grains plus solubles in feedlot diets. An experiment was conducted using 264 crossbred steers (BW = 385 ± 23 kg) in a randomized block design to estimate the energy value of individual components. Diets were formulated to equal the fat, fiber, and protein components of a diet consisting of 40% wet distillers grains plus solubles (WDGS; DM basis). Diets included a corn-based control (CON) or WDGS (40% of diet DM) replacing corn or diets with equal proportions of fiber (FIBER; corn bran and deoiled germ), protein (PROT; corn gluten meal), or fat (FAT; corn germ) with condensed distillers solubles included at 10% (DM basis). These diets have the same proportions of each component relative to the 40% DGS diet. A 10% condensed distiller solubles (CCDS) diet was also included for comparison of the component diets relative to CON. There were a total of 6 dietary treatments with 5 pens/treatment. Dry matter intake was greatest for FAT and PROT; intermediate for fiber; and least for WDGS, CON, and SOL ($P = 0.04$). Average daily gain was greatest for WDGS; intermediate for FAT, PROT, and FIBER; and least for SOL and CON ($P < 0.01$). Feed efficiency was greatest for WDGS; intermediate for CON, SOL, PROT, and FIBER; and least for FAT ($P < 0.01$). Final carcass-adjusted BW and HCW were greatest for WDGS; intermediate for CON, FAT, PROT, and FIBER; and least for SOL ($P < 0.01$). Fat depth was greatest for DGS; intermediate for PRO, FIBER, and SOL; and least for FAT and CON ($P = 0.02$). Marbling score and LM area were not different among treatments ($P \geq 0.13$). Feeding WDGS compared with CON improved feedlot performance and carcass characteristics. It is unclear what component is responsible for improved performance and carcass characteristics when feedlot cattle are fed distillers grains diets compared with a CON diet as no single component fed to steers improved performance as much as WDGS.

Key Words: components, distillers grains plus solubles, feedlot cattle

215 **Modifying different components of distillers grains and the impact on feedlot performance.**

Z. E. Carlson^{1,*}, C. J. Bittner², D. B. Burken¹, G. E. Erickson², J. C. MacDonald², ¹University of Nebraska–Lincoln, Lincoln, ²University of Nebraska, Lincoln.

The composition of distillers grains has potential to change as corn components are removed for further ethanol production. Crossbred yearling steers ($n = 448$; initial BW = 364 ± 13 kg) were used in a completely randomized block design to determine the effect of altering distillers grains composition on animal performance and carcass characteristics. Treatments were 1) negative control (CON) with 81.5% blend of high-moisture corn and dry-rolled corn; 2) positive control (DG), in which corn replaced dried distillers grains plus solubles at 50% of diet; 3) nonpelleted corn stover (STV), treated with calcium oxide, which contained 18.75% solubles, 12.5% treated stover, and 18.75% high-protein distillers grains; 4) pelleted corn stover at same DM inclusion as STV; 5) bran (BRN), which included 18.75% solubles, 12.5% isolated fiber, and 18.75% high-protein distillers grains; 6) bran medium protein (BRN-MED), which contained 24.4% solubles, 16.2% isolated bran, and 9.4% high-protein distillers; and 7) bran low protein (BRN-LOW), which had 30% solubles and 20% isolated bran (DM basis). Animal performance and carcass characteristics were analyzed using the PROC MIXED procedures of SAS with pen as the experimental unit. Block was a fixed effect and treatments were evaluated when the F test was significant ($P < 0.05$). Single degree of freedom contrasts were developed to determine effects of exchanging components in distillers grains. Intakes and ADG were greater for DG compared to CON, but G:F was similar between CON and DG (0.146 vs. 0.147, respectively; $P = 0.75$). However, combining bran, solubles, and protein together in proportions similar to distillers grains reduced G:F ($P < 0.01$) compared to DG. Replacing bran with treated corn stover further reduced feed efficiency ($P < 0.01$). No difference between pelleting corn stover or not ($P = 0.60$) was observed for ADG and G:F. Intake decreased with pelleting corn stover ($P < 0.02$) without affecting ADG or G:F. There was a quadratic effect for DMI as protein was removed between BRN, BRN-MED, and BRN-LOW ($P < 0.04$) but there was no impact on ADG or G:F. Decreasing proportions of protein did not negatively impact feed efficiency, possibly due to solubles concentration increasing with decreasing protein inclusion. These data suggest that replacing bran normally found in distillers grains with corn stover increases intake and reduces feed efficiency, whether pelleted or not. Diets formulated with isolated ingredients of distillers grains did not mimic performance of distillers grains, suggesting some component or components was missing.

Key Words: components, corn stover, distillers grains plus solubles

216 **Influence of dry-rolled corn processing and distillers grain inclusion rate on rumen pH, volatile fatty acids, and ammonia concentration and in vitro methane production.** F. E. Doscher*, M. C. Ruch, J. D. Kirsch, C. R. Dahlen, S. Rahman, M. S. Borhan, M. L. Bauer, K. C. Swanson, *North Dakota State University, Fargo.*

Increased dried distillers grains with solubles (DDGS) inclusion and decreased corn particle size have been shown to lower ruminal pH and reduce methanogenic bacteria and hydrogen production. Objectives were to determine the effects of dry-rolled corn processing and DDGS inclusion rate on ruminal pH, VFA and NH_3 concentration, and in vitro methane production. Eight ruminally cannulated Holstein steers (526 ± 3.6 kg) were assigned to treatments in a 2×2 factorial arrangement with factors including 1) particle size (coarse-rolled corn [2.5 mm] or fine-rolled corn [1.7 mm]) and 2) DDGS inclusion level (20 or 40%). Diets were formulated to meet or exceed NRC recommendations and were offered ad libitum. The experiment was designed as a 4×4 Latin square with 7 d of diet adaptation and 7 d of sample collection. Ruminal pH was measured using wireless pH sensors (Kahne Ltd.) with measurements taken every 5 min from d 3 to 5 of the collection period. To determine VFA and NH_3 concentration, approximately 200 mL of ruminal fluid was sampled from d 3 to 5 in a manner to represent every other hour in a 24-h cycle. Gas production was examined on d 1 and 7 of the collection period using 4 replicates per treatment. Approximately 0.375 g of each of the 4 dietary substrates was added to 250-mL flasks with 175 mL of McDougall's buffer and 37.5 mL of ruminal fluid. The flasks were flushed with CO_2 , fitted with pressure monitor caps, and placed in an oscillating water bath at 39°C for 24 h. A gas pressure monitoring system (ANKOM) was used to measure the changes in pressure relative to atmospheric pressure as a consequence of gas produced during fermentation. Data were analyzed using the MIXED procedure of SAS with statistical significance declared at $P \leq 0.05$. Ruminal pH was not affected ($P \geq 0.07$) by treatment while NH_3 concentration was greater ($P = 0.02$) in steers fed 20% DDGS. Steers fed fine-rolled corn had greater ($P = 0.02$) concentrations of butyric acid. Total gas production and methane concentration were not influenced ($P \geq 0.08$) by particle size or DDGS inclusion level. Urea was supplemented in diets containing 20% DDGS to meet DIP requirements, which likely accounted for the increase in NH_3 . Despite a rise in ruminal butyric acid, acetate and propionate were not affected ($P \geq 0.20$), possibly reducing the likelihood of hydrogen capture and subsequent methane mitigation.

Key Words: bovine, corn, distillers, rumen

217 **Impact of dietary nitrate and sulfate on methane to carbon dioxide ratio and performance of finishing steers.** A. C. Pesta^{1,*}, R. G. Bondurant¹, S. C. Fernando², G. E. Erickson², ¹*University of Nebraska–Lincoln, Lincoln*, ²*University of Nebraska, Lincoln.*

Sixty crossbred steers (initial BW = 416 ± 36 kg) were used in a 2×2 factorial design experiment to evaluate the effect of dietary addition of nitrate and sulfate on performance and $\text{CH}_4:\text{CO}_2$ ratio of finishing steers. Cattle were limit fed 5 d prior to trial initiation and weighed on 3 consecutive days, the average of which was used as initial BW. Steers were stratified by BW and assigned randomly to 1 of 4 treatments (15 replications/treatment). Treatments consisted of a corn-based diet with 0 or 2.0% nitrate (diet DM) and 0 or 0.77% calcium sulfate (designed to not exceed 0.4% dietary S). Steers were gradually adapted to nitrate over a 28-d step-up period. One case of nitrate toxicity was observed during the study. At time of feeding, exhaled breath samples were collected from each steer every 2 wk throughout the study using a custom-built gas collection system and were analyzed for CH_4 and CO_2 using gas chromatography. Carbon dioxide was used as an internal marker and $\text{CH}_4:\text{CO}_2$ was used to quantify the effects of diet on methane emission. No interactions were observed between nitrate and sulfate additions for DMI and ADG but nitrate and sulfate additions tended to interact for G:F ($P = 0.07$). Feeding 2.0% nitrate decreased final BW and HCW ($P = 0.02$), while sulfate had no effect ($P = 0.16$). Addition of nitrate and sulfate each decreased DMI ($P < 0.01$), the combination of which decreased DMI by 20% compared to cattle fed neither additive. Similarly, nitrate decreased ($P < 0.01$) and sulfate tended to decrease ($P = 0.07$) ADG; when nitrate and sulfate were combined, ADG was 16% lower than that of steers receiving neither additive. For the G:F interaction, steers fed sulfate alone had lower G:F whereas steers fed nitrate alone had similar G:F as no additives. When nitrate and sulfate were combined, G:F was actually numerically greatest. A nitrate \times sulfate interaction was observed for methane emissions ($P = 0.04$), where cattle fed only sulfate had the greatest $\text{CH}_4:\text{CO}_2$; steers fed nitrate or neither additive were intermediate. Steers receiving a combination of nitrate and sulfate had the lowest $\text{CH}_4:\text{CO}_2$. Feeding a combination of nitrate and sulfate can decrease $\text{CH}_4:\text{CO}_2$ but decreases DMI and ADG.

Key Words: methane, nitrate, sulfate

218 **Impact of crude glycerin supplementation on rumen and duodenal microbial populations in beef cattle diets.** A. McCain*, *University of Nebraska, Lincoln.*

The use of crude glycerin as a feed supplement in beef cattle diets may be an efficient energy source, but changes in ruminal microbial populations are undocumented. The objective of

this experiment was to determine the effects of crude glycerin on the prevalence of 5 ruminal bacteria species (*Selenomonas ruminantium*, *Anaerovibrio lipolytica*, *Fibrobacter succinogenes*, *Butyrivibrio fibrosolvens*, and *Megasphaera elsdenii*). Seven ruminally and duodenally fistulated beef steers were used in a 4 diet, 4 period, 7 animal, column \times row transformation design. Steers were fed 0, 4, 8, and 12% glycerin in diets consisting of wheat straw, soybean hulls, and soybean meal. Glycerin replaced soybean hulls in the control diet. Samples were taken from ruminal and duodenal cannulas 8 h postfeeding on the last day of a 21-d period. Total DNA was extracted from each sample and was quantified using real-time PCR with species-specific PCR primers. Real-time assays were performed using the SYBR Green reporter assay and relative fold change in the rumen and duodenum were calculated using the DD CT method relative to the control. Data was analyzed using the MIXED procedures of SAS. The model included glycerin concentration, animal, and period. Contrasts were developed to test linear and quadratic change in species abundance relative to the control. In the rumen, *S. ruminantium* linearly increased up to 18-fold at 12% glycerin supplementation ($P = 0.02$) and *A. lipolytica* linearly increased up to 14-fold at 8% glycerin supplementation ($P < 0.01$). *Fibrobacter succinogenes*, *B. fibrosolvens*, and *M. elsdenii* displayed no significant changes in the rumen ($P > 0.27$). In the duodenum, *S. ruminantium* and *A. lipolytica* linearly increased up to 9-fold ($P < 0.001$) and up to 8-fold ($P < 0.001$) at 8 and 12% glycerin supplementation, respectively. *Fibrobacter succinogenes* and *M. elsdenii* showed no significant changes in the duodenum ($P > 0.86$). *Butyrivibrio fibrosolvens* quadratically increased up to 22-fold at 12% glycerin supplementation in the duodenum ($P < 0.001$). An increase in *A. lipolytica* is indicative of an increase in propionate, which could increase G:F, while an increase in *S. ruminantium* indicates an increase in lactate being produced in the rumen. An insignificant effect on *F. succinogenes* suggests that fiber digestion may not be negatively affected by an increase in dietary glycerin.

Key Words: beef cattle, glycerin, microbial community

RUMINANT NUTRITION: DAIRY AND BEEF COW NUTRITION AND FORAGE SUPPLEMENTATION

- 219 **Effects of maternal nutrition during gestation in ruminant maternal and fetal and offspring viscera energy use and hypothalamic neurohormone content in the offspring.** L. Prezotto*, North Dakota State University, Fargo.

The extensive use of grazing systems for ruminant livestock and the high variation in forage quality throughout the year have important impacts on production. Changes in feed quality

and availability cause alteration in the nutritional and physiological status of gestating animals. Modifications of the maternal nutritional environment throughout fetal development can have an impact on later performance of the offspring. Adjustments in the maternal metabolism have been correlated with an increase in maternal energy use during pregnancy and also further adjustments that occur in the dam's metabolism to provide adequate O₂, nutrients, and energy reserves for fetal growth and maternal maintenance systems. Moreover, energy utilized by fetal visceral tissues can be altered in response to changes in maternal feed intake. Prolonged changes in maternal feed intake during early pregnancy, the time that fetal brain development is taking place, can result in up- and/or downregulation of neurohormones that play an important role in controlling how energy utilization and feed intake of these offspring will occur later in life. We designed 3 different studies with the main objective to investigate how maternal nutrient restriction throughout gestation or during different periods of gestation affects visceral organs metabolism in the dam and in the fetus. Furthermore, our objective was to understand the effects of developing in an intrauterine growth restriction environment might have on postnatal liver and small intestine mass and energy use and on the protein content of neurohormones that control feed intake and energy metabolism, from specific nuclei of the hypothalamus. Our results indicated that maternal hepatic and jejunal mass and energy use are impacted by nutrient restriction; however, they can be altered by realimentation strategically offered during different stages of gestation. The same impacts are observed in fetal visceral development and metabolism and in liver energy use in postnatal life. Moreover, arginine supplementation appears to be a nutritional strategy that diminishes the possible deleterious effects in maternal and fetal visceral metabolism in response to nutrient restriction. Finally, maternal nutrient restriction throughout gestation caused decreased number of cells in the hypothalamus of the offspring that express POMC protein, perhaps influencing energy metabolism in the offspring.

Key Words: energy use, neuropeptide, viscera

- 220 **Methane production and diet digestibility by growing cattle fed high- or low-quality forage.**

A. C. Pesta^{1,*}, M. L. Jolly¹, P. J. Kononoff², S. C. Fernando², G. E. Erickson², ¹University of Nebraska-Lincoln, Lincoln, ²University of Nebraska, Lincoln.

Six noncannulated crossbred steers (initial BW = 369 \pm 17) were used in a 3-period switchback design growing study to evaluate the effects of forage quality on methane production and total tract digestibility. Treatments consisted of either a high-quality forage diet (HQ; 60:40 blend of alfalfa hay and sorghum silage plus 20% modified distillers grains) or low-quality forage diet (LQ; ground cornstalks plus 20% modified distillers grains). Twenty-one-day periods consisted of 11 d

of adaptation and 4 d of total fecal collection using fecal bags followed by headbox CH₄ and CO₂ data collection for 2 consecutive 23-h periods on d 20 and 21. Steers were also esophageally tubed for analysis of VFA concentration and microbial community structure on d 20 prior to feeding. Methane and CO₂ were determined using gas chromatography. Data were analyzed using a mixed model with period and treatment as fixed effects and steer as the random variable. Intake of DM was dramatically greater for the HQ (9.8 kg/d) compared to the LQ (6.6 kg/d). Based on feed refusal analysis, ration sorting occurred when steers were fed the LQ. Intake of OM and ADF was greater ($P < 0.01$) and intake of NDF tended to be greater ($P = 0.06$) for cattle consuming the HQ. Digestibility of DM was also greater for steers on the HQ ($P = 0.05$). Steers consuming the LQ produced 132 L CH₄ and 1,654 L CO₂ compared to 210 L CH₄ and 2,404 L CO₂ produced by those consuming the HQ. This resulted in production of 63 and 69% of the daily volumes (L/d) of CH₄ and CO₂, respectively, of those cattle of consuming the HQ ($P < 0.01$). Steers fed the LQ also had a lower CH₄:CO₂ ($P = 0.03$) compared to those consuming the HQ: 0.082 and 0.090, respectively. When methane emissions are expressed as a function of nutrients digested, production of CH₄ in liters/kilogram of OM digested was not impacted by diet ($P = 0.14$), which may be related to dramatic intake differences in this study.

Key Words: digestibility, forage quality, methane

221 **Effect of tannin-containing legume forages on crude protein degradation in vitro.** N. F. Johnson*, M. E. Lees, M. S. Kerley, H. D. Naumann, *University of Missouri, Columbia.*

Research in our laboratory has demonstrated greater than 10% improvements in feed efficiency by balancing beef cattle diets for post-ruminal AA. To achieve this, protein sources with low rumen degradability must be used. Expensive animal proteins or treated soybean meal (SBM) are the most commonly available sources. Therefore, it is prudent to examine forages with low rumen degradability as alternatives. Tannin-containing forages have been shown to create high proportions of rumen undegradable protein (RUP) due to protein binding properties of condensed tannins (CT). The objective of this study was to evaluate the ability of selected warm-season perennial legumes containing CT to decrease ruminal CP degradation in vitro. We hypothesized the extent of ruminal CP degradation would be inversely related to forage CT protein precipitation ability. Six legume species were evaluated. Three field replications of each CT-containing forage species and 1 replication of alfalfa (minimal CT) were mixed in a 1:1 ratio with SBM. For the forage, SBM samples were weighed into tubes, inoculated with a 1:3 mixture of strained rumen fluid and McDougall's buffer, and closed with stoppers fitted with 1-way valves. Samples were fermented for 0, 12, 24 and 48 h in a 39°C shaking water bath. Tubes were centrifuged to remove

supernatant, dried at 55°C, and analyzed for DM and CP disappearance. Supernatant subsamples were taken for ammonia analysis at 0, 4, 8, 12, 16, 24, 36, and 48 h of fermentation, at which times pH was measured. All tannin-containing forages were more effective at protecting protein from degradation in vitro than alfalfa. Increased CT concentration decreased the potential extent of CP degradation and tannin-containing forages had greater percent DM and CP remaining at all hours compared to alfalfa and a SBM control. Plant protein precipitable phenolics concentration, a measure of biologically active CT, was negatively correlated ($P < 0.0001$) with CP digestibility ($R^2 = -0.72$), protein solubility ($R^2 = -0.75$), and the extent of CP degradation ($R^2 = -0.78$). *Lespedeza stuevei* Nutt. (tall lespedeza) and 2 ecotypes of *Acacia angustissima* var. *hirta* (Nutt.) B.L. Rob (Prairie acacia) were identified as plants contributing exceptionally high protection from in vitro ruminal SBM protein degradation when mixed in a 1:1 ratio. Current research is expanding upon these results to evaluate these plants as RUP sources in ruminant diets.

Key Words: condensed tannins, forage legumes, rumen undegradable protein

222 **Three summer forage finishing systems effect on lamb growth and carcass characteristics.** J. S. McCutcheon^{1,*}, H. N. Zerby², S. C. Loerch³, F. L. Fluharty³, ¹The Ohio State University, Mount Gilead, ²The Ohio State University, Columbus, ³The Ohio State University, Wooster.

With lambs, there is a lack of information comparing grazing alfalfa versus other summer forages and the effects on lamb growth rate and carcass characteristics. The objective of the study was to compare 3 forage finishing systems on lamb growth rate and carcass characteristics. Weaned wether ($n = 54$) lambs blocked by BW were used to evaluate the effect of finishing systems on rate of growth and carcass composition. Each treatment consisted of 3 fields of 6 lambs per field. The finishing systems were grazed alfalfa (ALF), grazed chicory (CHI), and grazed sorghum-sudangrass (SSG). The forages were rotational grazed. Each field was subdivided using temporary electric netting and each paddock was grazed for 3 d with a 28-d rest between grazing events. Forage analysis revealed ALF had lesser ADF and NDF content than CHI and SSG throughout the trial ($P < 0.05$) and greater CP content for all but 6 wk ($P < 0.05$) out of the 15-wk trial period. Predetermined contrasts between ALF and the other finishing systems were conducted using LSMESTIMATE in PROC MIXED. Overall ADG for ALF lambs (0.22 kg/d) was not different ($P > 0.05$) than SSG lambs' ADG (0.20 kg/d) and trended lesser ($P = 0.07$) than CHI lambs' ADG (0.25 kg/d). The slaughter target was predetermined to be the time when forage became limiting. The SSG lambs were slaughtered 14 d earlier than either the ALF or CHI lambs due to frost. The SSG lambs produced lighter carcasses with lesser dressing percentages than

the ALF lambs ($P < 0.05$). The ALF lambs were not different in carcass weight, loin eye area, and back fat depth from the CHI lambs ($P > 0.05$). There was a trend for reduced dressing percentage of the ALF lambs when compared with the CHI lambs ($P = 0.08$). All 3 forage treatments produced adequate rate of gain but would need additional grazing time for lambs to reach adequate carcass weights.

Key Words: carcass, grazing, lamb

224 **Nutritional management strategies to improve growth and feed efficiency of prepubertal dairy heifers.** T. S. Dennis*, T. D. Nennich, *Purdue University, West Lafayette, IN.*

The future of the dairy industry depends on well-developed replacement heifers. Emphasis on improving preweaned calf nutrition has predominated in the industry, but opportunities exist to improve nutrition and management of heifers postweaning. We aimed to investigate common feed management strategies seen in the industry and their effects on growth, feed efficiency (FE), and rumen development of heifers 4 to 8 mo of age. Studies were designed as pen- and individually fed animal trials, with data analyzed as repeated measures using PROC MIXED of SAS. Delivering feed using a total mixed ration (TMR) is common practice on dairy operations, as nutrients are delivered consistently with increased labor efficiency. We compared feeding a common diet delivered by feeding hay and concentrate separately (HF), hay side dressed with concentrate (SBS), and a TMR, observing that FE of HF- and SBS-fed heifers was 8 to 10% greater overall compared to heifers fed a TMR ($P = 0.10$). Additionally, HF-fed heifers were 13.5 kg heavier ($P < 0.01$) at the end of the study and had 5.6% greater DMI overall ($P < 0.01$) compared to SBS- and TMR-fed heifers. Since FE was improved when concentrate was fed separate from forage, we subsequently researched increasing proportions of dietary concentrate for growing heifers and the effects when switched to a high-forage diet. Heifers fed 80% concentrate were the heaviest, tallest, and most feed efficient during the treatment period ($P < 0.01$) but performed poorly when switched to a high-forage TMR (60% hay) compared to heifers previously fed 60 or 40% concentrate. Additionally, molar proportions of propionate ($P < 0.01$) and butyrate ($P = 0.03$) were greater when heifers were fed 80 or 60% concentrate, potentially influencing rumen development. We then evaluated diets differing in nonfiber carbohydrates (NFC) in order to alter rumen fermentation and increase FE. Interestingly, heifers fed low-NFC diets with added fat had higher ADG ($P = 0.05$) and FE ($P = 0.07$) compared to heifers fed high-NFC diets despite similar dietary ME and CP content. However, in a concurrent study evaluating low- and high-NFC diets with individually fed animals, ADG ($P = 0.02$) and frame height ($P = 0.03$) were increased for high-NFC-fed animals. Overall, our results suggest feeding diets with highly digestible carbohydrates to promote greater FE

and skeletal growth postweaning. Greater understanding of the effects of feed management strategies on growing heifer performance has been achieved from our research, allowing more precise feeding recommendations and development of feeding programs to improve heifer management.

Key Words: feed efficiency, growth, heifer

225 **Rumen microbial protein synthesis in total mixed ration vs. component fed high-producing dairy cows.** A. Nikkhah*, *University of Zanjan, Zanjan, Iran.*

The objective was to determine effects of total mixed ration (TMR) delivery vs. component feeding of forage and concentrate (CFC) on rumen microbial protein synthesis in high-producing lactating cows in a noncompetitive environment. Four multiparous (665 ± 65 kg BW; 67 ± 20 d in milk; mean \pm SD) and 4 primiparous (583 ± 43 kg BW; 85 ± 36 d in milk) lactating Holstein cows housed in free individual boxes (4 by 3 m) were used in a crossover design experiment with two 25-d periods. Each period had 20 d of adaptation. Cows received a diet, based on barley grain and a mixture of corn silage and alfalfa hay, prepared and presented as either TMR or CFC. The forage to concentrate ratio was 50:50 (DM basis), permitting 5 to 10% daily orts. Two milliliters of urine sample was taken daily for the last 5 d of each period, diluted 5 times in distilled water, and stored at -20°C for later analysis of purine derivatives (allantoin and uric acid) to estimate duodenal microbial protein flow. Cows were experimented under thermoneutral conditions. Cows were milked twice daily at 0500 and 1700 h. Data were analyzed using mixed models with fixed effects of treatment, parity, and their interaction and random effects of period and cow within parity. Least square means were estimated with the REML method, and degrees of freedom were calculated using the Satterthwaite method. Daily urinary excretion of allantoin (411 vs. 421 mmol/d), uric acid (47 vs. 49 mmol/d), and total purine derivatives (458 vs. 470 mmol/d) were not influenced ($P > 0.10$) by feeding system (TMR vs. CFC, respectively). As a result, daily estimates of duodenal microbial protein flow were not different for cows fed TMR vs. CFC, respectively (2,202 vs. 2,260 g/d; $P > 0.10$). Neither parity nor its interaction with feeding system affected urinary purine derivatives and microbial protein flow estimates. The results suggest that feeding high-producing dairy cows TMR vs. CFC did not influence the factors contributing to rumen microbial protein synthesis, indicating that rumen conditions and function were not affected by feeding system in a noncompetitive environment. Findings have important economical, management, and health implications for commercial dairy enterprises.

Key Words: dairy cow, feeding system, microbial protein

226 **Dietary factors affecting fatty acid digestion and metabolism in lactating dairy cows.** J. P. Boerman^{1,*}, M. J. VandeHaar¹, A. L. Lock¹, J. L. Firkins², S. B. Potts³, N. St-Pierre², ¹*Michigan State University, East Lansing*, ²*The Ohio State University, Columbus*, ³*University of Maryland, College Park*.

Our research examined the effects of different dietary factors on fatty acid digestion, metabolism, and energy partitioning in lactating dairy cattle. Digestibility estimates of individual fatty acids from previous studies were analyzed using meta-analysis and meta-regression. Meta-analysis results indicated that there were minor differences in the digestibility of individual fatty acids. However, using meta-regression, C18:0 digestibility was reduced as the amount of C18:0 reaching the duodenum increased ($P < 0.001$), while the digestibility of other fatty acids was unaffected by their respective flow through the duodenum. The amount of C18:0 reaching the duodenum negatively impacted the digestibility of all 18-carbon fatty acids (all $P < 0.05$). We determined the effects of increasing dietary supplementation of C18:0 on production parameters, digestibility, and incorporation of fatty acids into milk fat. Stearic acid (C18:0) was supplemented at 0.8, 1.5, and 2.3% of diet DM compared to a nonsupplemented diet. Dry matter intake was linearly increased by C18:0 supplementation ($P < 0.05$). However, we observed no effect of C18:0 supplementation on yields of milk or milk components (all $P > 0.25$). Stearic acid supplementation resulted in reduced digestibility of total fatty acids ($P < 0.001$) and 18-carbon fatty acids ($P < 0.001$), with no effect on the yield of preformed milk fatty acids ($P = 0.69$). Based on the aforementioned results and our recent work with C16:0 supplementation, we examined the effects of partly replacing dietary starch with fiber and fat to provide a diet with similar NE_L density on yields of milk and milk components and on energy partitioning in midlactation cattle. A high-fiber and -fatty acid diet (HFF) containing 2.5% C16:0-enriched fatty acid supplement was compared to a high-starch diet (HS) containing 33% corn grain. Dry matter intake ($P = 0.10$) and energy intake ($P = 0.60$) were similar between treatments. Compared with HS, the HFF treatment reduced milk yield, milk protein concentration, and milk protein yield (all $P < 0.05$) but increased milk fat concentration, milk fat yield, milk energy output, and milk to feed ratio (ECM/DMI; all $P < 0.001$). The HFF partitioned fewer nutrients towards body reserves as evident by reduced BW gain, BCS, and subcutaneous fat thickness (all $P < 0.05$). Using calculated energy values, the HFF allocated less energy towards body gain and more towards milk production (both $P < 0.01$). Our results indicate that C18:0 digestibility was negatively impacted by increasing duodenal flow of C18:0, increasing C18:0 in the diet did not impact yields of milk or components, and feeding diets higher fiber and fatty acids to midlactation cows may partition less energy to body tissue gain and more to milk.

Key Words: digestibility, energy partitioning, fatty acids

227 **Effect of ensiling time and exogenous protease addition on nitrogen fractions and ruminal in vitro starch digestibility in whole-plant corn silage from varied hybrid types, maturities, and particle size.** L. F. Ferraretto^{*}, R. D. Shaver, *University of Wisconsin, Madison*.

The objective of this study was to evaluate the effects of ensiling time and exogenous protease addition on soluble CP (%CP), ammonia-N (%N), and ruminal in vitro starch digestibility (ivStarchD) in whole-plant corn silage (WPCS) of varied hybrid types, maturities, and particle size. Samples from 3 hybrids (brown midrib [BMR], dual purpose [DP], or floury-leafy [FLY]) at 2 harvest maturities (two-thirds of milk line [early; ER] or 7 d later [LT]) with 2 theoretical lengths of cut settings on the forage harvester (0.64 or 1.95 cm) were collected at harvest, treated with or without exogenous protease, and ensiled in triplicate in vacuum-sealed plastic bags for 0, 30, 60, 120 and 240 d. Therefore, the experiment consisted of 120 treatments (3 hybrids \times 2 maturities \times 2 particle size \times 2 protease treatments \times 5 time points) and 360 minisilos (3 replications per treatment). Data were analyzed as a split-split-plot design using PROC MIXED of SAS with the fixed effects of hybrid, maturity, particle size, protease addition, ensiling time, and their interaction and the random effects of hybrid \times maturity and hybrid \times maturity \times particle size. Vitreousness measured on unfermented kernels on the day of harvest was 83.0, 47.5, and 42.0%, on average, for BMR, DP, and LFY, respectively. Although %N did not differ ($P > 0.10$), %CP tended to increase (41.4 vs. 42.1% of CP; $P = 0.06$) and ivStarchD approached a trend for an increase (60.9 vs. 61.8% of starch; $P = 0.11$) with exogenous protease addition. A protease \times maturity interaction was observed ($P = 0.01$) with protease increasing ivStarchD in LT but not ER. Gradual increases were observed ($P < 0.001$) over time from 0 to 240 d for %CP and %N concentrations. Likewise, the ivStarchD measurements increased with ensiling time ($P < 0.001$; 56.2, 58.8, 61.2, 63.3, and 67.3% of starch for 0, 30, 60, 120, and 240 d, respectively). Ensiling time \times hybrid interactions was observed ($P = 0.001$) for %N and %CP concentrations with greater values for FLY than other hybrids only after 120 d of ensiling. Similarly, ivStarchD was greater for FLY than DP only after 60 d of ensiling. Length of the ensiling period did not attenuate negative effects of kernel vitreousness on starch digestibility in WPCS. Results suggest that exogenous protease addition may reduce the negative effects of maturity on starch digestibility in WPCS and merits further investigation.

Key Words: corn silage, ensiling time, starch digestibility

228 **Estimation of rumen-undegradable protein across high-protein feedstuffs using in situ and in vitro procedures.** H. A. Paz Manzano*, S. C. Fernando, P. J. Kononoff, *University of Nebraska, Lincoln.*

The objective of the study was to compare the estimate of rumen-undegradable protein (RUP) of the Cornell fermentation procedure to those obtained using the in situ or ammonia release procedures. To do so, 5 independent batch samples of 7 different feedstuffs were collected. The feedstuffs used in this study included 3 sources of blood meal (BM1, BM2, and BM3), canola meal (CM), low-fat distillers dried grains with solubles (LFDG), soybean meal (SBM), and expeller soybean meal (ESBM). In situ incubations of 16 h were conducted using 2 Holstein cows (days in milk 210 ± 17 and milk yield 27.3 ± 8.00 kg) fitted with flexible ruminal cannulas. Two in vitro procedures were used, Cornell fermentation and ammonia release. Both in vitro procedures required the incubation of the samples in rumen inoculum, specifically in plastic tubes (50 mL) for the ammonia release and Erlenmeyer flasks (125 mL) for the Cornell fermentation procedures. Measurements of ammonia and total VFA were required in the ammonia release procedure while correction for microbial contamination was done using a sample of neutral detergent residue from corn silage in the Cornell fermentation procedure. The in situ and the ammonia release procedures were conducted at the

University of Nebraska–Lincoln while the Cornell fermentation procedure was conducted by a commercial laboratory. Data from the in situ procedure were analyzed as a randomized complete block design and the model included the fixed effect of feedstuff and the random effects of replicate and load within feedstuff, and data from the in vitro procedures were analyzed as a complete randomized design and the model included the fixed effect of feedstuff and the random effect of load within feedstuff. For BM1, BM2, BM3, CM, LFDG, SBM, and ESBM, RUP was 14.7, 70.2, 59.3, 24.3, 23.1, 31.2, and $63.0 \pm 3.93\%$ CP based on the in situ procedure; 32.5, 67.6, 67.5, 32.1, 48.8, 32.3, and $65.8 \pm 3.46\%$ CP based on the ammonia release procedure; and 28.8, 90.1, 93.5, 45.3, 66.8, 36.4, and $62.8 \pm 0.87\%$ CP based on the Cornell fermentation procedure. Across feedstuffs, ranking based on RUP was similar for all procedures. Rumen-undegradable estimates obtained using the Cornell fermentation procedure were greater ($P < 0.05$) for BM2, BM3, CM, and LFDG and similar ($P \geq 0.20$) for SBM and ESBM compared to the other procedures. For BM1, RUP estimated using the in situ procedure was lower ($P < 0.01$) compared to the in vitro procedures. Despite analytical differences, ranking of RUP values from the Cornell fermentation procedure was similar to the other procedures across feedstuffs.

Key Words: in situ, rumen-undegradable protein

ANIMAL BEHAVIOR, HOUSING, & WELL-BEING: FEED INTAKE AND LAMENESS IN LIVESTOCK

- 229 **Health and performance comparison of Pyramid 5 plus Presponse SQ versus Bovi-Shield Gold One Shot.** D. L. Hamlin^{1,*}, B. L. Vander Ley², W. J. Sexten³, C. A. Payne^{4,5}, S. Zuidhof⁶, C. A. Jones⁶, ¹University of Missouri, Columbia, ²Department of Veterinary Medicine and Surgery, University of Missouri, Columbia, ³Division of Animal Sciences, University of Missouri, Columbia, ⁴Department of Veterinary Medicine and Surgery, University of Missouri, Columbia, ⁵University of Missouri Extension, Columbia, ⁶Boehringer Ingelheim Vetmedica, Inc., St. Joseph, MO

Two hundred and sixty-five high risk crossbred steers (251.4 kg \pm 3.5) were used in a completely randomized design to compare the efficacy of two multivalent respiratory virus and bacteria combination vaccines on performance and health. Calves with unknown management and health history were purchased from 4 Missouri livestock auctions. On arrival calves received metaphylaxis and 7-way clostridial vaccine and were randomly assigned to pen and vaccine treatments, Bovi-Shield Gold One Shot (BSG) (Zoetis Animal Health, Kalamazoo, MI) or Pyramid 5 plus Presponse SQ (P5P) (Boehringer-Ingelheim Vetmedica). The objective was to identify differences in performance, health, and/or cost of gain (COG) between vaccine treatments. Calves were offered a ration containing an antimicrobial and coccidiostat for the initial 14 d. On d 14, calves were transitioned to a growing ration and revaccinated with their respective vaccine. Over the 70 d growing period vaccine did not influence treatment rate or mortality ($P > 0.05$). Initial BRD treatment rates for both treatment groups were 37.3%, with 12.3% treated twice and 3.3% treated three times. Treatment mortality was 5.4% for BSG and 2.9% for P5P. ADG (1.67 kg/d), DMI (6.78 kg/d), feed efficiency (0.246 kg/kg), and final BW (367.5 kg) were all reduced ($P < 0.05$) due to morbidity. Healthy calves had greater ADG (1.85 kg/d), DMI (7.25 kg/d), feed efficiency (0.257 kg/kg), and final BW (379.5 kg). A vaccine by morbidity interaction occurred for COG ($P < 0.05$). Deads out COG was lowest ($P < 0.05$) for healthy calves and not different ($P > 0.05$) due to vaccine. Deads out COG for morbid calves was intermediate for BSG and greatest for P5P ($P < 0.05$). Deads in COG was lowest ($P < 0.05$)

for healthy P5P, intermediate for healthy BSG, and greatest ($P < 0.05$) for morbid calves regardless of vaccine. Vaccine did not influence health or performance.

Key Words: cost of gain, morbidity, vaccine

- 230 **Relationship between lesions observed on farm and on the carcass and the influence of mixing pigs before slaughter.** N. van Staaveren^{1,2,*}, D. L. Teixeira², A. Hanlon¹, L. A. Boyle², ¹School of Veterinary Medicine, University College Dublin, Belfield, Dublin, Ireland, ²Pig Development Department, Teagasc Animal and Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork, Ireland

Lesions on the carcass can be included at meat inspection as indicators of pig welfare on farm. However, it is unknown how well carcass lesions reflect lesions observed on farm and how they are influenced by practices such as mixing in the preslaughter period. Three hundred pigs were sent to slaughter over 5 slaughter days. On the morning of slaughter pigs were randomly allocated to 1 of 3 treatments (n = 20/group; 6 focal pigs/group): boars unmixed (MUM), boars mixed (MM), and boars mixed with gilts (MF). Frequency of aggressive and mounting behavior after mixing was recorded. Skin and tail lesions were scored according to severity (0–5) on farm and on the carcass. Skin lesions were also recorded on focal pigs in the lairage. Loin bruising was assessed on the carcass according to severity (0–2). Correlations between skin and tail lesions as measured on the carcass and on the farm were calculated. Effect of treatment and time on behavior and lesions were analyzed by SAS V9.3 PROC MIXED. MM pigs performed more aggressive behavior than MUM (50.4 \pm 10.72 vs. 20.3 \pm 9.55; $P < 0.05$) and tended to perform more than MF pigs (37.2 \pm 10.77; $P = 0.06$). MM pigs performed more mounting than MF and MUM pigs (30.9 \pm 9.99 vs. 11.4 \pm 3.76 and 9.8 \pm 3.74, respectively; $P < 0.01$). MUM pigs tended to show a smaller increase in skin lesion score from farm to lairage than MF and MM pigs, and MM pigs showed a greater increase than MF pigs ($P = 0.08$). However, on the carcass no effect of mixing on skin lesions or loin bruising was found. No correlations were found between aggressive/mounting behavior and carcass skin lesions and loin bruising. Skin lesion score on the carcass was correlated with skin lesion score on farm ($r = 0.21$, $P < 0.01$). Similarly, carcass tail lesion score was positively correlated with farm tail lesion score ($r = 0.18$; $P < 0.01$). Mixing boars prior to slaughter stimulates mounting and aggressive behavior; however, the increase in these behaviors is not reflected in higher skin lesion or loin bruising scores on the carcass. Carcass skin and tail lesion scores

are correlated with those recorded on farm, suggesting that such information recorded at meat inspection could be used by farmers to inform their herd health/welfare plans.

Key Words: carcass lesions, entire male pigs, mixing

231 Does lameness affect the lying down sequence

in sows? J. A. Calderón Díaz^{1,*}, J. D. Stock²,
K. Stalder²¹*Department of Animal Science, Iowa State University, Ames,* ²*Iowa State University, Ames*

This study was designed to identify and pictorially depict differences in the lying down sequence (i.e., postures adopted and movements during the process) in nonlame and lame gestating sows. Ten multiparous sows (average parity 3.5 ± 1.6) with different degrees of lameness on the rear legs (lameness scored from 0 = nonlame to 5 = nonambulatory) were used for this study. Two sows were sound (score 0), 2 sows had a score of 1 (general stiffness, nonlame), 3 sows had a score of 2 (mildly lame), 2 sows had a score of 3 (lame, would not place weight on affected limb), and 1 sow had a score of 4 (severely lame). Sows were removed from their gestation stalls and moved to a gestation pen where they were video recorded for one lying down event after feeding time. The digital video camera was positioned at the rear of the individual pen where the profile of the sow was visible during video recording. Observations ceased when the sow successfully lied down. From the video recording, 10 picture frames per second were extracted using AVcutty v3.5, and postures and movements that occurred during the lying down sequence were identified. Finally, a set of three images per sow were selected to pictorially depict the lying down sequence. In the present study, we did not observe differences among lameness scores in the different postures or movements during the lying down sequence from the video recording. All the sows followed the lying sequences previously described by Seaton Baxter in 1984 where i) the sow drops into a kneeling position, ii) then the sow rotates the upper part of her body to bring a shoulder and side of the head to rest on to the floor, and iii) finally, the sow lowers her hindquarters and finishes in either ventral or lateral recumbency, except for the sow that received a lameness score of 4 that showed uncontrolled lying down behavior (i.e., losing control on one or more limbs and rapidly falling down) and finished the sequence in a “dog sitting” position. Results suggest that lameness scores do not greatly affect the lying down sequence. However, this could be due to the limited sample size and/or the fact that lameness recorded in this study was not severe enough to affect the lying down sequence. Further studies are required using a greater sample size that is more representative of all lameness scores.

Key Words: lameness, lying down sequence, pictorial depiction

Table 232. Correct classification (%) for postural behaviors in nursery pigs

Behavior	Series of 2 min	Individual extract
Active behaviors	97.1	91.2
Lying sternally	86.1	83.9
Lying on left side	89.1	85.5
Lying on right side	71.2	69.8
Average	85.8	82.6

232 Automated monitoring of swine behavior using accelerometers: Classification of behavior of nursery pigs from acceleration patterns.

S. Cui^{1,*}, J. E. Anderson², L. Wang¹, J. Deen³, Y. Li¹, ¹*West Central Research and Outreach Center, University of Minnesota, Morris,* ²*University of Minnesota, Morris,* ³*University of Minnesota, St. Paul*

Behavioral monitoring is essential for animal welfare research. This study was to validate automated monitoring of swine behavior using accelerometers. Twelve pens of 8 pigs weaned at 4 wk were used. In each pen, 4 focal pigs were selected randomly for behavioral monitoring which occurred at 5 wk and 7 wk of age. Each focal pig was fitted with a digital accelerometer (Onset Pendant G. Data Logger) on the rear leg, which recorded instant acceleration in 3 dimensions at 10 s intervals for 24 h. During the same period, behaviors of focal pigs were recorded continuously using digital cameras. Video recordings were viewed to register four postural behaviors (lying on right side, lying on left side, lying sternally, and active behaviors consisting of standing, walking, eating, and drinking) that the pigs were performing continuously for 2 min. A total of 1,276 two-minute observation sets were collected from the video recordings, including 618 sets for active behaviors, 330 for lying sternally, 182 for lying on left side, and 146 for lying on right side. Acceleration data series corresponding to each behavior were extracted, resulting in a total of 16,579 individual extracts taken from the accelerometers every 10 s. The Discriminant Analysis Procedure of SAS (Enterprise Miner, Version 12.3) was used to predict each behavior using the acceleration data. Data were randomly divided into training and evaluation data sets, each containing approximately half the individual extracts for each behavior. The variables used to classify behavior were the instantaneous accelerations in the x, y, and z directions, the magnitude of the acceleration vector, and the angle tilts for the x, y, and z components. On average, 83% individual extract and 86% series of 2 min were classified correctly for the four behaviors (Table 232). The correct classification was the highest for active behaviors and the lowest for lying on right. The classification results suggest excellent ability for the classification model to distinguish between four postural behaviors but difficulty distinguishing between active behaviors like standing, walking, drinking, and eating in nursery pigs.

Key Words: accelerometer, behavior, pigs

233 **Behavior of groups of gestating sows on electronic feeders under commercial conditions.** K. Vande Pol^{1,*}, M. Ellis¹, C. Carrillo-Espino¹, J. Guldner¹, S. Vootkur¹, B. A. Peterson², A. M. Gaines², ¹*University of Illinois at Urbana-Champaign, Urbana, IL*, ²*The Maschhoffs, Carlyle, IL*

Group-housing systems for gestating sows using electronic sow feeders (ESF) offer producers an alternative to gestation stalls. However, little is known about the behavior of sows fed using ESF under typical commercial conditions. Such information could facilitate improvements in design and management of ESF systems. This preliminary observational study evaluated the behavior of sows in mixed-parity (\geq parity 1) static groups fed using an ESF in a commercial gestation housing facility which consisted of 20 pens (capacity of 80 sows/pen) with 1 ESF/pen. This study involved 2 of the ESF pens (A and B) and used video cameras to continuously record behavior at the entrance to the ESF over 4 d. Group size and floor space for pens A and B were 74 and 75 sows and 1.79 and 1.77 m²/sow, respectively; sows in both pens were in wk 12 of gestation. The ESF in Pen A was a modified design, with an additional gate at the entrance, in an attempt to reduce the number of multiple entries (i.e., when more than 1 sow enters the ESF at sow changeover), a potential cause of aggression. A changeover was defined as when a sow entered the ESF (either fully or partially) and included feeding and nonfeeding visits. The feeding cycle started at 1500 h each day. The number of sows entering the ESF was recorded for each changeover over the 4-d period. Differences between pen means, based on feeder-related behavior for each 24-h period of the 4-d study period, were evaluated using a chi-square test. The total number of entries per day to the ESF averaged (mean \pm standard deviation) 158.6 \pm 23.9, and there was a trend ($P = 0.10$) for feeder entries to be less for Pen A than B (144.0 \pm 8.8 and 173.3 \pm 23.0/d, respectively). The number of feeding entries was similar ($P > 0.05$) for the 2 pens (76.5 \pm 1.9 and 78.5 \pm 4.7/d for A and B, respectively); however, the number of nonfeeding entries was less ($P < 0.05$) for Pen A than B (67.5 \pm 9.0 and 94.8 \pm 24.7/d, respectively). The number of multiple entries to the feeder was less ($P < 0.05$) for Pen A than Pen B (11.3 \pm 2.5 and 27.5 \pm 10.8/d, respectively). The results of this preliminary observational study provide insights into the behavior of sows using ESF under commercial conditions and suggest that the ESF design may modify feeder related behavior, an area that warrants further research.

Key Words: electronic sow feeder, sow behavior, sow housing system

234 **Physiological characteristics of slow growing pigs from birth to market.** Y. He^{1,*}, J. Deen², G. C. Shurson¹, Y. Li³, ¹*Department of Animal Science, University of Minnesota, St. Paul*, ²*University of Minnesota, St. Paul*, ³*West Central Research and Outreach Center, University of Minnesota, Morris*

In all-in/all-out production systems, pigs that cannot reach desired market weight according to pig flow schedules are sold at much lower value than their contemporaries. The objective of this study was to identify characteristics of these pigs in order to understand physiological causes of slow growth. Growth performance of 440 pigs was monitored from birth to marketing. Pigs were weighed individually at birth, weaning (4 wk), nursery exit (9 wk), and marketing (22 to 25 wk). To evaluate the competitive ability of pigs at the feeder, feed consumption rate was measured on 96 focal pigs at 8 wk of age, consisting of the 2 heaviest and 2 lightest pigs from each of 24 randomly selected pens. Blood samples were collected from 48 focal pigs in 12 pens at nursery exit and marketing to analyze for essential amino acids, growth hormone, IGF-I, and leptin concentrations. In addition, loin muscle area (LMA) and backfat thickness (BF) were measured for all pigs using a real-time ultrasound imaging scanner at 22 wk. Pigs were categorized as slow, average, and fast growers based on market weight adjusted to 170 d of age (slow growers < 105 kg, average growers between 105 and 125 kg, and fast growers > 125 kg). The Mixed Procedure of SAS was used to compare differences among the pig categories. Compared with fast growers, slow growers had lighter weight at birth (1.13 vs. 1.64 kg, SE = 0.18; $P < 0.01$), weaning (5.1 vs. 8.1 kg, SE = 0.51; $P < 0.01$), and nursery exit (18.6 vs. 28.0 kg, SE = 1.97; $P < 0.01$), ate slower (14.2 vs. 18.1 g/min, SE = 1.79; $P = 0.01$), and had less BF (1.8 vs. 2.3 cm, SE = 0.05; $P < 0.01$) and smaller LMA (32.0 vs. 41.8 cm², SE = 1.58; $P < 0.01$). The concentration of IGF-I at nursery exit was positively correlated with final BW ($R^2 = 0.36$, $P < 0.01$) and ADG during the grower-finisher period ($R^2 = 0.19$, $P < 0.01$), indicating low IGF-I concentrations may be associated with slow growth. Concentrations of essential amino acids, growth hormone, and leptin did not differ among pig categories. These results suggest that slow growing pigs can be identified before nursery exit by light weights, slow eating rates, and low concentrations of IGF-I.

Key Words: hormones, pigs, slow growth

235 **Identifying risk factors of slow growth of pigs from birth to marketing.** Y. He^{1,*}, G. C. Shurson¹, Y. Li², J. Deen³, ¹*Department of Animal Science, University of Minnesota, St. Paul*, ²*West Central Research and Outreach Center, University of Minnesota, Morris*, ³*University of Minnesota, St. Paul*

Pigs that grow significantly slower (slow-growing pigs) than their contemporaries may experience complication in animal

welfare. Identifying risk factors of slow growth can help producers develop management strategies to mitigate this problem. The objective of this study was to evaluate factors associated with slow growth of pigs from birth to marketing. Risk factors evaluated included farrowing location (bedded group pens vs. crates), feeder space allowance during nursery (5 vs. 2 feeder spaces/pen of 8 pigs), dam parity (parity = 1 vs. parity > 1), total litter size born (≤ 14 vs. > 14), gender, weight at birth, weaning (4 wk), and nursery exit (9 wk). Pigs ($n = 440$) farrowed by 65 sows (parity = 1 to 7) were studied. Pigs were categorized as slow, average, and fast growers based on market weight adjusted to 170 d of age (slow growers < 105 kg, average growers between 105 and 125 kg, and fast growers > 125 kg). The Mixed Procedure of SAS with repeated measures was used to compare the growth performance from birth to marketing among the pig categories. The Logistic Procedures were used to identify risk factors of slow growth. Slow growers accounted for 10%, average growers for 49%, and fast growers for 41% of pigs marketed. On average, slow growers needed an extra 20 d to reach the target market weight of 115 kg compared with fast growers. Pigs that were lighter than the 30th percentile at birth (≤ 1.36 kg), at weaning (≤ 6.4 kg), and at nursery exit (≤ 20.0 kg) were 4 (odds ratio, Confidence Interval (CI) = 2.0 to 6.6; $P < 0.001$), 6 (CI = 3.0 to 10.3; $P < 0.001$), and 18 times (CI = 7.9 to 39.9; $P < 0.001$), respectively, more likely to become slow growers. Compared with barrows, gilts (odds ratio = 2.2, CI = 1.2 to 4.0; $P = 0.01$) were more likely to become slow growers. Less feeder space allowance (odds ratio = 1.8, CI = 1.0 to 3.3; $P = 0.05$) during the nursery period was a risk factor for slow growth. Litter size, dam parity, and farrowing location were not associated with slow growth. These results suggest that light BW before nursery exit, gender, and feeder space allowance during the nursery period are risk factors of slow growth.

Key Words: pigs, risk factors, slow growth

236 Water disappearance rates in late-finishing pigs.

C. Bernhard^{1,*}, A. Nelson¹, N. S. Grohmann¹, M. Ellis¹, T. E. Weber², M. J. Ritter², ¹University of Illinois at Urbana-Champaign, Urbana, ²Elanco Animal Health, Greenfield, IN

There is limited contemporary published information on the water intake of finishing pigs, particularly to heavier BW typical for the industry. Such information is essential when estimating concentrations of products to be delivered via the water supply. The objective of this study was to measure water disappearance rates of late-finishing pigs kept at typical floor spaces and taken to relatively heavy weights. The study was carried out over a 5-wk period at a research facility of the University of Illinois using 60 pigs grown from 96.3 ± 0.02 kg to 128.4 ± 1.68 kg BW. Pigs were kept in groups of 10 at a floor space of 0.62 m²/pig and had ad libitum access to feed and water. Diets were based on corn and soybean meal, were

formulated to meet the recommendations of NRC (2012), and were in meal form. Water was provided via one cup-type drinker/pen, and a water meter was installed in the water line before the drinker to measure the volume of water delivered within a range of $\pm 1.5\%$. Water meter readings were taken 3 times/d at 07:00, 12:00, and 17:00. Pigs were weighed at the start and end of the study, and the amount of feed delivered to the feeders was recorded. Overall ADG, ADFI, and G:F were 0.94 ± 0.047 kg, 3.20 ± 0.072 kg, and 0.295 ± 0.0106 kg/kg, respectively. Water disappearance averaged 10.85 ± 1.996 L·pig⁻¹·day⁻¹ with a range across pens from 8.83 to 14.04 L·pig⁻¹·day⁻¹. Data for the three daily time periods (07:00-12:00; 12:00-17:00; 17:00-07:00) were analyzed using the Proc Mixed procedure of SAS, with the model used including the fixed effect of time period and the random effect of replicate (pen). The three daily time periods had different ($P < 0.001$) water disappearance rates. Water disappearance was greatest during the afternoon, least during the night, and intermediate during the morning (0.87, 0.26, and 0.64 L·pig⁻¹·h⁻¹ for the periods from 12:00-17:00, 17:00-07:00, and 07:00-12:00, respectively, SEM 0.052). This study provides data on water disappearance, which includes both water intake and wastage, of late-finishing pigs kept at commercial floor spaces to BW that are typical for the industry.

Key Words: late finishing, pig, water intake

237 Influence of feeding approaches, adaptation length, and direct-fed microbial inclusion on animal temperament and relationships with growth performance, feeding behavior, and carcass characteristics in feedlot steers.

J. J. Gaspers*, K. C. Swanson, J. M. Young, T. C. Gilbery, S. R. Underdahl, M. L. Bauer, G. P. Lardy, G. L. Stokka, North Dakota State University, Fargo

Crossbred steers (391 ± 2.8 kg, $n = 113$) were assigned randomly to a $2 \times 2 \times 2$ factorial arrangement of treatments ($n = 14$ or 15 per treatment) to determine the effects of conventional vs. natural feeding approaches (using monensin, tylosin, trenbolone acetate, and estradiol vs. none), grain adaptation length (14 vs. 28 d), and direct-fed microbial supplement (DFM; with or without) containing live microorganisms and fermentation extracts. Diets consisted of corn, dried corn distillers grains with solubles, and 10% forage (hay and corn silage). Individual feed intake and feeding behavior was monitored using the Insentec roughage intake control system (Insentec, B. V., Marknesse, the Netherlands). Weights were taken on two consecutive days at the beginning and the end of the trial and once every 28 d throughout. While weighing, temperament data were taken using chute score (1 = calm to 5 = struggling continuously), exit score (1 = walk to 4 = gallop), and exit velocity (m/s). Chute score, exit score, and exit velocity were negatively correlated with HCW and marbling ($P < 0.05$). Temperament scores did not have significant correlations with

feeding behavior or growth performance. Average DMI was positively correlated with time spent at feeder, number of visits, ADG, HCW, yield grade, marbling, and back fat ($P < 0.05$). Time spent at feeder was positively correlated with number of meals, ADG, and HCW ($P < 0.05$). Number of visits per day was negatively correlated with G:F ($P = 0.008$). The number of meals per day was negatively correlated with marbling ($P = 0.05$). Average daily gain was positively correlated with G:F, HCW, and back fat ($P < 0.05$) and negatively correlated with KPH ($P = 0.05$). Steers that were adapted over 14 d had higher chute scores, exit scores, and exit velocities than steers on the 28 d adaptation treatment. Conventionally fed steers had increased exit velocities ($P = 0.005$) compared to naturally fed steers. Chute scores and exit scores decreased over the 140 d trial while exit velocities increased ($P < 0.001$). Temperament may be associated with differences in HCW and marbling. Approaches and adaptations to feeding finishing diets may have an impact on temperament of cattle in the feedlot.

Key Words: direct-fed microorganism, finishing cattle, implants, ionophores, temperament

BREEDING AND GENETICS

238 Differences in feed efficiency during the nursery phase of pigs divergently selected for residual feed intake during grow-finish phase. J. R. Steckelberg*, E. D. Mauch, A. M. Dannen, N. V. L. Seroa, J. C. M. Dekkers, *Iowa State University, Ames*

Feed is the largest variable cost in swine production. Since 2001, purebred Yorkshire pigs at Iowa State University have been divergently selected for residual feed intake (RFI) during the grow-finish phase, with one line selected for increased feed efficiency (Low RFI line) and the other line selected for decreased feed efficiency (High RFI line). The performance of the RFI lines during the grow-finish phase has been extensively investigated, but little is known about these selection lines during the nursery phase. Therefore, the objective of the study was to evaluate the effects of selection for RFI in the grow-finish phase on feed efficiency during the nursery growth phase. Piglets from generation 10 of the RFI lines were evaluated for differences in average daily feed intake (ADFI), average daily gain (ADG), and feed conversion rate (FCR) during the nursery phase. Weaning-age piglets (27 ± 3 days) were group penned by litter (Low RFI: $n = 26$; High RFI: $n = 16$), with 9.5 ± 2.4 and 9.0 ± 2.6 piglets per pen for Low and High RFI, respectively, and pen feed intake was recorded for approximately 39 days. Weights were collected on all piglets ($n = 394$) at the beginning and end of the test period. ADFI, ADG, and FCR were calculated on a pen basis. Statistical analyses were run in SAS using a mixed procedure with a fixed effect of line and weighted by number of pig-

lets per pen. Results showed that Low RFI litters consumed less feed ($P < 0.0001$) and gained less weight on average ($P = 0.02$) than High RFI litters during the nursery period. Low RFI litters also had a lower FCR than the High RFI litters ($P < 0.001$). The average ADFI was 0.54 and 0.67 kg/day for the Low RFI and High RFI lines, respectively. Average ADG estimates were 0.39 kg/day for the Low RFI line and 0.43 kg/day for the High RFI line. The Low RFI litters had an average FCR of 1.39 (kg feed/kg gain) compared to 1.58 for the High RFI line. In conclusion, piglets selected for increased feed efficiency based on RFI during the grow-finish phase also consumed less feed and had increased feed efficiency during the nursery phase. However, similar to the grow-finish phase, growth rate was also slightly lower for the low RFI line in the nursery phase. A second replicate to validate these findings is currently underway. Funding provided by AFRI-NIFA grant #2011-68004-30336.

Key Words: feed intake, nursery piglets, RFI

239 Impact of harvest weight on the relative growth performance and carcass characteristics of progeny of two swine sire lines. N. S. Grohmann^{1,*}, M. Ellis¹, C. M. Shull², B. A. Peterson², ¹*University of Illinois at Urbana-Champaign, Urbana*, ²*The Maschhoffs, Carlyle, IL*

The relative performance of the progeny of 2 sire lines was evaluated with a total of 2784 pigs in a commercial wean-to-finish facility to determine the impact of sire line and gender on growth performance and carcass characteristics of pigs sent for harvest at 4 harvest weights (111, 125, 138, and 145 kg). Separate studies were conducted within each harvest weight (HW); each study used a RCBD with a 2×2 factorial arrangement of treatments: 1) sire line (A vs. B) and 2) gender (barrows vs. gilts). Pigs were housed from weaning (6.7 ± 0.31 kg BW) to the respective HW in groups of 29 with ad libitum access to feed and water. Within each HW, pigs were sent for harvest in 4 groups over a 5-wk period at a commercial facility, and standard carcass grading measures were collected. Final pen mean BW for the 4 studies were 111.1 ± 2.95 , 122.0 ± 2.23 , 134.5 ± 2.56 , and 141.6 ± 2.63 kg, respectively. Barrows had greater ($P < 0.05$) overall ADG and ADFI and 10th rib backfat depth than gilts at all HW but similar ($P > 0.05$) overall G:F. The two sire lines had similar ($P > 0.05$) ADG at the 2 lighter HW; Line A grew faster ($P = 0.004$) than Line B at HW of 138 kg (22.7 g/d) and tended to grow faster ($P = 0.09$) at HW of 145 kg (13.6 g/d). Line A had lower ($P < 0.05$) ADFI than Line B at the 2 lighter HW [1.83 vs. 1.87 kg/d (SEM 0.028) at 111 kg; 1.92 vs. 1.97 kg/d (SEM 0.035) at 125 kg], but at the 2 heavier HW there was no difference ($P > 0.05$) between the lines for ADFI. Line A had greater ($P < 0.05$) G:F than Line B at all HW except at 138 kg HW, for which there was no difference ($P > 0.05$) between the lines. Carcass yield was lower ($P < 0.05$) for Line A than B at the 2 heavier HW [74.8% vs. 75.2% (SEM

0.15) at 138 kg HW; 74.8% vs. 75.5% (SEM 0.10) at 145 kg HW]; however, at the 2 lighter HW the lines had similar ($P > 0.05$) carcass yield. Line A had lower ($P < 0.05$) 10th rib back-fat depth but similar ($P > 0.05$) *Longissimus* muscle depth at all HW. These results suggest that when evaluating sire lines for growth and carcass characteristics, the final BW can influence the difference between the lines.

Key Words: harvest weight, pig, sire line

240 **Association of IgG concentration in colostrum with diarrhea in piglets born to Minpig and Landrace sows.**

S. Cui^{1,*}, X. Huang¹, Y. Xu¹, X. Wang¹, Y. Li², ¹Northeast Agricultural University, Harbin, China, ²West Central Research and Outreach Center, University of Minnesota, Morris

Minpig is a native breed in northeastern China, well known for its good meat quality, high prolificacy, and high resistance to disease. Diarrhea in piglets is a common disease that can cause significant losses for swine producers. To investigate resistance of Minpig to diarrhea, 31 Minpig sows and their 335 piglets were compared with 35 Landrace sows and their 351 piglets. The two breeds of sows were housed in pens on solid concrete floors in two identical rooms. From birth to weaning (5 wk), the feces and anus of all piglets were scored daily to assess the severity of diarrhea using the following criteria: no diarrhea (score = 0) indicates that feces appeared normal; slight diarrhea (score = 1) indicates that feces formed soft blobs but had thick liquid substance; moderate diarrhea (score = 2) indicates that feces were loose and pulpy with semiliquid substance; severe diarrhea (score = 3) indicates that feces were watery, had no solid pieces, and were entirely liquid with mucus and pus. Litter diarrhea index during lactation was calculated using the following equation: litter diarrhea index (LDI) = total fecal scores in a litter/total number of piglets nursed by the sow. Colostrum samples were collected from all sows at 0 h and 12 h after farrowing to determine concentrations of IgG using ELISA. Compared with Landrace sows, Minpig sows had a higher accumulative amount of IgG (830.61 ± 67.58 vs. 742.49 ± 80.47 ; $P < 0.05$) between 0 h and 12 h in colostrum (IgG0-12, the area of trapezoid under a line between 0 h and 12 h where the x axis represented the time after farrowing and the y axis represented the IgG concentration at that time). In addition, IgG0-12 was negatively correlated with LDI in both breeds ($r = -0.5189$ for MinPig, $P < 0.05$; $r = -0.5077$ for Landrace, $P < 0.05$). Sows were categorized as slight, moderate, and severe diarrhea groups based on LDI according to the Fisher method and Fastclus process. No severe diarrhea group was observed in Minpig sows. Compared with Landrace sows, Minpig sows had higher IgG0-12 in both slight (885.30 ± 58.02 vs. 786.93 ± 35.91 ; $P < 0.01$) and moderate (775.79 ± 31.74 vs. 698.19 ± 56.82 ; $P < 0.05$) diarrhea groups. These results suggest that IgG concentrations in colostrum can be associated with the resistance of piglets to diarrhea, and high IgG levels

in the colostrum of Minpig sows result in stronger resistance of Minpig piglets to diarrhea compared with Landrace piglets.

Key Words: colostrum, diarrhea, Landrace, Minpig, piglet

241 **Identification of early blood differentially expressed genes between two pig lines divergently selected for feed efficiency: Potential biomarkers for feed efficiency.**

H. Liu^{1,*}, Y. Nguyen², D. Nettleton³, J. C. M. Dekkers⁴, C. K. Tuggle¹, ¹Bioinformatics and Computational Biology Program, Department of Animal Science, Iowa State University, Ames, ²Department of Statistics, Iowa State University, Ames, ³Bioinformatics and Computational Biology Program, Department of Statistics, Iowa State University, Ames, ⁴Iowa State University, Ames

Improving feed efficiency (FE) of domestic animals is of economic, social, and environmental significance. However, measuring FE is expensive and time-consuming. Thus, predictive biomarkers for FE are greatly needed. In this study, we attempted to identify early stage differentially expressed genes (DEGs) between two Yorkshire lines of pigs divergently selected for FE based on residual feed intake (RFI), with an ultimate goal of developing early biomarkers for FE. Blood samples were collected at 35–42 days of age from Generation 9 piglets of the two lines, which were later randomly assigned to two diets with different fiber and energy contents, and each pig's RFI was measured. We also measured the complete blood count (CBC) of all blood samples. Blood samples of 8 animals with extremely low RFI for the low RFI line and extremely high RFI for the high RFI line on each diet were selected for RNA sequencing, with one sample dropped due to low RNA quality. Globin transcripts were depleted by an RNase H-mediated method before RNA-seq library construction. After backward feature selection, the model for read counts included line, CBC covariates (neutrophil, lymphocyte, monocyte, and basophil), and technical variables (processing batch, RNA concentration before globin depletion, RNA integrity number (RIN) after globin depletion). Using the QuasiSeq package, we found 454 DEGs ($q \leq 0.05$) between the two lines, with 50 DEGs with fold change ≥ 2 . With the high RFI line as a reference, gene ontology-biological process (GO-BP) terms, including the small molecule biosynthetic process, lipid biosynthetic process, steroid biosynthetic process, and positive regulation of immune system process, were overrepresented among up-regulated genes, while signaling, the RNA biosynthesis process, and cellular response to stimulus were overrepresented among down-regulated genes ($q \leq 0.15$). Weighted gene coexpression network analysis showed that the eigengene expression in 4 modules was highly associated with lines ($P < 3.9E-07$, $R^2 > 0.59$), and GO-BP terms of the lipid metabolic process, lipid biosynthetic process, steroid biosynthetic process, and response to

Table 242. Estimates of F, EBV, true BV (\pm SE), and accuracy in G861 for heritability 0.3

	Pedigree selection			Genomic selection		
	90 Groups	18 Groups	9 Groups	90 Groups	18 Groups	9 Groups
F, %	8.2 \pm 0.1	6.3 \pm 0.1	6.2 \pm 0.1	2.6 \pm 0.0	2.3 \pm 0.0	2.2 \pm 0.0
EBV	4.53 \pm 0.03	4.48 \pm 0.03	4.48 \pm 0.03	6.47 \pm 0.10	6.39 \pm 0.10	6.49 \pm 0.10
True BV	4.55 \pm 0.06	4.50 \pm 0.06	4.50 \pm 0.06	6.42 \pm 0.10	6.39 \pm 0.10	6.39 \pm 0.10
Accuracy	0.540	0.525	0.530	0.852	0.850	0.849

stimulus were overrepresented among the top 2 modules. We will use qRT-PCR to validate the DEGs of ≥ 2 -fold change in the original samples and new representative samples of the two lines. Taken together, this study suggests that the blood expression level of genes involved in several biosynthetic processes might be related to the difference in FE of the two lines. In the future, the identified DEGs and genes highly associated with line will be further validated and selected to build a bio-marker-based classifier for FE. Support from USDA-NIFA-AFRI-2011-68004-30336 is acknowledged.

Key Words: differentially expressed genes, feed efficiency, pig

242 A simulation study on the effect of nested vs. factorial mating on response to pedigree and genomic selection. W. L. Hsu^{1,*}, R. L. Fernando¹, J. C. M. Dekkers¹, J. Arango², P. Settar², J. E. Fulton², N. P. O'Sullivan², A. Wolc^{1,2}, ¹*Iowa State University, Ames*, ²*Hy-Line International, Dallas Center, IA*

The objective was to investigate the effect of nested vs factorial mating on genetic gain and inbreeding (F) in 10 generations (G) of selection. Phenotypes and marker genotypes were simulated following 850 generations of random mating in a population size of 500 (G0-800) and 100 (G801-850) to generate linkage disequilibrium between loci. The trait was controlled by 500 QTL randomly distributed across 20 chromosomes (30 morgans), and genomic selection was based on 50,000 randomly distributed SNPs. QTL effects were from a normal distribution and scaled to simulate a heritability of 0.1, 0.3 or 0.5. The QTL and marker loci were chosen to have minor allele frequency ≥ 0.01 . Selection based on pedigree (BLUP) or genomic EBV started in G851. Genomic EBVs were predicted using GenSel-BayesB with training data from all previous generation(s). Three mating designs were compared; the first was nested mating each with 90 sires mated to 6 dams (90 mating groups); the second and third were partial factorial designs with random mating of 5 sires with 30 dams in each of 18 groups or 10 sires and 60 dams in each of 9 groups. In the designs, full- and half-sib matings were avoided, and in the factorial designs a dam was allowed to mate with more than 1 sire. Each generation, 1,350 male progeny without records and 2,700 female progeny with records were simulated. Based on EBV, the top 90 males and 540 females were selected to be parents of the next generation. The average EBV, true BV, accuracy, and pedigree-based F were computed from 100 repli-

cates for each design (Table 242). Results were consistent for three levels of heritability. After 10 generations of pedigree or genomic selection, F was significantly higher ($P < 0.05$) for the nested than for the factorial designs. The mating systems had no significant effect on response to either pedigree or genomic selection, but genomic selection had greater response and less inbreeding than pedigree selection.

Key Words: factorial mating, genomic selection, nested mating

243 Timing of ovulation in gilts relative to last Matrix feeding. B. L. Quick^{*}, T. J. Safranski, *University of Missouri, Columbia*

Previous research has shown 85% of gilts treated with Matrix will show estrus 4–9 days after last Matrix feeding. Although these data are helpful in establishing when to AI, it would be beneficial to have a better understanding of timing of ovulation and not just have a range of timing of estrus. In this study we wanted to see if we could assess timing of ovulation in Matrix-treated gilts by performing transrectal ultrasonography. Between June and August of 2014, 3 groups consisting of 10 cycling gilts each were used to evaluate timing of ovulation relative to last Matrix feeding using transrectal ultrasonography. These groups consisted of Landrace or Landrace/Large White gilts (Choice Genetics USA) with an average age of 7.5 months and an average of 2 estrous cycles prior to Matrix feeding over all 3 groups. Gilts were housed in gestation stalls in a mechanically ventilated barn during the duration of this study. Each gilt was fed 15 mg of Matrix daily for 14 d per label instructions. Transrectal ultrasonography was performed starting 24 hours after last Matrix feeding and then at 4 hour (n = 10) or 6 hour (n = 20) intervals, continuing until each gilt ovulated or until day 9, whichever came first; 4 gilts did not ovulate. Ovulation was determined by either visualization of CL or the absence of follicles for 2 subsequent scans. From our results, we concluded that timing of ovulation relative to last Matrix feeding was found to be 134.6 \pm 13.4 hours (5.6 \pm 0.56 days). Estrus detection was not performed during this study, but estrus detection performed at this farm typically finds that average estrus occurs at day 5.9 after last Matrix feeding. Having greater knowledge of timing of ovulation relative to last Matrix feeding may allow investigation into more precise timing of insemination.

Key Words: gilt, Matrix, ovulation

244 **Hair coat shedding and the relationship with productive traits in beef cattle.** L. D. Watson^{1,*}, B. Kutz¹, J. G. Powell², A. H. Brown Jr.², ¹University of Arkansas, Fayetteville, ²Department of Animal Science, University of Arkansas Division of Agriculture, Fayetteville

The objective of this study was to determine potential relationships of hair coat shedding with phenotypic data for cow age, body weight of cow at weaning, body condition score of cow at weaning, body weight of cow preweaning, body condition score of cow prebreeding, pregnancy rate, birth weight of calf, and calf weaning weight. Over a three year period mature cows and replacement heifers ($n = 555$) were scored for coat shedding on a scale from 1 to 5 at approximately 28-day intervals. A score of 5 indicated the cow had a full winter coat, and a score of 1 represented a slick, short summer coat. For each cow, the first month a score of 3 (approximately 50% shed) or less was reached was considered the month of first shedding (MFS), and MFS occurred in May, June, or July. Data were analyzed in general linear model or frequency and correlation procedures of SAS. Cows exhibiting MFS in May were older ($P < 0.01$) compared to cows exhibiting MFS in July and intermediate for cows exhibiting MFS in June, with ages of 6.77, 6.0, and 5.02 years of age, respectively. Calf birth weight was heaviest ($P = 0.015$) for cows exhibiting MFS in May and lightest for cows exhibiting MFS in July. Calf weaning weight was similar ($P = 0.8$) for all MFS categories, with May, June, and July cows exhibiting calf weaning weights of 206.7, 205, and 204.3 kg, respectively. Cow body weight at weaning was heaviest ($P = 0.05$) in cows exhibiting MFS in May (525.4 kg) and lightest in cows with MFS in July (450.6 kg). No differences were noted in body condition score of cows at weaning or of cows prebreeding. Overall pregnancy rate tended to be higher ($P = 0.085$) for cows exhibiting MFS in May (91.4%) and lowest in cows with MFS in July (86.7%). Cow MFS was correlated ($P < 0.05$) with cow age ($r = -0.179$), calf birth weight ($r = -0.092$), cow body weight ($r = -0.201$), and prebreeding cow body weight ($r = -0.187$). In these data, MFS score had a tendency to impact pregnancy rates. Shedding of the winter hair coat was noted to be related to cow age, maternal body weight at weaning, and calf birth weight.

Key Words: cattle, hair coat, shedding

245 **Economic gain associated with genomic selection for health in a terminal sire line in pigs.** C. M. Dematawewa^{1,*}, A. Grosse Holthaus², H. Simianer³, J. C. M. Dekkers¹, ¹Iowa State University, Ames, ²University of Göttingen, Göttingen, Germany, ³Georg-August-University, Göttingen, Germany

Commercial application of genomic selection (GS) for health depends on economic gains possible relative to costs. The ob-

jective of this study was to determine improvements in the overall breeding goal (ΔH) and discounted net returns ($\Delta\Omega$) from incorporating genomic selection for health in a terminal sire line breeding program in pigs. A sire line with 40 boars and 1000 sows was simulated deterministically using ZPLAN+ software. Each dam produced 8 piglets/litter (4 males, 4 females) and 20 piglets/year. Selected males and females started breeding at one year of age and continued for 1 and 2 years, respectively. Selected males (40) were mated to 50,000 crossbred females (Large White \times Landrace) to produce commercial piglets. Days to market weight (DAYS) and backfat thickness (BF) (heritabilities of 0.4 and 0.5 and economic weights of $-\$1.77$ and $-\$1.70$ per genetic SD, respectively) were recorded on all animals in the nucleus. A health trait (HEALTH) was defined with a genetic SD of 1.0 (heritability = 0.05) and an economic weight that was half of (case A) or equal to (case B) that of DAYS. Three scenarios were considered for trait correlations. Absolute values of all phenotypic and genetic correlations were 0.3 and 0.2, respectively. All genetic and phenotypic correlations were positive except between DAYS and BF for Scenario I and between DAYS and the other two traits for Scenario III. The planning horizon was 10 years (discount rate = 0.05). Fixed and variable costs at the nucleus were \$50 and \$300 per animal, with additional costs of \$100 for genotyping and \$10 for recording HEALTH. Inclusion of genomic predictions for HEALTH in selection indexes for sires and dams increased ΔH per year and $\Delta\Omega$ over the planning horizon when accuracy of genomic prediction ($r_{MG-HEALTH}$) was increased, mainly due to greater genetic gain in HEALTH. Scenario III (with favorable correlations) with case B showed the highest genetic and economic gains. At $r_{MG-HEALTH}$ of 0.8, ΔH and $\Delta\Omega$ for Scenario III (case B) were \$101.33/year and \$510.83/sow in the nucleus, compared to \$86.11/year and \$396.93/sow without GS. However, the highest extra responses at $r_{MG-HEALTH}$ of 0.8 were under Scenario I (case B), with increases of 28.9% for ΔH and 135.5% for $\Delta\Omega$, partly because of low responses without GS. These responses indicate the potential of implementing GS for health in commercial scenarios. Funding was provided by Genome Canada.

Key Words: genomic selection, health, swine breeding

EXTENSION – BEEF/SMALL RUMINANT

246 **Effect of estrus activity when evaluating feed efficiency in heifers.** G. R. Dahlke^{1,*}, P. J. Gunn², ¹Iowa State University, Ames, ²Department of Animal Science, Iowa State University, Ames

The objective of this trial was to evaluate the impact estrus activity has on feed efficiency measurements. Virgin, yearling, Angus and Sim-Angus heifers from six weaning contemporary groups numbering 169 total head were placed into a 70 day feed

intake trial as described by the Beef Improvement Federation guidelines. All heifers received Kamar estrus detection patches at the start of the trial to assist in estrus detection. Daily, individual animal feed dry matter intake was measured, and estrus activity was monitored. At the end of the trial the number of estrous cycles along with the calculated residual feed intake (RFI) and residual gain (RG) were evaluated for each animal using the SAS PROC MIXED procedure. Heifers that did not show any estrus activity, those that appeared to undergo puberty and display their first estrous cycle, and those that showed consistent estrous cycles were compared. Those animals that appeared to undergo puberty and display their first estrous cycle while on test showed poorer RFI ($P < 0.11$) and RG ($P < 0.05$) when compared to those that did not cycle. When compared with those that consistently cycled, the same pattern continued with RFI ($P < 0.03$) and RG ($P < 0.02$). The animals that cycled consistently and those that did not show any estrus activity did not appear to differ with RFI ($P < 0.34$) and RG ($P < 0.34$).

Key Words: estrus, heifers, RFI

247 **Effects of diet, housing, and season systems on feedlot cattle finishing programs.** J. G. Njoka*, M. P. Hoffman, P. J. Berger, L. L. Schulz, Iowa State University, Ames

A four-year study was conducted using yearling steers ($n = 1,987$; BW average weight was 318 kg) of mixed British breeds. The overall objectives of this study were to evaluate feedlot performance, carcass characteristics, and expected economic projections when steers were placed on feed at the beginning of each season in different diet-housing systems. Diets were 1) a mixture of processed high moisture corn grain (77% DM) and whole plant corn silage and 2) a whole plant corn silage diet (35% DM). In addition, protein, vitamin, and mineral supplement was provided to meet dietary requirements. Housing consisted of 1) shelter (open lot with access to overhead shelter), 2) no shelter (open lot without access to an overhead shelter but provided with a windbreak), and 3) confinement (open front-side confinement barn). PROC MIXED of SAS was used for analysis with pen ($n = 20$) as the experimental unit. The effects of diet, housing, season, and year influenced ADG ($P < 0.001$), as well as the interaction of diet \times season ($P < 0.05$), but did not affect dry matter intake ($P > 0.05$). The FE was affected by diet ($P < 0.001$), year, and the interaction of diet \times season ($P < 0.05$). The effects of diet, housing, season, and year affected HCW and DP ($P < 0.001$). In addition, BF, KPH, YG, and QG were affected by dietary treatment ($P < 0.001$) and season ($P < 0.05$) but not by the effects of housing ($P > 0.05$). Economic analysis showed that shelter corn (SC) steers had 3.2% higher income per head than those in shelter silage (SS) facilities. Moreover, steers in no shelter corn (NSC) groups had 3.9% better income per animal than cattle fed in no shelter silage (NSS). Besides, steers fed in confinement corn (CC) received 2.2% higher income per head compared to those fed in confinement silage

(CS) system. Overall, SC steers had the highest income per head, with a 6% advantage over the CS group, which had the lowest income per head. Steers fed a corn-based diet had better returns than those fed a corn silage-based diet. Winter steers in NSS had the lowest income, which represented 7.4% difference between the highest incomes attained by steers in the SC system. During spring and summer, the SC system had the highest income per steer, followed by NSC and then the CC group.

Key Words: carcass characteristics, cattle, economics, feedlot performance

248 **Harvest method and feeder type effect on corn stover intake and waste.** N. E. Mertz^{1,*}, D. J. Tomczak¹, W. J. Sexten², ¹University of Missouri, Columbia, ²Division of Animal Sciences, University of Missouri, Columbia

Thirty nonlactating, mid-gestation crossbred cows (575 ± 59 kg) were used in a 5×5 Latin square to evaluate harvest method and processing effects on corn stover (CS) DMI and waste. Dry CS (90% DM) was harvested prior to baling by mowing and raking (DMR) or raking only (DR) and barn stored. High-moisture CS (58% DM) was mowed, raked (WMR), and then baled and wrapped to exclude oxygen. CS bales were offered in a conventional open bottom ring feeder (R) or processed through a 20 cm screen and offered in fence-line bunks (B). High-moisture CS feeding was hypothesized to increase DMI and reduce waste. A distillers grain based supplement containing monensin at $200 \text{ mg} \cdot \text{cow}^{-1} \cdot \text{day}^{-1}$ was offered separate from CS at $1.58 \text{ kg} \cdot \text{cow}^{-1} \cdot \text{day}^{-1}$. Stover DMI was calculated by subtracting ORTs and collected waste from DM on offer, then divided by number of cows per pen. Daily CS DMI was greater ($P < 0.05$) for DR-R (9.2 kg, 1.56% BW) and WMR-B (9.0 kg, 1.53% BW) compared to DMR-B (7.2 kg, 1.22% BW) and DR-B (7.5 kg, 1.28% BW); DMR-R (8.3 kg, 1.41% BW) was not different ($P > 0.05$) from all other treatments. Daily waste was greater ($P < 0.05$) for DMR-R (10.0 kg) and DR-R (9.1 kg) compared to DMR-B (1.2 kg), DR-B (0.7 kg), and WMR-B (0.4 kg). Daily waste as a percent of DMI was greater ($P < 0.05$) for DMR-R (127.8%) and DR-R (109%) compared to DMR-B (18.4%), DR-B (9.6%), and WMR-B (4.6%). Stover quality was greater ($P < 0.05$) for WMR-B initial (65.1% NDF, 37.4% ADF) and waste (65.4% NDF, 38.2% ADF) than all other treatments. Initial CS NDF was greater ($P < 0.05$) in DMR-R (81.9%) compared to DMR-B (79.3%) and DR-B (78.6%); DR-R (79.9%) was not different ($P > 0.05$) from all other dry treatments. NDF in CS waste was lower ($P < 0.05$) in DMR-B (72.7%) compared to DMR-R (79.6%) and DR-R (78.3%); DR-B (75.0%) was not different ($P > 0.05$) from all other dry treatments. Offering CS in ring feeders allows for selection behavior and resulted in greater DMI and waste. Dry CS bunk feeding was effective at reducing waste but reduced DMI. Feeding processed high-moisture, higher-quality CS in fence-line bunks resulted

in the greatest DMI and least waste.

Key Words: corn stover, harvest method, hay waste

249 Herd health observations in an intensively managed cow-calf production system.

J. M. Warner^{1,*}, K. H. Jenkins², R. J. Rasby¹, M. K. Luebke², D. R. Smith³, G. E. Erickson¹, T. J. Klopfenstein¹, ¹University of Nebraska, Lincoln, ²University of Nebraska, Scottsbluff, ³Mississippi State University, Mississippi State

Given heightening interest in alternative cow-calf production systems, data regarding animal health are critical yet limited in the literature. This report presents cow-calf health observations from 2 years of a continual study evaluating the feed efficiency of early weaning in an intensively managed (total drylot confinement) cow-calf production system. Multiparous (4.6 ± 1 year), crossbred (Red Angus × Red Poll × Tarentaise × South Devon × Devon), lactating beef cows (n = 156) with summer-born calves at side were blocked by prebreeding BW (H, M, L), stratified by calf age, and assigned randomly to 1 of 4 treatments within strata. The study was a randomized complete block design with a 2 × 2 factorial arrangement of treatments with three replications (pens) per treatment per year (total n = 24). Treatment factors were 1) location, eastern (ARDC) or western (PHREC) Nebraska, and 2) calf age at weaning, 91 ± 18 (EW) or 203 ± 16 (NW) d of age. At each location, EW cows and calves and NW pairs were fed a common diet (60:40 distillers grains:crop residue [year 1]; 40:40:20 corn silage:distillers grains:crop residue [year 2], DM basis) from the time of early (October) to normal (January) weaning. Cattle were maintained in earthen feedlot pens adjacent to other cattle during calving (prior to trial initiation) and the weaning portion of the study. Cows received two annual vaccinations: 1) prior to calving (ScourGuard 4KC) and 2) prior to breeding (Bovi-Shield Gold FP 5 VL5 HB). Calves were vaccinated 1) at birth (Vision 7 Somnus) and 2) at 90 d of age (Vision 7 Somnus + Bovi-Shield Gold 5). Data were analyzed using the GLIMMIX procedure of SAS. Incidences of cow morbidity and neonatal calf diarrhea were absent. However, occurrence of bovine respiratory disease (BRD) in calves varied by location and year. Bovine respiratory disease rates across weaning treatments were 0% and 26% ($P \leq 0.01$) at PHREC and ARDC, respectively (year 1). In year 2, 0% and 84% (32 of 38) of calves were diagnosed with BRD at ARDC and PHREC, respectively ($P \leq 0.01$). While calves were 3.5–5.0 months of age when treated for BRD, no mortality was observed regardless of year or location. Divergence in BRD incidence was likely related to stressors, including weaning, weather, and exposure to other animals. These data are essential for developing recommendations for producers managing cowherds in alternative production systems.

Key Words: cow-calf pairs, health, production system

EXTENSION – DAIRY

250 Relationships between in vitro ruminal fermentation parameters and dairy performance.

K. Mjoun^{1,*}, A. M. Gehman², ¹Alltech, Brookings, SD, ²Alltech, Inc., Nicholasville, KY

The in vitro gas production technique (IVGPT) is a valuable tool to evaluate feeds for ruminants by estimating the extent of digestion, rates of digestion of the different carbohydrates fractions, and end products of fermentation. One hundred sixty samples of dairy TMR of known animal performance (FCM, and DMI) were analyzed using an IVGPT (IFM, Alltech, Inc.). Feed samples were fed to cows at various stages of lactation, averaging 159 ± 43 DIM, milk yield 36.2 ± 5.9 kg, FCM 34.3 ± 5.4 kg, and feed efficiency (FE; FCM/DMI) 1.49 ± 0.19. Nutrient concentrations DM, CP, NDF, ADF, starch, NFC, and TDN were 48 ± 6.2, 17.5 ± 1.56, 31.7 ± 4.28, 19.45 ± 3.17, 25.9 ± 4.48, 38.5 ± 5.3, and 69.0 ± 3.65% (DM basis). Fermentation profile reflected the variation in chemical composition of the feeds. Fast pool gas production (FP) and its corresponding rate were 63.3 ± 9.6 mL/g DM and 20.0 ± 4.02%/h, respectively, whereas values for the slow pool (SP) were 112.6 ± 9.7 mL/g DM and 4.56 ± 0.47%/h, respectively. Total gas production (TGP) was 176 ± 12.6 mL/g DM. Estimated starch degradation rate averaged 10.69 ± 1.30%/h. True dry matter digestibility averaged 79.1 ± 3.17%. Microbial biomass (MBM) and net VFA production averaged 109 mg/g DM and 24.0 mM, respectively. Samples were stratified into deciles based on milk yield and correlation, and multiple regression analyses were conducted. The FCM was positively correlated ($P < 0.05$) with FP ($r = 0.63$), SP degradation rate ($r = 0.73$), TGP ($r = 0.91$), starch degradation rate ($r = 0.79$), TDMD ($r = 0.86$), and VFA ($r = 0.63$). The MBM was negatively correlated with FCM ($r = -0.66$), but when it was calculated based on the level of DMI ($r = 0.73$), the relationship was highly positive. Similar correlation strengths were observed for DMI and FE. Of the dietary nutrient concentrations, only carbohydrate fractions were correlated with FCM and DMI. Specifically, fiber (NDF, ADF, lignin) was negatively correlated with FCM, DMI, and FE ($r = -0.86$ to -0.75), whereas starch, NFC, and TDN were positively related to FCM, DMI, and FE ($r = 0.68$ to 0.92). Regression of FCM against fermentation profile parameters resulted in a predictive equation that included TGP, SP rate of degradation, and VFA (FCM = $-480.5 + 34.4 \times \text{SPR} + 1.57 \times \text{TGP} + 4.55 \times \text{VFA}$; $R^2 = 0.95$), demonstrating the importance of fermentability and fiber digestion rate in defining milk production level. Feed intake was similarly predicted by TGP and SP degradation rate (DMI = $-94.7 + 10.27 \times \text{SPR} + 0.58 \times \text{TGP}$; $R^2 = 0.87$). Among the chemical composition parameters, TDN concentration explained 82.2% of the variation observed in milk yield. For DMI, NDF concentration explained 69% of the observed variation in DMI. The IFM can

be a useful tool to evaluate the nutritive value of dairy TMR.

Key Words: dairy performance, digestion kinetics, in vitro ruminal fermentation

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- 251 **Mature cow body weight associations with calf growth and feed intake traits.** D. L. Beam^{1,*}, K. J. Stalder¹, A. J. Heinrichs², C. D. Dechow², ¹Iowa State University, Ames, ²Pennsylvania State University, University Park

The purpose of this study was to understand the association between heifer calf growth and feed intake traits with cow mature body weight. Data were collected for Holstein heifer calves from six different calf trials of varying lengths conducted at Pennsylvania State University between 2003 and 2010. Measurements of calf hip height, starter feed intake, and body weight were collected for periods ranging from 4 to 8 weeks after birth. Resulting data were divided into high, medium, and low ranking groups according to calf hip height, starter feed intake, body weight, and growth rate. Calf growth data were merged with 37,403 mature body weight records from 75 cows taken from lactations 1, 2, and 3. Mixed model equations methods were used to evaluate the data. Lactation, days in milk, treatment within trial, calf groups, and lactation by days in milk were fitted as fixed effects, while cow, cow by lactation, and calendar week by year were included as random effects. Cows from the low growth rate classification as calves were significantly ($P < 0.01$) lighter as mature cows, weighing 45.3 ± 14.70 kg and 52.7 ± 14.44 kg less than cows from the intermediate and high growth rate calf classifications, respectively. In the same manner, cows from the low starter intake classification as calves were significantly ($P < 0.01$) lighter as mature cows, weighing 47.2 ± 15.37 kg and 47.1 ± 15.11 kg less than cows from the intermediate and high starter intake calf classifications, respectively. No mature body weight differences were observed for cows that differed for hip height or body weight as calves ($P > 0.10$). Results from this study suggest that low growth rate and starter feed intake in calves could be indicative of future low mature cow body weight.

Key Words: body weight, feed intake, growth rate

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- 252 **Conception rate for postpartum dairy cows treated with different gonadorelin (GnRH) products for first or resynchronized timed AI.** S. E. Poock*, M. C. Lucy, University of Missouri, Columbia

Different GnRH products are used for timed AI (TAI) in postpartum dairy cows. The objective was to compare conception rate (CR) for cows treated with either Factrel (Zoetis Animal Health, Florham Park, NJ) or Cystorelin (Merial, Duluth, GA) GnRH before first TAI or resynchronized (resynch; second service or greater) TAI. Holstein cows ($n = 3938$) in a confinement-style dairy in northeast Missouri were assigned to weekly cohorts ($n = 22$) based on calving date. Cows were

treated with “Presynch Ovsynch” (PGF_{2α}, 14 d, PGF_{2α}, 14 d, GnRH, 7 d, PGF_{2α}, 56 h, GnRH, 16 h, TAI) so that first TAI was 68 to 74 d postpartum. PGF_{2α} was Lutalyse (5 mL; 25 mg; Zoetis). The GnRH product was either Factrel (2 mL; 100 µg; $n = 1945$) or Cystorelin (2 mL; 100 µg; $n = 1993$) and was alternated weekly for cows assigned to cohorts. There were first TAI ($n = 1790$) and resynch TAI ($n = 2148$) cows within each cohort. The resynch began 32 d after TAI (GnRH, 6 d; ultrasound pregnancy diagnosis, 1 d; and then for non-pregnant cows, PGF_{2α}, 56 h, GnRH, 16 h, TAI). The trial was conducted in two seasons [winter (Jan to Feb; $n = 1203$) and summer/fall (July to Oct; $n = 2735$)] during 2012. Cows were fed a TMR, milked thrice daily, and milk tested monthly for volume, somatic cell count (SCC), fat%, protein% (prot%), and milk urea nitrogen (MUN). Data were analyzed by using logistic regression. There was no effect of GnRH treatment ($P > 0.10$) on TAI CR (36% vs. 37%; Factrel vs. Cystorelin, respectively) and no treatment interaction with any of the tested effects (service number, parity, season, etc.; $P > 0.10$). TAI CR was greater ($P < 0.05$) at first TAI (38%) than resynch TAI (35%) and was greater ($P < 0.001$) in winter (44%) than in summer/fall (33%). Milk production (305ME), fat%, and MUN did not affect TAI CR, but both SCC and protein% affected TAI CR. The TAI CR decreased ($P < 0.05$) from lowest (<100,000; 38%; $n = 2493$) to highest (>500,000; 32%; $n = 440$) SCC quartile. The TAI CR increased from lowest (2.5 or less; 25%; $n = 185$) to highest (3.2 or greater; 39%; $n = 560$) octile for milk prot%. In conclusion, GnRH product did not affect TAI CR for first or resynch TAI in an Ovsynch-based program. Other factors affected TAI CR, including service number (lesser for second service or greater), season (lesser in summer), SCC (lesser for cows with greater SCC), and milk prot% (greater for cows with greater prot%).

Key Words: dairy cow, GnRH, Ovsynch

EXTENSION – SWINE

- 253 **A decision support tool to evaluate sow housing options.** R. O. Bates^{1,*}, R. A. Betz², E. A. Ferry³, ¹Department of Animal Science, Michigan State University, East Lansing, ²Michigan State University Extension, Marshall, ³Michigan State University Extension, Cassopolis

Housing gestating sows in individual stalls is commonplace across the pork industry. However, due to increased consumer scrutiny of this management practice and legislative mandates in some states, pork producers are faced with changing their gestation housing system from individual stalls to group housing. Previous work completed by Michigan State University Extension (MSUE) indicated that a leading educational priority for pork producers was the need to compare the initial in-

vestment and subsequent operating costs for different types of group housing options. A Sow Housing Options Tool (SHOT) was developed for users to compare either different group housing systems or different options for a particular group housing system. The SHOT is a capitalization model that uses a producer's current sow productivity to model the number of pigs produced per year, which is used to evaluate how changes in gestation housing may alter the farm's annual pig production. The SHOT provides the user with examples for five possible group housing options: 1) floor feeding, 2) nongated stalls, 3) trickle feeding, 4) electronic sow feeding, and 5) free access stalls. The user will enter present feed and operating costs to develop their current cost of production. Furthermore, the user will enter current interior building dimensions or proposed interior building dimensions along with the overall interior space allocation per sow. In addition, the user will also enter estimates of either remodeling costs or new construction costs for different gestation housing options under consideration. The model will account for different depreciation rates for different capital input costs. This will provide a more realistic estimated cost of production when comparing different group sow housing options. For new construction, the user will input cost estimates provided by contractors and equipment manufacturers. For remodeling projects, SHOT will determine if current production can be maintained without subsequent building additions based on user inputs. The SHOT will also estimate the amount of additional space needed to maintain current productivity if a production shortfall is anticipated. The model will subsequently estimate the total cost for each proposed gestation sow housing scenario as well as estimate the projected annual operational cost on a per sow and per pig weaned basis. The model is flexible and will allow pork producers the opportunity to override certain aspects of the model based on their current productivity or cost of production estimates. The SHOT is available from MSUE.

Key Words: capitalization model, group housing, sow

254 Labor requirements and repeatability of sow body condition measures. M. Knauer*, M. Bryan, North Carolina State University, Raleigh

The objective of the study was to estimate the labor requirements and repeatability of common sow body condition measures. Two technicians each evaluated crossbred sows ($n = 25$) twice for body condition score (BCS), sow caliper score, and backfat (BF). Sows were housed in individual gestation stalls. Visual BCS was scored from the rear of the sow by palpating the spinous process. A scale of 2 (thin) to 4 (overconditioned) was used. The sow caliper was used to measure the angularity from the spinous process to the transverse process at the last rib. An angle of $<125^\circ$ was classified as a score of 2 (thin), 125° to 132.5° was a 3 (ideal) and $>132.5^\circ$ was categorized as a 4 (overconditioned). Backfat was measured 6 cm from the spinous process at the last rib using a Renco Lean-Meater

A-mode ultrasound machine. Time required to measure all 25 sows was captured for each body condition trait and replicate. Data were analyzed in SAS. The PROC GLM procedure was used to estimate labor requirements on a per sow basis. Fixed effects included body condition measure, technician, and replicate. The PROC CORR procedure was used to calculate the repeatability within and between technicians. Measuring sow body condition using the caliper and BCS required less ($P < 0.01$) labor than BF (5.5 and 4.9 vs. 14.2 s per sow, respectively). Yet labor required to measure sows did not differ ($P > 0.05$) between technicians or replicates. Repeatability for BCS, the sow caliper, and BF was 0.82, 1.00, and 0.89, respectively, for Technician A and 0.90, 0.89, and 0.93, respectively, for Technician B. Between technicians, repeatability for BCS, the sow caliper, and BF was 0.85, 0.97, and 0.96, respectively. In comparison with Technician A, Technician B had similar ($P > 0.05$) mean values for BCS (3.60 vs. 3.74, respectively), the sow caliper (3.76 vs. 3.78, respectively), and BF (18.48 vs. 18.40 mm, respectively). Results suggest measuring BCS or sow caliper score requires less labor than evaluating BF and all three methods are highly repeatable.

Key Words: caliper, labor, repeatability

255 Effect of lactation feeder type on sow performance in a commercial unit. A. J. Cross^{1,*}, A. Gelderman², R. C. Thaler¹, ¹South Dakota State University, Brookings, ²Standard Nutrition, Sioux Falls, SD

Maintaining production while increasing efficiency and decreasing costs is a major concern for pork producers. Feed is the single largest component of the cost of pork production, and poor feeder design can lead to significant feed wastage. Decreasing the amount of feed wastage would greatly impact feed cost per sow. A new feeder was designed to reduce the amount of feed wasted by sows during lactation. The new feeder is a raised (25.4 cm) stainless-steel flat-bottomed feeder with a fan agitator. The objective of this study was to determine the effect of lactation feeder type, either a conventional feeder (Round) or a new feeder design (Millerdale), on average daily lactation feed disappearance and sow performance. A total of 218 sows from nine different farrowing groups were utilized in this study at a commercial operation. In each farrowing group, 26 sows were randomly assigned by parity to one of two treatments at time of farrowing. Daily feed disappearance, number born alive and weaned, litter weight at birth and weaning, sow weight 24 h after farrowing and at weaning, and return to estrus were measured for each sow. Average daily feed disappearance was evaluated using sow parity, treatment, replicate, the interaction between treatment and replicate, sow weight at farrowing, sow weight at weaning, and litter weaning weight. There was no difference observed in sow weight 24 h after farrowing, number weaned, litter weaning weight, and return to estrus between the two feeders ($P > 0.05$). Average daily feed disappearance was different

between the feeder types ($P < 0.05$), with sows utilizing the Millerdale feeders exhibiting lower daily feed disappearance than the sows using the Round feeder. Sow weight at weaning tended to be lower ($P = 0.073$) for sows on the Millerdale feeder. Feeder type had no effect on the change in litter weight or size between birth and weaning. These data indicate that using the Millerdale feeder resulted in lower daily feed disappearance, while having little effect on sow performance. Since piglet performance was not changed and sow weight only tended to be reduced, it could be assumed that most of the extra feed disappearance by sows using the Round feeder was feed being wasted and not actually consumed. Therefore, it appears that the Millerdale feeder decreased the amount of feed wasted by sows, which would have a positive impact on profitability for pork producers.

Key Words: feed wastage, feeder, sow

256 **Documentation of factors that contribute to the variation of pork nutrient composition.** M. Kerns¹, B. Rossman¹, S. Liewer¹, M. Powell¹, S. Herr¹, S. Taylor¹, J. Colletti¹, S. M. Lonergan^{1,*}, P. Boettcher², R. Charrondiere², ¹Iowa State University, Ames, ²Food and Agriculture Organization of the United Nations, Rome, Italy

The Food and Agriculture Organization (FAO) and International Network of Food and Data Systems (INFOODS) have combined efforts to create the Food Composition Database for Biodiversity (<http://www.fao.org/infoods/infoods/en/>). This database demonstrates differences in food composition and can be utilized by both nutritional and agricultural industries for research, education, and policy decisions. The database contains over 6,000 food entries covering cereals, vegetables, and a variety of animal products. The existing database does not contain data on pork composition. Thus, the objective was to compile data on pork nutrient composition to be added to the FAO/INFOODS database. These data focused on factors affecting the differences in pork composition based on differing breeds of swine and management practices. After a literature search resulting in 89 peer-reviewed publications, 36 publications were dismissed. The remaining 53 were selected for data extraction and generated 253 independent food composition entries containing lipid, water, protein, ash, fatty acid, carbohydrate, vitamin, and mineral content. There were a total of 110 different breeds, breed crosses, and genotypes, 41 differing management practices, and 8 independent cuts. A significant range in pork composition across breeds and varying management practices was found. A total of 107 entries contained total water content, 68 with total protein content, and 234 entries contained data on total fat content. The results document that pork composition varies across breed, especially when comparing local breeds to transboundary breeds. For example, the fat content of the *Longissimus dorsi* of a Landrace is 0.66 g/100 g edible portion on a fresh weight basis (EP),

Table 256. Composition and range of data from pork *Longissimus dorsi* entered into the Food Composition Database for Biodiversity

	Minimum	Breed of minimum	Maximum	Breed of maximum
Water (g/100g EP)	61.7	Manglista	78.3	Yorkshire × Landrace
Protein (g/100g EP)	16.8	Duroc × (Large White × Mong Cai)	24.4	Large White
Lipid (g/100g EP)	0.66	Landrace	18.2	Mangalista

while that of the Mangalitsa is 18.2 g/100 g EP. The results of this research document that data on micronutrient content in pork are not readily available. Furthermore, there is a gap in the knowledge regarding nutrient content of muscles and cuts other than the pork loin. Finally, the results show management practices and feedstuffs are significant factors that affect composition of critical nutrients in pork. Inclusion of these data in the FAO/INFOODS database is critically important because pork is the most widely consumed animal protein in the world.

Key Words: biodiversity, INFOODS database, pork composition

257 **Concentration of the nonstarch polysaccharide 1,3-β-glucan and α-mannan protein in corn derived distillers grains with solubles.** J. E. Ferrel^{*}, A. A. Ahmed, B. J. Krabel, D. M. Anderson, T. A. Marsteller, *Elanco Animal Health, Greenfield, IN*

Feedstuffs for swine nutrition such as the by-product of ethanol production, corn distillers drains with solubles (DDGS), contain a variety of nonstarch polysaccharides (NSP) including 1,3-β-glucan (BG) and the α-mannan (AM) component of glycoproteins. The BG and AM in the DDGS are primarily contributed by the cell walls from *Saccharomyces cerevisiae* used in the corn-based ethanol fermentation process. Furthermore, both BG and AM are recognized as biological modifiers that are resistant to enzymes produced endogenously in the gastrointestinal tract of the pig and are antinutritive components in the diet. The objectives of the study were to determine the concentration of BG and AM in cohort-split samples of the cereal grain by-product DDGS and to develop an estimate model to predict the results based on the crude protein content of DDGS. Crude protein, moisture, crude fat, and crude fiber (28.10%, 15%, 10.04%, 6.45%, respectively) of the composite sample were previously determined using wet chemistry procedures from a commercial laboratory. Amino acid concentrations including lysine, isoleucine, leucine, methionine, threonine, valine, alanine, aspartic acid, cysteine, glutamic acid, glycine, and proline were also determined. A composite sample from 40 serial samples in a 25 ton lot was split into 20 samples of equal weight. The BG concentration was estimated using an enzymatic kit (K-EBHLG 03/13 Enzymatic Yeast Beta-glucan) from Megazyme (Megazyme International Ireland Limited, Bray, Ireland). Quantitative determination of the

monosaccharides galactose and mannose in the samples was also determined by high performance anion exchange chromatography with pulsed amperometric detection (HPAEC-PAD) before and after hydrolysis with hydrochloric acid (Eurofins Scientific, Inc. Analytical Laboratory Amsterdam, The Netherlands). The BG and AM concentrations ranged from 1.875 to 2.234% with a mean average of 2.072 w/w% (SD = 0.108) and 0.88 to 1.12% with a mean average of 1.018 w/w% (SD = 0.039), respectively. Comparing the results to known cell wall architecture in *S. cerevisiae* allowed testing the possibility of using the protein content in DDGS to estimate the BG and AM concentrations by calculation. Results of this experiment would slightly overstate the BG contribution in comparison to known results for cell wall architecture, allowing the concept of estimating by difference in protein contribution to slightly underestimate known values. A better knowledge of BG and AM concentrations in DDGS lots readily obtained through routine or calculated methods may provide an opportunity to improve pig performance through understanding their concentrations and the potential antinutritive impact of these highly reactive biological modifiers.

Key Words: α -mannan, NSP, 1,3- β -glucan

448 **Impact of farrowing induction on the time of farrowing in sows.** J. J. Nankivil¹, M. Ellis¹, B. A. Peterson², C. M. Shull², E. Parr², ¹University of Illinois, Champaign-Urbana, ²The Maschhoffs, Carlyle, IL.

The effect of farrowing induction on the time of farrowing was evaluated using 152 multiparous sows (parities 2 to 9) in a commercial facility. The study was carried out as RCBD with 2 treatments (76 sows/treatment): Control (no farrowing induction) and Induced (induced on d 114 of gestation). Sows had previously been administered OvuGel prior to a fixed-time insemination and were given a single dose of 10 mg prostaglandin (Lutalyse 5 mg/mL) between 0700 and 0800 h on d 114. Farrowings were attended by animal care staff between 0600 and 1600 h daily but were unattended at other times. Gestation length was shorter ($P = 0.003$) for the Induced treatment compared to the Control treatment (114.7 d vs. 115.3 d, respectively). There was no effect ($P > 0.05$) of farrowing induction on total number of piglets born (13.0 vs. 13.7, for Induced and Control; SEM 0.42), or for the number and percentage of piglets born alive (12.2 and 93.8% vs. 12.6 and 92.5%, respectively), born dead (0.7 and 5.4% vs. 0.8 and 5.9%, respectively), or mummified (0.1 and 0.7% vs. 0.2 and 1.5%, respectively). Induction increased ($P < 0.05$) the percentage of farrowing occurring from 0600 to 1200 h on the d following induction (37.6% vs. 23.9%, for Induced and Control, respectively) but reduced the percentage occurring from 0000 to 0600 h (9.5% vs 17.7%, respectively), and 1200 to 1800 h (31.5% vs 36.3%, respectively). The total number of farrowings attended (completely or in part) was greater (P

= 0.03) for the Induced than the Control treatment (75.0% vs 57.9%, respectively). In conclusion, farrowing induction in sows that had been synchronized for insemination using OvuGel increased the number of farrowings occurring during the normal working day without affecting litter size.

Key Words: farrowing, induction, pigs

GROWTH, DEVELOPMENT, MUSCLE BIOLOGY, AND MEAT SCIENCE: GROWTH, DEVELOPMENT, MEAT SCIENCE, & MUSCLE BIOLOGY POSTER

258 **Impact of narasin (Skycis) on live performance and carcass traits of pigs sold in a three-phase marketing system.** E. K. Arkkfeldt^{1,*}, S. N. Carr², P. J. Rincker², G. L. Allee³, A. C. Dilger⁴, D. D. Boler⁴, ¹University of Illinois, Urbana, ²Elanco Animal Health, Greenfield, IN, ³Pork Tech, LLC, Columbia, MO, ⁴University of Illinois at Urbana-Champaign, Urbana.

The objective was to evaluate the effect of feeding narasin (Skycis; Elanco Animal Health, Greenfield, IN) on growth performance, efficiency, and carcass characteristics of finishing pigs sold in a 3-phase marketing system. Pigs ($N = 1,232$) were housed in 56 single sex pens, divided into 2 even blocks based on age. Within each block, 14 pens were fed either 0 (control) or 15 mg/kg narasin for the final 85 d of finishing (initiated at an average of 52.95 kg BW). In each pen, 18% of pigs were sold in the first marketing group (d 64 of dietary treatment), 50% were sold in the second marketing group (d 78), and 32% were sold in the third marketing group (d 85). Data were analyzed as a randomized complete block design with pen as the experimental unit. The model included fixed effects of diet, sex, and their interaction. Block and replicate nested within block were random variables. Carcass data from marketing group 3, block 2 was not collected due to inclement weather. Narasin had no effect on growth performance traits ($P > 0.05$) in phases 1 (d 1–28) or 2 (d 28–56). Regardless of sex, pigs fed narasin tended to have a 1% greater overall ADG than pigs fed the control diet ($P = 0.07$; 0.99 vs. 0.98 kg) and had a 1.2% greater G:F than pigs fed the control diet ($P = 0.03$; 0.347 vs. 0.343). In the first marketing group, barrows fed narasin had greater ADFI than gilts fed the same diet ($P = 0.03$). Overall pooled effects of feeding narasin tended to reduce ($P = 0.08$) loin depth by 1.1% (60.00 vs. 60.66 mm); however, no effects of narasin on carcass weight, yield, or leanness were observed in marketing groups 1 and 2 ($P \geq 0.21$). In marketing group 3, barrows fed narasin had a 0.9 percentage unit reduced estimated lean compared with barrows fed control ($P = 0.04$; 51.1 vs. 52.0%). Regardless of sex, estimated lean of pigs from the third marketing group fed narasin was 0.55 percentage units ($P < 0.01$; 52.19 vs. 52.74) less than controls. This

Table 260. Live weights, live weight change (LWC), ADG, loin eye muscle area (LEA), and backfat thickness (BF) measurements in Katahdin and Texel × Katahdin (T×K) crossbred ram lambs

Live weights	Week 0, kg	Week 2, kg	Week 4, kg	Week 6, kg	Week 8, kg	LWC, kg	ADG, g	LEA, cm ²	BF, mm
Katahdin	33.79	34.31	36.51	42.19	44.50	10.71	191	11.38	4.5
T×K	35.02	34.72	36.88	41.88	43.16	8.14	145	11.68	4.6
SE	0.98	0.97	0.94	1.08	1.23*	0.25*	4.4*	1.65	1.2

* $P < 0.05$.

is likely due to narasin pigs from the 3 marketing group being 0.98 mm fatter ($P = 0.03$) than controls (21.72 vs. 22.70). Feeding narasin for up to 85 d had little impact on growth performance within marketing group but did increase overall ADG. Although differences were observed within marketing group, overall pooled results suggest feeding narasin did not change carcass characteristics of finishing pigs.

Key Words: carcass, growth, narasin

259 Effect of silicate on growth performance, meat quality, and characteristics in finishing pigs.

V. Sharma^{1*}, M. Bakhtiar¹, S. Mohana Devi¹, J. H. Cho², I. H. Kim¹, ¹*Department of Animal Resource & Science, Dankook University, Cheonan, South Korea*, ²*Department of Animal Science, Chungbuk National University, Cheongju, South Korea*.

The strategy of including various detoxifying clays in the diet has been given considerable attention in the scientific field. Dietary supplementation with different silicate clay such as zeolite, kaolin, bentonite, clinptilolite, and biolite improves growth performance. This study was conducted to evaluate the effects of silicate supplementation on growth performance, meat quality, and meat palatability in finishing pigs. Fifty-six pigs [(Landrace × Yorkshire) × Duroc] with average BW of 94.20 ± 1.28 kg were used in a 30-d feeding study. Dietary treatments included (1) basal diet and 2) basal diet + 0.3% silicate. Silicate was added to the control diet at the expense of ground corn and all diets contained sufficient AA, vitamins, and minerals. Pigs fed with diet supplemented with 0.03% silicate had increased meat color compared with their control counterparts. All data were subjected to the GLM procedures of SAS (1996) and differences among treatments were separated by Duncan's multiple range test. The variability in the data was expressed as SE. Probability values less than 0.05 were considered significant. No significant difference was observed on meat quality except the meat color (a* and b*) was increased ($P < 0.05$) by silicate supplementation. Dietary feeding of silicate showed a significant effect ($P < 0.05$) on palatability compared to their controls. Taste, aroma, tenderness, and juiciness had no significant effect. Supplementation of finishing pigs with 0.3% of silicate did not find any significant response in fatty acid profiles of LM. When a diet containing silicate was fed to the finishing pigs, it significantly affects overall meat color, a*, b*, and palatability of meat.

Key Words: growth performance, meat quality, silicate

260 Effect of genotype and dietary supplement on live weight changes and average daily gains in ram lambs.

T. Wuliji^{1*}, J. D. Caldwell¹, B. C. Shanks¹, H. Smith², H. Hilsenbeck¹, L. S. Wilbers¹, A. Bax¹, S. Azarpajouh¹, ¹*Department of Agriculture and Environmental Sciences, Lincoln University, Jefferson City, MO*, ²*Callaway County Extension Center, Fulton, MO*.

Hair and meat sheep production is a diversified livestock enterprise in the United States. Whereas terminal sheep breed such as Texel has a reputation for high carcass yield and leanness, hair sheep may be better adapted to marginal or poor grazing conditions and disease resistance. The objective of this study is to evaluate postweaning growth and carcass performance in Katahdin (KAT) and Texel × Katahdin crossbred (T×K) ram lambs in an 8-wk pen feeding experiment. Forty-five ram lambs, consisting of 21 KAT and 24 TxK ram lambs, were evenly divided into 3 group feeding pens by stratification using both initial live weight (LW) records and genotype. Rams were provided ad libitum access to the same quality hay and water supply as per pen. Corn grain supplements were offered at 340 (g/lamb)/d for 1 wk as an adaptation period and increased to 636 (g/lamb)/d during the 8-wk trial. The LW (kg) and ADG (g) were recorded at biweekly intervals. The back fat thickness (BF; mm) and loin eye muscle area (LEA; cm²) were measured using an ultrasound scanning machine fitted with backfat probe over 12th rib of lambs. Live weight, ADG, LEA, and BF measurements were analyzed by the mixed procedures of SAS. Mean values of LW changes, ADG, LEA, and BF measurements are shown in Table 260. The live weight records at biweekly intervals did not differ except at the eighth week interval ($P < 0.05$). The total weight changes and ADG were significantly higher ($P < 0.05$) for KAT compared with T×K. There was no statistical difference between groups for LEA and BF measures, although these were recorded slightly higher for T×K ram lambs. The current results showed that Katahdin ram lambs perform slightly but significantly better than Texel × Katahdin crossbred lambs in pen feeding condition with corn grain supplements.

Key Words: average daily gain, genotype, live weight

261 **The effect of adipose tissue inclusion over pork loins on dual-energy x-ray absorptiometry measurements.** M. Kipper^{1,2}, C. Pomar^{2,*}, M. Marcoux², ¹*Universidade Federal de Santa Maria, Santa Maria, Brazil*, ²*Agriculture and Agri-Food Canada, Sherbrooke, QC, Canada.*

Dual-energy X-ray absorptiometry (DXA) measurements can be affected by the special distribution of sample tissues. The objective of this study was to evaluate the impact of adding adipose tissues (AT) over pork loins on DXA measurements. Four commercial pork loins and 3 square pieces of AT were scanned with a GE Lunar Prodigy Advance DXA device equipped with total body GE Lunar Encore software in thin and standard configurations. All images were analyzed using a custom region of interest. The loins were individually positioned on the DXA table and kept in the same position until the end of tests. The AT pieces were positioned over the loins one by one without (NoOvPos) or with (OvPos) overlapping to measure bone mineral density (BMD; g/cm²), bone mineral content (BMC; g), bone area (BA; cm²), and fat and lean masses (g). Loin DXA measurements without AT inclusion were subtracted from loins after AT inclusion and the analysis of covariance performed to study the effects of DXA configuration, AT positioning, AT inclusion, and all interactions. Linear regressions were generated afterwards. The AT pieces had 69 and 57% fat in NoOvPos and OvPos AT positioning, respectively. Dual-energy X-ray absorptiometry measurements were not affected by device configurations but the interaction between AT inclusion and AT positioning was significant ($P < 0.05$) for BMC, BA, and fat and lean masses. Bone mineral density was not affected ($P > 0.05$) by any factor. The regression slopes between AT inclusion in NoOvPos positioning and BMC, BA, and fat and lean masses were, respectively, -0.013, -0.016, 0.698, and 0.315. The equivalent slopes in OvPos positioning were, respectively, -0.016, -0.019, 0.591, and 0.438. All intercepts were not different ($P > 0.05$) from 0. The inclusion of AT over the loins reduced the values of BMC and BA but not BMD values. The difference between slopes was in general small and, therefore, the special distribution of sample tissues is not expected to have an important effect on DXA measurements. Dual-energy X-ray absorptiometry, therefore, can be used to measure pork loin composition.

Key Words: adipose tissue, dual-energy X-ray absorptiometry, pork loin

262 **Effects of feeding generic ractopamine (Actogain) with or without the combination of monensin and tylosin phosphate on growth performance, carcass characteristics, and tenderness of finishing steers.** B. M. Bohrer^{1,*}, H. O. Galloway¹, D. M. Meeuwse², J. L. Beckett³, M. D. Edmonds⁴, E. D. Sharman⁴, W. M. Moseley², H. B. Vanimisetti², A. L. Schroeder², A. C. Dilger¹, D. D. Boler¹, ¹*University of Illinois at Urbana-Champaign, Urbana*, ²*Zoetis, Inc., Kalamazoo, MI*, ³*Beckett Consulting, Fallbrook, CA*, ⁴*Johnson Research LLC, Parma, ID.*

The objective was to evaluate the effects of feeding generic ractopamine HCl (G-RAC; Actogain; Zoetis) with or without the combination of monensin and tylosin on growth performance, carcass characteristics, and tenderness of finishing steers. Ractopamine HCl (RAC) has previously been fed to finishing cattle under the trade name Optaflexx (Elanco Animal Health). Actogain is a feed ingredient containing RAC used to improve rate of weight gain and feed efficiency in cattle fed in confinement for slaughter the last 28 to 42 d on feed. Monensin (MON) and tylosin (TYL) are fed to beef cattle to prevent or control coccidiosis and reduce the incidence of liver abscesses when fed in combination with RAC. Steers ($N = 1,230$) were finished in 6 blocks of 3 pens each (1 pen per treatment) and were assigned to 1 of 3 different finishing diets: no G-RAC with MON and TYL (CON + MON/TYL), with G-RAC without MON and TYL (G-RAC - MON/TYL), or with G-RAC with MON and TYL (G-RAC + MON/TYL). Steers fed G-RAC - MON/TYL had 12 kg greater ($P < 0.0001$) final BW, 0.34 kg greater ($P < 0.0001$) ADG, 0.02 units greater ($P < 0.0001$) G:F, and 8 kg greater ($P < 0.0001$) HCW compared with steers fed CON + MON/TYL. Steers fed G-RAC + MON/TYL had 7 kg greater ($P = 0.01$) final BW, 0.24 kg greater ($P < 0.001$) ADG, 0.02 units greater ($P < 0.0001$) G:F, and 5 kg greater ($P < 0.0001$) HCW than steers fed CON + MON/TYL. Interestingly, steers fed G-RAC - MON/TYL had 5 kg greater ($P < 0.01$) final BW than steers fed G-RAC + MON/TYL; however, steers fed G-RAC - MON/TYL had 1.06 and 1.00 kg greater ($P < 0.0001$) DMI compared with steers fed G-RAC + MON/TYL and CON + MON/TYL, respectively. No treatment effects ($P \geq 0.10$) were observed for yield grade parameters (excluding HCW) and calculated yield grade. Marbling scores were 20.3 units (20% of one marbling score) less ($P = 0.01$) in steers fed G-RAC + MON/TYL compared with steers fed CON + MON/TYL. No treatment effects ($P \geq 0.06$) were observed for Warner-Bratzler shear force after 14 or 21 d of postmortem aging. In conclusion, final BW, ADG, G:F, and HCW were increased in steers fed G-RAC with or without MON/TYL when compared with steers fed CON + MON/TYL, whereas other carcass characteristics were only minimally affected, similar to results from RAC-fed cattle.

Key Words: Actogain, beta-agonist, ractopamine, steer

263 **Effects of cold rearing temperature on meat quality parameters on loin and ham muscles in pigs.** J. Faure^{1,*}, L. M. Lefaucheur², B. Lebret³, ¹*INRA Agrocampus Ouest, Rennes, France*, ²*INRA, Saint-Gilles, France*, ³*INRA, Saint Gilles, France*.

This study aimed at evaluating the influence of cold (CD) rearing environment versus thermoneutrality (TN) during postweaning (CD: 23 to 15°C; TN: 28 to 23°C) and growing–finishing periods (CD: 12°C; TN: 23°C) on pig LM and ham, adductor femoris (AF), semimembranosus (SM), gluteus superficialis (GS), muscle metabolism, and meat quality and determining the reversibility of these effects. Three groups of pigs were constituted according to their postweaning and growing–finishing thermal environments: CD–CD ($n = 18$), CD–TN ($n = 18$), and TN–TN ($n = 24$). In LM muscle, CD–CD pigs had higher glycolytic potential (GP; $P < 0.001$) and lower pH 24 h postmortem (pHu; $P < 0.001$) and higher drip loss ($P = 0.02$), color saturation, and intramuscular fat (IMF; $P < 0.001$) content compared with TN–TN. In AF and SM muscles, CD–CD pigs exhibited also lower pHu compared with TN–TN and CD–TN pigs. Cold–TN pigs exhibited higher pHu and lower GP but IMF and drip loss similar to TN–TN pigs in LM. No difference in color were found between CD–TN and TN–TN pigs in LM and GS, but CD–CD pigs exhibited higher redness and yellowness in both muscles. Cold environment affected appearance (higher redness) and texture (lower fibrousness) of loin and improved pork odor but did not modify tenderness or juiciness. Short- and long-term effects of low temperature during rearing period could explain meat quality differences at commercial slaughter weight. Most of short-term effects of cold environment on muscle metabolism are persistent at older stages and influence pork meat quality.

Key Words: meat quality, pig, rearing temperature

264 **Correlation of fatty acid composition and iodine value among three fat depots in pork carcasses.** C. C. E. J. Villela^{1,*}, R. B. Cox¹, G. C. Shurson¹, K. M. Compart¹, P. E. Urriola¹, L. J. Johnston², ¹*Department of Animal Science, University of Minnesota, St. Paul*, ²*West Central Research and Outreach Center, University of Minnesota, Morris*.

Feeding diets containing high inclusion (>40%) of distillers dried grains with solubles (DDGS) reduces fat quality in pork. Pork processors often determine fatty acid composition of jowl as a predictor of fat composition in other higher value cuts. However, the differences in fatty acid composition among fat depots have not been studied extensively. Therefore, the objective was to evaluate differences in fatty acid composition among fat depots and evaluate their correlation. Mixed sex pigs ($n = 216$; initial BW = 24 ± 4 kg) were blocked by BW and allotted to 1 of 3 diets: a basal corn–soybean meal diet with 40% DDGS (dietary fat = 4.8%), basal diet plus 5%

cottonseed oil (dietary fat = 10.3%), or basal diet plus 8% crude glycerol (dietary fat = 6.6%) for the last 6 wk before harvest. Although diets were not isocaloric, AA to ME ratios were equal among diets within each of the 3 feeding phases. At slaughter, 48 gilts (16 from each treatment harvested on 1 d) had all layers of fat sampled from the tip of the jowl, backfat at the 10th rib, and belly from the caudal end at the ventral midline. Fatty acid composition of fat samples was analyzed using gas chromatography and iodine value (IV) was calculated according to the American Oil Chemists' Society (1998). A split-plot analysis was used to analyze IV and linoleic acid (C18:2) concentrations among fat depots. No differences ($P = 0.07$) were observed for IV (78.2, 79.5, and 78.1; SE = 2.66) of jowl, backfat, and belly fat, respectively. Concentration of C18:2 was greater ($P < 0.01$) for backfat ($28.4\% \pm 3.9$) than for jowl ($25.6\% \pm 3.9$) and belly ($26.7\% \pm 3.9$). Iodine values (IV) of jowl and belly ($r = 0.60$), jowl and backfat ($r = 0.84$), and belly and backfat ($r = 0.63$) were correlated ($P < 0.0001$). Similarly, C18:2 concentrations of jowl and belly ($r = 0.66$), jowl and backfat ($r = 0.94$), and belly and backfat ($r = 0.67$) were correlated ($P < 0.0001$). Although all correlations were highly significant, IV and C18:2 composition of jowl explained only about 40% of the variation in IV and C18:2 concentration of belly. However, jowl was a more reliable predictor of IV and C18:2 composition of backfat. In conclusion, IV and C18:2 concentration of jowl can be used to predict IV and C18:2 concentration of backfat but is less reliable for predicting composition of belly fat.

Key Words: fat depot, iodine value, pigs

265 **Quality of broiler meat fed byproduct of guava during the initial phase.** M. D. de Oliveira, A. J. Silva Junior, C. N. Souto, C. L. Andrade, H. P. F. Xavier, K. T. Andrade, A. G. Mascarenhas, H. H. D. C. Mello*, *Universidade Federal de Goiás, Goiânia, Brazil*.

Research has been conducted to verify the antioxidant potential of natural products and agro-products. The byproduct of agribusiness guava is rich in phenolic compounds that have antioxidant potentials. An experiment was carried out aimed to evaluate the antioxidant potential of a guava byproduct (decanter) as a nutritional additive in broiler diets aimed at improving the quality of meat. The experiment was conducted at the Poultry Department, Federal University of Goiás. The experiment had approval from the Animal Ethics Committee of Federal University of Goiás. Two hundred eighty-eight female chicks (1-d-old Cobb 500 lineage) were distributed using a completely randomized design consisting of 4 treatments and 6 replications of 12 broilers/each cage. The experimental diets were provided isonutritives. Treatments consisted of 4 levels of inclusion of decanter in the experimental diet (0, 0.5, 1.0, and 1.5%). The diets were provided to broilers from 1 to 21 d old. The variables analyzed were pH and colorimetry of breast meat and thigh. Color determinations (values L*, a*, and b*) were measured at

Table 265. Colorimetric and pH measurements of breast meat of broilers at 21 d of age fed byproduct of guava (decanter) in the diet

Treatment	L*	a*	b*	pH
0% guava byproduct	40.65	4.38	6.36	5.96
0.5% guava byproduct	39.65	4.05	5.36	6.08
1.0% guava byproduct	40.53	4.81	6.68	5.95
1.5% guava byproduct	40.89	4.32	6.49	5.96
P-value	0.6762	0.7326	0.2391	0.5813
CV, %	3.96	25.99	15.91	2.59

3 different points in the ventral portion of the breast and thigh muscles using a calorimeter. For analysis of pH, readings were made in triplicate in ventral muscle using the pH meter. Data were submitted to ANOVA. The computer statistical program R was used. No significant ($P > 0.05$) difference was observed between the colorimetric and pH measurements of breast meat and thigh of broilers in the initial phase fed different levels byproduct of guava in the diet (Table 265). We conclude that use of the byproduct of guava as a nutritional additive in broiler diet did not influence meat quality of broilers.

Key Words: additives, broiler, guava

266 Effects of dietary level and withdrawal period of distillers dried grains with solubles on pork belly fat iodine value.

J. E. Estrada^{1,*}, M. Ellis¹, S. J. Hardman¹, A. M. Gaines², B. A. Peterson², O. F. Mendoza², ¹University of Illinois, Champaign-Urbana, ²The Maschhoffs, LLC, Carlyle, IL.

There is concern over the potential negative effects of feeding corn distillers dried grains with solubles (DDGS) to growing-finishing pigs on fat composition and quality, particularly of the belly. The objective of this study was to evaluate the effect of increasing dietary level of DDGS (8.8% crude fat) and of DDGS withdrawal period prior to harvest on belly fat iodine value (IV). A randomized complete block design was used with a 3×4 factorial arrangement of treatments: 1) DDGS inclusion levels 20, 40, and 60% and 2) DDGS withdrawal period 0, 3, 6, and 9 wk prior harvest. A control (0% DDGS fed throughout the study) was included as a contrast treatment. The study was carried out in a commercial facility using a total of 3,536 pigs housed in mixed-sex groups of 34 (8 pens/treatment); start and end BW were 23.4 ± 4.43 and 129.5 ± 12.04 kg, respectively. At the end of the growth period, pigs were harvested at a commercial facility and a fat sample was taken from the anterior end of the belly from a randomly selected sample of half of the pigs in the pen (equal numbers barrows and gilts). Iodine value was measured using near-infrared spectroscopy. Increasing dietary DDGS inclusion level linearly increased ($P < 0.001$) belly fat IV (67.5, 71.2, 74.6, and 77.3 g/100 g for 0, 20, 40, and 60% DDGS, respectively; SEM 0.43). Withdrawing DDGS from the diet prior to harvest linearly reduced ($P < 0.001$) belly fat IV (77.9, 75.4, 73.1, and 70.6 g/100 g for withdrawal periods of 0, 3, 6, and 9 wk, respectively; SEM 0.33). Regression of belly fat IV on timing of DDGS withdrawal showed that the

rate of decrease was greater ($P < 0.001$) for pigs previously fed the higher levels of DDGS (slopes of linear regression -0.45 , -0.82 , and -1.17 g/100g for the 20, 40, and 60% DDGS inclusion levels, respectively). The results of this study suggest that the increase in belly fat IV from feeding DDGS can be mitigated by feeding diets without DDGS prior to harvest and that the extent of change in IV during the withdrawal period is influenced by the level of DDGS fed previously.

Key Words: distillers dried grains with solubles, iodine value, pigs, withdrawal

267 Effectiveness of flavor enhancers in reduced sodium natural deli-style turkey breast.

C. G. Bower*, B. Cleveland, D. E. Burson, G. Sullivan, University of Nebraska, Lincoln.

The objective of this study was to determine the quality, textural, and sensory effects of natural flavor enhancers on reduced-sodium natural deli-style turkey breast when compared to a full-sodium, traditionally produced product. Chunked and formed turkey breast rolls (25% extended) were manufactured using 4 treatment formulations: 1) reduced-sodium natural deli-style turkey breast (NTB) containing 1.5% salt, 1% sugar, and 0.5% dehydrated high-protein turkey stock; 2) NTB plus 0.1% dehydrated yeast extract (NTB+YE); 3) NTB plus 0.1% dehydrated turkey broth (NTB+TB); and 4) full sodium control containing 2% salt, 1% sugar, and 0.5% sodium phosphate. Turkey rolls were cooked to an internal temperature of 71°C, stabilized overnight at 1°C, and sliced. Samples were evaluated for texture profile analysis (TPA), consumer sensory evaluation, cook yield, slice yield, slice foldability, slice peelability, salt, pH, and objective color (L*, a*, and b*). For TPA, the control had higher scores for gumminess, cohesiveness, springiness, and chewiness compared to all treatments ($P < 0.0001$), whereas there was no difference among the reduced-sodium treatments. All treatments had similar hardness. During sensory evaluation, the NTB treatments were found to be softer than the control ($P < 0.0001$). The control was juicier ($P < 0.0001$) and had the greatest turkey flavor ($P = 0.0035$), salt flavor ($P < 0.0001$), flavor acceptability ($P < 0.0001$), texture acceptability ($P < 0.0001$), and overall acceptability ($P < 0.0001$). The NTB+YE was found to be juicier than NTB ($P = 0.034$). There was no difference among any of the treatments for chewing texture or off-flavor. The control had a greater cook yield than all treatments ($P < 0.0001$). The control also had lower L* values than all treatments ($P = 0.0131$) whereas there was no difference in a* or b*. The control also had the highest peelability score ($P < 0.0001$) whereas NTB was higher than NTB+YE ($P = 0.0424$). There were no differences among treatments for number of slice yield or foldability. The control had greater salt concentration ($P < 0.0001$) and higher pH ($P = 0.0018$) than all NTB treatments. The control and NTB+YE had similar water activity, whereas NTB and NTB+TB had a higher water activity than the control ($P = 0.004$). Results indicated the quality,

yield, and textural attributes of traditionally prepared deli-style turkey breast is difficult to achieve with reduced sodium and natural ingredients and the use of turkey broth and yeast extract has little effect on these attributes.

Key Words: deli turkey, flavor enhancers, reduced sodium

268 Effects of varying corn or soybean coproduct inclusion in finishing diets of feedlot heifers on carcass characteristics and fresh meat quality.

M. A. Nelson*, J. Johnston, A. DiCostanzo, R. B. Cox, *University of Minnesota, Saint Paul.*

The impact of using corn or soybean coproduct in high or low corn grain finishing diets of feedlot heifers was evaluated. Forty-four purebred Limousin heifers were used in a randomized design with 4 treatments: 65% corn grain (CG) diets with either 20% modified distillers grains with solubles (MDGS) or a combination of glycerin and high-fiber, high-protein soybean coproduct (SOY; HI+SOY) or 25% CG diets with 60% MDGS or with 40% MDGS and 20% SOY (LO+MDGS+SOY). All heifers received melengestrol acetate and Rumensin. Experimental unit was individual heifer, as all animals were fed individually using a Calan gate system. Response variables evaluated included carcass characteristics and fresh meat quality characteristics. Heifers were fed finishing diets for 129 d and were humanely harvested at a commercial facility. Hot carcass weight, 12th rib back fat (BF), rib eye area (REA), percent KPH, and marbling score were collected 48 h postmortem by trained plant personnel. Carcasses were fabricated by plant personnel and strip steaks were collected for drip loss, Warner–Bratzler shear force, and retail shelf life evaluation. Six readings per strip steak were recorded for Warner–Bratzler shear force values and 8 replicates were recorded for 7-d retail shelf life on strip steaks. There was no treatment effect for HCW ($P = 0.37$), BF ($P = 0.10$), REA ($P = 0.63$), KPH ($P = 0.67$), or marbling score ($P = 0.18$). Drip loss did not differ among treatments ($P = 0.85$). Treatment affected Warner–Bratzler shear force ($P = 0.03$) of strip steaks. Warner–Bratzler shear force of strip steaks from HI+SOY (3.17 kg) and LO+MDGS+SOY (3.79 kg) were different ($P = 0.02$). Treatment did not affect subjective scores for lean color ($P = 1.00$), surface discoloration ($P = 0.19$), and overall appearance ($P = 0.52$) of strip steaks. Results indicate feeding high levels of corn or soy coproduct in feedlot heifer diets does not have an effect on carcass characteristics, drip loss, or subjective retail shelf life evaluation; however, combining all coproducts in a low grain inclusion diet impacted Warner–Bratzler shear force.

Key Words: beef, fresh meat quality, modified distillers grains

Table 269.

Crystalline AA:	Grain source					
	Sorghum			Corn		
	Low	Medium	High	Low	Medium	High
d 0 to 21						
ADG ¹ , g	486	473	469	473	479	478
ADFI ¹ , g	745	722	740	729	729	739
G:F ¹	0.658	0.660	0.638	0.654	0.664	0.651

¹SEM was 19.8, 33.8, and 0.01 for ADG, ADFI, and G:F, respectively.

NONRUMINANT NUTRITION: PROTEIN AND AMINO ACID NUTRITION

269 Effects of increasing crystalline amino acids in sorghum- or corn-based diets on nursery pig growth performance. K. E. Jordan*, J. Nemechek, M. A. Goncalves, R. D. Goodband, M. D. Tokach, S. S. Dritz, J. M. DeRouchey, J. C. Woodworth, *Kansas State University, Manhattan*

A total of 300 pigs (PIC 1050; initially 10.6 kg BW) were used in a 21-d study to compare the effects of increasing crystalline AA in sorghum- and corn-based diets on nursery pig growth performance. Treatments with 5 pigs per pen and 10 pens per treatment were arranged in a 2 × 3 factorial with main effects of grain source (sorghum vs. corn) and crystalline AA supplementation (low, medium, or high). Because replacing increasing amounts of soybean meal with crystalline AA changes the NE of the diet, all diets were formulated 5.04 g SID Lys:Mcal NE. The Lys concentration in the diets was formulated at 95% of the pig's estimated requirement to ensure that the other AA, on a ratio relative to Lys, would not be underestimated. Amino acid ratios to Lys and standardized ileal digestibility (SID) coefficients used were obtained from NRC (2012). The grain sources and soybean meal were analyzed for AA profile and diets formulated from these concentrations. Sorghum AA concentrations were 0.17% Lys, 0.13% Met, 0.23% Thr, 0.08% Trp, and 0.33% Val. Corn was analyzed to be 0.23% Lys, 0.17% Met, 0.28% Thr, 0.06% Trp, and 0.36% Val. Soybean meal was analyzed to be 2.86% Lys, 0.65% Met, 1.82% Thr, 0.68% Trp, and 2.13% Val. The low AA fortification contained L-lysine HCl and DL-methionine. The medium AA fortification contained L-lysine HCl, DL-methionine, and L-threonine, and the high AA fortification contained L-lysine HCl, DL-methionine, L-threonine, and L-valine. Overall, there were no main or interactive effects ($P > 0.05$) of grain source or AA supplementation rate detected for ADG, ADFI, or G:F. This suggests that balancing to the third, fourth, or fifth limiting AA is possible in both sorghum- and corn-based diets with the use of crystalline AA without detrimental effects on growth performance. Results also suggest that corn and sorghum elicit similar nursery pig performance when serving as

the only grain source in the diet.

Key Words: corn, nursery pig, sorghum

270 **Effects of increasing standardized ileal digestible threonine:lysine ratio on performance of weaned pigs challenged with *Escherichia coli* K88.**

B. Jayaraman^{1,*}, J. K. Htoo², C. M. Nyachoti¹,

¹University of Manitoba, Winnipeg, MB, Canada,

²Evonik Industries AG, Hanau-Wolfgang, Germany

An experiment was conducted to evaluate the effects of dietary standardized ileal digestible (SID) threonine:lysine (Thr:Lys) ratio on performance and plasma urea nitrogen (PUN) concentration in piglets subjected to an *Escherichia coli* K88 (*E. coli* K88) challenge and fed antibiotic-free diets. Thirty-five individually housed mixed-sex pigs (Duroc × [Yorkshire × Landrace]) with an initial BW of 7.3 ± 0.5 kg and weaned at 21 ± 1 d were randomly assigned to 5 dietary treatments with 7 pig replicates per treatment. Dietary treatments contained increasing levels of SID Thr:Lys ratios (55, 59, 63, 67, and 71%). Diets were corn-wheat-soybean meal based with a constant SID Lys of 1.18% that was set to be the second limiting AA but adequate in other AA. Pigs had ad libitum access to feed and water for the 14 d. On d 8, piglets were orally challenged with 6 mL of *E. coli* K88 (2×10^9 cfu/mL). Body weights and feed disappearance were recorded weekly to determine ADG, ADFI, and G:F. Blood samples were collected on d 0, 7, and 14 to determine PUN. During the prechallenge period (d 0–7), increasing SID Thr:Lys increased ADG (102, 113, 119, 138, and 100 g/d; quadratic, $P \leq 0.05$) and G:F (0.64, 0.65, 0.77, 0.75, and 0.68; quadratic, $P \leq 0.05$), with the highest being 67% and 63% for ADG and G:F, respectively. The curvilinear-plateau regression estimated that ADG and G:F was maximized at a SID Thr:Lys of 65% and 66%, respectively. During the postchallenge period (d 8–14), there were no effects of increasing SID Thr:Lys on PUN, ADFI, and G:F, which suggests that the *E. coli* challenge used in this experiment was insufficiently sensitive to activate immune system stimulation in weaned pigs. During the overall period (d 0–14), increasing the SID Thr:Lys trended to increase ($P = 0.08$) the ADG, and the greatest responses in ADG and G:F were achieved with a dietary SID Thr:Lys ratio of 67%.

Key Words: *Escherichia coli*, piglets, threonine:lysine

271 **Effects of dietary protein and rapidly fermentable carbohydrate contents on bacterial metabolites and intestinal microbiota composition in weanling pigs.**

V. V. Almeida¹, M. C. Thomaz², A. J. C. Nuñez¹, P. V. A. Alvarenga², F. R. Castellini², Y. V. Silva-Guillen², K. M. Ajuwon^{1,*}, ¹Department of Animal Sciences, Purdue University, West Lafayette,

²Department of Animal Science, São Paulo State University, Jaboticabal, SP, Brazil

One hundred and eight barrows weaned at 21 d (5.82 ± 0.96 kg initial BW) were used to evaluate the effects of dietary crude protein (CP) and dried citrus pulp (DCP; rapidly fermentable carbohydrate source) contents on lactate concentration and bacterial counts in the hindgut digesta. Pigs were blocked by initial BW and randomly assigned to 4 treatments with 9 replicate pens per treatment and 3 pigs per pen in a randomized complete block design. Treatments were arranged as a 2×2 factorial, with 2 CP contents (HCP and LCP; high- and low-CP diets, respectively) and 2 DCP contents (0 and 7.5%, as-fed basis). The HCP treatments consisted of feeding 20 and 21% CP diets (as-fed basis) throughout the pre-starter I (1 to 14 d) and pre-starter II (15 to 28 d) phases, respectively. For the LCP treatments, CP contents were 16 and 17% for the pre-starter I and II diets, respectively. Dietary AA contents were balanced by supplementation with crystalline AA to maintain constant ratios in relation to standardized ileal digestible Lys. Cecum and colon digesta samples were collected from 1 pig per pen on d 7 and 28 postweaning for lactate determination by colorimetry and *Lactobacillus* and total coliform enumeration (TCE) using de Man, Rogosa, and Sharpe medium and Petrifilm coliform count plates, respectively. Statistical analyses were conducted using the MIXED procedure of SAS. No treatment × day interactions were observed ($P > 0.05$) for all variables. Lactate production in the cecum was not influenced ($P > 0.05$) by treatment. There was a CP × DCP interaction for colon lactate concentration ($P = 0.02$), in which adding 7.5% dietary DCP increased ($P = 0.01$) colon lactate concentration only for pigs fed the LCP diet. *Lactobacillus* counts in both the cecum and colon were not affected ($P > 0.05$) by treatment. There was also a CP × DCP interaction for TCE in the colon ($P = 0.02$) and cecum ($P = 0.05$). Added DCP decreased ($P = 0.04$) TCE in the colon of pigs fed the LCP diet (3.24 and 1.47 \log_{10} cfu/g for 0 and 7.5% DCP, respectively) and tended to increase ($P = 0.08$) TCE in the cecum only for pigs fed the HCP diet (2.76 and 4.37 \log_{10} cfu/g for 0 and 7.5% DCP, respectively). In conclusion, adding 7.5% DCP in low-protein AA-supplemented diets inhibits the proliferation of harmful bacteria in the hindgut, thus enhancing intestinal health of piglets. However, those positive effects are not observed when feeding diets higher in protein.

Key Words: intestinal health, lactate, piglets

272 **Evaluation of rendered animal protein sources on growth performance and blood chemistry in growing pigs.**

Y. Lei^{1,*}, S. C. Kim¹, M. Mohammadi Gheisar¹, M. C. Nyachoti², I. H. Kim¹, ¹Department of Animal Resource and Science, Dankook University, Cheonan, South Korea, ²University of Manitoba, Winnipeg, MB, Canada

A 6-wk growth assay was conducted to determine the effects of animal skin protein from swine and cattle on growth performance, body condition, and blood characteristics in grow-

ing pigs. A total of 96 pigs (23.5 kg) were allotted into pens with 4 pigs/pen and 6 pens/treatment. Treatments were 1) a corn-soybean-meal based control and the control diet with 2) 1.5% hydrolyzed render meal (HRM), 3) 1.5% swine skin meal (SSM), or 4) 1.5% cattle hide meal (CHM). The HRM and enzyme-treated skin meal were obtained from the Woosin food company (Pocheon, Gyeonggi, Korea) and was produced using a dry processing method at 130°C and under 500 kPa of steam. Chromium oxide was added to the diet as an indigestible marker at 0.20% for 7 d prior to fecal collection during the 6th week for calculating apparent total tract digestibility of dry matter (DM), nitrogen (N), and energy (E). The data obtained were analyzed using the general linear model procedure of SAS as a randomized complete block design by ANOVA. Pen was considered to be the experimental unit. Variability in the data is expressed as the standard error, and a probability level of $P < 0.05$ was considered to be statistically significant. Average daily gain (ADG) was improved in response to SSM treatment compared with other treatments ($P < 0.05$). Pigs fed with HRM, SSM, and CHM diets showed increased ($P < 0.05$) average daily feed intake (ADFI) and decreased ($P < 0.05$) gain-to-feed ratio compared with pigs fed the control diet. There were no differences in DM, N, or E digestibilities among treatments. Neither backfat thickness nor lean percentage of pigs were affected by dietary treatment. No differences were observed in blood concentrations of creatinine or BUN, and activities of serum GOT and GPT did not differ among the dietary treatment groups. In conclusion, the supplementation of SSM in growing pig diets improved the growth rate and feed intake of pigs, but its usage in swine diets is limited by the poor protein quality.

Key Words: animal-derived protein, enzyme, growing pigs

273 Determination of protein and amino acid digestibility of microbially converted soybean meal in comparison to fish meal. S. M. Sinn^{1,*}, W. Gibbons¹, M. Brown¹, J. M. DeRouche², C. L. Levesque¹, ¹South Dakota State University, Brookings, ²Kansas State University, Manhattan

Fish meal (FM) is included in weaned pig diets as a high quality, easily digestible ingredient, but it is becoming increasingly critical to find alternative high quality ingredients for weaned pig diets due to sustainability concerns. Further processing has allowed soybean meal to become more tolerated by young pigs to increase the nutrient availability and reduce antinutritional factors, such as oligosaccharides, glycinin, and beta-conglycinin. These antinutritional factors result in gut inflammation and reduced growth performance. A modified soybean meal product may provide a locally produced alternative to fish meal in early pig diets. A novel microbially converted soybean meal (MCSBM) has recently been developed with *Aureobasidium pullulans* to increase the protein content

Table 273. Standard ileal digestible amino acid content (%) in two protein sources fed to pigs.

Amino Acid	Fish meal	Microbially converted soybean meal	SEM	P-value
Crude protein	88.8	90.3	3.0	0.625
Lysine	93.8	88.8	0.8	<0.001
Methionine	93.8	91.0	0.8	0.009
Threonine	92.7	88.1	1.2	0.007
Isoleucine	94.8	91.0	0.7	0.004
Leucine	95.1	91.6	0.8	0.005
Valine	92.6	90.4	0.9	0.072
Histidine	92.0	89.6	1.2	0.119
Phenylalanine	92.5	90.9	0.8	0.125
Arginine	93.1	94.5	2.6	0.640

and reduce the antinutritional factors. A digestibility trial was conducted to determine the standard ileal digestibility (SID) of protein and amino acids in FM and MCSBM as a potential replacement for FM in weaned pig diets. Six ileal-cannulated barrows (30 ± 1.6 kg BW) were used in a 3 × 3 Latin square design with 3 periods of 7 d each (5 d acclimation and 2 d ileal collection of 8 h/d). Pigs were randomly assigned, within period, to one of three experimental diets (FM, MCSBM, and nitrogen-free) where FM and MCSBM were each included as the sole protein source. Titanium dioxide was included in each diet at 0.1% as an indigestible marker. Feed allowance per period was provided at 2.5 × maintenance energy requirement (106 kcal/kg BW^{0.75}) based on measured BW at the beginning of each period. At the beginning of periods 1, 2, and 3, pig BW were 37 ± 1.1, 39.2 ± 2.4, and 42.6 ± 2.7 kg, respectively. Data were analyzed using a t-test in SAS. The SID of lysine, methionine, threonine, isoleucine, and leucine were higher ($P < 0.05$) in fish meal than MCSBM. There was no difference in SID for all other measured amino acids or crude protein. In conclusion, MCSBM contained similar digestible amino acid and crude protein contents compared with FM.

Key Words: digestibility, fish meal, microbially converted soybean meal

274 Concentration of nutrients and predicted concentration of swine ME among types and sources of animal protein by-products. P. E. Urriola^{1,*}, B. J. Kerr², G. C. Shurson¹, ¹Department of Animal Science, University of Minnesota, St. Paul, ²USDA-ARS, Ames, IA

Rendered animal by-products can be a source of energy and nutrients in swine diets, but utilization is limited due to variable composition among products and sources. Prediction equations for energy and nutrient concentration can be used to help manage variability, but robust data sets are required to avoid biases. Therefore, the objective of this experiment was to construct a robust data set (% as is) of DM, CP, ether extract (EE), ash, Ca, and P as well as GE content among sources of blood meal (BM), chicken by-product (CBP), chicken meal (CM), feather meal (FM), meat and bone meal (MB), meat

Table 274. Average concentration of nutrients (% , as is) and predicted concentration of GE and ME (kcal/kg DM) for growing pigs among sources of animal protein by-products

Product	CP	EE	Ash	Ca	P	GE	ME ¹	ME ²
BM	89.2	1.77	2.95	0.36	0.34	5267	2,920	3,173
CBP	65.7	14.24	13.05	3.43	2.06	5133	3,760	2,521
CM	65.5	12.73	18.00	5.89	3.23	4880	3,584	2,141
FM	84.8	6.05	2.33	0.48	0.27	5410	2,974	3,177
MB	53.8	11.42	27.30	9.02	4.31	4187	3,240	1,888
MM	55.1	14.52	24.17	7.79	3.82	4537	3,391	1,922
PB	61.2	12.53	22.66	7.35	3.60	4566	3,142	1,893
PM	65.5	12.91	17.15	5.04	2.77	4945	3,515	2,204
Overall	65.8	10.05	17.73	5.59	2.79	4713	3,238	2,327

¹ME = 6,982 + (0.283 × GE, kcal/kg) - (6.26 × CP, g/kg) - (3.75 × EE, g/kg) + (129.47 × P, g/kg) - (54.91 × Ca, g/kg) - (6.57 × ash, g/kg).

²ME = 13,587 - (1.25 × GE, kcal/kg) - (3.51 × CP, g/kg) + (3.51 × P, g/kg) - (16.4 × ash, g/kg).

meal (MM), poultry by-product (PB), and poultry meal (PM). Animal by-products (n = 196) were collected across multiple suppliers, states, product types, and plants over 2 years. The greatest variability (CV) was observed for Ca (65%) and P (59%) content, which is explained by variability in ash (55%) content. The second most variable nutrient was EE (44%), which ranged from 1.5% in BM to 14.5% in MM. Concentration of ME (kcal/kg DM) was predicted using chemical composition of nutrients and varied (1,888 to 3,760 kcal/kg DM) depending on product and equation that was utilized. This data set includes the majority of animal protein by-products available in North America and suggests that large variability in ME content can be managed by utilizing prediction equations, but these equations need to be validated.

Key Words: animal by-products, energy, swine

NONRUMINANT NUTRITION: FEED ADDITIVES AND TECHNOLOGIES

275 Effects of feeding increasing levels of a proprietary yeast blend on sow reproductive performance over a two-parity period. R. Song*, K. W. Purser, R. E.

Musser, C. D. Hagen, *NUTRIQUEST, Mason City, IA*

This study evaluated the effects of feeding increasing levels of yeast blend (Evosure™) on sow reproductive performance over a two-parity period at a commercial sow facility designed and staffed to conduct research. A total of 401 sows (PIC 1050; parity 1 to 9) randomly selected from the commercial herd were allotted randomly to one of four dietary treatments containing 0 (CON), 0.25, 0.375, or 0.50 g/kg yeast blend in both gestation and lactation diets, resulting in approximately 100 sows per treatment. Experimental diets were fed from day 3 of gestation until weaning over two successive parities with sows remaining on the same treatment. Analysis of variance was conducted to analyze the data using the MIXED procedure of SAS. Parity was used as covariate in the model for all parameters if it was significant ($P < 0.05$).

Weaning age was used as covariate for analyzing pig weaning weight. Orthogonal polynomial contrasts were used to determine the linear effect of dietary yeast blend. Feeding increasing levels of yeast blend linearly increased litter birth weight ($P < 0.05$) and pig birth weight ($P < 0.08$) in both parity periods. Specifically, feeding yeast blend at 0.50 g/kg resulted in 8.2% greater litter birth weight (18.3 vs. 16.9 kg, $P = 0.003$), 8.0% greater pig birth weight (1.32 vs. 1.22 kg, $P < 0.001$) in the Parity 1 period, and 4.4% greater pig birth weight (1.31 vs. 1.26 kg, $P = 0.004$) in the Parity 2 period relative to feeding CON. In addition, the percentage of small pigs at birth ($BW \leq 1.13$ kg) was also significantly reduced ($P < 0.003$) in sows fed 0.50 g/kg yeast blend in both parity periods. Moreover, the percentage of preweaning mortality was significantly lower in sows fed 0.50 g/kg yeast blend in the Parity 2 period (10.8 vs. 14.4%, $P = 0.03$). Furthermore, feeding increasing levels of yeast blend linearly increased pig weaning weight in both parity periods ($P < 0.05$). Compared to sows fed CON, sows fed 0.50 g/kg yeast blend showed 4.1% greater pig weaning weight in the Parity 1 period (5.71 vs. 5.49 kg, $P = 0.03$) and 5.6% greater pig weaning weight in the Parity 2 period (4.83 vs. 4.57 kg, $P = 0.01$). Total born, born alive, sow BW change during lactation, and wean-estrus intervals were not affected by dietary treatments in any parity period. These results indicate that feeding a proprietary yeast blend to sows in gestation and lactation will positively affect pig birth weight, weaning weight, and preweaning mortality, and these effects seem to be consistent over a two-parity period.

Key Words: reproductive performance, sows, yeast blend

276 Efficacy of adding β-mannanase to hulled (44% CP) and dehulled (48%) soybean meal on growth performance, blood chemistry, fecal microflora, and fecal noxious gas emission in growing pigs.

M. Jung*, Y. Lei, V. Sharma, S. D. Upadhaya, I. H. Kim, *Department of Animal Resource and Science, Dankook University, Cheonan, South Korea*

Soybean meal is widely used as the major protein source in swine diets, but it occurs in several forms with varying protein content. This experiment was conducted to determine the efficacy of adding β-mannanase to hulled and dehulled corn soybean meal-based diets on parameters in growing pigs. A total of 140 growing pigs with an average BW of 25 kg were allotted to pens and fed diets with main effects of CP concentration (44 vs 48%) and β-mannanase supplementation (none vs 0.05%). Treatments were arranged as a 2 × 2 factorial arrangement. Pigs were weighed at 0, 3, and 6 weeks of the experimental period while feed consumption was recorded on a per pen basis to calculate ADG, ADFI, and G:F. Chromium oxide (2 g/kg) was added to the diets as an indigestible marker to measure digestibility. Fresh fecal samples were obtained from at least two pigs in each pen at the end of the experiment

to determine the ATTD of DM, energy, and N. One gram of the composite fecal sample from each pen was diluted with 9 mL of 1% peptone broth and then homogenized. Viable counts of bacteria were then conducted by plating serial 10-fold dilutions onto MacConkey agar plates and *Lactobacilli* medium III agar plates. Additionally, 150 g of feces and 150 g of urine were mixed well and stored in plastic boxes. The samples were fermented for 7 d at room temperature (25°C). The concentrations of gas were determined on d 1, 3, 5, and 7 during the fermentation period. There were no interactions among the effects of CP concentration and β -mannanase addition. Hulled SBM improved ($P = 0.05$) the ADFI of pigs overall and tended to improve ($P = 0.07$) it during the first 3 weeks (1731 g, 1569 g) compared with dehulled SBM (1666 g, 1465 g). The G:F ratio improved ($P < 0.05$) overall as well as during 3 weeks of feeding ($P < 0.05$) with dehulled SBM compared with hulled SBM (0.426, 0.469 vs 0.396, 0.411). β -mannanase supplementation reduced ($P < 0.05$) *E. coli* population and tended ($P = 0.09$) to reduce NH_3 concentration after 24 h of fermentation. Dehulled SBM tended to reduce ($P = 0.07$, $P = 0.08$, respectively) NH_3 emission on d 3 and d 5 of fermentation. However, β -mannanase supplementation had no effect on ADG, ADFI, G:F, ATTD of nutrients, or BUN. In conclusion, β -mannanase supplementation partially had positive effects on reducing *E. coli* population and NH_3 emission. Among SBM, dehulled SBM showed a positive effect on feed efficiency and a tendency to reduce NH_3 emission.

Key Words: dehulled soybean meal, hulled, mannanase

277 **Influence of protected organic acid blends in diets with different nutrient densities on growth performance, nutrient digestibility, and fecal noxious gas emission in growing pigs.**

B. Balamuralikrishnan^{1,*}, D. Jung¹, K. Y. Lee², S. D. Upadhyaya¹, I. H. Kim¹ ¹*Department of Animal Resource and Science, Dankook University, Cheonan, South Korea*, ²*Morningbio Co., Cheonan, South Korea*

An experiment was conducted to determine the effects of protected organic acid blends in diets of varied nutrient concentrations on growth performance, nutrient digestibility, and fecal noxious gas content in growing pigs. A total of 80 pigs [(Landrace \times Yorkshire) \times Duroc] with an average initial BW of 22.6 kg were used in a 6-week trial. Pigs were allocated randomly into one of four treatments in a 2 \times 2 factorial arrangement with two levels of energy and nutrient density (low and high energy, CP and lysine) and protected organic acids (0 and 0.1%) according to sex and BW (5 replicates with 2 gilts and 2 barrows per pen). Pigs fed high nutrient density diets had greater ($P < 0.05$) ADG (630 g vs 615 g) and G:F (0.445 vs 0.409) than those fed low nutrient density diets. Likewise, pigs fed the protected organic acid diet had greater ($P < 0.05$) ADG (630 vs 615 g) than pigs fed diet without protected or-

ganic acids in low nutrient density diets, and ADG was also greater in the high nutrient density diet with or without protected organic acids (645 vs 630 g). However, there was an interaction ($P = 0.03$) for G:F among treatments with organic acids and the density of diets. The digestibility of DM tended to be improved ($P = 0.08$) in pigs fed the high nutrient density diets (74%) compared with the low nutrient density diet (73%). However, digestibility of N and gross energy was not influenced by the nutrient density. Likewise, protected organic acid supplementation did not influence ($P > 0.05$) DM, N, or gross energy digestibility. Organic acid supplementation reduced ($P < 0.05$) H_2S content from feces on d 1, 3, 5, and 7 of incubation. The low nutrient density diet had less ($P < 0.05$) H_2S gas content on d 1 of incubation. In conclusion, dietary supplementation with protected organic acids with the high nutrient diets improved growth performance in growing pigs.

Key Words: growth performance, microflora, protected organic acid

278 **Protected organic acid blends as an alternative to antibiotics in finishing pigs.** J. K. Kim^{1,*}, M. Jung¹, K. Y. Lee², S. Mohana Devi¹, I. H. Kim¹, ¹*Department of Animal Resource and Science, Dankook University, Cheonan, South Korea*, ²*Morningbio Co., Cheonan, South Korea*

Organic acids are of interest in pig feeding as promoters of gut health and growth as pressure mounts to reduce or eliminate the use of antibiotics as growth promoters. A total of 120 finishing pigs [(Yorkshire \times Landrace) \times Duroc] with an average BW of 49.7 kg were used in a 12-wk growth assay to determine the effects of protected organic acids blends (fumaric, malic, and citric acid) on growth performance, nutrient digestibility, fecal microflora, meat quality, and fecal gas emission. Pigs were allotted to pen based on BW and sex, with 4 pigs/pen and 10 pens/treatment. Treatments were a corn soybean meal-based diet as the control and the control with 0.1% and 0.2% protected organic acid blends. Dietary treatment with protected organic acid blends linearly increased ($P < 0.001$) ADG during 0 to 6 week and 6 to 12 week as well as overall with the increase in the inclusion level of organic acids in the diet. However, ADFI and G:F were not influenced by organic acids supplementation. The DM (75.3%, 77.5% vs 72.63%), N (76.05%, 79.05% vs 72.68%), and energy digestibility (78.97%, 79.43% vs 74.3%) increased linearly ($P < 0.001$) with the increase in the dose of protected organic acid blends during 12 weeks. During weeks 6 and 12, fecal ammonia emission linearly decreased ($P = 0.01$ and $P < 0.001$, respectively) on d 3 and d 5 of fermentation and acetic acid emission decreased linearly ($P < 0.001$) on d 5 and d 7 of fermentation in week 12. Supplementation of organic acid blends linearly increased the longissimus muscle area (49.16 cm², 50.79 cm² vs 47 cm²) with increasing level of organic acids. Based on sensory evaluation, the score for the color of meat showed lin-

ear and quadratic effects ($P < 0.001$, $P < 0.002$ respectively), and the score for the firmness of meat showed quadratic effects ($P = 0.003$) with the increase in the level of organic acid blends in the diet. During week 6, the increment in the level of protected organic acid blends linearly decreased ($P = 0.01$) *E. coli* counts and linearly increased ($P = 0.004$) *Lactobacillus* counts in the feces. During week 12, a linear reduction ($P < 0.001$) of *E. coli* counts and the tendency for a linear increase ($P = 0.06$) in the *Lactobacillus* count in the feces were observed with the increase in the level of organic acid blends. In conclusion, 0.2% protected organic acids blends positively affected growth performance, nutrient digestibility, fecal gas emission, and meat quality in finishing pigs.

Key Words: growth performance, microflora, protected organic acids

279 **A study on the effect of phytogetic supplementation on growing-finishing pigs.** M. Mohammadi Gheisar¹, P. Y. Zhao^{1,*}, S. Shanmugam¹, D. Jung¹, J. D. Hancock², I. H. Kim¹, ¹*Department of Animal Resource and Science, Dankook University, Cheonan, South Korea*, ²*Kansas State University, Manhattan*

The present study aims to analyze the effect of phytogetic supplementation in growing-finishing pigs. A total of 144 pigs with an average initial body weight (BW) of 29.69 ± 2.57 kg were used in a 16-wk trial. Treatments were arranged with low and high energy density levels of phytoGENICS. Each pen housed 5 pigs, and there were 6 pens/treatment. Treatments were arranged with 2 levels of energy density (low or high energy density) and 2 levels (0 or 100 ppm) of phytoGENICS using AromexMEPlus blended with thyme 22%, rosemary 11%, and *Quillaja* 19% obtained from Delacon, Austria. The experimental pig treatment consists of grower (1 to 6 weeks), early finisher (7 to 12 weeks), and late finisher (13 to 16 weeks) periods. The data were analyzed as a 2×2 factorial design by using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC) with the pen as the experimental unit. The means of the treatments were compared using Duncan's multiple range tests, with $P < 0.05$ indicating significance. During wk 1 to 6, pigs fed low energy (LE) diets had much higher (Low vs. High, $P < 0.01$) ADFI and a lower (Low vs. High, $P < 0.05$) G:F ratio, and pigs fed the high energy (HEA) treatment had a higher ($P < 0.05$) G:F ratio and higher digestibility of N in the feces. Overall, phytoGENICS supplementation led to a significant increase (-Phy vs. +Phy, $P < 0.05$) in the G:F ratio and a significant decrease (-Phy vs. +Phy, $P < 0.05$) in the ADFI. Application of a high energy level (Low vs. High, $P < 0.05$) improved the G:F ratio. The ADFI was decreased ($P < 0.05$) in the HEA treatment compared with LE and HE treatments. Feeding phytoGENICS to growing-finishing pigs led to a significant increase of the G:F ratio and digestibility of N in the feces.

Key Words: noxious gas, nutrient digestibility, phytoGENICS

280 **A study on the effect of phytoGENICS on weanling pigs challenged with *Escherichia coli* K88.**

M. Begum^{1,*}, A. Hosseindoust¹, H. Y. Shin¹, J. D. Hancock², I. H. Kim¹, ¹*Department of Animal Resource and Science, Dankook University, Cheonan, South Korea*, ²*Kansas State University, Manhattan*

Phytogetic feed additives have become attractive alternatives in animal diets. The objective of the present study was to evaluate the effect of a phytogetic-based feed additive in weanling pigs after dietary challenged with *E. coli* K88. In total, 120 crossbred pigs [(Yorkshire \times Landrace) \times Duroc] with an initial BW of 6.09 ± 0.96 kg (21 d of age) were assigned randomly to 1 of 4 dietary treatments. Each pen housed 5 pigs, and there were 6 pens/treatment. Treatments include T1, negative control (without antibiotics); T2, T1 + antibiotic (Apramycin 150 ppm at Phase 1 + Tiamulin 39 ppm at Phase 2 and Phase 3); T3, T1 + 0.05% phytoGENICS; and T4, T1 + 0.2% commercial mix of organic acids (Commercial). Six pigs per treatment (1 pig per replicate) were orally challenged with 2 mL (1.0×10^8 cfu/mL) *E. coli* K88. The digestibility of DM, N, energy, ash, Ca, and P was measured using the Wiley mill method. The chromium was analyzed via UV absorption spectrophotometry. Data were analyzed by using GLM procedures of SAS (1996), with each pen being used as the experimental unit. The means of the treatments were compared by Duncan's multiple range test with a $P < 0.05$ indicating significance. Overall, the ADG in the T3 treatment was higher ($P < 0.05$). At wk 1, the ATTD of DM was increased ($P < 0.05$) in the T4 treatment. The ATTD of ash in the T3 and T4 treatments was greater ($P < 0.05$). At wk 3, pigs fed the T4 diet had significantly higher ($P < 0.05$) ATTD of DM. The ATTD of ash and Ca was significantly increased ($P < 0.05$) in the T4 treatment. Pigs fed the T3 diet had a higher ($P < 0.05$) ATTD of P. At wk 6, the ATTD of ash was significantly increased ($P < 0.05$) in the T1 and T3 treatments. The data indicate that phytoGENICS positively affects growth performance in weanling pigs, indicating its use as alternatives in the diets of weanling pigs to significantly improve ADG under challenge with *E. coli* K88.

Key Words: *Escherichia coli* K88, growth performance, phytoGENICS

281 **Effects of fermented, aged garlic concentration supplementation in diets of lactating sows and their piglets.** S. C. Kim^{1,*}, T. S. Li¹, P. Y. Zhao¹,

M. C. Nyachoti², I. H. Kim¹, ¹*Department of Animal Resource and Science, Dankook University, Cheonan, South Korea*, ²*University of Manitoba, Winnipeg, MB, Canada*

It has been suggested that garlic might improve the growth performance of pigs. This study was conducted to determine the effects of fermented, aged garlic on lactating sows and their piglets. Experimental period was fifty-eight days, from

thirty days before farrowing to weaning. A total of twenty sows (Landrace × Yorkshire) were randomly assigned to treatments. Dietary treatments consisted of 1) CON (basal diet), 2) FG1 (CON + 0.1% Fermented Aged Garlic Feed Additive), 3) FG2 (CON + 0.2% Fermented Aged Garlic Feed Additive), and 4) IFG (CON + 0.1% Imported Fermented Aged Garlic Feed Additive). All diets based on corn and soybean meal were provided and formulated to meet or exceed the NRC (2012) following a lactating sow feed program; sows were fed two times a day, with restricted feeding, and were allowed ad libitum access to water. The lactation period was 21 d. The growth performance, blood profiles, and nutrient digestibility of sows were analyzed at farrowing and weaning, and the fecal diarrhea score of piglets was measured every week. All data were subjected to the statistical analysis as a randomized complete block design using the GLM procedures of SAS (SAS Inst. Inc., Cary, NC), and the pen was used as the experimental unit. Before carrying out statistical analysis of the microbial counts, logarithmic conversion of the data was performed. Differences among treatment means were determined using Duncan's multiple range tests with a $P < 0.05$ indicating significance. In this study, body weight loss of sows fed FG1, FG2, and IFG treatments was significantly lower ($P < 0.05$) than that of sows fed the CON diet during the lactating period. Piglets of sows fed the FG1, FG2, and IFG diets had higher body weight at week 3 and the end of the experiment ($P < 0.05$). ADG of piglets was significantly higher when sows were fed the FG2 and IFG diets rather than the CON diet at week 1 ($P < 0.05$). Fecal microflora population of piglets was decreased in the FG1, FG2, and IFG treatments ($P < 0.05$). Therefore, the results of this study suggested that Fermented Aged Garlic Feed Additive could improve the growth performance of sows and piglets.

Key Words: blood characteristics, fermented garlic, growth performance

282 Effects of a novel protease enzyme (CIBENZA) on finishing pig growth performance and carcass characteristics. E. W. Stephenson^{1,*}, J. M. DeRouchey¹, J. Escobar², J. C. Woodworth¹, M. D. Tokach¹, R. D. Goodband¹, S. S. Dritz¹, ¹Kansas State University, Manhattan, ²Novus International, Inc., St. Charles, MO

A total of 1,170 pigs (PIC 337 × 1050; initial BW 25.5 kg) were used in a 131-d study to determine the effects of a protease enzyme on growth performance and carcass characteristics of finishing pigs. Dietary treatments consisted of 1) a positive control diet formulated to provide 90% of the estimated standardized ileal digestible (SID) Lys requirement, 2) a negative control diet formulated to provide 90% of the SID Lys requirement minus the expected nutrient release (approximately 27 kcal/kg and 3.4% Lys) from the protease enzyme (CIBENZA DP100, Novus International, Inc., St. Charles,

Table 282.

Item	Positive control	Negative +DP100	Negative control	SEM
d 131, kg	133.3 ^a	132.6 ^{ab}	130.2 ^b	1.253
ADG, kg	0.831 ^a	0.826 ^{abx}	0.811 ^{by}	0.006
ADFI, kg	2.184 ^{ab}	2.207 ^a	2.148 ^b	0.021
G:F	0.381	0.375	0.378	0.003
HCW, kg	98.4	97.4	96.8	0.903
Yield, %	73.8 ^{ab}	73.5 ^a	74.4 ^b	0.262

^{a,b}Superscripts differ, $P < 0.05$. ^{x,y}Superscripts differ, $P < 0.10$.

MO), and 3) the negative control diet with the addition of 0.05% CIBENZA DP100 (600,000 U protease/g). Pens of pigs were randomly allotted to 1 of the 3 treatments, with 26 pigs per pen and 15 replicates per treatment. Pigs were harvested (average final BW of 132 kg) at a commercial facility. Overall (d 0 to 131), pigs fed the positive control diet had an increased ($P < 0.05$) ADG of 0.02 kg compared to pigs fed the negative control diet. Pigs fed the negative control diet plus CIBENZA DP100 had increased ($P < 0.05$) ADFI (2.7%) and a tendency for improved ($P = 0.09$) ADG (1.8%) compared to pigs fed the negative control diet without the enzyme. No differences were observed in ADG, ADFI, or G/F between pigs fed the positive control and those fed the negative control plus the protease enzyme, which suggests that the release values attributed to the enzyme were accurate. The only observed effect on carcass characteristics was for yield, in which the pigs fed the negative control diet with enzyme had a lower ($P < 0.05$) carcass yield (0.9 percentage units) compared to pigs fed the negative control diet without enzyme. These data suggest that the protease enzyme CIBENZA DP100 will elicit improved growth performance when added to diets formulated at 90% of the pig's estimated SID lysine requirement.

Key Words: finishing pigs, growth, protease enzyme

283 Impact of an endo-1,4-β-D-mannanase in nursery diets on two genetic populations of pigs selected for soybean meal allergic response. J. E. Ferrel^{1,*}, F. A. Cabezón², A. P. Schinckel², B. T. Richert², J. S. Radcliffe², T. S. Stewart², ¹Elanco Animal Health, Greenfield, IN, ²Purdue University, West Lafayette

A trial was conducted to evaluate 28% soybean meal (SBM) inclusion, with or without endo-1,4-β-D-mannanase (Hemicell- HT 1.5X, Elanco Animal Health, Greenfield, IN) enzyme on nursery pigs from two genetic lines selected for high (HL) and low (LL) sensitivity to soy proteins. Forty-eight pigs (initial BW = 5.87 kg ± 0.05; 23 d age) were weaned into group pens with free access to a soy-free corn-milk product based diet. After a 4 d adaptation, pigs were allocated in a randomized complete block design into individual pens, 12 pen replications per treatment, blocked by ancestry and BW, assigned to one of two dietary treatments in a 2 × 2 factorial arrangement for 14 days. Experimental diets consisted of 28% SBM and 28% SBM + 0.08 MU/kg mannanase. Feed intake and BW were recorded at d 7 and d 14. Data were analyzed using PROC

MIXED of SAS. There were no interactions to report for the study. For week 1, there were no differences between genetic lines for ADG ($P = 0.67$; 137 vs 157 g) and GF ($P = 0.70$; 0.383 vs 0.432) HL and LL, respectively. Week 1 ADFI was different ($P < 0.05$) for HL and LL (273 vs 348 g, respectively). During week 1, enzyme supplementation had no significant effect on ADG ($P = 0.35$; 130 vs 169 g) and GF ($P = 0.21$; 0.326 vs 0.488) for diets without and with mannanase, respectively. During week 2, there were no differences between genetic lines for ADG ($P = 0.92$; 422 vs 419 g), ADFI ($P = 0.54$; 558 vs 586 g), or GF ($P = 0.44$; 0.754 vs 0.728) of HL and LL, respectively. Week 2 ADG ($P = 0.32$; 404 vs 438 g) was similar without enzyme supplementation versus with, respectively. Overall, there was no effect of genetic line on ADG ($P = 0.80$; 280 vs 288 g), ADFI ($P = 0.14$; 432 vs 467 g), or GF ($P = 0.36$; 0.652 vs 0.617) for HL and LL, respectively. Overall, enzyme supplementation had no significant effect on final BW ($P = 0.26$; 10.54 vs 11.08 kg), ADG ($P = 0.26$; 265 vs 303 g), ADFI ($P = 0.15$; 416 vs 467 g), or GF ($P = 0.56$; 0.623 vs 0.646) for diets without and with mannanase, respectively. The inclusion of mannanase had no significant effect on growth performance of weaned pigs fed soybean based diets, regardless of genetic sensitivity from day 4 to 18 postweaning. Although increases in numerical differences were present for pigs fed mannanase, the study design potentially lacks the power to pick up these differences as significant.

Key Words: allergy, genetic lines, mannanase, pigs, soybean

284 **Antioxidants reduce lipid peroxidation of dried distillers grains with solubles (DDGS) and distillers corn oil (DCO) stored under high-temperature and -humidity conditions.** A. R. Hanson^{1*}, P. E. Urriola¹, L. J. Johnston², G. C. Shurson¹, ¹Department of Animal Science, University of Minnesota, St. Paul, ²West Central Research and Outreach Center, University of Minnesota, Morris

This experiment was conducted to evaluate lipid peroxidation in reduced oil DDGS (RO-DDGS; 5.0 % ether extract, EE), high oil DDGS (HO-DDGS; 13.0 % EE), and 2 sources of DCO (DCO-1, 1.2, 0.08, and 0.48% moisture, impurities, and unsaponifiabiles [MIU]; and DCO-2, 1.2, 0.01, and 0.1% MIU). One lot of each ingredient was divided into 18 samples (~908 g for DDGS or 2 kg of DCO). Six samples of each ingredient were mixed with either no supplemental antioxidants (CON), Rendox-CQ (REN; 1,000 mg/kg EE; Kemin, Industries, Des Moines, IA), or Santoquin-Q4T (SAN; 1,500 mg/kg EE; Novus Intl., St. Louis, MO). Each mixture ($n = 72$) was split into thirds, and 1 portion was immediately frozen at -20°C (d 0). Two portions were stored under hot ($38.6 \pm 0.1^{\circ}\text{C}$) and humid conditions ($94.0 \pm 0.3\%$) for 14 or 28 d. The MIXED procedure of SAS was used to evaluate the effects of ingredient, antioxidant, storage time, and interactions,

with d 0 values used as a covariate. Storage for 14 and 28 d increased the peroxide value (PV), *p*-anisidine value (AnV), and thiobarbituric acid reactive substances (TBARS) of DCO and DDGS by 3- to 4-fold ($P < 0.05$). Over the entire storage period, PV of DCO-1 and HO-DDGS (12.3 and 12.6 ± 0.3 meq O_2/kg oil, respectively) exceeded ($P < 0.05$) that of DCO-2 and RO-DDGS (9.6 and 9.3 ± 0.3 meq O_2/kg oil, respectively). Adding REN or SAN ($P < 0.05$) reduced TBARS and AnV relative to CON (TBARS = 11.0 ± 0.2 mg malondialdehyde eq/kg oil and AnV = 6.5 ± 0.2) over the entire period (mean of d 14 and 28), but TBARS and AnV did not differ ($P > 0.05$) between antioxidants (TBARS = 6.1 and 5.9 ± 0.2 mg malondialdehyde eq/kg oil and AnV = 1.9 and 1.8 ± 0.2 for REN and SAN, respectively). The PV on d 14, d 28, and overall was less ($P < 0.05$) with either antioxidant relative to CON (16.0 meq O_2/kg), but PV of ingredients with SAN exceeded ($P < 0.05$) REN (8.8 and 8.0 ± 0.2 meq O_2/kg oil for SAN and REN, respectively). In summary, antioxidants reduced peroxidation of DDGS and DCO by approximately 50% during 28 d of storage at 38.6°C and 94.0% relative humidity, but neither antioxidant completely stabilized the ingredients.

Key Words: antioxidant, distillers corn oil, dried distillers grains with solubles

285 **Effects of a multicomponent enzyme product in diets with and without wheat middlings on the performance of nursery pigs during the first 23 d postweaning.** H. J. Kim^{1*}, T. C. Tsai¹, J. R. Bergstrom², J. J. Chewning³, J. K. Apple¹, C. V. Maxwell¹, ¹Department of Animal Science, University of Arkansas Division of Agriculture, Fayetteville, ²DSM Nutritional Products, Inc., Parsippany, NJ, ³Swine Research Services, Inc., Springdale, AR

Pigs (PIC 29 \times 380, initial BW = 6.72 ± 1.17 kg, $n = 200$) were blocked by BW at weaning (21 ± 3 d) and allotted to 1 of 5 pens (5 pigs/pen) within each of 8 blocks to evaluate the effects of dietary supplementation with a multicomponent enzyme product (MEP) during the first 23 d postweaning. Pens within blocks were randomly assigned to 1 of 5 treatments in a $2 \times 2 + 1$ factorial arrangement. The dietary treatments were 1) a moderately complex diet without wheat middlings (CON), 2) CON with 10% wheat middlings (WM), 3) CON with MEP 1 (C+MEP 1), 4) WM with MEP 1 (WM+MEP 1), and 5) WM with MEP 2 (WM+MEP 2). All diets were pelleted and met or exceeded the NRC (2012) nutrient requirements over 2 diet phases. Pigs fed diets containing wheat middlings had reduced (Midd effect; $P < 0.01$) ADG in phase 2 (d 9 to 23) and for the overall experiment (phases 1 and 2 combined, d 0 to 23); however, ADG was improved (MEP 1 effect; $P < 0.05$) with the inclusion of MEP 1 in phase 2 and for the overall experiment. Similarly, ADFI was reduced (Midd effect; $P < 0.05$) in pigs fed wheat mid-

dlings in phase 1 and for the overall experiment, and pigs fed MEP 1 had greater (MEP 1 effect; $P < 0.05$) ADFI in phase 2 and for the overall experiment. Pigs fed WM+MEP 2 had improved ($P < 0.05$) ADFI in phase 2 and overall when compared to those fed the WM treatment. During phase 2 and the overall experiment, G:F was decreased (Midd effect; $P < 0.01$ and 0.06 , respectively) with dietary wheat middlings, and no effect of MEP 1 was observed. For pigs fed the WM treatment compared to WM+MEP 2, G:F was increased ($P < 0.05$) during phase 2. Overall G:F was improved ($P < 0.05$) for pigs fed WM+MEP 1 compared to WM+MEP 2. At the end of the experiment (d 23 postweaning), BW was reduced in pigs fed wheat middlings (Midd effect; $P < 0.01$) but was improved (MEP 1 effect; $P < 0.05$) by the addition of MEP 1. These results indicate that dietary wheat middlings decreased growth performance in early nursery phases, but the growth of pigs was increased by feeding MEP 1 in diets with or without dietary wheat middlings.

Key Words: multicomponent enzyme product, nursery pigs, wheat middlings

286 Effects of endo-1,4- β -D-mannanase on growth performance and carcass characteristics of finishing pigs fed ractopamine HCl and marketed in a 3-cut strategy. K. D. Haydon¹, P. J. Rincker¹, J. E. Ferrel¹, M. J. Schneider¹, C. W. Hastad^{2,*}, K. F. Coble², R. A. Cain², ¹Elanco Animal Health, Greenfield, IN, ²New Fashion Pork, Jackson, MN

A total of 1,138 pigs (TR4 \times Fast \times L02; initially 111.7 kg \pm 0.4152 kg) were used in a 35-d study to determine the effects of endo-1, 4- β -D-mannanase (Hemicell HT 1.5X, Elanco Animal Health, Greenfield, IN) on growth performance and carcass characteristics of finishing pigs fed ractopamine HCl (Paylean, Elanco Animal Health, Greenfield, IN) and marketed in a 3-cut strategy. Pens of pigs were allotted to 1 of 2 dietary treatments with 18–19 pigs per pen and 30 replications per treatment. The two treatment diets utilized were a corn-soybean meal-based control diet containing 7.4 ppm of ractopamine HCl and the control diet with the addition of endo-1,4- β -D-mannanase (0.08 MU/kg). Pigs were marketed out of each pen on d 7, 21, and 35 with approximately 20, 30, and 50% of the beginning inventory removed at each marketing event, respectively. From d 0 to 7, there were no differences in growth performance between treatments. However, from d 7 to 21 and d 21 to 35, pigs fed the diet containing endo-1,4- β -D-mannanase had increased ($P < 0.05$) ADG and tended to have improved ($P < 0.10$) G:F compared to those fed the diet without. Overall, from d 0 to 35, pigs fed the diet containing endo-1, 4- β -D-mannanase tended ($P < 0.10$) to have increased ADG and improved G:F. Carcass data for pigs marketed on d 7 were not available for analysis. However, when carcass data for pigs slaughtered on d 21 and 35 were combined, pigs fed endo-1, 4- β -D-mannanase had in-

Table 286.

Item	Control	Control + 0.03% Hemicell	SEM	Probability, $P <$
BW, kg				
d 0	112.1	111.2	0.43	0.132
Average at market	140.1	139.8	0.37	0.492
ADG, kg	1.06	1.09	0.014	0.066
G:F	0.351	0.357	0.010	0.071
Carcass ADG, kg	0.964	0.990	0.042	0.012
Carcass yield, %	76.67	77.12	0.093	0.001

creased ($P < 0.05$) carcass ADG and carcass yield. In conclusion, the addition of endo-1, 4- β -D-mannanase to finishing pig diets containing ractopamine may be useful in improving growth performance and carcass characteristics.

Key Words: endo-1,4- β -D-mannanase, finishing pig, ractopamine HCl

287 Chromium yeast in diet for early finishing pigs.

D. Baffa¹, M. I. Hannas^{1,*}, H. Rostagno¹, L. Albino¹, F. Rutz², C. Pereira³, M. Almeida¹, L. Lopes¹,

¹Universidade Federal de Viçosa, Viçosa, Brazil,

²Universidade Federal de Pelotas, Pelotas, Brazil,

³Universidade Estadual de Santa Cruz, Itabuna, Brazil

To evaluate the use of chromium yeast in diets for pigs during the early finishing phase a total of 72 castrated male pigs (72.10 \pm 3.38 kg) genetically selected for lean deposition (DanBred \times DanBred genetic lines) were allotted in a randomized block design with two treatments, a control diet (CN) or control diet + chromium yeast (CrY) with eight replicates and two animals per experimental unit. Diets were formulated to meet or exceed the nutritional requirements of pigs proposed by Rostagno et al. (2011). Chromium yeast was added at 400 ppb to the CN diet formulated to contain 3300 kcal/kg ME, 15.39, 0.87, 0.54, and 0.24% CP, SID Lys, Ca, and P, respectively, in a corn and soybean meal based diets. Pigs had free access to feed and water throughout the experimental period (14 days). Daily feed waste during the total period was manually collected and weighed. Pigs were weighed at the beginning and at the end of the experimental period to calculate average daily gain (ADG), average daily feed intake (ADFI), and feed conversion rate (F:G). Data were analyzed using the GLIMMIX procedure of SAS (SAS Inst., Cary, NC) with blocks as randomized effect and treatment as fixed effects, and means were compared by F test at 5% of probability. No differences ($P < 0.05$) were observed from 0 to 14 days for final BW, ADG, ADFI, and F:G between pigs fed the CN or CrY diet. The performance of pigs from 72 to 88 kg was greater than what is suggested for pigs with high genetic potential, which may have limited the effect of chromium in this phase. The chromium yeast did not improve the performance results when used in the diet for finishing pigs for a short period.

Key Words: additives, microminerals, swine

Table 288. Energy and nutrient digestibility values in growing pigs fed diets with different ME levels supplemented or not with Probios Guard

Item	Treatments				CV%
	3200 ME	3200 ME+PG	3300 ME	3300 ME+PG	
DE	3494b	3517b	3588ab	3623a	2.369
ME	3424b	3459ab	3523ab	3564a	2.745
ME _n	3322b	3350b	3427ab	3466a	2.556
CP	18.26a	18.68a	16.44b	16.37b	3.11
EE	3.05c	3.22c	4.28b	4.89a	11.10
CF	4.88a	5.02a	4.35b	4.15b	9.84
NDF	9.37	10.05	9.07	9.35	8.29
ADF	4.21b	4.28b	4.75ab	4.89a	9.12
MM	3.14ab	3.50a	2.69b	2.85ab	16.42
Ca	0.34	0.41	0.39	0.37	22.46
P	0.43	0.44	0.42	0.45	9.01

Means in the same row followed by different letters differ by SNK test ($P < 0.05$).

288 Effect of probiotic on energy and nutrient digestibility in growing pigs. G. Silva¹, A. Saraiva^{2,*}, M. I. Hannas², H. Rostagno², S. Salgueiro², G. Viana², M. Almeida², ¹Universidade Federal dos Vales do Jequitinhonha e Mucuri, Diamantina, Brazil, ²Universidade Federal de Viçosa, Viçosa, Brazil

The effect of the probiotic Probios Guard (PG - Chr Hansen, Denmark), on metabolizable energy (ME) and digestibility of nutrients in growing pigs was investigated using 32 castrated male pigs (31.2 ± 4.7 kg) allotted in a randomized block design in a 2 × 2 factorial arrangement (diets with 3200 and 3300 kcal/kg EM with 0 or 400 g/t PG) with 8 replicates and 1 pig per experimental unit. The total experimental period was 10 days, which included 5 days of adaptation of pigs to the metabolism cages and 5 days for feces and urine collection. Digestible energy (DE), metabolizable energy (ME), metabolizable energy corrected for nitrogen (ME_n), and the digestibility of nutrients [crude protein (CP), ether extract (EE), crude fiber (FD), neutral detergent fiber (NDF) and acid detergent fiber (ADF), mineral matter (MM), calcium (Ca), and phosphorus (P)] were determined (Table 288). Higher values ($P < 0.05$) of DE, ME, and ME_n were determined with the 3300 ME+PG diet. The values of DE, ME, and ME_n determined using the 3300 EM diet were similar ($P > 0.05$) to those obtained with the 3200 EM and 3200 EM+PG diets. The 3300 EM and 3300 EM+PG diets resulted in lower CP digestibility. The diet with 3300 EM+PG resulted in the highest digestibility of EE compared to the other diets. The greater digestibility coefficient values ($P < 0.05$) of EE and ADF were obtained with the 3300 EM+PG diet. In conclusion, the addition of Probios Guard in the diet with 3300 kcal/kg ME for growing pigs increased the ME value as a result of improved digestibility of ADF and EE.

Key Words: additives, metabolism, metabolizable energy

289 Effect of feeding encapsulated butyric acid (ButiPEARL) in nursery diets containing reduced lactose levels on the growth performance of weaning pigs. B. T. Kremer¹, L. Ochoa^{2,*}, A. L. Wagner³, ¹Kemin Agrifoods North America, Madison, WI, ²Kemin Industries, Inc., Des Moines, IA, ³Cooperative Research Farms, Richmond, VA

There has been limited research to establish if ButiPEARL (BP), a source of encapsulated butyric acid, can replace lactose and milk by-products in swine nursery diets without affecting the growth performance of pigs. Therefore, this study was carried out to evaluate the effects of feeding BP at 500 ppm on nursery diets with reduced levels of lactose on the growth performance of weaning pigs. The study was conducted as a RCBD (blocking factor = weight and sex) with the following dietary treatments: 1) Positive Control (PC): standard lactose levels without BP; 2) Negative Control (NC): PC - 6 percentage units of lactose, without BP; 3) PC+BP: PC with 500 ppm of BP; 4) Lac -1%+BP: PC - 1 percentage unit of lactose with 500 ppm of BP; 5) Lac -3%+BP: PC - 3 percentage units of lactose with 500 ppm of BP; and 6) Lac -6%+BP: PC - 6 percentage units of lactose with 500 ppm of BP. The study was carried out over a 42 d study period using 12 replicates with 720 weaning pigs (5.46 ± 0.25 kg) in 72 pens. During the study period, the following levels of lactose in the PC were fed during each dietary phase: Phase 1 (7 d): 15%; Phase 2 (7 d): 12% (7 d); Phase 3 (14 d): 9%; and Phase 4 (14 d): 0%. All pigs were fed a common diet in Phase 4, with no added BP. Pigs were housed in two rooms that had not been cleaned following cessation of the previous trial, with ad libitum access to feed and water. The PC had 11.8 and 12.0% higher ($P \leq 0.05$) overall ADG and ADFI than the NC. All pigs fed BP had a similar ($P > 0.05$) overall performance across lactose levels. On average, BP fed pigs had a lower ($P \leq 0.05$) overall ADG and ADFI (5.7 and 6.5%, respectively) than the PC and a higher ($P \leq 0.05$) overall ADG and ADFI (6.8 and 6.1%, respectively) than the NC. There were no treatment effects ($P > 0.05$) for overall G:F. These results suggest ButiPEARL may be used as a partial replacement for lactose in swine nursery diets.

Key Words: ButiPEARL, butyric acid, lactose, nursery pig

290 Chromium yeast and ractopamine in diets for finishing pigs. D. Baffa, M. I. Hannas^{*}, H. Rostagno, L. Albino, G. Viana, M. Xavier Jr., Universidade Federal de Viçosa, Viçosa, Brazil

To evaluate nutritional plans (NP) with chromium yeast (CrY) and ractopamine (RAC) for finishing pigs, 72 barrows with initial BW 72.10 ± 3.38 kg, genetically selected for lean deposition (DanBred × DanBred lines), were allotted in a randomized block design with four treatments, nine replicates and two pigs per experimental unit. Diets with or without CrY

Table 290. Performance of barrows in different nutritional plans during the finishing phase

Item	NP1	NP2	NP3	NP4	P-value
	Control/ Control	Control/ RAC	CrY/CrY	CrY/ CrY+RAC	
Final BW, kg	125.35 ^C	135.00 ^A	128.25 ^{BC}	132.21 ^{AB}	<0.001
ADG, kg/day	1.27 ^C	1.50 ^A	1.34 ^{BC}	1.43 ^{AB}	<0.001
ADFI, kg/day	3.69	3.75	3.63	3.61	0.638
F:G	2.91 ^A	2.50 ^B	2.74 ^{AB}	2.57 ^B	<0.001

^{A-C}Different letters in the same row differ ($P < 0.05$) for Tukey-Kramer adjusting t-test.

and RAC were used in two experimental periods of 14 and 28 days, respectively, resulting in four NPs: NP1 = Control/Control; NP2 = Control/RAC; NP3 = CrY/CrY, and NP4 = CrY/CrY+RAC. CrY and RAC were added to the diets at 400 ppb and 10 ppm, respectively. For the first experimental period, diets were formulated to contain 3300 kcal/kg ME and 15.35, 0.54, and 0.26% CP, Ca, and available P, respectively. For the second experimental period, diets were formulated to contain 3300 kcal/kg ME and 14.91, 0.53, and 0.24% CP, Ca, and available P, respectively. SID lysine in the diets with or without RAC was 0.93 and 0.78%, respectively. The effects of the NP were analyzed using the MIXED procedures of SAS (SAS Inst., Cary, NC) with blocks used as random effect in the model. Barrows in the Control/RAC NP had greater ($P < 0.001$) final BW and ADG than those fed Control/Control and CrY/CrY NPs. Pigs in the CrY/CrY+RAC NP showed higher ($P < 0.001$) final BW and ADG compared to pigs in the Control/Control NP. The NPs had no effect ($P > 0.05$) on ADFI. Pigs in the Control/RAC and CrY/CrY+RAC NPs had the best F:G compared to pigs in Control/Control NP. Pigs fed CrY/CrY NP had intermediate F:G ($P < 0.001$) that was similar to the results obtained with the other NPs. These results confirm the potential of CrY and RAC as feed additives to improve pig performance during the finishing phase.

Key Words: additives, microminerals, swine

291 A standardized protected blend of phytonutrients improves performance of lactating sows.

C. Oguey^{1,*}, C. Bruneau², ¹*Pancosma, Geneva, Switzerland*, ²*Pancosma, Saint-Hyacinthe, QC, Canada*

In monogastric animals, a standardized blend of capsaicin oleoresin, cinnamaldehyde, and carvacrol (XT, XTRACT 6930, Pancosma) was shown to positively affect fat digestibility and gut immune modulation, resulting in enhanced available nutrients, in better gut integrity and health, and finally in more energy available for production. Given these modes of action, XT should be beneficial to the performance of lactating sows. Therefore a study was designed to evaluate the effect of XT supplementation on performance of sows raised under commercial conditions. A total of 428 sows were randomly allocated from 15 days before farrowing until piglets' weaning to one of the two treatments: CT: basal diet and XT: basal diet

supplemented with 100 g/t XT. Animals had ad libitum access to feed and water. Sows' ADFI during gestation and lactation, backfat loss during lactation, and weaning to estrus interval were individually recorded. Piglet birth weight, number of piglets born alive, and the weights of piglets at birth weaning were evaluated per sow. Results were statistically analyzed by ANOVA, using the treatment, the parity and their interaction as fixed effects. XT did not affect sow ADFI during gestation and lactation, backfat loss, and piglets' weight gain during suckling ($P = 0.28$). However, XT significantly increased the number of piglets born alive by 0.75 piglets/sow ($P = 0.01$). The treatment \times parity interaction had an effect on lactation ADFI and weaning to estrus interval. More specifically, XT increased ADFI during lactation of primiparous sows compared to CT (+4.5%, $P = 0.03$) but not in multiparous sows (mean: 6.2 kg·h⁻¹·d⁻¹, $P = 0.96$). Finally, XT decreased the weaning to estrus interval by 1.6 days in multiparous sows ($P = 0.03$) but had no effect on this outcome in first parity animals (mean 5.5 days, $P = 0.40$). These results suggest that XT has the potential to improve sow performance during lactation under commercial conditions via more piglets born alive for all the sows, a higher intake of primiparous sows, and a reduced weaning to estrus interval in multiparous animals.

Key Words: phytonutrients, sow performance

292 Effect of supplying a nucleotide product (NuPro) to sow diets on growth performance and immune response of the offspring in the nursery. I. F. Hung^{1,*}, R. S. Samuel², K. A. Dawson², M. D. Lindemann¹, ¹*University of Kentucky, Lexington*, ²*Center for Animal Nutrigenomics and Applied Animal Nutrition, Alltech Inc., Nicholasville, KY*

Nucleotides have reported benefits in diets for young mammals. Studies have demonstrated their ability to alter several biological responses, including improving growth and immunity, during stress periods. Experiment 1 was conducted to evaluate the effect of dietary supplementation of nucleotides to late gestating sows on the performance of the piglets during nursery. Sows ($n = 37$) were randomly assigned to 2 dietary treatments: 1) a corn-soybean meal control diet or 2) the control diet with 1% soybean meal replaced by NuPro (NT; 44% CP, ~6% total nucleic acids; Alltech Inc.). The dietary treatments were started about d 101–102 of gestation and continued throughout lactation. At weaning, piglets ($n = 104$) from sows on each diet were split into 2 groups and fed diets that contained 0 or 2.5% NT to replace soybean meal in a 28-d study which resulted in a 2 \times 2 factorial arrangement. The data were analyzed using GLM program of SAS. Supplying NT to sow diets had no effect on litter size, litter weight, or mortality at birth and weaning ($P > 0.20$). In the nursery, there was no difference in piglet body weight, daily gain, or daily feed intake. However, pigs that consumed the NT diet (regardless of the sow treatment) tended to have numerically

decreased feed:gain ratio compared with control pigs at Wk 2 ($P = 0.11$; 1.42 vs. 1.62), in Phase 1 ($P = 0.17$, 1.25 vs. 1.42), and for the total period ($P = 0.12$; 1.43 vs. 1.52). Experiment 2 was conducted to investigate the effect of NT on the immunocompetence of weaned pigs. Piglets ($n = 64$) from sows not fed NT were fed the same diets as in Experiment 1. There was no difference between treatments in the growth performance during the 28-d study. After the 28-d study, pigs were challenged with either phosphate buffered saline (PBS) or a lipopolysaccharide (LPS) solution. For the LPS-challenged pigs, those that consumed NT diets tended to lose less weight ($P < 0.08$; -0.34 vs -0.98 kg) and consumed more feed ($P < 0.04$; 0.39 vs 0.26 kg) within 24 hours postchallenge. Serum TNF- α concentration at 2 h postinjection ($P < 0.01$; 4,470 vs 10,873 pg/mL) and serum IL-6 concentration at 4 h postinjection ($P < 0.03$; 4,590 vs 14,649 pg/mL) were also decreased in NT-fed pigs compared with control pigs. In conclusion, adding NT to the nursery diets had limited effects on growth in the relatively clean environment of these studies. However, dietary NT supplementation reduced weight loss and altered aspects of the immune response in a disease-challenge model.

Key Words: nucleotide, nursery, immunity

293 Enzyme supplementation to improve soy hull value in finishing diets. G. A. Apgar, O. Falomo*,
Southern Illinois University, Carbondale

Soybean hulls are a by-product of soybean processing, often priced competitively for consideration in swine diets. Their use in swine diets is limited by concerns of digestibility and energy content of the ration. However, use of exogenous enzymes in diets containing soy hulls may enable higher inclusion rates without reducing growth performance. The purpose of this study was to evaluate the efficacy of a commercially available enzyme with protease and carbohydrase activity when added to either corn-soybean meal based diets or diets containing 20% soy hulls. One hundred twenty-eight pigs (78.08 ± 9.1 kg) were allotted to 16 pens and randomly assigned one of four treatments offered in two phases (grower 68–91 kg and finisher 91–125 kg). Dietary treatments were 1) corn-SBM, 2) 1 + 1,000 ppm enzyme mixture, 3) corn-SBM + 20% soy hulls, and 4) 3 + 1,000 ppm enzyme mixture. Pen served as the experimental unit. Pigs were offered dietary treatments on an ad libitum basis. Pig weight and feed disappearance were measured every 14 days until all pigs averaged 125 kg (49 days). Criteria of interest were ADG, ADFI, and G:F within phase. Three pigs were removed during the study due to poor performance (2) or death (1), none of which were related to dietary treatments. Daily feed intake data for these pens was adjusted for pig-days at removal. Data were analyzed using the Proc Mixed function of SAS (SAS Inst. Inc. Cary, NC) with treatment and replicate in the model. Treatment LS means were separated using the PDIF function and considered significant at $P < 0.05$. Dietary treatments did not alter

ADG (1.00, 1.11, 0.86, 1.10 kg/d for treatments 1–4, respectively), ADFI (2.52, 2.45, 2.19, 2.26 kg/d), or G:F during the grower phase ($P > 0.12$). In the finisher phase, however, ADG for pigs fed treatment 2 was greater than for pigs fed treatment 1 (0.98 vs. 0.83 kg/d; $P = 0.02$) and treatment 3 (0.81 kg/d; $P = 0.013$) and tended to be greater than for pigs fed treatment 4 (0.86 kg/d; $P = 0.051$). Neither ADFI nor G:F was impacted by the treatments during the finisher phase. These data suggest enzyme supplementation improves finisher ADG but does not impact ADFI, G:F, or grower performance.

Key Words: enzyme, pigs, soy hulls

294 Effect of dietary betaine and ractopamine on growth and carcass characteristics in finishing pigs housed under high ambient temperatures.

S. M. Mendoza^{1,*}, E. van Heugten¹, C. E. Zier-Rush²,
R. D. Boyd^{1,2}, ¹North Carolina State University,
Raleigh, ²The Hanor Company, Inc., Franklin, KY

Betaine is an osmolyte that helps to maintain water homeostasis and cell integrity, which is essential during heat stress. We hypothesized that supplemental betaine would improve growth that is depressed during heat stress and possibly has a greater outcome combined with ractopamine. Two studies were conducted to determine 1) the effects of betaine in combination with ractopamine and 2) the optimal betaine level for late finishing pigs. High environmental temperatures were imposed by gradually increasing temperatures over 10 d to the target high temperature of 32°C. In Exp. 1, pigs ($n = 1,477$, BW = 91.6 ± 3.1 kg) were assigned within weight blocks and sex to 1 of 4 dietary treatments arranged in a 2 × 2 factorial RCB design. Treatments consisted of diets without or with ractopamine (5 ppm for 21 d followed by 8.8 ppm to market), and each of these diets was supplemented with either 0 or 0.2% of betaine. Pigs were housed approximately 22 pigs per pen using a total of 68 pens. Betaine reduced ADFI ($P = 0.001$; 2.80 vs. 2.92 kg/d) and ADG ($P = 0.05$; 0.78 vs. 0.83 kg/d) but did not impact carcass characteristics. Ractopamine reduced ($P = 0.04$) ADFI, improved ($P < 0.001$) gain:feed (0.295 vs. 0.265), market weight (125.8 vs. 122.1 kg), carcass yield (74.9 vs. 73.8%), loin depth (63.6 vs. 60.0 mm), and lean percentage (53.1 vs. 51.7%), and reduced backfat (20.7 vs. 22.0 mm). In Exp. 2, pigs ($n = 2,193$, BW = 95.6 ± 3.5 kg) were assigned within weight blocks and sex to 1 of 5 dietary treatments in a RCB design. Pigs were housed in pens with approximately 22 pigs each, using a total of 100 pens. Treatments consisted of diets supplemented with 0, 0.0625, 0.125, 0.1875% of betaine and the 0% betaine diet supplemented with ractopamine as in Exp. 1. Betaine decreased carcass yield in a quadratic manner ($P = 0.076$; 74.1, 73.5, 73.8, and 73.9 for 0, 0.0625, 0.125, 0.1875% of betaine, respectively) but did not impact other responses. Ractopamine improved ($P < 0.001$) gain:feed (0.334 vs. 0.295), market weight (121.6 vs. 118.5 kg), carcass yield (74.7 vs. 73.8%), loin depth (61.7 vs. 59.0

mm), and lean percentage (53.5 vs. 52.5%) and reduced back-fat (18.8 vs. 20.4 mm). Collectively, data indicate that under commercial conditions, betaine did not improve performance of pigs housed under high ambient temperatures, regardless of ractopamine inclusion. Ractopamine improved pig growth and carcass characteristics under high ambient temperatures.

Key Words: betaine, finishing pigs, ractopamine

295 **Efficacy of xylanase and β -glucanase in sows fed wheat-barley-based diet.** H. Manu^{1,*}, A. Owusu-Asiedu², S. K. Baidoo¹, ¹*Southern Research and Outreach Center, University of Minnesota, Waseca,* ²*DuPont Industrial Biosciences-Danisco Animal Nutrition, Waukesha, WI*

Sow body weight losses during lactation is one of the most important parameters related to its reproductive life and longevity. Forty-eight gestating sows (initial BW 256.9 \pm 24.0 kg; parity 3.6 \pm 0.24) and their resulting piglets were used to evaluate efficacy of carbohydrase containing a combination of xylanase (1,220 units/kg) and β -glucanase (152 units/kg; Axtra™ XB; DuPont Industrial Biosciences-Danisco Animal Nutrition, UK) in a wheat-based diet in gestation, lactation, and litter performance. Sows were weighed individually, and back-fat thickness was measured on d 93 of gestation, a day after farrowing, and at weaning (d 18 of lactation). Sows were randomly assigned to one of two dietary treatments (0 or 100 g XB/metric ton of feed) from d 93 of gestation and throughout lactation. Basal diet was formulated to contain 2,263 kcal/kg NE, 15.4% NDF, 6.40 ADF%, 0.96% Lys, 0.24% Met, and 0.60% Thr. Feed intake of sows was recorded daily, and effect of dietary treatments on litter performance was evaluated at farrowing and weaning. The data were analyzed as a completely randomized design using the GLM procedure of SAS. The model includes parity, farrowing group, enzyme, and their interaction. The sow and the litter was the experimental unit, and statistical significance was set at $P \leq 0.05$. Dietary treatments did not affect ($P > 0.05$) sow ADFI, litter weight, or ADG of piglets. However, compared with control, sows fed XB lost less ($P = 0.04$) BW during lactation (-0.22 vs -8.4 kg). The differences in the lactation associated body weight loss, combined with similar performance for the litters and BF thickness of sows, indicate that the added carbohydrase containing xylanase and β -glucanase combination improved the efficiency with which sows translate ingested nutrients (energy and protein) into milk components, thereby preventing sow body protein loss associated with lactation.

Key Words: enzyme, gestation, lactation, sow and litter performance

Table 295. Carbohydrase supplementation on sow performance

	XB, g/metric ton			<i>P</i> -values			
	0	100	SEM	XB	XB \times Parity	Group	Parity
Parity	3.6	3.6	0.24				
Sow BW before farrowing, kg	264.9	256.6	4.86	0.24	0.89	0.68	0.02
Sow BW at farrowing, kg	247.8	237.7	4.62	0.12	0.99	0.36	<0.01
Sow BW at weaning, kg	239.3	237.2	4.69	0.75	0.98	0.45	<0.01
Body weight change, kg	-8.40 ^a	-0.22 ^b	2.66	0.04	0.38	0.79	0.41
Back fat change, kg	-2.56	-2.51	0.41	0.93	0.38	0.01	0.34
Lactation feed intake, kg	101.68	101.52	4.74	0.98	0.20	0.41	0.04
N, number of sows	24	24					

^{a,b}Means in the same row with different superscripts differ.

296 **Impact of soybean meal level and β -mannanase in nursery diets on two genetic populations of pigs selected for soybean meal allergenic response.** J. E. Ferrel¹, E. R. Otto-Tice^{2,*}, M. D. Asmus², A. M. Jones², A. P. Schinckel², B. T. Richert², J. S. Radcliffe², T. S. Stewart², ¹*Elanco Animal Health, Greenfield, IN,* ²*Purdue University, West Lafayette, IN*

One hundred ninety-two pigs (initial BW = 6.67 \pm 0.05 kg; 23d of age) were utilized to evaluate the effect of 14 and 28% soybean meal (SBM) inclusion, with or without β -mannanase enzyme, on nursery pigs from two genetic lines selected for high (HL) and low (LL) sensitivity to soy proteins. The 14 and 28% SBM diets contained varying amounts of milk products to make the diets similar in key nutrients. Pigs were weaned into group pens and fed a soy-free diet for a 6 d adaptation period. Pigs were allocated in a randomized complete block design into mixed gender pens of 4 pigs/pen, blocked by ancestry and BW, and assigned to one of four diets in a 2 \times 2 \times 2 factorial design for d 0–19 followed by a common diet with or without enzyme for d 19–33. Diets were 28% SBM; 28% SBM + enzyme (0.08 MU/kg); 14% SBM; 14% SBM + enzyme (0.08 MU/kg) from d 0 to 19 and 23% SBM with or without enzyme (0.08 MU/kg) from d 19 to 33. For d 0–19 there was a SBM by enzyme interaction ($P = 0.02$) for ADG; 28% SBM enzyme improved ADG by 9.5%, while 14% SBM ADG was reduced 6.8% by enzyme supplementation. Pigs fed 28% SBM had increased ADFI ($P = 0.002$) but tended to have reduced G:F ($P = 0.07$). The LL pigs had increased ADFI ($P < 0.03$) but reduced G:F ($P < 0.01$) compared with HL. For d 19–33 and overall, there was a line by SBM by enzyme interaction ($P = 0.05$) for ADG. The HL pigs fed 28% SBM plus enzyme supplementation significantly improved ADG ($P < 0.05$), while in all other combinations of SBM level and line were not significant. For d 19–33, pigs fed 14% SBM had improved G:F ($P = 0.01$) compared with pigs fed 28% SBM. Overall, there was a SBM

by enzyme interaction ($P = 0.05$) for ADFI. For pigs fed 14% SBM, intake was reduced by enzyme addition, while 28% SBM ADFI increased with enzyme supplementation. There was a line by enzyme interaction ($P = 0.007$) for G:F; the HL had significantly improved G:F with enzyme supplementation (0.612 vs 0.658), whereas the LL had a slight numerical reduction in G:F (0.620 vs 0.600). Overall, HL pigs had improved G:F ($P = 0.04$) and reduced ADFI ($P = 0.008$) compared with LL. Pigs fed 14% SBM had improved G:F ($P = 0.01$) compared with pigs fed 28% SBM. In high soy-sensitivity pigs fed higher SBM levels, supplemental β -mannanase has the potential to improve nursery performance (ADG and G:F) compared with the low soy-sensitive pigs.

Key Words: allergy, genetic lines, mannanase, pigs, soybean

NONRUMINANT NUTRITION: FEED INGREDIENTS

- 297 **Influence of pineapple by-product on nursery pig performance.** U. D. S. Ruiz^{1,*}, G. F. Ramos¹, F. E. L. Budiño², G. D. V. Polycarpo³, T. S. Vasconcelos¹, C. D. Silva Júnior¹, J. A. Oliveira¹, A. Faria¹, ¹Universidade Estadual Paulista, Dracena, Brazil, ²Institute of Animal Science and Pastures, Nova Odessa, Brazil, ³University of São Paulo, Pirassununga, Brazil

High fiber feedstuffs can promote gut health in piglets and may be an interesting tool to improve the animal growth. This study evaluated the performance of nursery pigs fed a control diet or 1 of 3 diets with increasing levels (3.4; 6.8; 10.3%) of pineapple by-product (90.7% DM, 67.5% total dietary fiber, 7.08% CP, 3,951 kcal of GE/kg, as-fed basis). Growth performance [ADG, ADFI, and feed conversion ratio (FCR)] was evaluated from weaning (d 0) to d 14 (phase 1), from d 15 to d 30 (phase 2), and from d 31 to d 45. Fifty-six pigs (5.05 \pm 0.89 kg) were housed 2 per pen in phase 1, and 28 pigs were housed one per pen in phases 2 and 3, with free access to feed and water. Diets were composed of corn, soybean meal, dairy products, and spray-dried blood plasma, supplemented with minerals, vitamins, and AA. The pineapple by-product was added to the diets at the expense of corn. In phases 1, 2, and 3 the diets provided at least 3,400, 3,375, and 3,230 kcal of ME/kg; 220, 215, and 190 g/kg of CP; and 14.5, 13.3, and 10.9 g/kg of digestible lysine and presented from 7.7 to 16.0, 9.2 to 15.3, and 9.4 to 19.0% of total dietary fiber, respectively. A complete randomized block design according to the animals' weight was adopted; the pen was considered the experimental unit. Results were submitted to ANOVA and regression analysis, and the control diet was compared to each of the 3 pineapple by-products diets by Dunnett's test from

d 0 to d 14 (period 1), from d 0 to d 30 (period 2), and from d 0 to d 45 (period 3). The ADG, ADFI, and FCR of pigs in period 1, ADG and FCR in period 2, and ADFI and FCR in phase 3 were similar ($P > 0.05$). Increasing dietary inclusion of pineapple by-product linearly increased ($P < 0.05$) ADFI from d 0 to 30 in 44.1% (390 vs 562 g). From d 0 to d 45, the ADG of the pigs presented a quadratic ($P < 0.05$) response, and pigs fed the diet with 3.4% of pineapple by-product had a 50.15% higher ADG ($P < 0.05$) than the animals submitted to the control diet (509 vs 339 g). Feeding nursery pigs with a low inclusion of a high fiber feedstuff, such as pineapple by-product in 3.4% of the diet, is an interesting strategy to improve the ADG of pigs.

Key Words: growth performance, insoluble fiber, piglets

- 298 **Digestibility of crude fat and energy from a microalgae meal for nursery pigs.** R. M. Delles^{1,*}, S. Gregory², C. L. Levesque³, R. S. Samuel¹, ¹Center for Animal Nutrigenomics and Applied Animal Nutrition, Alltech Inc., Nicholasville, KY, ²Alltech Inc., Nicholasville, KY, ³South Dakota State University, Brookings

Alltech SP1 is derived from a heterotrophically grown microalgae meal that contains at least 67% fat (CCAP 4087/2; Alltech, Inc.). Fats are commonly added to swine diets as sources of energy to support growth and optimize feed efficiency. However, for accurate feed formulation, knowledge of the energy and fat digestibility of a feedstuff is needed. The objective of this study was to quantify the digestibility of crude fat and energy from SP1 for nursery pigs. Diets containing 0, 2, or 4% SP1, with no other added fat, were fed to 12 individually housed nursery pigs over 3 one-week periods in a Latin square design, thus providing 12 replicates of each diet. Pigs were acclimated to the metabolism pens and dry diets for one week immediately postweaning before the first dietary treatment began. Grab samples of feces were collected on days 6 and 7 of each dietary treatment period. The apparent total tract digestibility (ATTD) was determined by analyzing for the concentration of acid insoluble ash (AIA) in the feed and feces. Diets were formulated based on the predicted energy content of SP1 (calculated based on chemical composition and according to Powles et al., 1995) by decreasing the inclusion of corn as the inclusion of SP1 increased. As expected, the gross energy of the diets increased with the inclusion of SP1 (3,726 vs. 3,809 vs. 3,898 kcal/kg; $P < 0.01$). The ATTD of energy did not differ ($P > 0.10$) between dietary treatments, averaging 82%. Therefore, the diet containing 4% SP1 provided 35 kcal/kg more metabolizable energy (ME) than the 0% SP1 diet. Crude fat concentration was highest ($P < 0.05$) in fecal samples from the pigs fed the 4% SP1 diet. However, digestibility of crude fat was not different ($P > 0.30$) between dietary treatments. Although there were no differences in pig

performance within each period, the ATTD of energy was greater ($P < 0.05$) in period 3 compared to period 1, demonstrating the effect of the growth and development of the gastrointestinal tract on energy digestibility. Dietary supplementation with up to 4% SP1 did not alter ATTD of crude fat or energy in nursery pigs. Consequently, the predicted energy value for SP1 (5,300 kcal ME/kg) was demonstrated to be an appropriate value to utilize for feed formulation.

Key Words: algae, digestibility, energy

299 **Lipid digestibility and energy values of corn and soybean oil containing varying levels of free fatty acids (FFA) in nursery pigs.** B. J. Kerr^{1,*}, G. C. Shurson², ¹USDA-ARS, Ames, IA, ²Department of Animal Science, University of Minnesota, St. Paul

Two experiments were conducted to evaluate the impact of FFA in soybean oil (SO), corn oil (CO), or distillers corn oil (DCO) on the lipid's subsequent DE, ME, and ether extract (EE) digestibility. Two groups of 54 pigs weaned at 28 d of age were fed a common starter diet from d 1 to 7, followed by feeding groups their respective experimental diet (either 100% basal or 90% basal + 10% test lipid) from d 8 to 14. For the next 10 d (d 15 to 24) pigs were moved to individual metabolism crates for continued diet adaptation and to become accustomed to twice daily feeding regimen and being housed in metabolism crates. Total fecal and urine collection occurred on d 25 to 29 to determine total tract energy and lipid digestibility. Final BW and ADFI were 13.3 kg and 450 g for Exp. 1 and 15.8 kg and 500 g for Exp. 2, respectively. Diets consisted of SO and SO FFA, with or without 6% lecithin (Exp. 1), or CO containing 0 or 95% FFA or DCO containing 5, 10, or 15% FFA (Exp. 2). In Exp. 1, adding lecithin interacted with FFA level, reducing DE, DE as a percentage of GE, and ME in SO FFA but not in SO ($P < 0.01$). Lecithin had no effect on EE digestibility, while feeding SO FFA reduced EE digestibility compared with SO ($P < 0.01$). Neither FFA level nor lecithin addition affected ME as a percentage of DE. In Exp. 2, pigs fed CO FFA had similar DE, EE digestibility, ME, and ME as a percentage of DE as CO, even though DE as a percentage of GE was higher in CO FFA than for CO ($P < 0.05$). Increasing levels of FFA in DCO reduced DE, DE as a percentage of GE, and ME ($P < 0.05$) but had no effect on EE digestibility or ME as a percentage of DE. These results indicate that FFA in SO or CO have little effect on EE digestibility or subsequent DE and ME values, while increasing concentrations of FFA in DCO reduces EE digestibility and subsequent DE and ME values.

Key Words: digestibility, distillers corn oil, energy, free fatty acids, nursery pigs

300 **Effect of feeding wheat mill run on diet nutrient digestibility and growth performance in starter pigs.** H. García^{1,2}, L. F. Wang^{2,*}, J. L. Landero², E. Beltranena^{2,3}, M. Cervantes¹, A. Morales¹, R. T. Zijlstra², ¹Instituto de Ciencias Agrícolas, Universidad Autónoma de Baja California, Mexicali, Mexico, ²Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB, Canada, ³Alberta Agriculture and Rural Development, Edmonton, AB, Canada

Wheat by-products from flour milling could be an alternative feedstuff to reduce feed cost of pigs. Thus, the objective was to evaluate how graded substitution of soybean meal (SBM) and wheat with wheat mill run influenced nutrient digestibility and growth performance in starter pigs. The wheat mill run contained (as-fed) 12.1% ADF, 37.0% NDF, 16.8% CP, and 0.74% lysine. Diets were balanced for NE using canola oil and for AA using crystalline AA to contain 2.41 Mcal NE/kg and 4.39 g standardized ileal digestible (SID) Lys/Mcal NE. Five pelleted wheat-based diets containing 0, 5, 10, 15, or 20% wheat mill run in substitution for up to 15% SBM and 5% wheat were fed to 160 weaned pigs (housed in pens of 4 pigs) for 3 wk (d 1–21) starting 2 wk after weaning at 21 d of age. Freshly voided feces were collected by grab sampling on d 19–20. Increasing inclusion of wheat mill run to 20% linearly reduced ($P < 0.001$) diet apparent total tract digestibility (ATTD) of DM by 4 percentage units and diet ATTD of GE by 2.9 percentage units but did not affect ATTD of CP. Diet NE values predicted using measured diet DE values and analyzed macronutrients linearly increased ($P < 0.05$) by 0.02 Mcal/kg with increasing inclusion of wheat mill run, indicating that the NE value of wheat mill run was underestimated for weaned pigs. Increasing dietary inclusion of wheat mill run tended to linearly reduce ($P = 0.07$) ADFI by 65 g/d for d 1–7, linearly increased ($P < 0.05$) G:F by 0.10 for d 8–14, and did not affect growth performance variables in other weeks. Overall (d 1–21), increasing dietary inclusion of wheat mill run did not affect ADFI, ADG, or G:F. In conclusion, up to 20% wheat mill run can replace 15% SBM and 5% wheat in diets formulated to equal NE and SID Lys and fed to nursery pigs starting 2 wk after weaning without detrimental effects on growth performance.

Key Words: growth performance, pig, wheat mill run

301 **Effect of dietary inclusion of insoluble fiber from sugar cane on carcass traits of finishing pigs.** M. S. F. Oliveira^{*}, M. C. Thomaz, M. M. Lima, P. V. A. Alvarenga, F. F. Castro, M. V. Marujo, D. J. Rodrigues, Department of Animal Science, São Paulo State University, Jaboticabal, SP, Brazil

The inclusion of fibrous ingredients in the diet of finishing pigs may be an interesting alternative for production of heavy

Table 301. Carcass traits from swine fed different levels of insoluble fiber from sugar cane

	Experimental diets					SEM
	D0	D5	D10	D15	D20	
HCW, kg	108.72	100.99	99.93	95.61	86.8	1.93
Yield, %	80.1	80.2	80.02	79.8	78.45	0.56
Lean meat, %	51.28	51.45	51.56	53.65	53.82	1.14
Backfat thickness, mm	17.54	16.25	15.52	12.66	11.46	1.24
Loin depth, mm	64.8	63.38	64.85	57.69	59.12	1.82
Loin eye area, cm ²	43.68	42.55	43	41.22	38.44	1.42
Fat area, cm ²	28.11	24.11	23.66	19.9	15.52	1.19

pigs with lean meat. The aim of this study was to evaluate what effects insoluble fiber (extracted from sugar cane) in the diets of finishing pigs has on the carcass traits. Fifty barrows were blocked by initial BW (79.33 ± 2.20 kg) and randomly assigned to one of five treatments with ten replicate pens per treatment and one animal per pen. Treatments consisted of corn/soybean meal-based diets formulated to contain 0, 5, 10, 15, or 20% insoluble fiber, and the level of calculated ME (3230, 3069, 2905, 2745, and 2586 kcal/kg) was decreased according to increased dietary fiber. The animals were slaughtered when mean BW was approximately 130 kg. The half-carcass weight was expressed as percentage of live body weight. The backfat thickness, loin depth, loin eye area, and fat area were measured at the location of the last ribs, in the region of the last thoracic vertebra to the first lumbar. Data were analyzed using PROC MIXED in SAS 9.2. Results indicated that the hot carcass weight decreased (linear, $P < 0.01$) as the amount of insoluble fiber increased in the diet. Pigs fed diets with insoluble fiber had carcasses with decreased backfat thickness (linear, $P < 0.01$), fat area (linear, $P < 0.01$), and loin depth (linear, $P < 0.05$). However, yield, lean meat percentage, and loin eye area were not different ($P > 0.15$) among treatments. In conclusion, insoluble fiber appears to cause lower carcass weights without affecting carcass yield, lean percentage, or the loin eye area and, as a great benefit, reduces backfat thickness.

Key Words: dietary fiber, fat, yield meat

- 302 **Effects of corn distillers whole stillage and condensed distillers solubles on growth performance, carcass characteristics, and pork sensory quality of growing-finishing pigs.** X. Yang^{1,*}, C. Nath², A. Doering³, J. H. Goihl⁴, S. Baidoo¹, ¹*Southern Research and Outreach Center, University of Minnesota, Waseca*, ²*Agricultural Utilization and Research Institute, Marshall, MN*, ³*Agricultural Utilization and Research Institute, Waseca, MN*, ⁴*Agri-Nutrition Services, Inc., Shakopee, MN*

The objective of this study was to investigate the effects of liquid feeding high levels of corn distillers whole stillage (CDWS) and corn condensed distillers solubles (CCDS) on growth performance, carcass characteristics, belly firmness,

and meat sensory qualities of growing-finishing pigs. A total of 256 pigs were blocked by sex and initial BW (13.5 ± 2.5 kg), and pens of pigs (8 pigs/pen) were allocated randomly to 1 of 4 dietary treatments (8 pens/treatment): 1) corn-soybean meal based diet as control throughout, 2) 25% CDWS + 5% CCDS, 3) 19.5% CDWS + 10.5% CCDS, and 4) 19.5%, 26%, and 32.5% CDWS + 10.5%, 14%, and 17.5% CCDS in phases 1 (28 days), 2 (38 days), and 3 (60 days), respectively. Treatment inclusion levels for treatments 1, 2, and 3 were fed during all three phases of the experiment. Inclusion levels of CDWS and CCDS were on an 88% dry matter basis. Pen was the experimental unit. Growth performance data were analyzed by analysis of covariance with initial body weight as a covariant. The nonparametric Friedman test was employed for analysis of the taste panel data. Other data were subjected to analysis of variance. Control pigs had greater ($P < 0.05$) average daily gain (0.911 vs. 0.847, 0.854, 0.853 kg/d) and feed efficiency (ADG/ADFI 0.366 vs. 0.330, 0.341, 0.340) than pigs in the other 3 treatments during the overall period. Compared with the control, the other 3 groups had lower ($P < 0.05$ or $0.05 < P < 0.10$) carcass weight and backfat depth due to lighter ($P < 0.05$) slaughter body weight, but similar ($P > 0.05$) dressing percentage, loin muscle depth, and lean percentage were observed among the 4 treatments. Inclusion of CDWS and CCDS reduced ($P < 0.05$ or $0.05 < P < 0.10$) belly firmness but did not influence ($P > 0.05$) the overall like, flavor, tenderness, and juiciness of loin chops when compared with the control group. In conclusion, our results indicate that including 30–50% of a mixture of whole stillage and condensed distillers solubles in the growing-finishing diets may reduce growth performance, carcass weight, and belly firmness but does not affect pork sensory qualities.

Key Words: condensed distillers' solubles, liquid feeding, pig, whole stillage

- 303 **Effects of extrusion of corn and oats on the digestibility of energy and nutrients in diets fed to pigs.** Y. Liu^{*}, O. J. Rojas, H. H. Stein, *University of Illinois, Urbana*

An experiment was conducted to determine the effects of extruding corn and oats on concentration of DE and ME and the apparent total tract digestibility (ATTD) of energy and nutrients when fed to growing pigs. Three diets were formulated to contain the same concentration of corn (53%), oats (15%), and soybean (32%). The treatments were 1) nonextruded corn, nonextruded oats, and extruded full fat soybeans; 2) nonextruded oats, extruded corn, and extruded soybeans; and 3) extruded oats, extruded corn, and extruded soybeans. Thirty-six barrows (initial BW: 21.62 ± 2.04 kg) were housed in metabolism cages and allotted to a randomized complete block design with 3 diets and 12 replicate pigs per diet. Feces and urine were collected for 5 d following a 7-d adaptation period. The concentrations of DE and ME and the ATTD of CP, GE, ADF,

Table 303. Effects of extruding corn and oats on the apparent total tract digestibility (ATTD) of energy and nutrients and the concentration of DE and ME

Item	Diet ¹			SEM	P-value
	1	2	3		
ATTD, GE, %	85.88 ^b	88.04 ^a	87.82 ^a	0.44	<0.01
ATTD, CP, %	84.51 ^b	86.98 ^a	86.54 ^a	0.63	<0.05
ATTD, ADF, %	37.33	46.96	43.70	3.04	0.09
ATTD, NDF, %	49.96 ^b	59.92 ^a	50.37 ^b	1.93	<0.01
DE in diet, kcal/kg	3,652 ^b	3,851 ^a	3,845 ^a	18.96	<0.01
ME in diet, kcal/kg	3,495 ^b	3,718 ^a	3,709 ^a	25.45	<0.01

¹Diet 1 = nonextruded corn, nonextruded oats, and extruded soybeans; Diet 2 = nonextruded oats, extruded corn, and extruded soybeans; Diet 3 = extruded oats, extruded corn, and extruded soybeans.

and NDF were calculated. Results indicated that the ATTD of CP and GE and the concentrations of DE and ME were greater ($P < 0.05$) in pigs fed the extruded corn and soybeans diet and the extruded corn, oats, and soybeans diet compared with pigs fed the diet containing nonextruded corn and oats and extruded soybeans. The ATTD of ADF was not different among dietary treatments, but the ATTD of NDF was greater ($P < 0.05$) in the extruded corn and soybeans diet than in the other diets. In conclusion, extrusion of corn increases the ATTD of energy, protein, and NDF of diets fed to growing pigs.

Key Words: digestibility, extrusion, pigs

304 Effects of chemical, physical, or enzymatic treatments on concentration of digestible and metabolizable energy and on apparent total tract digestibility of energy, organic matter, and detergent fiber in distillers dried grains with solubles fed to growing pigs. O. J. Rojas*, H. H. Stein, *University of Illinois, Urbana*

An experiment was conducted to determine the effects of chemical, physical, or enzymatic treatments on concentration of DE and ME and the digestibility of energy, OM, and detergent fiber in distillers dried grains with solubles (DDGS). Sixty-three barrows (initial BW: 76.1 ± 6.1 kg) were placed individually in metabolism cages and allotted to a randomized complete block design with 7 diets and 9 replicate pigs per diet. A corn-based diet was formulated consisting of 97.0% corn, and 6 additional diets were formulated by mixing corn with 50.0% DDGS that was untreated (DDGS-CV) or extruded (DDGS-EX), treated with sodium hydroxide (DDGS-Na), treated with calcium oxide (DDGS-Ca), treated with a mixture of cellulases and xylanases (DDGS-Ce), or with a mixture of hemicellulases and xylanases (DDGS-NZ). After a 5 d adaptation period to the diet, feces and urine samples were collated for 5 d. The apparent total tract digestibility (ATTD) of GE, OM, ADF, and NDF and the DE and ME were calculated for each diet using the direct procedure and for each source of DDGS using the difference procedure. The ATTD of GE in corn, DDGS-CV, DDGS-EX, DDGS-Na, DDGS-Ca, DDGS-Ce, and DDGS-NZ was 86.6, 71.7, 72.8, 73.3, 70.4,

75.0, and 73.9%, respectively. The ATTD of GE was greater ($P < 0.01$) in corn than in all other ingredients. The ATTD of GE in DDGS-Ce was greater ($P < 0.01$) than in DDGS-Ca and DDGS-CV, but the ATTD of GE was not different among DDGS-EX, DDGS-Na, DDGS-Ce, and DDGS-NZ. The ATTD of NDF was less ($P < 0.01$) in DDGS-Ca than in corn, DDGS-Na, DDGS-Ce, and DDGS-NZ. The ATTD of ADF was less ($P < 0.01$) in corn and DDGS-EX than all the other diets, but the ATTD of ADF was greater ($P < 0.01$) in DDGS-EX than in corn. The ME was less ($P < 0.01$) in DDGS-EX (3,501 kcal/kg DM), DDGS-Na (3,458 kcal/kg DM), DDGS-Ca (3,318 kcal/kg DM), DDGS-NZ (3,545 kcal/kg DM), and DDGS-CV (3,442 kcal/kg DM) than in corn (3,738 kcal/kg DM) and DDGS-CE (3,701 kcal/kg DM). In conclusion, in this experiment, no significant improvement in ME or ATTD of GE, OM, NDF, or ADF was observed if DDGS was extruded or treated with sodium hydroxide, calcium oxide, or an enzyme mixture of hemicellulases and xylanases. However, treatment of DDGS with cellulases and xylanases resulted in an increase in ATTD of GE and OM and in ME compared with untreated DDGS.

Key Words: DDGS, enzymes, pig

305 Effect of feeding distillers dried grains with solubles and conjugated linoleic acid on growth performance, carcass characteristics, and fat quality in finishing pigs. C. B. Brown^{1,*}, M. Ellis¹, B. A. Peterson², A. M. Gaines², D. I. Golz³, ¹University of Illinois at Urbana-Champaign, Urbana, ²The Maschhoffs, LLC, Carlyle, IL, ³BASF Corporation, Florham Park, NJ

The effect of feeding conjugated linoleic acid (CLA) and distillers dried grains with solubles (DDGS) on growth performance and carcass and fat quality was evaluated in a study performed under commercial conditions. The study started at a BW of 92.2 ± 1.20 kg and ended after 70 d. A RCBD with 15 treatments that involved all combinations of 3 DDGS levels (0% DDGS, 30% DDGS, and 30% for 42 d followed by 0% for the last 28 d of the study), 3 CLA levels (0, 0.5, and 1.0%), and 3 CLA feeding durations (0, 14, and 28 d prior to harvest) was used. The CLA product used contained 60% of CLA isomers. There were 11 pens of 20 pigs/treatment and 3,300 total pigs on the study. At the end of the growth period, pigs were sent for harvest at a commercial plant. Belly quality measurements were collected 24 h after harvest; iodine value (IV) was measured on a sample of backfat from the clear plate using near-infrared spectroscopy. All data meeting the criteria for normality were analyzed using the PROC MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). Including 30% compared to 0% DDGS in the diet reduced ($P < 0.05$) ADG and G:F by approximately 4%, carcass yield by approximately 0.6 percentage units, and belly firmness by 1 point and increased ($P < 0.05$) IV by on average 7.4 g/100 g (68.9 to 76.3). With-

drawing DDGS from the diet for the last 28 d increased ($P < 0.05$) ADG by approximately 2%, G:F by approximately 3%, carcass yield by approximately 0.5 percentage units, and belly firmness by 0.5 points and reduced ($P < 0.05$) IV by 3.6 g/100 g (76.34 to 72.73) compared to feeding 30% DDGS throughout the study. Feeding CLA had no effect ($P > 0.05$) on growth performance; however, feeding diets with 1% CLA for 28 d increased flop distance ($P = 0.02$) by 1.1 cm and subjective firmness score ($P = 0.004$) by 0.2 points. Including CLA at either 0.5 or 1.0% reduced ($P < 0.05$) IV by 1.4 and 1.7 g/100 g, respectively, and including CLA in the diet for either 14 or 28 d reduced iodine value ($P < 0.05$) by 1.1 and 2.0 g/100 g, respectively, compared to controls (0% CLA). The results of this study suggest that feeding DDGS reduced growth performance, carcass yield, and fat firmness and withdrawing DDGS from the diet 4 wk before harvest and/or feeding CLA can improve fat firmness.

Key Words: CLA, DDGS, fat quality

306 Feeding value of cull lentils for growing and finishing swine. L. Eastwood, D. A. Gillis, M. R. Deibert, D. Beaulieu*, *Prairie Swine Centre, Inc., Saskatoon, SK, Canada*

Lentils are often downgraded due to chipping, wrinkling, or staining. For example, it is estimated that 61% of Saskatchewan lentils in 2014 will be feed grade. Two trials were conducted to provide data on the feeding value of cull lentils for swine. The first trial used 10 ileal cannulated growing pigs (35 to 60 kg BW) fed 1 of 5 diets. Treatments were a lentil-free control plus 4 treatments arranged as a 2×2 factorial (15 or 30% inclusion \times 2 lentil samples [grade 2 or 3]) in a RCBD with 3 periods. Total tract DE and apparent ileal digestible AA (AID) were determined, and NE was calculated (NRC, 2012). Nutrient content of the lentils was calculated by difference using the 15% inclusion level, as an interaction between sample and digestibility was observed at the 30% level. The CP content was comparable between the 2 samples (25.4%). Crude fiber (45.2 and 36.1% for grades 2 and 3, respectively) and fat (6.7 and 12.3% EE; grades 2 and 3, respectively) varied. The NE content of the grade 2 sample (2.28 Mcal NE/kg) was 60 kcal lower than the grade 3 sample (2.34 Mcal NE/kg), and the AID of AA (ranged from 28 to 55% for the 18 AA measured) of the grade 2 sample was 30 to 40% lower than the grade 3 sample. In the second experiment, these NE and AID values were used to formulate isonitrogenous, isoenergetic diets with 0, 10, 20, or 30% inclusion of the grade 3 sample and fed to 200 growing (35 to 60 kg) and 200 finishing pigs (90 to 120 kg). There was no effect of lentil inclusion on ADFI or feed efficiency ($P > 0.10$). Lentil inclusion had no effect on ADG of the grower pigs ($P > 0.10$) but increased ADG (linear, $P = 0.02$) in the finishing pigs (1.02, 1.02, 1.03, 1.07 kg/d; 0, 10, 20 and 30% inclusion levels, respectively), indicating that AA and energy digestibility values determined in the growing

pig underestimated the nutritive value for finishing pigs. Up to 30% cull lentils can be included in the diets of both growing and finishing swine with no adverse effects on ADG, ADFI, or feed conversion. Proximate analysis (CF, EE, CP) can be used to estimate if individual lentil samples will have nutrient values comparable to that reported here.

Key Words: digestibility, lentils, swine

307 Amino acid digestibility in rice coproducts fed to growing pigs. G. A. Casas^{1,*}, J. Almeida², H. H. Stein¹, ¹*University of Illinois at Urbana-Champaign, Urbana*, ²*Lindenwood University, Saint Louis, MO*

The objective of this research was to determine the apparent ileal digestibility (AID) and the standardized ileal digestibility (SID) of CP and AA in 2 sources of full fat rice bran (FFRB), 1 source of defatted rice bran (DFRB), and broken rice when fed to growing pigs. Seven finishing pigs with an average initial BW of 70.07 ± 6.3 kg were used. Pigs were surgically fitted with a T-cannula in the distal ileum. Animals were allotted to a 7×7 Latin square design with 7 diets and 7 periods. Seven diets were prepared, but 1 diet was unrelated to this experiment. One diet was based on bakery meal, and 1 diet was based on broken rice. Three additional diets were formulated by mixing bakery meal and each of the 2 sources of FFRB (FFRB-1 and FFRB-2) or DFRB. The last diet was an N-free diet that was used to estimate the basal ileal endogenous losses of CP and AA. The AID of CP and AA in bakery meal and broken rice was calculated using the direct procedure, but the AID of CP and AA in both sources of FFRB and in DFRB was calculated using the difference procedure. The AID and SID of CP and AA in broken rice were greater ($P < 0.05$) than the AID and SID of CP and AA in all other ingredients. The AID of CP and AA was greater ($P < 0.05$) in both sources of FFRB than in DFRB except for Arg, Lys, Phe, Thr, Trp, Asp, Glu, and Cys. The SID of AA was greater ($P < 0.05$) in both sources of FFRB than in DFRB, except for Lys, Thr, Trp, Val, and Gly. The SID for the average of indispensable, dispensable, and total AA in broken rice was greater ($P < 0.05$) than in the other ingredients. The average SID of AA in DFRB was less ($P < 0.05$) than in the other ingredients. The concentrations of standardized ileal digestible CP and indispensable AA in DFRB were greater ($P < 0.05$) than in all other ingredients. In conclusion, the AID and SID of CP and AA in broken rice were greater than in FFRB and DFRB, but the greater concentrations of CP and AA in FFRB and DFRB than in broken rice result in greater concentrations of SID CP and AA in FFRB and DFRB than in broken rice.

Key Words: amino acids, broken rice, defatted rice bran, digestibility, pig, rice bran

Table 309.

Diet type: Added fat, %:	30% DDGS		No DDGS		Probability, $P <^1$		
	0	5	0	5	Diet × Fat	Diet	Fat
ADG, kg	0.93	1.01	0.99	1.01	0.05	0.06	0.01
ADFI, kg	3.14	3.08	3.21	3.19	0.47	0.01	0.18
G:F	0.297	0.328	0.308	0.317	0.01	0.90	0.01
Final BW, kg	124.4	125.8	125.4	125.8	0.34	0.40	0.14
HCW, kg	90.7	91.6	91.9	92.3	0.56	0.03	0.12
Carcass yield, %	72.75	72.67	73.05	73.24	0.29	0.01	0.63
Jowl IV, g/100g	73.02	73.48	71.49	72.28	0.42	0.01	0.01

¹SEM for ADG, ADFI, G:F, Final BW, HCW, carcass yield, and jowl IV were 0.014, 0.029, 0.004, 0.75, 1.22, 0.55, 0.132, and 0.210, respectively.

308 Effects of wheat source and particle size in pelleted diets on finishing pig growth performance and caloric efficiency. J. A. De Jong*, J. M. DeRouchey, M. D. Tokach, R. D. Goodband, S. S. Dritz, C. B. Paulk, J. C. Woodworth, C. K. Jones, C. R. Stark, *Kansas State University, Manhattan*

A total of 576 pigs (PIC 327 × 1050; initial BW = 43.6 kg) were used to determine the effects of wheat source and particle size on finishing pig growth performance and caloric efficiency (CE). The same wheat-soybean meal-based formulation was used for all treatments. Pigs were allotted to 1 of 6 dietary treatments (12 pens/treatment with 8 pigs/pen) which included either hard red or soft white winter wheat at three different mean particle sizes (245, 465, 693; and 258, 402, 710 μ, respectively). All diets were fed in pelleted form (4 mm diameter pellets). Pellet durability was improved at the lowest particle sizes for both hard red (88.5, 81.2, 74.2%) and soft white (54.5, 50.9, 48.7%) winter wheat. Percentage fines were similar across wheat sources (24.0, 22.9, 26.9 vs 22.2, 27.2, 24.1%). There was a tendency ($P < 0.07$) for a quadratic particle size × wheat source interaction for ADG (1.03, 1.01, 1.03 vs 0.97, 1.00, 0.99; SEM = 0.01), ADFI (2.66, 2.59, 2.67 vs. 2.54, 2.58, 2.56; SEM = 0.03), and both DM (87.7, 87.0, 88.0 vs. 85.8, 87.7, 85.1; SEM = 0.80) and GE (68.3, 64.5, 66.3 vs. 62.3, 67.5, 64.9; SEM = 1.94) digestibility because the lowest ADG, ADFI, and both DM and GE digestibility values were for 400-μ hard red winter wheat, and the highest were for 400-μ soft white winter wheat. Despite this trend for interaction, overall, feeding hard red winter wheat improved ($P < 0.05$) ADG (1.02 vs. 0.99 kg; SEM = 0.008), ADFI (2.64 vs. 2.56 kg; SEM = 0.02), and CE on both an ME (8.13 vs. 8.50 Mcal/kg; SEM = 0.17) and NE (4.63 vs. 4.77 Mcal/kg; SEM = 0.25) basis compared with soft white winter wheat. There were no main effects ($P > 0.10$) of particle size or particle size within wheat source. In summary, fine grinding wheat from ~700 to 250 μ in pelleted diets had no effect on growth or carcass traits, and feeding hard red winter wheat improved ADG, ADFI, and caloric efficiency (ME and NE basis) compared with feeding soft white winter wheat.

Key Words: finishing pig, particle size, pellet, wheat

309 Effects of 30% dried distillers grains with solubles and 5% added fat prior to slaughter on growth performance and carcass characteristics of finishing pigs. K. F. Coble*, J. M. DeRouchey, M. D. Tokach, R. D. Goodband, J. C. Woodworth, S. S. Dritz, *Kansas State University, Manhattan*

A total of 1,258 pigs in two groups (initially 105.8 kg; PIC 337 (group 1) or 327 (group 2) × 1050) were used in a 20-d experiment to determine the interactive effects of 30% dried distillers grains with solubles (DDGS) and 5% added fat prior to slaughter on growth performance and carcass characteristics of finishing pigs. All pigs were fed a common diet with 30% DDGS until 20 d prior to slaughter. Then all pens were weighed and allotted to treatments with 20 replicate pens per treatment. Dietary treatments were arranged in a 2 × 2 factorial with 2 diet types (corn-soybean meal-based diet with or without 30% DDGS) and added fat (0 or 5%; group 1 = tallow; group 2 = choice white grease). There were no treatment × group interactions as the responses to dietary treatment were similar across groups, regardless of fat source or DDGS level. Overall, there were diet type × added fat interactions for ADG ($P < 0.10$) and G:F ($P < 0.05$) with pigs fed the diet containing 30% DDGS having greater ADG and G:F improvements when fat was added compared with those fed the corn-soybean meal-based diet without DDGS. Although diet type did not affect final BW, pigs fed the diet containing DDGS had decreased HCW ($P < 0.05$), which was the result of decreased carcass yield ($P < 0.05$). Adding 5% fat did not affect carcass yield. Jowl fat iodine value was increased by added fat ($P < 0.05$) and feeding DDGS ($P < 0.05$). In conclusion, adding 5% fat to finishing pig diets containing 30% DDGS approximately 20 d prior to slaughter improved ADG and G:F but did not overcome the reduction in carcass yield from feeding DDGS.

Key Words: fat, fiber, finishing pig, withdrawal

NONRUMINANT NUTRITION: GROW-FINISH NUTRITION

- 310 **Effects of vitamin D₃ injection or drinking water administration on serum 25-hydroxycholecalciferol status of nursery pigs.** Y. D. Jang^{1,*}, J. Y. Ma¹, N. Lu¹, J. Lim¹, R. L. Stuart², M. D. Lindemann¹, ¹University of Kentucky, Lexington, ²Stuart Products Inc, Bedford, TX

Two experiments were conducted to evaluate the effect of administration of vitamin D₃ (VD₃) to nursery pigs by injection or by drinking water. At weaning, a total of 51 crossbred pigs (27 and 24 pigs in Exp. 1 and 2, respectively) were allotted to 3 replicates of 3 and 2 treatments for Exp. 1 and 2, respectively. Treatments were, in Exp. 1, 1) control, no vitamin administration, 2) intramuscular injection (INJ), 0.8 mL of 50,000 IU of VD₃ per mL at weaning, and 3) water administration (H₂O), 5,493 IU of VD₃ per L of drinking water for 14 d postweaning, and, in Exp. 2, 1) control, no vitamin administration, and 2) water administration (H₂O), 92 IU of D-α-tocopherol and 5,493 IU of VD₃ per L of drinking water for 28 d postweaning. In Exp. 1, all pigs were injected with ovalbumin at weaning and d 14 postweaning as an immune stimulant, and in Exp. 2, the lightest 2 pigs within each pen were injected (INJ) additionally with 2 mL of 500 IU of D-α-tocopherol, 50,000 IU of retinyl palmitate, and 50,000 IU of VD₃ per mL. A common nursery diet was fed to all pigs during the experiments. In Exp. 1, serum 25-hydroxycholecalciferol (25-OHD₃) concentrations were increased after VD₃ administration ($P < 0.01$) in which the INJ and H₂O groups had greater values than the control group through d 35 and d 21 postadministration, respectively [$P < 0.05$; peaks of 36.0, 46.0, and 79.1 ng/mL for control (d 14 postadministration), H₂O (d 7–14 postadministration), and INJ (d 3 postadministration), respectively]. In Exp. 2, serum 25-OHD₃ concentrations were also increased after VD₃ administration ($P < 0.05$) in which those values increased to peak at d 3 postadministration in the INJ groups regardless of water treatment ($P < 0.05$; 146.6 and 154.4 ng/mL for control and H₂O, respectively) and at 14 and 28 postadministration in the control and H₂O groups without INJ, respectively ($P < 0.05$; 35.7 and 79.4 ng/mL, respectively). Even though the INJ groups had greater serum 25-OHD₃ concentrations than the groups without INJ through d 7 postadministration regardless of water treatments ($P < 0.05$), the H₂O-only group had greater values than the INJ-only group from d 21 ($P < 0.05$; 76.4 and 64.5 ng/mL, respectively) postadministration onward. In conclusion, serum 25-OHD₃ concentrations in nursery pigs can be enhanced either by VD₃ injection or drinking water administration at weaning.

Key Words: injection, nursery pigs, vitamin D₃, water administration

Table 311.

Variable ¹	Dietary SDP, %			Pooled SEM
	0.0	2.5	5.0	
ADG, g	122	158	187	5.01
ADFI, g	201	236	255	5.34
Gain:feed	0.60	0.67	0.73	0.01
Final BW, kg	8.06	8.58	8.98	0.13

¹ For all variables dietary level of SDP was linear ($P < 0.01$).

- 311 **Effect of dietary level of spray-dried plasma on performance of weaned pigs.** J. D. Crenshaw*, J. M. Campbell, J. Polo, APC, Inc., Ankeny, IA

Weaned pigs (average age at weaning, 21 ± 2 d; average BW at weaning, 6.3 ± 0.9 kg) used in three different experiments were fed one of three dietary treatments for 14 d after weaning to determine if pig performance was affected by diets containing different levels (0, 2.5, or 5.0%) of spray-dried plasma (SDP). All diets were fed ad libitum in mash form and were formulated to contain 1.60% lysine and 3.41 Mcal ME/kg. Diets were nonmedicated and contained corn, soybean meal, dried whey, and 8.04% soy protein concentrate (SPC) that was partially or completely replaced by 2.5% or 5.0% SDP on an equal lysine basis. In experiment 1, all pigs were weaned as a single group into a single nursery room. In experiment 2 and 3, pigs were weaned as two separate groups approximately two weeks apart into two different nursery rooms. Nursery rooms were not cleaned and sanitized prior to the start of the experiments to increase potential environmental stress. There were 8, 10, and 11 pens assigned per dietary treatment in experiments 1, 2, and 3, respectively, with 5 pigs per pen in experiments 1 and 2 and 5 or 6 pigs per pen in experiment 3. No pigs died during any of the experiments. Final data were analyzed for the effects of experiment and level of SDP as prior analysis indicated no significant ($P > 0.20$) interaction of experiment by dietary level of SDP for any variables indicating performance response to SDP was consistent by experiment. Results reported in Table 311 are least squares means for dietary level of SDP. ADG, ADFI, gain:feed, and final BW of pigs increased linearly ($P < 0.01$) as dietary level of SDP was increased in the diet. Final BW of pigs fed diets with 5% SDP for 14 days postweaning was approximately 0.9 kg greater than that of pigs fed the control diet containing SPC. In conclusion, the results of these experiments confirm those of past studies that both ADG and ADFI of pigs increased as dietary level of SDP was increased.

Key Words: pigs, environmental stress, spray-dried plasma.

- 312 **Comparison of spray-dried bovine plasma versus spray-dried porcine plasma in diets for weaned pigs.** J. D. Crenshaw*, J. M. Campbell, J. Polo, APC, Inc., Ankeny, IA

Table 312.

Variable	Dietary protein source					Pooled SEM
	SPC	SDBP1	SDBP2	SDPP1	SDPP2	
ADG, g ¹	119	176	169	172	175	6.01
ADFI, g ^{1,2}	177	208	211	244	236	6.14
Gain:feed ^{1,2}	0.67	0.84	0.80	0.70	0.73	0.02
Final BW, kg ¹	8.48	9.26	9.20	9.24	9.25	0.14

¹ SPC versus average of all other treatments, $P < 0.05$.

² Average of SDBP versus SDPP, $P < 0.05$.

Weaned pigs (average age at weaning, 21 ± 2 d; average BW at weaning, 6.8 ± 0.9 kg) were fed one of five dietary treatments for 14 d after weaning to determine if pig performance variables were affected by diets containing two separate manufacturing lots of either 6.0% spray-dried bovine plasma (SDBP1, SDBP2) or 6.0% spray-dried porcine plasma (SDPP1, SDPP2) compared to a control diet containing 9.65% soy protein concentrate (SPC). All diets were fed ad libitum in mash form and were formulated to contain 1.45% SID lysine and 3.41 Mcal ME/kg. Diets were nonmedicated and contained corn, soybean meal, dried whey, and SPC or the spray-dried plasma source. Pigs were weaned as two separate groups approximately two weeks apart into two different uncleaned nursery rooms to create additional stress at weaning. There were a total of 11 pens (5–6 pigs/pen) assigned per dietary treatment. No pigs died or were removed from the study. Data variables reported in Table 312 are least squares means for dietary treatment. Treatment comparisons of SPC versus average response of all other treatments or average response of pigs fed diets with SDBP versus that of pigs fed diets with SDPP are shown in the table. Pigs fed diets with SDBP or SDPP had higher ($P < 0.05$) ADG, ADFI, gain:feed, and final BW than pigs fed the control SPC diet. ADG and final BW of pigs fed diets with either SDBP or SDPP were not different ($P > 0.10$). Pigs fed diets with SDPP had higher ($P < 0.05$) ADFI than pigs fed diets with SDBP, while gain:feed of pigs fed diets with SDBP was improved compared to pigs fed diets with SDPP. In conclusion, average final BW of pigs fed diets with either SDBP or SDPP for 14 days postweaning was approximately 0.7 kg greater than that of pigs fed the diet with SPC.

Key Words: pigs, spray-dried bovine plasma, spray-dried porcine plasma

313 Effect of different levels of fiber and protein on growth performance and fecal characteristics of weaned pigs. H. L. Li^{1,*}, M. K. Jung¹, M. M. Hossain¹, M. C. Nyachoti², I. H. Kim¹, ¹Department of Animal Resource and Science, Dankook University, Cheonan, South Korea, ²University of Manitoba, Winnipeg, MB, Canada

A total of 96 weanling pigs (7.4 ± 1.2 kg) were used in a 5-wk growth assay to determine the growth performance, fecal score, fecal microbial shedding, and ammonia emissions with dietary manipulation of fiber and protein content. Pigs were

allotted to dietary treatments based on their BW in a 2×2 factorial, with main effects of fiber concentration (low = 65 and 125g/kg in phases 1 and 2 and high = 100 and 140 g/kg in phases 1 and 2) and CP concentration (low = 170 g/kg vs high = 200 g/kg). There were 6 pigs/pen and 4 pens/treatment. The composite fecal sample (1 g) from each pen was diluted with 9 mL of 1% peptone broth and homogenized. The *E. coli* and lactobacilli colonies were counted immediately after removal from the incubator, and lactobacilli:*E. coli* ratio (L:C) was calculated. A gas sampling pump (Gastec Corp., model GV-100; Gastec detector tube No. 3M and 3La for NH₃) was utilized for gas detection. All data were analyzed according to a 4×4 replicated Latin square design using the GLM procedure of SAS (SAS, Cary, NC), with pen serving as the experimental unit. Treatment differences were considered significant at a level of 0.05. During the first phase of this experiment, pigs fed a high protein and high fiber diet grew faster ($P < 0.05$) than controls, and pigs fed a high fiber and low protein diet consumed more ($P < 0.05$) than control pigs during the second phase. There was no difference ($P > 0.05$) in fecal score among the treatments, but feces taken from pigs fed high fiber had lower ($P < 0.05$) concentrations of *E. coli* and a higher L:C ratio ($P < 0.05$). Ammonia in the feces was increased ($P < 0.05$) continuously from d 1 to 5 and decreased ($P < 0.05$) after d 5 of the experiment. The level of ammonia was higher ($P < 0.05$) in the feces of pigs fed high protein and high fiber diet ($P < 0.05$) compared with control pigs. In conclusion, the results of this study indicate that dietary manipulation influences bacterial counts and ammonia emission in the feces as well as growth performance during the postweaning period. Thus, high protein and moderate fiber content in the diet may have beneficial effects for weaning piglets.

Key Words: fiber, protein, weanling pigs

314 Evaluation of different zinc sources and levels on nursery pig performance. K. E. Jordan*, M. A. Goncalves, S. Nitikanchana, M. D. Tokach, S. S. Dritz, R. D. Goodband, J. M. DeRouchey, J. C. Woodworth, Kansas State University, Manhattan

Zinco+ (Jefo, Quebec, Canada) is an encapsulated ZnO that when added to diets at 500 ppm is suggested to elicit performance advantages similar to 3,000 ppm Zn from ZnO. To test this hypothesis, 294 pigs (PIC 327 \times 1050, initially 6.4 kg BW) were used in a 31-d trial to evaluate the effects of different Zn sources on nursery pig performance. Pigs were weaned at 21 d of age and fed pelleted diets for 7 d and a mash diet for the remainder of the 31-d trial. Each treatment had 7 replicate pens with 7 pigs per pen. All diets contained 110 ppm Zn from ZnSO₄ from the trace mineral premix. The 6 experimental diets included a control diet, the control with 390 or 1,390 ppm added Zn from Zinco+, and the control with 390, 1,390, or 2,890 ppm added Zn from ZnO. From d 7 to 21, adding dietary Zn from Zinco+ tended to increase (linear; $P = 0.06$) ADG and

Table 314.

Item	Total added Zn, ppm						SEM
	Control	Zinco +			ZnO		
	110	500	1,500	500	1,500	3,000	
d 7 to 21							
ADG, g	261	274	302	271	315	346	21.2
G/F	0.615	0.658	0.682	0.656	0.700	0.694	0.02
d 0 to 31							
ADG, g	303	311	319	318	332	347	10.5
G/F	0.617	0.636	0.634	0.643	0.644	0.642	0.01

improved (linear; $P < 0.01$) G:F. Increasing Zn from ZnO increased (linear; $P < 0.01$) ADG and ADFI and improved (quadratic; $P = 0.02$) G:F. Pigs had greater ($P < 0.01$) ADG and ADFI when 2,890 ppm Zn from ZnO was fed compared with pigs fed 390 ppm Zn from Zinco+. Day 21 BW increased linearly with increasing Zn from Zinco+ ($P < 0.03$) and Zn from ZnO ($P < 0.001$), with pigs fed 2,890 ppm Zn from ZnO having heavier ($P < 0.01$) BW compared with those fed 390 ppm of Zn from Zinco+. Overall (d 0 to 31), increasing Zn from Zinco+ did not affect growth performance, but increasing Zn from ZnO increased ($P < 0.01$) ADG and ADFI. Pigs fed 390 ppm of Zn from Zinco+ had poorer ADG ($P < 0.02$) and ADFI ($P < 0.01$) than pigs fed 2,890 ppm of Zn from ZnO. This study shows the growth promoting benefits of adding high levels of Zn from ZnO in diets fed to newly weaned pigs. Lower levels of Zn from Zinco+ did not elicit the same growth-promoting response as 2,890 ppm of Zn from ZnO.

Key Words: growth performance, nursery pig, zinc

315 Response of weaned pigs to spray-dried porcine plasma and feed-grade antibiotics compared with antibiotic-free vegetarian diet supplemented with 3 different levels of a source of phytonutrients.

F. Sandberg^{1,*}, J. Calderon², J. England¹, D. Hall¹,
¹Furst McNess Company, Freeport, IL, ²Iowa State University, Ames

The objective of this study was to compare growth promoting properties of dietary spray-dried porcine plasma (SDPP) and feed grade antibiotics (Chlortetracycline and Denagard) as a positive control (PC), with a vegetarian diet without any antibiotics or SDPP as a negative control (NC), with NC that had three levels of a blend of phytonutrients Natures Fuel (NF) added: the dietary levels were NF1 = 2,270 g/t, NF2 = 4,540 g/t, and NF3 = 6,810 g/t. Experiment 1 involved 1,334 pigs weighing 4.8 kg and lasted for 49 days; Experiment 2 involved 1,270 21-d old pigs weighing 5.1 kg and lasted for 37 days. In Experiment 1 pigs were diagnosed with *E. coli* scours 3 weeks on trial, which required water medication (Amoxicillin) on day 21, and in Experiment 2 pigs had therapeutic water medication (Amoxicillin) from day 0. A commercial wean-finish barn was used (33 pigs/pen, 8 pens/treatment) with a FANCOM feed system. Mixed model equations methods in SAS v9.3 PROC MIXED for repeated measurements

Table 315. Summary of performance from Experiments 1 and 2

	Experiment 1					
	PC	NC	NF1	NF2	NF3	SEM
ADG, g/d	413 ^a	358 ^b	367 ^b	359 ^b	341 ^b	9
ADFI, g/d	636 ^a	563 ^b	568 ^b	563 ^b	536 ^b	9
FCR	1.64 ^a	1.63 ^a	1.56 ^b	1.57 ^b	1.47 ^b	0.07
	Experiment 2					
	PC	NC	NF1	NF2	NF3	SEM
ADG, g/d	313 ^a	295 ^{a,b}	291 ^{a,b}	273 ^b	263 ^b	9
ADFI, g/d	468 ^a	440 ^{a,b}	468 ^a	431 ^{a,b}	390 ^c	18
FCR	1.50 ^a	1.54 ^a	1.57 ^a	1.57 ^a	1.43 ^a	0.06

was used, and the results are in Table 315. In Experiment 1 PC consumed more feed and grew faster than all other treatments ($P < 0.05$). NF1 had a numerically greater ADG than NC, and NF treatments improved FCR ($P < 0.05$), but NF3 reduced ADFI, which caused reduced ADG. In Experiment 2 there was no difference in ADG or ADFI between PC and NC. ADFI was numerically increased by NF1 over NC, and being equal to PC, but ADFI were numerically reduced by NF2 and significantly by NF3 ($P < 0.05$). Careful use of phytonutrients can improve performance in antibiotic free diets, but high levels can negatively affect performance.

Key Words: feed grade antibiotics, pigs, plant extracts, plasma

316 Response of weaned pigs to spray-dried porcine plasma and feed-grade antibiotics compared with antibiotic-free diets supplemented with polyclonal IgY antibodies (Wean Right) and plant extracts (Natures Fuel).

F. Sandberg^{1,*}, J. Calderon², J. England¹, D. Hall¹, C. Phillips³, B. Mitteness³,
¹Furst McNess Company, Freeport, IL, ²Iowa State University, Ames, ³Camas Inc, Le Center, MN

The objective of this study was to compare growth promoting properties of dietary spray-dried porcine plasma (SDPP) and feed grade antibiotics (Ab = Chlortetracycline and Denagard as a positive control PC) with a negative control diet (NC) without SDPP or Ab. The experiment involved 2,651 twenty-one-d-old weaned pigs housed in two commercial wean-finish barns (33 pigs/pen, 8 pens/treatment) with FANCOM feed weighing system. Feed treatments were added to a NC diet consisting of polyclonal IgY antibodies derived from hyperimmunized whole eggs (WR = Wean Right™) and plant extracts (NF = Natures Fuel™) to 21 d postweaning. Ten experimental diets in an incomplete factorial design were arranged in a 2 × 3 factorial (3 levels of WR and 3 levels of NF added to the NC diet), and two treatments were tested for additivity of WR and NF. Due to veterinarian diagnosed *E. Coli* scour in both barns, Barn 2 was water medicated with Amoxicillin from d 8 to 18. Data were analyzed using Proc. GLM from Minitab. Summary results from days 7 to 21 are shown in Table 316. There was no effect of treatment from d 0 to 7 on ADG and ADFI ($P > 0.05$). Water medica-

Table 316. Feed efficiency traits (least squares means and SEM) from weaned pigs fed 3 levels of Wean Right and 3 levels of Natures Fuel added to antibiotic free vegetarian diets

	D 7-21	PC	NC	NF	WR	NF+WR	SE
ADG, g/d	272	238	245	252	248	248	10
ADFI, g/d	324	335	322	318	302	302	10
Gain/feed	0.81 ^a	0.73 ^b	0.76 ^b	0.80 ^a	0.81 ^a	0.81 ^a	0.02
Viability, %	91.8	88.7	89.5	91.2	93.5	93.5	1.7

tion improved pig performance ($P < 0.05$). PC fed pigs had improved feed efficiency over NC fed pigs ($P < 0.05$). WR ($P < 0.05$) improved gain/feed ratio compared with NC diets. In summary, the dietary treatments of PC and the combination of Wean Right plus Natures Fuel resulted in similar feed efficiency ($G/F = 0.81$) and was improved ($P < 0.05$) over the NC diet regime ($G/F = 0.73$) in commercial nursery pigs.

Key Words: egg polyclonal IgY antibodies, feed grade antibiotics, pigs, plant extracts, plasma

317 Can the effects of lactose on nursery pig performance and immune parameters be attributed to glucose, galactose, a combination of both, or sucrose? Y. S. Li*, H. Tran, T. E. Burkey, P. S. Miller, University of Nebraska, Lincoln

To determine if lactose is effective as an energy substrate or benefits the immune system via the constituent monosaccharides, 96 crossbred nursery pigs (initial BW = 6.3 kg; d 21 to 23 postfarrowing) were allotted to 16 pens (4 pigs per pen; 4 pens per dietary treatment). The treatments were included in Phase 1 (d 0 to 14 postweaning) and Phase 2 (d 14 to 28 postweaning) diets. Diet 1 was a complex nursery diet supplemented with lactose (18% for phase 1 and 9% for phase 2, respectively); the other 3 diets were similar to diet 1 with 100% glucose, 50% glucose and 50% galactose, and 100% sucrose substituted for lactose, respectively. The nursery room was not cleaned after the previous experiment, and the room temperature was maintained at 23 to 24 °C to induce an environmental stress. Data were analyzed as a completely randomized design using the MIXED procedure of SAS. Individual BW and feed disappearance were measured weekly from d 0 to 28. Blood samples were collected weekly for the determination of serum IgA, IgG, and haptoglobin concentrations. Overall, dietary treatments did not affect ($P > 0.10$) BW (average 15.31 kg; d 28), ADG (319 g), or G:F (687 g/kg). However, pigs fed glucose + galactose diet had greater ($P < 0.05$) ADFI than pigs fed the lactose diet in Phases 1 and 2 (247 vs. 210 g and 744 vs. 648 g, respectively). The ADFI (730 g) of pigs fed the sucrose diet was greater ($P < 0.05$) compared to pigs fed the lactose diet (648 g) in Phase 2. There were no time × treatment interactions ($P > 0.10$) affecting circulating IgA, IgG, or haptoglobin. Serum IgA increased ($P < 0.05$) over time (d 0 to 28), whereas IgG decreased ($P < 0.05$) from d 0 to 21. Haptoglobin had a 4-fold increase ($P < 0.05$) from d 0 to 7 and a 2.5-fold decrease ($P < 0.05$) from d

7 to 14. Pigs fed sucrose had greater ($P < 0.05$) IgA than pigs fed lactose and glucose + galactose diets and tended to have greater ($P < 0.10$) IgA than pigs fed the glucose diet. There were no treatment effects ($P > 0.10$) on serum IgG or haptoglobin concentrations. In conclusion, when dietary lactose was substituted by the constituent monosaccharides (glucose and galactose), ADFI was increased in nursery pigs, although serum immune parameters were not affected.

Key Words: growth performance, lactose, nursery pigs

318 Differential expression of PEPT1 and PEPT2 mRNA in small intestine of Chinese Dongchuan pigs. Z. Liu*, Y. Huo, W. Fang, H. Xuan, L. Yu, W.

Bao, G. Zhao, Yangzhou University, Yangzhou, China

A significant part of amino nitrogen in the small intestine is absorbed in the form of oligopeptides rather than free amino acids, and the mammalian peptide transporters (*PepT1* and *PepT2*) play a pivotal role in the process of absorbing. However, the distribution of *PepT1* and *PepT2* mRNA in the small intestine of Dongchuan pigs, a high-quality local black pig breed in eastern China, was poorly studied. Therefore, the objective of this experiment was to investigate the expression of *PepT1* and *PepT2* mRNA in fattening Dongchuan pigs' small intestine in order to study the mechanism of oligopeptide transporters and promote nutrition study about Dongchuan pigs. Eight fattening Dongchuan pigs (72.55 ± 1.22 kg) were sacrificed, and duodenum, jejunum, and ileum tissue samples were obtained. Real-time PCR was used to measure the differential gene expression of *PepT1* and *PepT2* mRNA in intestinal segments, and the $2^{-\Delta\Delta Ct}$ ($\Delta\Delta Ct = Ct_{\text{target gene}} - Ct_{\text{housekeeping gene}}$) method was used to calculate relative abundance of target genes with *GAPDH* as a housekeeping gene. One-way ANOVA showed small intestinal tissue specificity had a significant effect on expression levels of both *PepT1* mRNA ($P < 0.01$) and *PepT2* mRNA ($P < 0.05$). The results showed that expression levels of *PepT1* mRNA in the jejunum ($P < 0.01$) and ileum ($P < 0.05$) were dramatically higher than that in the duodenum. The expression trend of *PepT1* mRNA was jejunum (1.18×10^{-2}) > ileum (8.02×10^{-3}) > duodenum (2.29×10^{-3}). Meanwhile, the expression level of *PepT2* mRNA in the duodenum was significantly higher than that in the ileum ($P < 0.01$). The expression trend of *PepT2* mRNA was duodenum (1.54×10^{-3}) > jejunum (9.06×10^{-4}) > ileum (2.32×10^{-4}). Further, mean expression level of *PepT1* mRNA (7.37×10^{-3}) in the small intestine was nearly a 7.5-fold change of *PepT2* mRNA (9.77×10^{-4}). To summarize, expression of *PepT1* mRNA was more pronounced in distal segments of the small intestine of Dongchuan pigs, while *PepT2* mRNA was mainly distributed in proximal intestinal tracts. Our results suggest that *PepT1* might be the major intestinal oligopeptide transporter in distal segments of the small intestine of Chinese Dongchuan pigs.

Key Words: Dongchuan pig, *PepT1*, *PepT2*

319 **Effect of a precision feeding strategy applied to groups of pigs in a commercial setting.**

L. Cloutier*, J. Rivest, G. Berthiaume, M. Morin,
*Centre de Développement du Porc du Québec Inc.,
Québec, QC, Canada*

The objective of this study was to validate the effect of a precision, i.e., multiphase, feeding strategy applied to groups of pigs segregated by sex and by weight in a commercial setting. Thus, 24 groups of 42 pigs (24.2 ± 2.9 kg) were used in this experiment according to a randomized complete block design with a factorial treatment structure. Pigs were initially divided by weight group (small, medium small, medium large, and large pigs) and then combined with room location to form a 6 level blocking factor, each block containing four double pens. Treatments were randomly assigned to double pens according to a 2×2 factorial arrangement with two feeding treatments (four-phase feeding program (4P) and multiphase group feeding program (MPG)) and two sexes (female and barrow). For MPG treatment, growth curves (as a function of growing-finishing days) were established for each sex within each weight group based on previous performances on the farm. Two feeding programs, one for each sex, defined the evolution of lysine concentration as function of weight. For each group of pigs (i.e., combination of weight group and sex), the desired lysine concentration was obtained by blending two feeds in different proportions. When compared to the 4P treatment, the MPG treatment significantly reduced lysine intake by 18% ($P < 0.001$). There was also no difference observed in terms of ADFI and feed efficiency between the two feeding treatments. Regarding ADG, MPG pigs tended to have a higher ADG (949 and 934 g/d; $P = 0.097$). Only one interaction between the feeding treatment and the sex was observed, and it was regarding lysine concentration ($P < 0.001$). Thus, MPG females had a higher lysine concentration in their feed when compared to barrows being given the same treatment ($+0.17$ g/kg; $P < 0.05$). As for the 4P treatment, there was no difference in lysine concentration between the feed given to the two sexes. For the effects of sex, females had a lower ADFI (-0.26 kg), ADG (-77 g), and fat depth (-2 mm) when compared to castrated males ($P < 0.05$). With reference to feed costs, when calculated with Quebec's 2013 feed prices, the multiphase strategy reduced feed costs by \$3.80/pig. The results of this study show that the multiphase feeding strategy, which had no effect on growth performances, could reduce nitrogen and lysine intake as well as reduce feed costs for swine producers.

Key Words: feeding cost, pig, precision feeding

320 **Apparent digestible energy content of commercial lipid sources fed to growing pigs.**

P. L. Chang^{1,*},
D. S. Rosero^{1,2}, O. Medina¹, A. Terpening¹,
E. van Heugten¹, ¹*Department of Animal Science,
North Carolina State University, Raleigh,* ²*The
Hanor Company, Inc., Franklin, KY*

This study was designed to evaluate lipid and GE digestibility of 7 commercial lipid sources varying in chemical composition (iodine value, IV; free fatty acids, FFA) and lipid peroxidation status (anisidine value, AnV; malondialdehyde, MDA). A total of 64 growing pigs (initial BW = 30.4 ± 0.43 kg) were housed individually and randomly allotted to 1 of 8 dietary treatments. Treatments consisted of a corn-soybean meal basal diet without added lipids and the basal diet supplemented with 8% of either soybean oil (IV = 129, FFA = 0%, AnV = 3, MDA = 1 mmol/L), tallow (IV = 44, FFA = 0%, AnV = 2, MDA = 0 mmol/L), poultry fat (IV = 68, FFA = 3%, AnV = 4, MDA = 7 mmol/L), pet food-grade poultry fat (IV = 76, FFA = 2%, AnV = 1, MDA = 14 mmol/L), yellow grease (IV = 64, FFA = 7%, AnV = 19, MDA = 28 mmol/L), brown grease (IV = 65, FFA = 23%, AnV = 12, MDA = 74 mmol/L), or restaurant grease (IV = 98, FFA = 8%, AnV = 36, MDA = 18 mmol/L). Lipid supplemented diets contained 1.03% standardized ileal digestible lysine and 3.69 Mcal ME/kg. Diets were fed ad libitum for 7 days followed by fecal collections for the next 3 days. Apparent total tract digestibility (ATTD) was calculated using TiO_2 as an indigestible marker. On d 10, blood samples were collected for plasma MDA analysis as a marker of oxidative stress. Pigs fed yellow grease had a 64% lower ADFI ($P < 0.001$; 0.62 vs. 1.73 kg/d) than pigs fed other diets, resulting in an overall BW loss during the 10 d feeding period ($P < 0.001$; ADG of -0.14 vs. 0.95 kg/d). Concentrations of MDA in plasma of pigs fed yellow grease were 86% greater ($P < 0.001$; 10.76 vs. 5.78 mmol/L) than those in pigs fed other lipid sources. Supplementation of lipids to the basal diet increased ATTD of crude fat ($P < 0.001$; 81.3 vs. 40.0%) and GE ($P < 0.05$; 88.4 vs. 85.8%). For lipid supplemented diets, ATTD of crude fat ranged from 79.7 to 82.9% and ATTD of GE ranged from 87.5 to 90.0%, and they were not different among lipid sources. Results indicate that there were no differences in the DE content of commercially available lipid sources that ranged widely in saturation level, content of FFA, and oxidative stability when fed to growing pigs. Nonetheless, caution is needed when feeding highly peroxidized lipid sources to pigs, as they can negatively impact performance.

Key Words: digestible energy, lipids, pigs

321 **Effects of algae-derived β -glucans on nursery pig growth performance and immune response under commercial conditions.**

M. A. Goncalves*, S. S. Dritz,
J. M. DeRouchey, M. D. Tokach, R. D. Goodband,
J. C. Woodworth, *Kansas State University, Manhattan*

A total of 2,484 pigs (PIC 337 \times 1050, initially 7.1 ± 0.12 kg) were used to determine the impact of increasing levels of a

commercial β -glucan (Algamune ZPC, Algal Scientific Corporation, Plymouth, MI) on growth performance and Porcine Circovirus Type 2 (PCV2) specific immune response of nursery pigs housed under commercial conditions. Pigs were allotted to 1 of 6 treatments in a randomized complete block design with BW as a blocking factor with 27 pigs/pen and 14 or 16 pens/treatment. Dietary treatments, fed in two phases from d 0 to 12 and d 12 to 40 postweaning, were a negative control diet or the negative control diet with 125, 250, 500, or 750 ppm added β -glucan in both phases or the negative control diet with 500 ppm added β -glucan during Phase 1 and the negative control diet in Phase 2. Phase 1 diets contained 1,910 ppm of zinc oxide. All pigs were vaccinated with PCV2 and *M. hyopneumoniae* vaccines with 2 mL per pig (1 mL FosterTM PCV and 1 mL RespireTM-One; Zoetis, Florham Park, NJ) at d 3 after birth and at weaning. Blood samples (12 pens/treatment) were collected at d 2, 18, and 38 of the trial from 12 pigs/treatment. For the immune response analysis, weight block within serum sampling period and pen within dietary treatment were included in the model as random effects. Pigs fed increasing β -glucan marginally decreased then increased (quadratic, $P = 0.09$) ADG (457, 448, 450, 453, and 461 \pm 15.5 g/d) and tended to increase (linear, $P = 0.10$) ADFI (692, 675, 685, 688, and 704 \pm 27.2 g/d). No evidence for differences was observed in G:F ($P = 0.36$). There was no evidence of a difference ($P > 0.54$) in ADG, ADFI, or G:F when comparing pigs fed 500 ppm β -glucan in both phases compared with pigs fed 500 ppm β -glucan only in Phase 1. There was a tendency (linear, $P = 0.07$) for decreased PCV2 neutralizing antibody titers as the inclusion of β -glucan increased. There was no evidence of differences ($P = 0.75$) in PCV2 neutralizing antibody titers between pigs fed 500 ppm in both phases and pigs fed 500 ppm only in Phase 1. In conclusion, dietary addition of up to 750 ppm of β -glucan in nursery pig diets from 7 to 25 kg had minimal impact on growth performance. Also, modulation of the specific immune response to PCV2 at d 38 after weaning was negatively related to increasing β -glucan under commercial conditions.

Key Words: β -glucans, immune response, nursery

322 The effects of tribasic copper chloride on growth performance and carcass characteristics of finishing pigs. J. Cohen¹, J. L. Usry^{2*}, N. R. Augspurger³, C. R. Little³, ¹*Micronutrients, Indianapolis, IN*, ²*Micronutrients, Social Circle, GA*, ³*JBS United, Inc., Sheridan, IN*

A total of 540 pigs (PIC 337 \times Camborough 29; initially 37.9 kg) were used in a 103-d study to determine the effects of tribasic copper chloride (TBCC; Intellibond C, Micronutrients, Indianapolis, IN) on growth performance and carcass characteristics of finishing pigs. Pens of pigs were allotted to 1 of 2 dietary treatments based on average pen weight in a randomized complete-block design with 27 pigs per pen and 10

Table 322. Effect of tribasic copper chloride in finishing pigs

	TBCC, mg/kg		Pooled SEM	Probability, $P <$
	0	200		
BW, kg				
d 0	37.9	38.0	0.471	0.615
d 103	128.2	130.1	0.988	0.060
ADG, g	868	888	12.248	0.036
ADFI, g	2,497	2,517	24.855	0.474
G:F, g/kg	347	353	3.441	0.070
HCW, kg	96.0	98.3	0.655	0.013
Carcass yield, %	75.8	76.4	0.300	0.136

replicates per treatment. Diets were corn-soybean meal-based with 20 to 30% dried distiller's grains with solubles. Treatments were the control diet with or without the addition of 200 mg/kg Cu from tribasic copper chloride. Both treatment diets contained 16 mg/kg of Cu from CuSO₄ in the trace mineral premix. Overall, ADG was increased ($P = 0.036$) by 2.3% for pigs fed TBCC compared to the control, resulting in 1.9-kg heavier ($P = 0.060$) final BW. There were no differences in ADFI between treatments. Thus, the growth response resulted in a tendency for greater ($P = 0.070$) G:F for pigs consuming diets containing 200 mg/kg supplemental Cu from TBCC. Hot carcass weights were 2.3 kg heavier ($P = 0.013$) for pigs fed TBCC compared to the control; however, carcass yield was not affected. Backfat, loin depth, and percent lean were also not influenced by dietary treatment. In summary, adding 200 mg/kg Cu from TBCC to diets for finishing pigs from 38 to 130 kg increased ADG and HCW and tended to increase G:F compared to pigs fed the control diet.

Key Words: copper, growth, pig

323 Effect of Zn sources and inclusion rate on growth performance and carcass composition in grower-finisher pigs. T. C. Tsai^{1*}, H. J. Kim¹, J. L. Usry², J. Cohen³, J. J. Chewning⁴, J. K. Apple¹, C. V. Maxwell¹, ¹*Department of Animal Science, University of Arkansas Division of Agriculture, Fayetteville*, ²*Micronutrients, Social Circle, GA*, ³*Micronutrients, Indianapolis, IN*, ⁴*Swine Research Services, Inc., Springdale, AR*

Pigs (n = 132, PIC 29 \times 380) were blocked by initial BW (average: 22.25 \pm 1.47 kg) and allotted to pens within six blocks. Pens were then randomly assigned to a 2 \times 2 factorial treatment regimen with 2 sources of Zn [Zn hydroxychloride (Intellibond Z or IBZ) or ZnSO₄] and 2 inclusion rates (60 and 120 ppm) for a 5 phase grower-finisher study. A Zn-free mineral premix with an additional 166 ppm of tribasic copper chloride (Intellibond C; Micronutrients) was incorporated into all diets. In addition, diets in phase 5 contained 10 ppm Paylean. All nutrients met or exceeded 2012 NRC recommendations. Pigs were scanned for BF and LM at the end of phase 4 and at study completion (average BW: 288 \pm 2.8 kg). HCW and Fat-O-Meater data were obtained at harvest. No significant Zn source by levels interaction was observed for growth. IBZ-fed

pigs grew faster in phase 2 ($P < 0.01$, 0.96 vs. 0.90 kg/d) and the combined phase 1 and 2 period ($P < 0.05$, 0.87 vs. 0.84 kg/d), had better G:F ($P < 0.02$, 0.40 vs. 0.38) during phase 2, and were heavier ($P < 0.02$, 67.6 vs. 65.7 kg BW) at the end of phase 2 than those fed ZnSO_4 . Intake, however, was similar between Zn sources in phases 1 to 4 ($P > 0.17$) although feeding higher Zn levels tended to reduce intake in phase 4 ($P > 0.09$, 3.06 vs. 2.86 kg/d). In phase 5, pigs fed ZnSO_4 had greater intake than those fed IBZ ($P < 0.05$; 3.08 vs. 3.32 kg/d), but ADG and G:F were similar ($P > 0.22$). In addition, increasing IBZ from 60 to 120 ppm during phase 5 decreased 10th rib BF (15.8 vs. 14.7 mm) and resulted in a 18.5 % increase in lean gain (8.1 vs. 9.6 kg), whereas increasing ZnSO_4 resulted in a higher 10th rib BF (13.3 vs. 16.4 mm) and lower lean gain (10.2 vs. 9.2 kg; interaction, $P < 0.05$). For the overall study, a numerically lower ADFI ($P = 0.19$, 2.48 vs. 2.57 kg/d) and higher G:F ($P = 0.16$, 0.35 vs. 0.34) in IBZ-fed pigs than ZnSO_4 -fed pigs was observed. The results of the current study suggest that pigs fed IBZ had improved ADG, G:F, and BW in early grower-finisher phases and had similar growth while consuming less feed in the final Paylean-fed phase.

Key Words: grower-finisher pigs, inclusion rate, Intellibond Zn vs. ZnSO_4

324 Predicting disease-challenged pig performance and energy and nutrient requirements using the NRC 2012 modeling module. S. M. Curry*, W. P. Schweer, N. K. Gabler, *Iowa State University, Ames*

Models can be used to estimate energy and nutrient requirements, evaluate feeding programs, and compare pig performance modeling estimates to those actually observed. The objective of this study was to use the NRC 2012 modeling module to predict performance and energy and nutrient requirements of disease-challenged growing pigs. Growth and feed intake data from a previously conducted study consisting of healthy pigs (Control) and porcine reproductive and respiratory syndrome (PRRS) virus, porcine epidemic diarrhea virus (PEDv), or a combination of PRRS and PEDv (PRP) challenged gilts were used as inputs. From these data a 14 d period was analyzed using observed BW gain (BWG) and ADFI. Within the modeling module, the selected nutrient systems were ME, standardized ileal digestibility (SID) of AA, and standardized total tract digestibility (STTD) of P, and the selected model for estimating nutrient requirements was for growing-finishing pigs. Treatment inputs for the 14 d test period for BWG and ADFI were, respectively, Control 8.8 and 1.04 kg, PRRS 5.8 and 0.78 kg, PEDv 8.0 and 0.92 kg, and PRP 3.8 and 0.73 kg. The diet ME content was set at 3,388 kcal/kg, and sex was specified as gilt so that the only adjustments made within the NRC 2012 modeling module were BWG and ADFI. Results for this 14 d challenge period predicted modeled Control gilt BWG (8.6 kg) to be similar to what we observed for these gilts. Compared to the observed BWG, the model overestimated BWG for PEDv

(8.6 kg), PRRS (8.4 kg), and PRP (8.2 kg) disease-challenged gilts. The model also overestimated ADFI for all treatments by 8–36%, and this was also reflected in ME intake. Utilizing observed BWG and ADFI, the model indicated no treatment differences in SID of AA (g/d), including Lys, Met, Thr, and Trp. There were no differences in predicted whole body protein deposition rates between the control (105 g/d), PRRS (104 g/d), PEDv (101 g/d), and PRP (99 g/d) disease-challenged gilts. This module should be limited to healthy pigs as it does not consider the catabolic state of disease-challenged pigs as represented by the observed reduction in BWG and ADFI. In conclusion, the NRC 2012 modeling module is accurate in predicting BWG and ADFI of healthy gilts; however, it did not reflect the observed BWG and ADFI of disease-challenged gilts.

Key Words: energy and nutrient requirements, pigs, predictions

ODOR AND NUTRIENT MANAGEMENT

325 Anaerobic digestion of high-ash, open-lot beef cattle manure. A. K. Watson*, G. E. Erickson, T. J. Klopfenstein, A. M. Schmidt, *University of Nebraska, Lincoln*

Nine 56.8-L anaerobic digesters were utilized to study biogas generation from beef cattle manure with varying OM content. Manure was collected from the settling basin of a finishing cattle barn with a sloped floor and flush system. Treatments consisted of pure manure (65% OM) or manure with soil (90% DM, 97% ash) added to create 40% and 15% OM manure. For all treatments, water was added to the manure-soil mixture to equal 9% DM when fed to digesters. All digesters received the same amount of OM each day (i.e., varying amount of soil and constant amount of manure). Digesters were on each treatment for a 41-d acclimation period after which measurements were taken for 5 d; 3 periods allowed all treatments to be evaluated on all digesters. Measurements included weight, DM, and OM of all material fed into and removed from each digester in order to calculate OM degradation of manure within digesters. A cone-bottom tank and intermittent mixing was used to aid in separating organic and inorganic particles within digesters and increase daily ash removal within the effluent stream. Concentration of methane within a known flow of N_2 gas was measured, and total methane production was calculated. Increased ash contamination of manure linearly decreased OM degradation from 63.2 to 54.1% for the 65 and 15% OM treatments, respectively (linear $P = 0.02$). The high level of ash contamination also decreased daily methane production from 0.589 to 0.425 L CH_4 per L digester volume daily for the 65 and 15% OM treatments, respectively (linear $P < 0.01$). This is equal to 0.187 and 0.139 L CH_4 per g of OM fed (linear $P = 0.02$) for the 65 and 15% OM treatments, respectively.

Table 326. Mean values, standard error of the mean, and *P*-value, obtained for the biogas and the methane potential production of feces of swine fed diets containing different levels of soluble fiber (SF)

	Control	Experimental diets				SEM	<i>P</i> -value
	1.5%SF	4%SF	8%SF	12%SF			
VS reduction, %	64.13	61.79	66.80	63.63	2.35	0.9275	
Biogas production, m ³	0.0806	0.0440	0.0839	0.0759	0.01	0.0097	
Methane production, m ³	0.0650	0.0363	0.0689	0.0601	0.01	0.0131	
Biogas, (m ³ /kg added SV)	1.5669	0.8569	1.8824	1.7002	0.13	0.0025	
Methane, (m ³ /kg added SV)	1.2631	0.7084	1.5459	1.3445	0.10	0.0035	
Biogas, (m ³ /kg added feces)	0.3416	0.1862	0.3554	0.3218	0.02	0.0096	
Methane, (m ³ /kg added feces)	0.2754	0.1540	0.2919	0.2545	0.02	0.0132	

The 40% OM treatment was intermediate for both L CH₄ per L digester volume daily and L CH₄ per g of OM fed. Of ash added to digesters, 20.5, 18.3, and 9.5% was not removed from the 65, 40, and 15% OM treatments, respectively (linear *P* = 0.12). This resulted in ash buildup (mineral or inorganic material that was added to the digester but not removed in the effluent and not degraded within the digester) of 17.0, 45.5, and 64.7 g/d, respectively, as % OM in the manure decreased (linear *P* < 0.01). With adequate daily cleanout of ash from digesters, lower OM manure can be used for anaerobic digestion, although methane yields may be slightly reduced.

Key Words: anaerobic digestion, beef cattle, methane

326 Anaerobic digestion of feces from finishing swine fed with different levels of soluble fiber.

D. J. Rodrigues^{1,*}, M. C. Thomaz¹, U. D. S. Ruiz², M. M. Lima¹, P. V. A. Alvarenga¹, F. F. Castro¹, S. Sgavioli³, ¹Department of Animal Science, São Paulo State University, Jaboticabal, SP, Brazil, ³Universidade Estadual Paulista, Dracena, Brazil, ³Department of Morphology and Animal Physiology, São Paulo State University, Jaboticabal, Brazil

Manure quantity and characteristics depend directly on physiology and health status of pigs and diet composition. As known, nutrient excretion increases when the animal has low feed:gain ratio. It was expected the use of soluble dietary fiber promoted significant changes in anaerobic digestion of feces. This study was conducted to determine the effect of increasing levels of dietary soluble fiber (SF) on the anaerobic digestion of the feces from finishing pigs in a qualitative feed restriction program. Twenty-one batch digesters of bench were assigned to 4 treatments in a complete randomized design with 3 replications for each. The treatments were prepared with feces from animals fed four different diets: control diet (basically composed of corn and soybean meal that contained 3229 kcal gross energy, 13.91% crude protein, 1.50% soluble fiber) and three isoproteic diets with purified pectin inclusion to increase the levels of soluble fiber to 4, 8 and 12% and consequently decrease levels of gross energy. Feces were collected when the animals had 100 kg and were mixed with water to obtain a 4% dry matter substrate. The volatile solids (VS) reduction, the biogas, and the methane quantity of production and their

potential production for the volatile solids and feces quantity added were evaluated. Statistical analyses were performed using the PROC GLM procedure of SAS. There were no differences (*P* > 0.05) for the volatile solids reduction. On the other hand, there was a cubic effect (*P* < 0.05) for the total biogas and methane production and their potential production. In conclusion dietetic soluble fiber inclusion showed good potential production of biogas and methane, probably because of the poor digestibility of the diets and consequently low feed:gain ratio of the animals.

Key Words: biogas, methane, pectin

327 Impact of feedlot facility design, diet, and cattle type on manure nutrient capture.

N. Kenney-Rambo^{1,*}, A. Nesseseth², A. DiCostanzo¹, ¹University of Minnesota, St. Paul, ²Extended Ag Services, Lakefield, MN

Increased fertilizer prices have generated interest in capturing value through manure in integrated crop and cattle feeding systems. Manure nutrient analysis results for solid (n = 689) and liquid (n = 186) manure samples were collected over 4 yr to determine the impact of facility design (open lot, bed pack from confinement barn, stockpiled manure, pit under slatted floor, or lagoon), cattle type (beef or dairy), and dietary energy value (grower or finisher) on manure nutrient concentrations. Manure nutrients were expressed as kg nitrogen (N), phosphate (P₂O₅), or potash (K₂O)/T of as-is material (solid) or as kg of these nutrients/3785 L (liquid). A combined data set (n = 483) was analyzed with projected annual cattle manure production values of 2.7 and 4.5 T/hd and 9463 L/hd, respectively, for open lot, bed pack, or pit under slatted floor, which were estimated to compare effects of facility design on manure nutrient contributions per head space. Data were analyzed using the MIXED procedure of SAS; effects of year and month were determined to have no effect and were dropped from the model. Dietary energy value was not included in the analysis of the liquid data set because only finisher diets were represented. Nutrient concentration of liquid manure samples from indoor pits was greater (*P* < 0.05) than that from lagoons across all nutrients. Nitrogen concentration of liquid samples (kg/3785 L) was greater (*P* < 0.05; 16.42 vs. 13.0) for dairy type cattle, and P₂O₅ also tended to be greater (*P* < 0.10; 7.6 vs 6.3) for dairy

type cattle Nitrogen concentration in solid samples (kg/T) was not impacted by facility type ($P > 0.10$); however, P_2O_5 concentration was lower ($P < 0.05$) in bed packs (4.6) compared to open lots (5.5) and stockpiled manure (6.0). Concentrations of all nutrients in solid manure samples were greater ($P < 0.05$) for beef cattle as compared to dairy type cattle. Dietary energy value did not impact ($P > 0.10$) nutrient concentrations of solid manure samples. Estimated annual manure N yield (kg/hd) differed ($P < 0.05$) with feedlot design. Manure N yield (kg/hd/yr) was greatest for indoor pits (58.5), intermediate for bed packs (39.0), and least for open lots (24.0). Manure P_2O_5 yield (kg/hd) was greater ($P < 0.05$) for bed pack (22.7) and indoor pit (24.9) facilities as compared to open lots (15.0). These results confirm that greater manure nutrients are captured by confinement feedlot facilities.

Key Words: beef cattle, feedlot design, manure nutrient

PHYSIOLOGY

328 Differential microRNA expression in sperm cells and seminal plasma due to PRRSV infection.

S. M. Calcaterra^{1,*}, D. L. Reicks², A. Feltus¹,
S. L. Pratt¹, ¹Clemson University, Clemson, SC,
²Swine Vet Center, Saint Peter, MN

The objectives of this study were to detect differentially expressed (DE) microRNAs (miRNAs) due to PRRSV infection in sperm cells and seminal plasma and to perform functional enrichment analyses on predicted targets of these miRNAs. All animal work was performed at the Swine Veterinary Center (Saint Peter, MN) where six terminal crossbred boars were inoculated intramuscularly with 2 mL of 2×10^4 viral RNA copies/mL PRRSV strain 1-8-4 on day 0. Semen was collected two days prior to inoculation (-2 dpi) and six days postinoculation (6 dpi). The cellular fraction was separated by centrifugation, and both sperm cells and seminal plasma aliquots were flash frozen and stored at -80°C . RNA was isolated using the mirVana miRNA Isolation Kit and used in custom microarray analyses (LC Sciences, Houston, TX) based on our porcine sperm cell and seminal plasma sequencing data. Individual microarrays were performed using 3 biological replicates from -2 dpi and 6 dpi. Differential expression was determined significant by $P < 0.05$ and a fold change threshold of less than or greater than twofold. Potential miRNA targets were predicted using miRanda 3.3a with a score threshold of 140 and energy threshold of -20 kcal/mol. Targets were then analyzed for enrichment of Gene Ontology (GO) and InterPro (IPR) terms and were considered to be enriched if $P < 0.01$ using the Bonferroni correction. Microarray analyses resulted in 83 DE miRNAs in sperm and 10 DE miRNAs in seminal plasma when comparing -2 dpi and 6 dpi. Enrichment analyses revealed that the predicted targets of 35 DE sperm miRNAs and 9 DE semi-

nal plasma miRNAs have functions and/or conserved protein domains that are significantly enriched when compared to the pig genome. Enriched terms of the sperm transcripts included lung epithelium development, cAMP response element binding protein, lactation, lung saccule development, regulation of cell size, positive regulation of cell adhesion, P2X7 purinoceptor, Peptidase S9B, Leucine-rich repeats, Peptidase C48, and phosphorylated immunoreceptor signaling. Transcripts from seminal plasma were enriched for ion channel activity, P2X purinoreceptor, transglutaminase, endoplasmic reticulum signal peptide binding, and signal recognition particles, among others. These data are the first to report differential miRNA expression in sperm and seminal plasma due to PRRSV infection. Further studies involving qPCR of predicted miRNA targets should be performed for a greater understanding of PRRSV infection at a molecular level.

Key Words: microRNA, PRRS, semen

329 Dairy cattle pregnancy rates and progesterone concentrations in Kuwait following single- and double-injection PGF_{2α} estrus synchronization protocols.

M. A. Aali^{*}, *Aridland Agriculture
Department, Kuwait Institute for Scientific
Research, Kuwait City, Kuwait*

The objective of this study was to compare in vivo progesterone (P_4) function and pregnancy rates (PR) in cows following single and double PGF_{2α} injections estrus synchronization protocols. Ninety-five lactating Holstein dairy cows were randomly divided into the single PGF_{2α} injection group (n = 42) and double PGF_{2α} injections group (n = 53) estrus synchronization protocols. The single PGF_{2α} injection protocol consisted of a PGF_{2α} injection (Lutalyse) regardless of the stage of the estrous cycle; the double PGF_{2α} injections estrus synchronization protocol consisted of two injections of Lutalyse 12 d apart regardless of the stage of the estrous cycle. Artificial insemination (AI; Day 0) was conducted 72 h after Lutalyse (2nd injection in the double Lutalyse treatment protocol). Milk P_4 concentrations were determined for days of Lutalyse injections (-3), 0, 7, 14, 21, 28, and 35 post AI. Pregnancy was diagnosed by ultrasonography on day 35 post AI. The pregnancy rates (PR; based on ultrasound) for the single Lutalyse and double Lutalyse treatment protocols, respectively, were $28 \pm 13.0\%$ and $33 \pm 11.0\%$ ($P > 0.05$). Progesterone profiles from the time of AI until pregnancy diagnosis were similar ($P > 0.05$) between the PGF_{2α} estrus synchronization methods. In conclusion, PR and corpus luteum function were not enhanced by the addition of a second PGF_{2α} injection, and therefore, a single PGF_{2α} injection was recommended to the farmers for synchronization of their cows.

Key Words: corpus luteum, PGF_{2α}, pregnancy

330 Nychthermal rhythm of dromedary camel's body temperature using two measurement techniques.

A. Al-Haidary*, K. Abdoun, E. Samara, A. Okab,
*Department of Animal Production, College of Food
and Agriculture Sciences, King Saud University,
Riyadh, Saudi Arabia*

Body temperature rhythm is a well-documented biological entity of homoeothermic animals, where it is controlled basically by a zeitgeber entrained circadian pacemaker located in the supra-chiasmatic nucleus of the hypothalamus. The aim of this study was to investigate the nychthermal rhythm of camel's body temperature using two different measurement techniques. The body temperatures was recorded on a total of 5 clinically healthy camels (*Camelus dromedarius*) using thermocouple data loggers surgically implanted in the peritoneum for recording core temperature or using thermistor fitted in close proximity to the tympanic membrane for recording tympanic temperature. Core (T_c) and tympanic membrane (T_{ty}) temperatures of camels showed circadian rhythm reaching minimum early in the morning (06:30–07:00 h) and maximum at the end of the day (17:30–18:30 h). The body temperature showed an oscillation range of 2.2°C and amplitude of 1.1°C for T_c and an oscillation range of 1.1°C and amplitude of 0.5°C for T_{ty} . The respective maximum (39.1 vs 38.9°C), minimum (36.9 vs 37.8°C), and mean (37.9 vs 38.4) values for T_c and T_{ty} did not significantly ($P > 0.05$) differ from each other. However, the time of acrophase and trough occurred earlier, and the amplitude and range of oscillation were twofold higher ($P < 0.05$) in T_c compared to T_{ty} . The obtained results indicate that the characteristics of tympanic membrane temperature did not significantly differ from that of core body temperature. Hence, the noninvasive technique of recording tympanic membrane temperature can be used as an alternative technique for measurement of body temperature.

Key Words: body temperature, camel, circadian rhythm

331 Receiver operator curve (ROC) characteristics for a pregnancy test based on milk progesterone (mP4) concentration before or one week after timed AI (TAI).

L. J. Wilsdorf, S. E. Poock, M. C. Lucy*,
University of Missouri, Columbia

Timed AI programs have increased reproductive efficiency in dairy herds. Refinements to TAI have improved effectiveness, but conception rates (CR) to TAI remain below 50%. The low TAI CR is partially explained by cows that either 1) do not have a corpus luteum when PGF_{2α} is administered, 2) fail to undergo luteolysis after PGF_{2α}, or 3) fail to ovulate after GnRH and TAI. Two experiments were conducted to test the hypothesis that mP4 before or 1 week after TAI could be used to identify cows that will not become pregnant because of one of the criteria stated above. In Exp. 1, Holstein cows (n = 223) that were either first AI or greater were treated with the "Ovsynch56"

protocol for TAI (GnRH, 7 d, PGF_{2α}, 56 h, GnRH, 16 h TAI). mP4 concentrations were measured -3, 0, and +7 d relative to TAI by using an automated analyzer (FT Multilyser; Förster Technik; Engen, Germany). Compared with nonpregnant (NP; n = 141) cows, pregnant (P; n = 82) cows had greater mP4 on d -3 (15.7 + 0.7 vs. 12.3 + 0.5 ng/mL; $P < 0.001$) and d +7 (17.2 + 0.8 vs. 13.4 + 0.6 ng/mL; $P < 0.001$). mP4 on d 0 was similar for P and NP cows (8.5 + 0.3 ng/mL). When mP4 concentrations were used as a test to predict pregnancy, the area under the ROC was 0.64 + 0.04 for d -3 and 0.67 + 0.04 for d +7. Both ROC were different ($P < 0.05$) from 0.5, meaning that mP4 around TAI was predictive of pregnancy. The ROC for d 0 (0.55 + 0.04) did not differ from 0.5 (could not be used as a pregnancy test). In Exp. 2 Holstein and Guernsey cows (n = 93) were subjected to Ovsynch56 for first TAI. mP4 concentrations were measured on d -4 (evening before PGF_{2α}) and d -2 relative to TAI. Compared with NP (n = 53), P (n = 40) cows tended to have greater mP4 on d -4 (27.3 + 1.4 vs. 23.8 + 1.2 ng/mL; $P < 0.06$). mP4 on d -2 was similar for P and NP cows (10.9 + 0.6 ng/mL). When mP4 concentrations were used as a test to predict pregnancy, the area under the ROC was 0.58 + 0.06 for d -4 and 0.54 + 0.04 for d -2. Neither ROC area differed from 0.5 ($P > 0.05$). In summary, mP4 testing around TAI was predictive of pregnancy in Exp. 1 but not in Exp. 2. The timing of the test relative to PGF_{2α} and TAI may be critical toward the development of a test to predict pregnancy outcome before or shortly after TAI.

Key Words: milk progesterone, pregnancy, timed AI

332 Effect of in utero exposure to lipotropic (one-carbon) nutrients on mammary developmental genomic signals in rat offspring.

W. S. Choi^{1,*}, K. Cho¹, L. Mabasa¹, C. Crane¹, M. Ribeiro de Almeida², C. S. Park³, ¹North Dakota State University, Fargo, ²University of Sao Paulo, Ribeirao Preto, Brazil, ³North Dakota State University Animal Sciences, Fargo

Lipotropes are methyl group-containing essential nutrients (including methionine, choline, folic acid, and vitamin B₁₂) that play key roles in one-carbon metabolism. One-carbon metabolism provides methyl groups for biological methylation pathways, including DNA methylation, which regulates the expression of genes. The objective of this study was to investigate the effect of maternal dietary lipotropes fortification on global DNA methylation and mRNA expression of genes involved in mammary gland development in female rat offspring. Pregnant Sprague-Dawley rats were divided into two groups and fed the control diet or lipotropes supplemented diet until parturition, at which point, all rats were fed the control diet until weaning. The control diet was AIN-93G rodent diet, while the lipotropes supplemented diet was designed to provide approximately 5 times the level of choline, folic acid, and vitamin B₁₂, whereas methionine was only 1.8 times greater than that of the control

diet to avoid methionine toxicity. At weaning, female offspring were randomly selected from each group and kept on the control diet until they were bred for collection of the mammary tissues at weaning. Tissues were analyzed for global DNA methylation and gene expression by a colorimetric assay and RT-PCR, respectively. Intrauterine exposure to dietary methyl nutrients significantly enhanced global DNA methylation in mammary tissues of offspring as compared with the control diet (4.6% vs. 3.9%; $P = 0.04$). In addition, lipotropic diet significantly increased transcription of DNA methyltransferase 1 (*DNMT1*) [$P = 0.02$], while also significantly decreasing the expression of methyl CpG binding protein 2 (*MECP2*) [$P = 0.05$] in mammary tissues. While *DNMT1* is responsible for maintenance and propagation of DNA methylation status, *MECP2* plays a role in DNA methylation-directed repression of gene transcription. Taken together, data suggest that dietary lipotropes influence mammary development via alteration of DNA methylation and the expression of genes involved in chromatin structure remodeling. The extent to which these maternal one-carbon nutrients-induced genomic changes affect lactation performance needs to be investigated.

Key Words: global DNA methylation, mammary development, one-carbon nutrients

333 Effects of sire breed, gender, and postnatal litter size on plasma concentrations of acyl ghrelin and its relationship with growth traits and feeding behavior in swine. C. A. Lents*, T. M. Brown-Brandl, G. A. Rohrer, W. T. Oliver, B. A. Freking, *U.S. Meat Animal Research Center, ARS, USDA, Clay Center, NE*

Feeding behavior is an important component of growth and feed efficiency in swine. Acyl ghrelin is a peptide produced in the stomach that is orexigenic. The role of ghrelin in regulating feeding behavior in swine under commercial conditions is unknown. The objective of this study was to determine the effect of sire breed, gender, and postnatal litter size on concentrations of acyl ghrelin in plasma and to determine the relationship of acyl ghrelin with growth traits and feeding behavior in pigs. Yorkshire-Landrace-Duroc (Y-L-D) dams were AI with semen from Y, L, or D sires. Within 24 h of birth, pigs were cross fostered into large (L; ≥ 12 pigs) or small (S; ≤ 9 pigs) litters. At 8 wk of age, pigs ($n = 240$) were blocked by sire breed, gender, and litter size and assigned to pens ($n = 6$) containing commercial feeders modified with a system to monitor feeding behavior. Total time eating, number of daily meals, and duration of meals were recorded for each individual pig. Body weight was recorded every 4 wk. Back fat (BF) and loin eye area (LEA) were recorded at the conclusion of the 12-wk feeding study. A blood sample was collected at week 8 of the study to quantify concentrations of acyl ghrelin in plasma by RIA. Barrows had greater total time eating ($P < 0.01$), grew faster ($P < 0.01$), and were heavier ($P < 0.05$) and fatter ($P < 0.001$) with larger LEA ($P < 0.05$) than gilts. The

pigs from S litters grew faster ($P < 0.04$) and were heavier ($P < 0.02$) and fatter ($P < 0.05$) with larger LEA ($P < 0.05$) than pigs from L litters. Plasma concentrations of acyl ghrelin were not affected by sire breed, gender, or postnatal litter size. Concentrations of acyl ghrelin in plasma were positively associated with number of daily meals ($P < 0.01$) and negatively associated with meal duration ($P < 0.03$), BF ($P < 0.05$), and ADG at weeks 4 and 8 of the study ($P < 0.01$). Variation in concentrations of acyl ghrelin was not associated with gender or early postnatal development in this study. A larger number of short duration meals may indicate that pigs with greater concentrations of acyl ghrelin consumed less total DM, which likely explains why they were leaner and grew more slowly. USDA is an equal opportunity provider and employer.

Key Words: ghrelin, growth, swine

334 Type I interferon response in calves experimentally infected with bovine viral diarrhea virus type 1b and *Mannheimia haemolytica*. C. A. Gifford*, J. L. Chase, J. Hernandez Gifford, B. K. Wilson, B. I. Gomez, D. L. Step, M. A. Montelongo, A. W. Confer, C. R. Krehbiel, C. J. Richards, *Oklahoma State University, Stillwater*

Bovine respiratory disease (BRD) remains one of the largest challenges facing the feedlot industry and is the leading cause of morbidity and mortality. Typically, BRD is caused by viral and bacterial coinfection. Bovine viral diarrhea virus type 1b (BVDV1b) is commonly observed in BRD cases. The BVDV genome contains a protease (Npro) which inhibits Type I Interferon (IFN) production in vitro, but in vivo, BVDV2 increased expression of Type I Interferon-stimulated genes (ISGs) in cattle fetuses that were either persistently or transiently infected. Mineral deficiencies are known to alter both immune responses and immune cell populations which could impact IFN signaling. Therefore, the objectives of the current study were to evaluate Type I Interferon response in mineral supplemented ($n = 6$) and mineral deficient ($n = 6$) calves experimentally infected with BVDV1b and *Mannheimia haemolytica* (MH). Diets were formulated to meet or exceed NRC (2000) nutrient requirements except for Cu, Mn, and Zn; deficient minerals were either supplemented at 150 mg of Cu, 130 mg of Mn, and 320 mg of Zn or left deficient for 46 d. After 46 d, calves were exposed to an animal persistently infected with BVDV1b for 4 d and then intratracheally challenged with MH. Peripheral blood leukocytes were collected prior to BVDV exposure (d-4), prior to MH challenge (0h), and 12 (12h) and 24 (24h) h after MH challenge. Three known ISGs, *ISG15*, *MX1*, and *RTP4*, were analyzed using qRT-PCR. Fold-change relative to the average d-4 value within group was calculated using the $\Delta\Delta C_t$ method. Fold-change for each gene was the dependent variable and tested against treatment, time, and treatment \times time using the MIXED procedure of SAS. There were no treatment or treatment \times time interactions (P

> 0.10), so treatments were pooled. There was a significant effect of time ($P < 0.05$) for all ISGs evaluated. At 0h, *ISG15* levels increased 44-fold compared to d-4 and were 60-fold greater for both 12h and 24h ($P < 0.01$). Though not as robust, both *RTP4* and *MX1* were increased ($P < 0.05$) after BRD challenge with maximum induction at 12h and were 6-fold and 12-fold greater than d-4 samples, respectively. Results indicate that the Type I Interferon pathway remains active after infection with BVDV1b and mineral deficiency did not impact the Type I Interferon response.

Key Words: BVDV, cattle, interferon, respiratory disease

335 Effects of mid- to late gestational energy source on jejunal crypt cell proliferation in the ewe and fetus. J. M. Larson^{1,*}, A. R. Smith¹, M. A. Berg², A. E. Radunz³, A. M. Meyer¹, ¹*Division of Animal Sciences, University of Missouri, Columbia*, ²*Department of Animal Sciences, University of Wisconsin–Madison, Madison*, ³*Department of Animal and Food Science, University of Wisconsin–River Falls, River Falls*

Recent studies show that maternal energy source during gestation affects fetal and postnatal growth, even when energy requirements are met. Small intestinal growth has previously been affected in ewe models of developmental programming resulting in altered ewe metabolism and fetal growth. We hypothesized that maternal and fetal jejunal proliferation would be responsive to gestational energy source. Single and twin-bearing mature Polypay ewes ($n = 14$; single service sire) were fed 1 of 3 energy sources beginning on d 67 ± 3 of gestation: ad libitum alfalfa haylage (HL), limit-fed whole shelled corn with additional CP to meet NRC recommendations (CN), or limit-fed corn dried distillers grains with solubles (DG). From d 116 of gestation until terminal surgeries, ewes fed HL were supplemented with corn gluten feed (10.4% of dietary DM) to account for late gestational energy demands of fetal growth. On d 130 ± 1 of gestation, nonsurvival surgeries were performed, and ewes were euthanized. The small intestine was weighed, and jejunal mucosal tissue was collected. Jejunal samples were immersion fixed and embedded in paraffin, sectioned, and stained, and images were taken for analysis of proliferating nuclei. Data were analyzed with gestational energy source and fetal number as fixed effects; sex was included in the model for fetal parameters. Ewe ($P = 0.96$) and fetal ($P = 0.66$) BW at surgery were not affected by energy source during gestation. Energy source tended ($P = 0.11$) to affect ewe jejunal mass (g and % BW), where ewes fed CN had greater ($P = 0.04$) jejunal mass than HL. Despite this, total small intestinal, duodenal, and ileal masses (g and % BW) were not affected ($P > 0.75$) by energy source. There were no differences ($P = 0.33$) in ewe jejunal proliferation (%) due to energy source. Fetal small intestinal relative mass (% BW)

tended ($P = 0.11$) to be affected by maternal energy source. Fetuses from DG ewes had greater ($P = 0.04$) relative small intestinal mass than CN. There were no differences ($P = 0.20$) in fetal small intestinal actual mass (g) among maternal energy sources. Fetal jejunal proliferation tended ($P < 0.15$) to be affected by maternal energy source. Specifically, fetal lambs from DG ewes tended ($P = 0.07$) to have greater proliferation than HL. Data suggest that maternal energy source during gestation may affect ewe and fetal small intestinal growth, which could impact whole animal measures.

Key Words: developmental programming, pregnancy, small intestine

336 Parturition somatotropin administration affects IGF-I and NEFA concentrations in serum and follicular fluid of first postpartum dominant follicle in Holstein heifers. D. A. Velasco Acosta^{1,*}, A. Schneider², C. Bespalhok Jacometo², J. A. Rincon², F. C. Cardoso¹, M. Nunes Corrêa², ¹*University of Illinois, Urbana*, ²*Federal University of Pelotas, Pelotas, Brazil*

The aim of this study was to determine the effects of parturition somatotropin administration on IGF-I and NEFA concentrations in serum and follicular fluid from the first postpartum dominant follicle of dairy heifers. Forty-nine late pregnant Holstein heifers were used from a commercial dairy herd in southern Brazil. Heifers were randomly assigned to two treatments: somatotropin (ST; $n = 29$), cows received two doses of somatotropin (500 mg/dose) at -28 and -14 days relative to calving; and Control (CN; $n = 30$), cows did not receive somatotropin application. Follicular development was monitored via ultrasound every 3 days starting at 8 DIM until the day in which the first dominant follicle reached a diameter of 16 mm. Follicular fluid from each cow (ST; $n = 9$ and CN; $n = 9$) was aspirated by ultrasound-guided transvaginal follicular aspiration. Blood samples were collected weekly from -28 days from expected calving to 28 ± 2 DIM via venipuncture of the coccygeal vein in one tube without anticoagulant. Serum and follicular fluid NEFA concentration was determined with a commercially available enzymatic-colorimetric kit, and IGF-I concentrations were determined using a competitive, liquid-liquid phase, double-antibody IGF-I radioimmunoassay procedure. Serum IGF-I concentration prepartum was affected by day ($P < 0.0001$), treatment ($P = 0.016$), and the interaction of day by treatment ($P = 0.0005$). Serum concentration of IGF-I was higher ($P < 0.0002$) at day -7 relative to calving. Also, serum IGF-I concentration prepartum was higher ($P < 0.05$) for ST (112.78 ± 3.95 mg/mL) than CN (97.37 ± 4.61 mg/mL). There was a day effect ($P < 0.0001$) for serum IGF-I concentrations postpartum. For NEFA serum concentrations prepartum there was an effect of day ($P = 0.006$) and interaction of day by treatment ($P = 0.0001$) but no effect of treatment ($P = 0.1185$). There was an effect of the day ($P < 0.0005$) for se-

rum NEFA concentrations postpartum. Follicular fluid IGF-I concentrations of the first postpartum dominant follicle was different ($P = 0.0557$) between ST (87.09 ± 7.73 mg/mL) and CN (64.26 ± 7.73 mg/mL). Follicular fluid NEFA concentration of the first postpartum dominant follicle was not different ($P = 0.6897$) between ST (0.71 ± 0.30 mEq/L) and CN (0.86 ± 0.33 mEq/L). In conclusion, prepartum injection of somatotropin in Holstein heifers increased serum IGF-I concentration prepartum and in follicular fluid of the first postpartum dominant follicle, potentially increasing the chance of ovulation in this class of follicles.

Key Words: dairy heifers, follicle, IGF-I, somatotropin

337 Effect of methionine and choline supplementation on postpartum follicular development in Holstein cows. D. A. Velasco Acosta^{1,*}, M. I. Rivelli¹, C. S. Skenandore¹, Z. Zhou¹, D. N. Luchini², M. Nunes Corrêa³, P. Cardoso¹, ¹University of Illinois, Urbana, ²Adisseo S.A.S., Alpharetta, GA, ³Federal University of Pelotas, Pelotas, Brazil

The aim of this study was to determine the effects of methionine, choline, and both methionine and choline supplementation during the transition period on postpartum follicular development in Holstein cows. Cows on their 2nd or greater lactation were assigned in a randomized block design into four treatments from -28 days relative to calving to 30 ± 1 DIM. Treatments were control (**CON**; $n = 10$, fed a basal diet and no supplemental methionine or choline), methionine (**MET**; $n = 9$, fed the basal diet and top-dressed with 0.08% of DM of diet/d of methionine, Smartamine M); choline (**CHOL**; $n = 9$, fed the basal diet and top-dressed with 60 g/d of choline, Reassure), and methionine and choline (**MET+CHOL**; $n = 12$, fed the basal diet and top-dressed with 0.08% of DM of diet/d of methionine and 60 g/d choline). Follicular development was monitored via ultrasound every 2 days starting at 7 DIM until first ovulation occurrence. At each examination, a sketch of each ovary was made, and the diameter and location of follicles >3 mm in diameter were recorded. Ovulation was defined as the disappearance (from one examination to the next) of a previously identified follicle >8 mm in diameter along with the detection of a CL in the same ovary in a further examination. Statistical analysis was performed using the MIXED procedure of SAS. Supplementation of methionine, choline, and both methionine and choline during the transition period did not affect the moment of the first postpartum ovulation (CON 14.93 ± 1.07 d, MET 14.28 ± 1.10 d, CHOL 14.30 ± 1.15 d and MET+CHOL 13.35 ± 1.00 d; $P = 0.7385$), the number of cows that ovulated the first follicular wave (CON 5/10 cows, MET 5/9 cows, CHOL 5/9, and MET+CHOL 7/12 cows; $P = 0.1817$), the diameter of the first postpartum dominant follicle (CON 20.51 ± 3.52 mm, MET 22.59 ± 3.52 mm, CHOL 15.83 ± 3.94 mm, and MET+CHOL 17.27 ± 2.78 mm; $P = 0.5362$), or the growing rate of the first postpartum

dominant follicle (CON 1.09 ± 0.20 mm/d, MET 1.36 ± 0.16 mm/d, CHOL 1.17 ± 0.23 mm/d, and MET+CHOL 1.01 ± 0.16 mm/d; $P = 0.6246$). In conclusion, supplementing methionine, choline, or both methionine and choline during the transition period seemed not to have an effect on postpartum follicular development of the 1st wave in Holstein cows.

Key Words: choline, dairy cows, follicle, methionine, transition period

RUMINANT NUTRITION 1

338 Total mixed ration vs. component feeding does not improve individually fed high-producing cow performance: Common wisdom challenged. A. Nikkhah*, University of Zanjan, Zanjan, Iran

The objective was to determine effects of total mixed ration delivery vs. component feeding in high-producing lactating cows in a noncompetitive housing environment. Four multiparous (665 ± 65 kg body weight; 67 ± 20 days in milk; mean \pm SD) and four primiparous (583 ± 43 kg body weight; 85 ± 36 days in milk) lactating Holstein cows housed in free individual boxes (4×3 m) were used in a crossover design experiment with two 25-d periods. Each period had 20 d of adaptation. Cows received a single diet, based on barley grain and a mixture of corn silage and alfalfa hay, prepared and presented as either total mixed ration (TMR) or component forage and concentrate (CFC). The forage to concentrate ratio was 50:50 (dry matter basis), permitting 5-10% dailyorts. Fecal and urine samples from individual cows were collected daily for the last 5 d of each period. Cows were milked twice daily at 0500 and 1700 h. Data were analyzed using Mixed Models with fixed effects of treatment, parity, and their interaction and random effects of period and cow within parity. Feeding TMR vs. CFC did not affect ($P > 0.10$) dry matter intake (21.0 vs. 21.2 kg/d), milk yield (35.1 vs. 35.3 kg/d), and milk contents of fat (3.3 vs. 3.2%), protein (3.0 vs. 3.03%), and lactose (4.9 vs. 4.8%). As a result, total daily milk solids production was not affected. Daily durations of eating (340 vs. 320 min/d), ruminating (300 vs. 300 min/d), and total chewing (660 vs. 620 min/d) were similar ($P > 0.10$) between TMR- and CFC-fed cows, respectively. The first meal length (FML), starting from feed delivery until the first noneating bout of ≥ 20 min, was 115 min in the TMR-fed cows and totally 152 min in the CFC-fed cows ($P < 0.01$). Urine (8.0 vs. 8.1) and fecal (6.2 vs. 6.0) pH were unaffected by TMR vs. CFC delivery ($P > 0.10$). Therefore, the results suggest that under a noncompetitive housing and feeding environment, feeding a high-producing diet as TMR vs. CFC does not affect production and intake behavior of lactating Holstein cows.

Key Words: dairy cow, feeding system, milk production

339 Component vs. total mixed ration feeding improves peripheral energetics in high-producing lactating dairy cows. A. Nikkhah*,
University of Zanjan, Zanjan, Iran

The objective of this study was to compare effects of total mixed ration (TMR) delivery vs. component feeding of forage and concentrate (CFC) on peripheral blood indicators of energy status in high-producing lactating cows in a noncompetitive housing environment. Four multiparous (665 ± 65 kg body weight; 67 ± 20 days in milk; mean \pm SD) and four primiparous (583 ± 43 kg body weight; 85 ± 36 days in milk) lactating Holstein cows in free individual boxes (4×3 m) were monitored in a crossover design experiment with two 25-d periods. Each period had 20 d of adaptation and 5 d of sampling and data collection. Cows were offered a single diet, based on barley grain and a mixture of corn silage and alfalfa hay, prepared and presented as either TMR or CFC. The forage to concentrate ratio was 50:50 (dry matter basis), permitting 5-10% dailyorts. Cows were experimented on under thermoneutral conditions and were milked twice daily at 0500 and 1700 h. Jugular vein blood samples were taken for two days in each period, twice daily just before milking. Data were analyzed using Mixed Models with fixed effects of treatment, parity, and their interaction and random effects of period and cow within parity. Least squares means were estimated with the restricted maximum likelihood method, and degrees of freedom were calculated using the Satterthwaite method. Feeding CFC instead of TMR increased ($P < 0.05$) blood concentrations of glucose (65 vs. 60 mg/dL) and BHBA (0.35 vs. 0.25 mmol/L), while decreasing ($P < 0.05$) those of NEFA (0.2 vs. 0.3 mmol/L). Blood urea nitrogen was not different between treatments (12.7 mg/dL). Neither parity nor its interaction with feeding system affected blood metabolites. The data do not support the conventional belief that feeding TMR is more energetically efficient than component forage and concentrate delivery. The results provide new insights into optimizing feeding systems in high-producing dairy cows for improved energy efficiency and animal health. Future studies are required before clear-cut guidelines can be formulated for on-farm practice.

Key Words: energetics, feeding system, lactating cow

340 Sugar beets for growing and finishing feedlot cattle. V. L. Anderson^{1,*}, C. L. Engel^{2, 1}*North Dakota State University, Carrington, 2Carrington Research Extension Center, North Dakota State University, Carrington*

Sugar beets produce excellent yields throughout the Northern Plains and are uniquely tolerant of saline soil conditions. Sugar beets contain more energy than corn silage (80% vs. 70% TDN) but are typically lower in DM (20% vs. 35%). A growing and finishing study was conducted to evaluate sugar beets at the NDSU Carrington Research Extension Center

in the fall and winter of 2013–14. One hundred forty-three weaned crossbred steer calves were blocked by weight into four weight groups and allotted to one of three treatments with four replicates per treatment. Pen was the experimental unit in the randomized complete block design. Sugar beets (BEET), beet pulp (PULP), and corn silage (CSIL) were compared in 1.30 Mcal NEg/kg growing diets and 1.40 Mcal NEg/kg finishing diets. The corn based rations included BEETS at 25.8% (DM) of the growing ration and 9.4% of the finishing diet. Chopped straw was included at 5% in all rations. Sugar beets were stored whole in an outdoor pile. Beets were processed weekly by chipping with a flail head manure spreader. Pressed beet pulp was fed as wet shreds (American Crystal Sugar, Hillsboro, ND). Well eared corn silage was harvested from irrigated fields at the Carrington Center. The trial started on November 12, 2013, and terminated on May 5, 2014. After approximately December 1, ambient temperatures were below freezing, and sugar beets were chipped and fed frozen. During the 63 d growing phase, DMI was greater ($P < 0.01$) for BEET (10.70 kg/d) and PULP (9.46 kg/d) diets than CSIL (9.05 kg/d) with improved ADG ($P < 0.03$) observed for BEET (1.99 kg/d) and PULP (2.00 kg/d) compared to CSIL (1.83 kg/d). Reduced G:F ($P < 0.04$) was observed for BEET compared to PULP and CSIL. During the 112 d finishing period, DMI was greatest ($P < 0.04$) for CSIL (10.81 kg) compared to PULP (10.05 kg) and BEET (10.31 kg) with a tendency for improved ADG ($P < 0.12$) at 1.91 kg for CSIL vs. 1.79 kg for PULP and 1.78 kg for BEET. Finishing G:F was not affected ($P > 0.43$) nor were any of the carcass traits ($P > 0.33$). Ensiling should be explored as an alternative storage method instead of chipping frozen beets.

Key Words: beef, feed, sugar beets

341 The influence of dry-rolled corn particle size and dried corn distillers grains plus solubles inclusion levels on digestibility in steers. F. E. Doscher*, M. C. Ruch, J. D. Kirsch, M. L. Bauer, K. C. Swanson,
North Dakota State University, Fargo

Eight cannulated Holstein steers (525 ± 3.6 kg) were used in a 4×4 Latin square experiment to examine the impact of fine- vs. coarse-rolled corn and 20 vs. 40 % dried distiller's grain with solubles (DDGS) inclusion on nutrient digestibility. Animals were housed in individual stalls in a temperature-controlled room. Dietary treatments consisted of 1) 65% coarse-rolled corn (2.5 mm) and 20% DDGS, 2) 45% coarse-rolled corn and 40% DDGS, 3) 65% fine-rolled corn (1.7 mm) and 20% DDGS, and 4) 45% fine-rolled corn and 40 % DDGS. Treatments were offered to ensure ad libitum intake and approximately 6 % feed refusal daily. Chromic oxide was added to each ration at 0.25 % as an external marker. Steers were provided experimental diets for a period of 14 d, and daily feed intake and fecal excretion were recorded during the final 7 d. Intake, excretion, and disappearance of DM, OM, CP,

NDF, and ADF were measured. Results were analyzed using the Mixed procedure of SAS. No differences were observed between treatments for intake or disappearance of DM or OM ($P \geq 0.24$). Intake, duodenal flow, and total tract disappearance of CP were greater ($P \leq 0.04$) in steers consuming 40% DDGS. Crude protein ileal flow and rumen microbial efficiency (microbial CP produced/OM fermented) were not influenced by treatment. Starch intake, fecal output, and total tract disappearance were greater ($P \leq 0.01$) in rations with 20% DDGS while no impact was observed for duodenal and ileal flow. Feeding coarse-rolled corn increased ($P = 0.02$) NDF digestibility (% of intake) while feeding 40% DDGS increased ($P \leq 0.01$) NDF intake, fecal output, and total tract disappearance. An interaction between corn and DDGS was observed ($P \leq 0.05$) for NDF total tract disappearance, apparent ruminal digestibility, and total tract digestibility with greater values present in treatments containing coarse-rolled corn and 20% DDGS. Intake, total tract disappearance, and total tract digestibility of ADF were greater ($P \leq 0.001$) in diets containing 40% DDGS. Duodenal flow and ileal flow of NDF and ADF were unaffected by treatment ($P \geq 0.06$). Results of this study indicate that increased corn grain inclusion rates have a greater impact on total tract disappearance of starch while CP and fiber disappearance and digestibility are more likely to be affected by increased DDGS.

Key Words: bovine, corn, distillers, nutrient disappearance

342 **Effect of particle size and exogenous enzymes on degradability of corn grain rehydrated and ensiled for a short time.** N. M. Lopes^{1,2}, M. N. Pereira¹, F. C. Cardoso^{2,*}, ¹Federal University of Lavras, Lavras, Brazil, ²University of Illinois, Urbana

At times, farmers may be obligated to open the corn silo sooner than what is recommended, causing a shorter time of storage, which can reduce the benefits of the ensiling process. Flint (FT) and flourey (FL) corn of varying particle sizes are known to have altered degradability due to time of ensiling. Therefore, our objective was to evaluate two enzymes in a complete randomized design, with 12 treatments from the combination of two corns (FT and FL), two particle sizes (260 and 320 cm²/g), and three enzyme combinations [amylase (A), protease (P), or both (AP)]. Each treatment was replicated in 5 bags. Silos were stored for one month in vacuum sealed bags, and each bag contained 1 kg of corn (75% DM). The enzyme concentration was 650 g/t for A, 200 g/t for P, and their sum for AP. The weight, pH, and temperature were measured at time of bag opening. Samples were analyzed for DM, prolamin, and 18 h in vitro degradability. Statistical analysis was performed using the MIXED procedure in SAS. At time point zero FL and FT had 29.86 and 30.48% DM with DM degradability of 32.0 and 33.8%, respectively. Among the three variables analyzed, there was a difference for hybrid on

prolamin (4.30 and 5.32 g/100 g DM; $P < 0.001$) and DM loss (-0.56 and -5.36% ensiled; $P < 0.0001$) for FL and FT, respectively. There was an enzyme effect for silo DM ($P = 0.004$), with the highest DM being 30.16% for AP, 29.93% for A, and 29.69% for P. Treatment AP had the smallest ($P < 0.001$) DM loss during the ensiling period (-0.008% ensiled) when compared to A (-2.575% ensiled) and P (-6.297% ensiled). In addition, treatment AP had the lowest temperature at silo opening (21.77°C; $P < 0.001$). Enzyme A increased ($P = 0.047$) the rate of degradability from 3 to 7 h, represented by the smallest Kd (-0.3312%/h) when compared to (-0.2523%/h) P and (-0.2581%/h) AP. In conclusion, degradability was not directly affected by corn processing or enzyme application. Rate of degradability was affected by enzyme application. Collectively, the results can be used in a strategy to control other variables that impact rehydrated corn grain silage quality.

Key Words: amylase, corn hybrid, dry corn silage, protease

343 **Effect of supplementing feedlot steers with a DHA-rich microalgae meal on performance, insulin sensitivity, and meat quality.** J. R. R. Carvalho¹, K. M. Brennan², J. P. Schoonmaker^{3,*}, ¹Universidade Federal de Lavras, Lavras, Brazil, ²Alltech, Nicholasville, KY, ³Purdue University, West Lafayette

Heterotrophic production of algal biomass provides a consistent, high quality source of docosahexaenoic acid (DHA; C22:6 n-3) in triglyceride oils that could be used as a ration supplement for feedlot steers to improve healthfulness of beef. Sixty Angus × Simmental steers (438 ± 6.4 kg) were allotted to 2 treatments (30 steers each, 6 pens, 5 steers per pen) to determine the effect of a supplemental DHA-rich microalgae meal (*Schizochytrium limacinum* CCAP 4087/2; 63.6 % fat; 17.9% DHA; Alltech Inc.) on performance, insulin sensitivity, and meat quality. Steers were fed basal diets containing 45% corn, 30% distillers dried grains with solubles (DDGS), 20% corn silage, and 5% supplement at 0800 daily. Basal diets were formulated to contain 16.1% CP, 1.32 Mcal/kg NE_g, and 0.12 mg/kg Se. A top-dress was delivered daily to provide 3 mg/hd selenium (Se; sodium selenite) to control steers and 3 mg/hd Se as organic Se (Sel-Plex, Alltech Inc.) + 100 g DHA-rich microalgae meal to algae steers. A glucose tolerance test (GTT) was performed 10 d prior to slaughter to determine glucose clearance and insulin production. Steers were slaughtered when a target BW of 621 kg was achieved. Fatty acid oxidation potential was determined by measuring thiobarbituric acid reactive substances (TBARS) on LD samples collected 24 h after slaughter and aged for 48 h or 21 d. Data were analyzed using the MIXED procedures of SAS. Weight and BW gain did not differ during the study ($P \geq 0.13$), but algae steers were in the feedlot 7 more d compared to control steers (111 vs. 104 d; $P = 0.04$). Overall DMI was decreased ($P = 0.002$) and gain:feed during the second half of the study was increased ($P = 0.04$) in algae compared to control

steers. Steers fed algae secreted less insulin ($P = 0.01$) and took longer to clear glucose ($P = 0.01$) during a 2 h GTT. Carcass traits did not differ between treatments ($P \geq 0.23$). Concentration of TBARS did not differ in LD aged for 48 h ($P = 0.91$), but when aged for 21 d, steers fed algae meal tended to produce LD with greater TBARS concentration compared to control steers ($P = 0.08$). In conclusion, DHA-rich microalgae meal decreases DM intake of steers and increases measures of fatty acid oxidation in meat aged for 21 d.

Key Words: algae, beef, DHA, TBARS

344 Forage production and stocker cattle performance on BMR Sudan grass and vegetative corn in upper Midwestern grazing systems. C. C. Nieman*, *University of Wisconsin–Madison, Madison*

Warm season annual grasses have the potential to increase carrying capacity for grazing systems in the Midwest. A study was conducted to test brown mid-rib (BMR) Sudan grass (SG) and corn for carrying capacity. Pastures of 1.14 ha were strip grazed with a “put and take” method involving eight 0.14 ha paddocks with a 3-day rotation frequency. At least four Holstein “tester” steers (318 ± 4 kg, mean \pm SEM) were assigned to each of six pastures. Additional “nontester” steers were added when biomass was greater than the estimated intake for tester steers (dry matter intake estimated at 3% body weight) over 3 days with assumed grazing efficiencies of 60% in SG and 90% in corn. Forage data were analyzed as a completely randomized design with week as a repeated measure and pasture as the experimental unit. Weight measurements were taken on two consecutive days before and after each 24 day grazing cycle. Tester steer Daily gain was averaged and analyzed as a completely randomized design with pasture as the experimental unit. Stocking rates for corn were 14.2 ± 0.5 steers/ha or 4650 ± 163 kg/ha and 7.1 ± 0.5 steers/ha or 2380 ± 163 kg/ha on SG. Measurements for pre- and postgrazing biomass were taken weekly in both treatments. For SG, three 0.61 m² quadrats were randomly set in each paddock and clipped 5 cm from the soil. For corn, three 3.05 m sections of row were randomly selected and harvested 5 cm from the soil. Grazing commenced when the corn treatment reached V7 and the SG reached 72 cm. Corn was strip grazed once, while SG was strip grazed twice with the second 24 day grazing cycle following a 40-day rest period. Pregrazing biomass was higher ($P < 0.05$) in corn averaging 2550 ± 261 kg/ha, while SG averaged 1980 ± 261 kg/ha. Harvested forage was also higher ($P < 0.05$) in corn averaging 2428 ± 255 kg/ha and 1780 ± 255 kg/ha for SG. Average daily gain was not significantly different ($P = 0.37$) between treatments (1.0 ± 0.12 kg/d vs. 0.84 ± 0.12 kg/d, for SG and corn). There was also no difference ($P = 0.41$) in gain per ha (285 ± 48 kg/ha for corn and 348 ± 48 kg/ha for SG). The same gain per hectare was achieved with a lower stocking rate and greater grazing days when SG was grazed.

Key Words: grazing, stocker, Sudan grass

345 Effect of trace mineral injection on growth and trace mineral status of nursing beef calves.

C. J. Brasche^{1,*}, J. B. Hall², M. E. Drewnoski¹,
¹*University of Nebraska–Lincoln, Lincoln*,
²*University of Idaho, Carmen*

The objective of this experiment was to determine the effect of an injectable trace mineral (TMI) on the growth and trace mineral status of nursing beef calves. Over two years, cows ($n = 200$ each year) received either a TMI (0.90 mL/91 kg BW) of Multimin90 containing Cu, Se, Mn, and Zn or no injection (CON) 50 d before the start of the calving season. Throughout the two years all cows were given access to a free-choice mineral containing Cu, Se, and Zn. Calves ($n = 194$ TMI, $n = 187$ CON) were assigned to the same treatment as their dams, and TMI calves received 1 mL of Multimin90 at one day of age (DOA). In both years cows assigned to TMI received a second injection at branding. In year one of the study calves in the TMI group also received injections (1 mL/45 kg BW) at branding (51 ± 1.3 DOA), and jugular blood was collected from calves ($n = 40$; 20 per treatment) prior to injection to determine trace mineral concentration. Data were analyzed using the MIXED Procedure of SAS with individual animal being the experimental unit. Plasma Se and Mn concentrations were increased ($P \leq 0.05$) in TMI ($88.8 \mu\text{g Se/L}$ and $23.1 \mu\text{g Mn/L}$) calves when compared to CON ($51.9 \mu\text{g Se/L}$ and $12.6 \mu\text{g Mn/L}$). Plasma Zn tended to be increased ($P = 0.06$) in TMI (1.16 mg/L) calves compared to CON (1.00 mg/L). No effect ($P = 0.54$) of TMI on plasma Cu (0.90 vs 0.86 mg/L , TMI vs CON, respectively) was observed. At weaning (DOA = 195 ± 0.8), liver biopsies ($n = 20$ per treatment per year) were performed to determine liver trace mineral concentrations. Liver Cu was increased ($P = 0.02$) in TMI (187 mg/kg) compared to CON (150 mg/kg), and liver Se of TMI (0.98 mg/kg) tended ($P = 0.10$) to be increased compared to CON (0.88 mg/kg). There was no significant difference ($P \geq 0.24$) in liver concentrations of Zn (113 vs. 108 mg/kg for TMI and CON, respectively) or Mn (11.4 vs. 12.2 mg/kg for TMI and CON, respectively). Concentrations of all trace minerals in the liver were considered adequate regardless of treatment. There was no effect ($P = 0.54$) of TMI on 205 d adjusted weaning weight (286 vs. $284 \pm 2.5 \text{ kg}$ for TMI and CON, respectively). Use of a TMI increased Se and Cu status but did not improve growth of calves in this study.

Key Words: calf, growth, injectable trace mineral

346 Performance of Nellore beef cattle fed with whole corn diet.

A. M. Mobiglia¹, F. R. Camilo¹,
A. A. Miszura¹, V. R. M. Couto^{1,*}, F. G. F. Castro²,
B. P. C. Mendonça², J. J. R. Fernandes¹, ¹*Universidade Federal de Goiás, Goiânia, Brazil*, ²*AgroCria, Goiânia, Brazil*

Higher amounts of whole grain in the diet increase the risk of ruminal acidosis due to abrupt changes that happen in the ru-

Table 346. Performance of Nellore bull feedlot fed with whole corn diet

Variables	MON		VM		SEM	P-value		
	10%SB	0% SB	10%SB	0% SB		Additive	Roughage	A × R
DMI (kg/d)	6.445	6.608	7.435	6.827	0.240	0.027	0.373	0.134
IBW (kg)	368	369	368	368	2.959	0.827	0.963	0.963
FBW (kg)	521	514	534	510	8.097	0.615	0.083	0.334
ADG (kg/d)	1.455	1.384	1.577	1.354	0.075	0.551	0.074	0.331
DMI/BW (%)	1.447	1.497	1.646	1.553	0.046	0.017	0.655	0.150
FE	0.228	0.209	0.213	0.209	0.009	0.186	0.100	0.830

men. Metabolic disorders that happen during adaptation to new high grain diets often times cause decreased feedlot performance. The objective was to evaluate effects of virginiamycin (VM) and monensin sodium (MON) in whole corn diet, with or without the use of roughage during adaptation on performance of feedlot cattle. The animals were kept in the feedlot in group pens (5 pens/treatment) for 106 d with a 21-d adaptation period. One hundred Nellore bulls were used in a randomized complete block design with a 2 × 2 factorial arrangement, with two kinds of additives (VM and MON) and two adaptation strategies, 4 treatments, and 5 replicates. Treatments were defined by VM (25 mg/kg of DM) and MON (30 mg/kg of DM), with or without sugarcane bagasse (SB) during the adaptation period as follows: VM 10% SB; VM 0% SB; MON 10% SB; and MON 0% SB. After the adaptation period, animals were fed ad libitum once daily with a diet containing 85% whole corn, 15% pelleted feed (soybean, minerals, and the additive). Dry matter intake (DMI) was higher ($p < 0.05$) for the VM compared to MON; however, the roughage in the diet did not affect the DMI (Table 1). The relationship between DMI and BW was higher ($p < 0.05$) in VM treatments. Differences were not observed between treatments for final BW (FBW) and average daily gain (ADG). There was no interaction between the additives and roughage source for any variables studied. In contrast, animals fed SB at the adaptation period tended ($P < 0.10$) to have higher FBW, ADG, and feed efficiency (FE) than animals fed treatments without bagasse, independent of the additive used. VM and MON had a similar effect on gain; however, MON decreased DMI compared to VM. The use of roughage source may increase the performance due to a greater adaptation of the Nellore bulls to whole corn diet.

Key Words: acidosis, adaptation period, feedlot

347 Effects of phytogenic additives on intake, growth performance, and carcass characteristics in steers fed high-concentrate diets. K. K. G. Moreira, J. T. Padua, V. R. M. Couto*, A. A. Miszura, D. G. De Sousa, D. S. Chaves, M. E. Maronezi, W. V. D. S. Santos, L. D. Da Silva, J. J. R. Fernandes, *Universidade Federal de Goiás, Goiânia, Brazil*

The objective of this study was to evaluate the effects of supplementing the diet of feedlot cattle with natural plants extracts on intake, growth performance, and carcass characteristics. One hundred fourteen Nellore steers (333.88 ± 2.43

of initial BW) were assigned to a randomized complete block design with 4 treatments and 5 replicates. Blocks were defined by initial BW, and pens (5 or 6 animals) were considered as replicates. Treatments were defined as follows: monensin (TM – control, Rumensin 80, Elanco Animal Health, Indianapolis, IN, 330 mg·steer⁻¹·d⁻¹); dry extract of *Stryphnodendron adstringens* (TS – 15 g·steer⁻¹·d⁻¹); commercial product 1 (TP1 - essential oils - commercial dose); and commercial product 2 (TP2 - extract of cashew nut - commercial dose). The composition of the diets was 19.49% of sugarcane bagasse and 80.51% of concentrate compound of corn, soybean meal, urea, and minerals. Means were compared using Tukey's test ($P < 0.05$). Additives did not influence final BW (kg), ADG (kg/d), dressing percentage, ADG of carcass (kg/d), and fat thickness (mm) ($P > 0.05$). TM Animals consumed less DM (kg/d) ($6.822 - P < 0.01$) and DMI/BW (%) ($1.668 - P < 0.01$) than animals in others treatments. TM had better FE (kg/kg) than TS and TP1 ($P < 0.01$) but was similar to TP2 ($P > 0.05$). In summary, monensin supplementation might be effective in growth performance primarily through reduced DMI of finishing steers.

Key Words: feedlot, natural plants extracts, Nellore steers

348 Roughage removal from feedlot diets improves feed efficiency in feedlot cattle. N. O. Minton*, A. M. Meyer, W. J. Sexten, M. S. Kerley, *Division of Animal Sciences, University of Missouri, Columbia*

Our objective was to compare how feeding systems (FS) used to feed finishing cattle affect feed efficiency within the feedlot. Feeding systems were traditional (TRAD), no roughage (NR), and balanced matched (BM). We hypothesize matching steers to diets formulated to match actual growth potential in addition to removal of roughage from the diet will result in greater efficiency of gain compared to steers fed a traditional feedlot diet. Steers ($n = 90$; 276.1 ± 3.0 kg) purchased through regional livestock markets were randomly placed into two separate feedlots. Within feedlot steers were stratified by BW, frame size, muscle score, color, and source and were randomly assigned to FS. TRAD FS received a diet formulated to meet NRC requirements for a desired ADG. Diets fed to NR and BM FS were formulated to meet estimated effective energy (EE) and amino acid (AA) requirements for a desired ADG without the inclusion of roughage. For the initial 28 d all BM steers were fed a diet formulated to achieve an ADG of

Table 347. Means and standard error of growth performance and carcass characteristics of finishing steers fed a total mixed ration supplemented with additives monensin (TM), dry extract of *Stryphnodendron adstringens* (TS), commercial product 1 (TP1), and commercial product 2 (TP2)

Items	Treatment				P-value
	TM ¹	TS ²	TP1 ³	TP2 ⁴	
Final BW (kg)	481.65 ^a ± 17.13	484.91 ^a ± 16.47	486.70 ^a ± 18.43	489.11 ^a ± 16.62	0.60
DMI (kg/d)	6.82 ^b ± 0.29	8.02 ^a ± 0.28	7.83 ^a ± 0.26	7.49 ^a ± 0.18	<0.01
DMI/BW (%)	1.67 ^c ± 0.02	1.96 ^a ± 0.03	1.90 ^{ab} ± 0.03	1.82 ^b ± 0.04	<0.01
ADG (kg/d)	1.39 ^a ± 0.06	1.42 ^a ± 0.04	1.44 ^a ± 0.07	1.46 ^a ± 0.05	0.52
FE (kg/kg)	0.21 ^a ± 0.01	0.18 ^b ± 0.01	0.18 ^b ± 0.01	0.19 ^{ab} ± 0.01	<0.01
Dressing percentage	56.24 ^a ± 0.46	54.97 ^a ± 1.56	56.40 ^a ± 0.32	56.44 ^a ± 0.38	0.55
ADG of carcass (kg/d)	1.00 ^a ± 0.05	1.03 ^a ± 0.04	1.04 ^a ± 0.05	1.05 ^a ± 0.04	0.25
Fat thickness (mm)	3.14 ^a ± 0.48	2.60 ^a ± 0.43	2.79 ^a ± 0.39	2.82 ^a ± 0.33	0.42

¹Monensin (Rumensin 80, Elanco Animal Health, Indianapolis, IN); ²Dry extract of *Stryphnodendron adstringens*; ³Commercial product 1; ⁴Commercial product 2 (extract of cashew nut - commercial dose)

2.2 kg. BM steers were blocked within feedlot by 28 d ADG into high (2.53 to 1.86 ± 0.21 kg), mid (2.07 to 1.61 ± 0.14 kg), and low (1.69 to 1.04 ± 0.21 kg) ADG groups. Overlap in ADG range between ADG blocks was a result of blocks being assigned within feedlot. TRAD, NR, and low BM (LBM) FS remained on their respective diets for the entirety of the experiment. High BM and mid BM FS were transitioned to LBM diet once they met estimated EE and AA requirements for each FS average ADG and BW. Completion of trial occurred prior to slaughter on d 157. Data were analyzed using PROC MIXED with feedlot serving as a random effect. Over a 157 d finishing period initial BW, final BW, ADG, and DMI were not different ($P > 0.10$) between FS. Feed conversion ratio (FCR) was not different ($P > 0.10$) between NR and BM or between TRAD and BM FS. However, the NR FS improved FCR by 9.8 percent compared to TRAD (4.6 vs 5.1 ± 0.18; $P \leq 0.05$) FS. In conclusion, more descriptive information on prior nutrition, health status, environment, and genetics on cattle entering the feedlot would benefit diet formulation to match actual growth performance. Furthermore, roughage free diets formulated to balance EE and AA requirements for growth improve feed efficiency compared to traditional feedlot diets.

Key Words: beef, feed efficiency, feedlot

RUMINANT NUTRITION 2

349 Effects of *Saccharomyces cerevisiae* fermentation product on rumen VFA concentrations.

K. L. Dorton*, T. Werner, J. Lin, A. Souder, A. M. Brainard, V. L. Nsereko, J. M. Butler, I. Yoon, *Diamond V, Cedar Rapids, IA*

Effects of *Saccharomyces cerevisiae* fermentation product (SCFP; Original XPC, Diamond V, Cedar Rapids, Iowa) on rumen volatile fatty acid (VFA) concentrations were measured in vivo and in vitro. In the in vivo study, eight cannu-

lated Jersey cows (nonlactating, nonpregnant) were utilized in a crossover design experiment consisting of two 28-d periods. Cows were housed in tie stalls containing individual feed bins and an automatic watering system. Cows were fed a TMR diet once daily that was top-dressed with one of two treatments: 14 g Control (grain mix) or 14 g SCFP. Rumen fluid samples were collected from each cow every 9 h from d 26 to 28, which represented every 3 h over a 24-h period (8 samples per cow). Samples were collected from 5 locations within the rumen (cranial dorsal, cranial ventral, central rumen, caudal dorsal, and caudal ventral), composited within cow, and strained. Samples were analyzed for VFA concentrations and pH. The in vitro study, performed concurrently with the in vivo study, utilized the Diamond V Rumen Activity Modifier Model (RAMM). Rumen fluid was collected from the 8 cows used in the in vivo study. The rumen fluid was strained and composited within cow treatment group to create one composite per treatment on d 28 of each period. Incubation bottles containing substrate (ground TMR), treatments (Control or SCFP), and rumen fluid (Control or SCFP) were incubated under anaerobic conditions at 39°C for 16 hours. After incubation, pH and VFA concentrations were determined. Data were analyzed using the fit model procedure of JMP. Cows supplemented with SCFP had greater ($P < 0.01$) total VFA, acetate, isobutyrate, isovalerate, and valerate concentrations (130.39 vs. 122.79; 81.33 vs. 76.66; 1.74 vs. 1.58; 2.03 vs. 1.70; 1.88 vs. 1.71 mM, respectively). Concentration of propionate tended to be greater ($P < 0.06$) in cows supplemented with SCFP (23.89 vs. 22.58 mM, respectively). In the in vitro model, SCFP increased ($P < 0.001$) total VFA, acetate, propionate, and butyrate concentrations (58.76 vs. 56.34; 29.67 vs. 28.53; 20.34 vs. 19.31; 7.76 vs. 7.56 mM, respectively). In both the in vivo and in vitro models, rumen VFA concentrations were greater when SCFP was supplemented.

Key Words: dairy, *Saccharomyces cerevisiae* fermentation product, VFA

350 **The effects of cysteamine on rumen fermentation, microbial protein synthesis, and bacterial abundance in lactating dairy cows.** H. Liu*, H. Yang, M. Lin, H. M. Babekir, G. Zhao, T. Ma, Z. Chen, *College of Animal Science and Technology, Yangzhou University, Yangzhou, China*

Forty mid-lactation Holstein cows (average body weight = 550 ± 22 kg; parity = 1 to 2; days in milk = 152 ± 23 d; milk yield = 18.8 ± 2.4 kg) were used in a completely randomized block design to investigate the effects of cysteamine (CS, supplied by Shanghai Walcom Biology Co., Ltd.) supplementation on rumen fermentation, microbial protein synthesis, and bacterial abundance. CS was added to the basal total mixed ration at doses of 0 (CON), 15, 30, 75, and 150 g/d. The experiment was conducted over a period of 10 weeks, including 2 weeks for adaptation and 8 weeks for data collection. Rumen fluid samples were collected before morning feeding at the end of weeks 4, 6, 8, and 10. Data were analyzed using PROC MIXED in SAS 9.0. Rumen pH ($P = 0.422$) and acetate concentration ($P = 0.744$) were not affected by treatments. Rumen ammonia-N concentration in the 75 g/d treatment was greater than CON and the 15 g/d treatment ($P = 0.001$). Total volatile fatty acid concentration in CON and 15 g/d treatment were higher compared with 75 g/d and 150 g/d treatments ($P = 0.007$). Cows fed 15 g/d CS had the lowest proportion of propionate ($P = 0.026$) and the highest acetate:propionate ratio ($P = 0.004$), compared with the other treatments. The concentration of protozoa protein ($P = 0.018$) and total microbial protein ($P = 0.041$) in the 75 g/d treatment were lower than CON. When considering rumen bacteria abundance, through a real-time PCR test we observed that the relative abundance of *P. ruminicola* in the 75 g/d treatment was higher than CON ($P = 0.001$). 30 g/d CS supplementation upregulated *B. fibri-solvens* abundance ($P < 0.001$). *F. succinogenes* levels of 30 g/d and 75 g/d treatment were upregulated, but that of 150 g/d group was downregulated ($P < 0.001$). Adding 75 g/d and 150 g/d reduced *R. albus* levels ($P < 0.001$). The *R. flavefaciens* abundance of the 15 g/d, 30 g/d, and 150 g/d treatments were lower than CON ($P < 0.001$). Based on the results of this study, low doses (0–30 g/d) of CS were useful for increasing rumen fermentation. However, 75 g/d CS supplementation reduced protozoa protein concentration, and 150 g/d CS reduced *F. succinogenes*, *R. albus*, and *R. flavefaciens* abundance, which indicated that high levels of CS inhibited the microbial activity.

Key Words: bacteria abundance, microbial protein synthesis, rumen fermentation

351 **Effects of feeding stockpiled tall fescue versus tall fescue hay to late gestation beef cows on circulating plasma amino acid concentrations in neonatal calves.** K. N. Niederecker^{1,*}, B. L. Vander Ley², M. C. Heller³, A. M. Meyer¹, ¹*Division of Animal Sciences, University of Missouri, Columbia*, ²*Department of Veterinary Medicine and Surgery, University of Missouri, Columbia*, ³*Department of Veterinary Medicine and Epidemiology, University of California, Davis*

We hypothesized that cows grazing stockpiled tall fescue (STF) during late gestation have increased nutrient intake compared with cows fed summer-baled hay, which would result in improved fetal development and subsequent calf performance. Forty-eight multiparous, spring-calving crossbred beef cows ($683 + 16$ [SE] kg, BW) were allocated by BW, BCS, age, and expected calving date to either strip-graze endophyte-infected STF (59.7% NDF, 12.3% CP; DM basis) in 4.05 ha pastures ($n = 4$) or consume ad libitum endophyte-infected tall fescue hay (HAY; 64.9% NDF, 6.2% CP; DM basis) in uncovered drylots ($n = 4$) beginning on d 188 ± 2 of gestation. Cows remained on their respective treatments until calving, but STF cows were moved to drylots at 7.0 ± 1.0 d precalving and fed ryelage (58.6% NDF, 12.3% CP; DM basis). At 52 ± 0.6 h postnatally, jugular blood samples were obtained from calves for plasma determination of circulating AA. Data were analyzed with treatment as a fixed effect and pasture or drylot as the experimental unit; calf date of birth and sex were included in the model when $P < 0.25$. Total AA and total essential AA concentrations ($\mu\text{mol/L}$) tended ($P \leq 0.11$) to be greater for calves born to STF cows than calves born to HAY cows. Total branched-chain AA were greater ($P \leq 0.05$) for calves born to STF cows compared with HAY as a concentration, percent of total AA, or percent of total essential AA. Plasma concentration of Val, Asn, Glu, and Pro were greater ($P \leq 0.04$) and Ile, Leu, Asp, and Cit tended ($P \leq 0.10$) to be greater for STF calves versus HAY; there were no differences ($P \geq 0.17$) in all other essential AA concentrations. When expressed as a percent of total AA, Val, Asn, and Glu were greater ($P \leq 0.05$) for STF calves than HAY. Plasma Val was greater ($P = 0.03$) for STF calves when expressed as percent of total essential AA. Conversely, calves born to HAY cows had greater ($P \leq 0.02$) Thr when expressed as a percent of total AA or total essential AA. In conclusion, calves born to STF cows had greater total, essential, and branched-chain AA concentrations, which may indicate increased nutrient supply to fetal and neonatal calves born to cows grazing STF.

Key Words: amino acids, developmental programming, pregnancy

352 **Effects of corn processing method and particle size on feedlot performance and carcass traits of yearling steers.** C. L. Engel^{1,*}, V. L. Anderson², C. S. Schauer³, ¹*Carrington Research Extension Center, North Dakota State University, Carrington,*

²*North Dakota State University, Carrington, ND,*

³*Hettinger Research Extension Center, North Dakota State University, Hettinger, ND*

The objective of this study was to evaluate the effects of corn processing and particle size on performance and carcass traits of steers fed finishing diets with decreasing forage levels. One hundred and twenty black crossbred yearling steers (initial BW 406.80 ± 1.23 kg) were blocked by BW and randomly allotted to 12 pens (10 steers/pen). The pens were assigned randomly to one of three corn processing treatments: 1) whole (WC), 2) dry rolled (RC), and 3) finely ground (GC). Mean particle size for WC, RC, and GC was 5.49 ± 0.14 mm, 2.84 ± 0.12 mm, and 1.35 ± 0.16 mm, respectively. Diets were similar in protein (≥13.4%) and energy (≥0.98 Mcal NEg/Kg), met or exceeded NRC nutrient requirements, and included modified distillers grains, grass hay, corn silage, Rumensin, vitamins, and minerals. Dietary forage levels for all treatments was 31.5 % initially (23% corn; DM basis) and decreased at 41 d intervals to 25.0 and 15.5% (35 and 53% corn, respectively), followed by a final level of 13.5% (55% corn) for the last 22 d. Forage levels were defined as the sum of the hay and 50 % of the dietary corn silage. Steers were weighed individually on d 0 and at each forage level decrease, over the 145 d trial. All cattle were harvested on the same date at a commercial abattoir. Carcass attributes evaluated after a 24-hour chill included 12th rib fat depth, LM area, KPH, marbling, and USDA yield grade. Performance and carcass characteristics were analyzed using the GLM procedure of SAS, with pen serving as the experimental unit. Final BW and overall ADG were similar ($P \geq 0.21$) for all treatments. DMI was similar ($P = 0.24$) for RC and GC and greatest ($P \leq 0.01$) for WC (13.56, 13.24, and 14.42 kg/d, respectively). Gain efficiency was lowest ($P < 0.01$) for WC (0.154) but similar ($P > 0.05$) between RC (0.169) and GC (0.166). All carcass characteristics, except KPH, were similar ($P \geq 0.07$) among treatments. The percent KPH was similar ($P > 0.05$) for RC and GC but greater for WC ($P = 0.01$). These results indicate processing corn by RC or GC to maintain a particle size between 1.35 ± 0.16 mm and 2.84 ± 0.12 mm will result in improved DMI and gain efficiency for finishing yearling steers fed diets with decreasing forage levels.

Key Words: beef, corn, particle size

353 **Effects of pennycress meal on rumen fermentation using a continuous culture system.** M. M. Masiero*, M. S. Kerley, *University of Missouri, Columbia*

Two experiments were conducted to determine pennycress meal (PCM) RUP value and characterize effects on microbial

fermentation. Four diets with increasing PCM [control (0%, CON), 5.5% (TRT1), 11% (TRT2), and 16% (TRT3) PCM] were fed (40 g/d) to continuous culture fermenters. Control diet had soybean meal (10%) as the major protein source. Corn (74%), soyhulls (10%), and vitamins and minerals (2.6%) were similar across diets. We hypothesized increasing PCM concentration would increase RUP flow and not influence microbial fermentation. Diets and parameters analyzed were the same for both experiments. Diets were randomly distributed over fermenters ($n = 24$), acclimated for 4 d, and sampled over 3 d. Fermenter content was monitored 4 h post-feeding for pH and analyzed for VFA (mM) and ammonia concentration (mM/dL). Data were analyzed as randomized complete design, using GLM procedure of SAS (SAS Inst. Inc., Cary, NC) with fermenter as experimental unit. For Exp. 1, propionate was greater ($P = 0.04$) for CON (13.68) compared to TRT1 (9.88). Valerate and isovalerate were greater ($P < 0.05$) for CON (1.35; 1.24) compared to TRT3 (1.14; 0.90). Acetate, butyrate, isobutyrate, total VFA, acetate:propionate, pH, and ammonia did not differ ($P > 0.05$) among diets. Organic matter digestibility was greater ($P < 0.01$) for CON (68.63) compared to treatments (TRT1 61.87; TRT2 60.57; TRT3 59.50). Bacteria nitrogen (g/d) was greater ($P = 0.03$) for CON (0.60) compared to TRT3 (0.44). Microbial efficiency, nitrogen digestibility, and RUP (g/d) did not differ ($P > 0.05$) among diets. For Exp. 2 acetate:propionate was greater ($P = 0.01$) for TRT3 (3.45) compared to CON (3.02). Acetate, propionate, butyrate, isobutyrate, isovalerate, valerate, total VFA, pH, and ammonia did not differ ($P > 0.05$) among diets. Microbial efficiency, bacterial nitrogen, nitrogen digestibility, and RUP did not differ ($P > 0.05$) among diets. In conclusion, increasing PCM concentration did not increase RUP flow and had no effects on microbial efficiency.

Key Words: fermentation, pennycress meal, RUP

354 **Performance by Katahdins grazing stockpiled toxic tall fescue, nontoxic tall fescue, or "Persist" orchardgrass: 1-year summary.** T. N. Drane^{1,*}, J. D. Caldwell¹, A. L. Bax¹, B. C. Shanks¹, L. S. Wilbers¹, A. J. Kempker¹, J. D. Walker¹, C. A. Clifford-Rathert¹, A. K. Busalacki², ¹*Department of Agriculture and Environmental Sciences, Lincoln University, Jefferson City, MO,* ²*Department of Life and Physical Sciences, Lincoln University, Jefferson City, MO*

Grazing stockpiled forages during the winter months may provide small ruminant producers a cheaper alternative to buying expensive feedstuffs. However, limited research has been conducted comparing the effects of stockpiling endophyte-infected tall fescue [*Lolium arundinaceum* (Scrib.) Darbysh; E+], novel endophyte-infected tall fescue (NE+), and Persist orchardgrass (*Dactylis glomerata* L.) on performance and reproductive rates by Katahdin ewes. A total of 48 spring-born Katahdin ewes (22

± 0.67 kg initial BW, 2.6 ± 0.09 initial BCS) were stratified by weight and BCS and allocated randomly to 1 of 6 groups representing 3 treatments: 1) E+, 2) NE+, or 3) Persist orchardgrass. Each treatment consisted of 2 replications (0.4 ha per replication) and 8 animals per replication. Data were analyzed using PROC MIXED of SAS with two preplanned orthogonal contrast statements to evaluate ewe performance: 1) the mean of E+ vs. the mean of NE+ and Persist orchardgrass and 2) the mean of NE+ vs. the mean of Persist orchardgrass. Pregnancy rates and percentage of multiple births were analyzed by the Chi-square procedure of SAS. Excess forage was grazed in early August, and 54 kg N/ha was applied on September 17, 2013. Beginning on November 14, 2013, grazing of stockpiled pastures was initiated and lasted a total of 77 d. At the beginning of the breeding season (December 16, 2013), one Katahdin ram that had passed a breeding soundness exam was introduced and remained in each group for 39 d. Ewe weights, BCS, and ADG did not differ ($P \geq 0.12$) across treatments. Pregnancy rates did not differ ($P \geq 0.19$) across treatments. Percentage of multiple births tended ($P = 0.07$) to be greater from NE+ and Persist orchardgrass compared with E+ (19 vs. 0%, respectively) and tended ($P = 0.07$) to be greater from NE+ compared with Persist orchardgrass. Therefore, grazing stockpiled endophyte-infected tall fescue, novel endophyte-infected tall fescue, or Persist orchardgrass during the winter months may result in similar ewe performance and pregnancy rates, but grazing stockpiled novel endophyte-infected tall fescue may improve the percentage of multiple births. This work was supported by the USDA National Institute of Food and Agriculture, Evans-Allen project #227400.

Key Words: fescue, sheep, stockpiling

355 Ruminal degradability and intestinal digestibility of crude protein in sorghum distillers dried grains compared to soybean meal and corn coproducts. B. J. Wild*, J. L. Anderson, A. D. Garcia, *Dairy Science Department, South Dakota State University, Brookings*

Our objective was to determine dry matter (DM) and crude protein (CP) ruminal in situ degradability and intestinal in vitro digestibility of sorghum distillers dried grains compared to soybean meal and other corn coproducts. In situ measurements were conducted using three mid-lactation, multiparous, ruminally cannulated Holstein cows (BW 797.3 ± 77.8 kg). Five feedstuffs were evaluated: sorghum distillers dried grain (SDDG), corn distillers dried grains (CDDG), reduced-fat corn distillers dried grains (RFDDG), corn gluten meal (CGM), and soybean meal (SBM). Duplicate samples were weighed into nylon bags and incubated in the rumen for 0, 2, 4, 8, 16, 24, and 48 h. Rumen degradation constants for DM and CP were estimated using the NLIN procedures in SAS version 9.3. Six additional replicates from each feedstuff were ruminally incubated at 16 h, and residues were used to determine in vitro in-

Table 355.

Item	SDDG	CDDG	RFDDG	CGM	SBM	SEM
CP, % DM	39.3	33.0	32.8	74.0	51.1	-
RDDM, % of DM	46.8 ^c	56.6 ^b	58.6 ^b	33.3 ^d	74.4 ^a	0.94
RDP, % of CP	35.5 ^c	48.7 ^b	50.2 ^b	31.8 ^c	70.0 ^a	1.04
RUP, % of CP	64.5 ^a	51.4 ^b	49.8 ^b	68.3 ^a	30.0 ^c	1.04
IDP, % of RUP	37.5 ^d	65.3 ^b	66.0 ^b	53.4 ^c	95.4 ^a	2.48
IADP, % of CP	24.2 ^c	33.5 ^{ab}	32.9 ^{ab}	36.5 ^a	28.6 ^{bc}	1.65
TDP, % of CP	59.8 ^d	82.2 ^b	83.1 ^b	68.2 ^c	98.6 ^a	1.17

^{a-d}Values with unlike superscripts differ by $P < 0.05$.

testinal digestibility of CP. Residues were incubated in a Daisy II incubator (Ankom Technology, Inc. Macedon, NY) with pepsin and pancreatin solutions for 1 h and 24 h, respectively. Intestinal protein digestibility (IDP), intestinally absorbable dietary protein (IADP = RUP \times IDP), and total digestible protein (TDP = RDP + IADP) were evaluated using MIXED procedures in SAS with feedstuff as a fixed variable and cow as a random variable in the model. Ruminally degradable DM (RDDM) was less in CGM and greater in CDDG, RFDDG, SBM compared to SDDG. Ruminally degradable protein (RDP) was greater in SBM, CDDG, and RFDDG compared to SDDG and CGM. Conversely, ruminally undegradable protein (RUP) was greater in SDDGS and CGM than in SBM, CDDG, and RFDDG. Estimated IDP, IADP, and TDP were least in SDDG compared to the other feeds. Results indicate CP from SDDG was less ruminally degradable and intestinally digestible compared to CDDG, RFDDG, and SBM. Concentrations of RDP and RUP were similar in SDDG and CGM; however, CGM had more total CP, IDP, and TDP.

Key Words: intestinal digestibility, rumen degradation, sorghum distillers dried grains

356 Influence of conventional vs. natural feeding approaches, adaptation length, and direct-fed microbial inclusion on growth performance and feeding behavior in finishing steers.

J. J. Gaspers*, G. L. Stokka, J. M. Young, T. C. Gilbery, S. R. Underdahl, M. L. Bauer, G. P. Lardy, K. C. Swanson, *North Dakota State University, Fargo*

Crossbred steers (391 ± 2.8 kg, $n = 113$) were assigned randomly to a $2 \times 2 \times 2$ factorial arrangement of treatments ($n = 14$ or 15 per treatment) to determine the effects of conventional vs. natural feeding approaches (using monensin, tylosin, trenbolone acetate, and estradiol vs. none), grain adaptation length (14 vs. 28 d), and direct-fed microbial supplement (DFM; with or without) containing live microorganisms and fermentation extracts on temperament. The relationships between temperament and feeding behavior, growth performance, and carcass characteristics were also examined. Diets consisted of corn, dried corn distillers grains with solubles, and 10% forage (hay and corn silage). Individual feed intake and feeding behavior were monitored using the Insentec roughage intake control system (Insentec, B. V., Marknesse, the Netherlands).

Weights were taken on two consecutive days at the beginning and the end of the trial and once every 28 d throughout. While weighing, temperament data were taken using chute score (1 = calm to 5 = struggling continuously), exit score (1 = walk to 4 = gallop), and exit velocity (m/s). Data were analyzed using Mixed, GLIMMIX, and Correlation procedures of SAS. Chute score, exit score, and exit velocity were negatively correlated with HCW and marbling ($P < 0.05$). Temperament scores did not have significant correlations with feeding behavior or growth performance. Average DMI was positively correlated with time spent at feeder, number of visits, ADG, HCW, yield grade, marbling, and back fat ($P < 0.05$). Time spent at feeder was positively correlated with number of meals, ADG, and HCW ($P < 0.05$). Number of visits per day was negatively correlated with G:F ($P = 0.008$). The number of meals per day was negatively correlated with marbling ($P = 0.05$). Average daily gain was positively correlated with G:F, HCW, and back fat ($P < 0.05$) and negatively correlated with KPH ($P = 0.05$). Steers that were adapted over 14 d had higher chute scores, exit scores, and exit velocities than steers on the 28 d adaptation treatment. Conventionally fed steers had increased exit velocities ($P = 0.005$) compared to naturally fed steers. Chute scores and exit scores decreased over the 140 d trial while exit velocities increased ($P < 0.001$). Temperament may be associated with differences in HCW and marbling. Approaches and adaptations to feeding finishing diets may have an impact on temperament of cattle in the feedlot.

Key Words: direct-fed microorganism, finishing cattle, implants, ionophores, performance

357 **Treatment of mature switchgrass and cornstalks with calcium hydroxide and comparison of untreated mature switchgrass and cornstalks as roughage in beef cattle feedlot diets.** C. A. Clark^{1,*}, G. R. Dahlke², D. L. Maxwell¹, S. K. Clark², M. L. Van Emon², D. D. Loy², S. L. Hansen², ¹*Armstrong Memorial Research and Demonstration Farm, Iowa State University, Lewis*, ²*Iowa State University, Ames*

An in situ digestibility study was completed to evaluate the effect of calcium hydroxide treatment of switchgrass and cornstalks. Bales of cornstalks and mature switchgrass were ground to pass a 17.78 cm sieve, and water was added to achieve 60% DM. A 2 × 2 × 2 factorial of treatments was utilized with the factors of roughage source (cornstalks or switchgrass), chemical treatment (none or calcium hydroxide at 7%), and duration of incubation (1 or 4 wk). After the allotted time, barrels were emptied and samples were collected, dried, ground (1 mm screen), weighed, and placed into Dacron bags (n = 3 bags·sample⁻¹·time point⁻¹). Bags were incubated in the rumen of a cannulated steer for 24, 36, or 48 h, then dried and weighed. There was an interaction between treatment and wk ($P < 0.001$). Digestibility of both roughages was improved

by chemical treatment and wk of chemical treatment ($P < 0.0001$); however, digestibility of untreated cornstalks did not differ due to wk of incubation ($P > 0.2$) while untreated switchgrass digestibility tended to be less after 4 wk of incubation ($P = 0.15$). A feeding trial using 121 crossbred steers (380 kg initial BW) was also conducted to evaluate the utilization of untreated mature switchgrass as a roughage source in feedlot diets. Steers were randomly allocated to 1 of 4 pens (n = 30 or 31 per pen), with 2 pens receiving cornstalks (STALK) and 2 pens receiving switchgrass (SWITCH) at 14.2% of diet DM. Cattle were fed for 131 days with Revalor IS implants administered on d 27 and d 77 of the feeding period and Optaflexx fed on the final 32 d on feed at 300 mg·steer⁻¹·d⁻¹. Cattle were marketed on a common date, and carcass data were collected. Data were analyzed using the MIXED procedure of SAS. When compared to STALK cattle, SWITCH cattle had lower marbling scores ($P = 0.0095$). Backfat, HCW, KPH, ribeye area, and yield grade did not differ between treatments ($P \geq 0.19$). Additionally, carcass-adjusted ADG did not differ between treatments ($P = 0.43$). Cattle fed SWITCH had lower DMI than STALK cattle ($P = 0.0004$), but G:F did not differ between treatments ($P = 0.9783$). In summary, untreated switchgrass may replace cornstalks at low inclusions in finishing diets, and digestibility of this low quality roughage may be improved through alkaline treatment.

Key Words: digestibility, feedlot, switchgrass

358 **Effects of increasing supplementation of rumen undegradable protein on plasma essential amino acid concentrations in beef cows consuming low-quality forage.** T. C. Geppert^{1,*}, A. M. Meyer², P. J. Gunn¹, ¹*Department of Animal Science, Iowa State University, Ames*, ²*Division of Animal Sciences, University of Missouri, Columbia*

The objective of this experiment was to determine the effects of increasing supplementation of MP from a moderately abundant RUP source (gluten meal; 62% RUP) on plasma AA concentrations in beef cows consuming low quality forage. We hypothesized increasing MP in the form of gluten meal would positively impact reproductive function around the time of ovulation, potentially through altered circulating AA. Nonpregnant, nonlactating mature beef cows (n = 24) were stratified by age, BCS, and BW and assigned to 1 of 3 isocaloric diets (1.06 Mcal/kg NE_m) consisting of ad libitum corn stover supplemented primarily with corn gluten meal to provide 100% MP requirements (CON), 125% MP requirements (MP125), or 150% MP requirements (MP150). Supplements were individually fed once daily, and coccygeal blood samples were taken prior to treatment initiation and on d 49 of the experimental period. Orthogonal contrasts were utilized to determine linear and quadratic treatment effects on plasma AA concentrations. At trial initiation, AA concentrations did not differ among treatments ($P > 0.10$). On d 49, total AA

Table 359. Simple effects of crude glycerin and soybean oil on intake and digestibility of Nellore bulls in feedlot

	Gly		No Gly		<i>P</i> -values		
	Oil	No Oil	Oil	No Oil	Gly	Oil	Gly × Oil
Intake, kg/d							
DM	8.45	9.72	8.87	10.30	0.04	<0.01	0.73
NDF	2.56	2.70	2.56	2.92	0.13	<0.01	0.13
Digestibility, g/kg							
DM	693.7 ^c	771.8 ^a	698.8 ^c	737.4 ^b	0.02	<0.01	<0.01
OM	700.5 ^c	777.9 ^a	706.4 ^c	743.5 ^b	0.04	<0.01	<0.01
NDF	429.5	563.6	403.9	517.9	<0.01	<0.01	0.37
EE	884.8 ^a	789.6 ^b	886.6 ^a	741.9 ^c	0.02	<0.01	0.01

and total essential AA concentrations were not affected ($P > 0.10$) by treatment; however, percent essential AA tended to increase linearly ($P = 0.06$) with increasing MP. Total concentrations of leucine, phenylalanine, citrulline, ketogenic AA, and branched-chain AA (BCAA) all increased linearly ($P < 0.04$), and total urea cycle AA tended to increase linearly ($P = 0.08$) relative to increased MP supplementation. Total lysine and tryptophan decreased linearly ($P < 0.04$) and total histidine tended to decrease linearly ($P = 0.09$) as MP supplementation increased. When expressed as a percent of total AA, ketogenic AA, BCAA, urea cycle AA, leucine, and phenylalanine increased linearly ($P < 0.01$), and arginine and essential proteogenic AA tended to increase linearly ($P < 0.09$) with increasing MP supplementation. As a percent of total AA, glycogenic AA, lysine, and tryptophan decreased linearly ($P < 0.04$) and threonine tended to decrease linearly ($P = 0.06$) as MP supplementation increased. In summary, supplementing excess MP using a protein source moderately abundant in RUP may shift plasma AA concentrations and profiles when fed to beef cows consuming low quality forage.

Key Words: branched-chain, ketogenic, urea cycle

different times for each period, for each animal, and averaged values were used for digestibility. To estimate the excretion of fecal matter, indigestible neutral detergent fiber was used. Data were analyzed using the MIXED procedure (SAS Inst. Inc., Cary, NC). There were no interactions between glycerin and soybean oil for DM and NDF intake ($P > 0.05$). Feeding oil or glycerin decreased DM intake ($P < 0.01$ and $P = 0.04$, respectively). Intake of NDF was not altered ($P = 0.13$) by inclusion of glycerin in the diets; however, inclusion of oil in the diet decreased NDF intake by 8.9%. For digestibility, there were interactions between the factors for DM, OM, and EE ($P < 0.05$). Digestibility of DM and OM was decreased by soybean oil and by a greater amount with glycerin included as well. Adding glycerin alone without oil increased DM and OM digestibility due to increased fiber digestibility. Adding oil in the diet increased EE digestibility. Thus, crude glycerin can be an alternative source of energy for Nellore bulls fed feedlot diets without depressing fiber digestibility.

Key Words: digestibility, glycerol, oil

359 Effect of crude glycerin and soybean oil on intake and digestibility of Nellore bulls. A. José Neto^{1,*},

E. Garbin Sgobi¹, G. Fiorentini¹, E. A. Oliveira¹, L. F. Prados², G. E. Erickson³, T. T. Berchielli¹,
¹São Paulo State University, Jaboticabal, Brazil,
²Universidade Federal de Viçosa, Viçosa, Brazil,
³University of Nebraska, Lincoln

Crude glycerin is a by-product in the production of biodiesel, and because of its availability and nutritional properties, it has become an attractive choice for use as a feed supplement for ruminant animals. The objective was to evaluate the DM and NDF intake and digestibility of Nellore bulls fed feedlot diets containing crude glycerin or soybean oil. We utilized 28 Nellore bulls (408 ± 28 kg and 18 ± 2 mo) in a completely randomized design with 4 treatments arranged as a 2×2 factorial with two levels of glycerin (0 or 10% on DMB) and two levels of soybean oil (0 or 6% on DMB). All treatments contained 60% corn silage and 40% concentrate. The experimental period was 105 d, with 21 d of adaptation and three periods of 28 d. Fecal samples were collected during three days, in 3

TEACHING

360 University of Nebraska–Lincoln feedyard management internship interest survey.

M. L. Bremer^{*}, R. A. Oglesbee, K. L. Gillespie, G. E. Erickson, J. C. MacDonald, T. J. Klopfenstein, University of Nebraska, Lincoln

Surveys have been administered each fall semester for the past four years (2011–2014) to undergraduate students enrolled in the Feedyard Management class at the University of Nebraska–Lincoln. Survey participation is voluntary as well as anonymous. The number of survey participants has varied across years and was 22 in 2011, 17 in 2012, 22 in 2013, and 43 in 2014. The survey consists of 25 multiple choice and short answer questions with the purpose of determining student perception of a career in the field of feedyard management and to gauge the success of recruitment efforts on participation in the feedyard management internship. The internship is a 6 month program where participants spend 6 weeks in the classroom and then 4½ months in a Nebraska feedyard following their undergraduate degree. Survey participants make

postgraduation plans at various times in their undergraduate career. Twenty-seven percent of participants made plans prior to entering college, 28% as freshmen or sophomores, 25% as juniors, and 20% as senior ($P = 0.99$) despite enrollment in the feedyard management class. It was observed that 42% of participants consider a career in feedyard management, whereas 25% have no desire, and 32% are undecided ($P = 0.98$). Interestingly, participants underestimate the salary of Nebraska feedyard managers. Across years, 44% ($P = 0.97$) perceived that feedyard managers were making \$40–50,000/year, whereas the actual average compensation for feedyard managers is closer to \$70,000/year. Internship interest as a result of recruitment efforts resulted in a numerical increase in desired participation from 10% to 26% though this difference was not statistically significant ($P = 0.85$) across years. Those who planned on participating in the internship perceived that that the internship would benefit them in various ways: gaining feedyard industry experience (41%), providing a segue to a career in feedyard management (18%), and providing experience needed to work in an allied industry (35%), and 6% stated that the internship would prepare them for graduate school ($P = 0.96$). All results were analyzed across years using the chi square t-test function of Microsoft Excel. Using the compilation of survey data, recruiting efforts are being targeted at reaching undergraduates early in their collegiate career to allow adequate planning for participation upon graduation. Information provided to students will accurately depict the current field of feedyard management as a career as the need for feedyard managers is prevalent in Nebraska.

Key Words: feedyard management, survey, undergraduate students

361 **An assessment of the reproductive physiology course at North Dakota State University reveals students are aware of the practical applications of hormones despite hormones being an unpopular topic in the classroom.** L. A. Lekatz^{1,*},

K. A. Vonnahme², ¹*Illinois State University, Normal*, ²*North Dakota State University, Fargo*

Student interest in a topic has been identified as an important indicator of motivation that influences student engagement and achievement in learning. Further, applications of classroom material to real-life situations make content more relevant to students which is also a major motivator for learning. Students enrolled in ANSC (Animal Science) 483 Reproductive Physiology at North Dakota State University in 2007 and 2008 were asked at the end of the semester to list their favorite topic and their least favorite topic covered during the semester. Students were also asked to “Give an example of what you learned in lecture that can be applied to livestock producer’s needs,” which will be referred to as the applied knowledge example. Student enrollment was 48 in 2007 and 47 in 2008. The favorite topic for both years was the parturition process (19.0% of

responses in 2007 and 11.5% of responses in 2008). The least favorite topic for both years was hormones (30.6% of responses in 2007 and 31.7% of responses in 2008). When analyzing the applied knowledge example for 2007, student responses discussed one of the following: 1) hormones and synchronization protocols and products (82.4% of responses), 2) detection of estrus (8.8% of responses), or 3) another topic (8.8% of responses). For 2008, student responses discussed one of the following: 1) hormones and synchronization protocols and products (72.1% of responses), 2) semen collection and extension (7.0% of responses), 3) parturition process (7.0% of responses), or 4) another topic (13.9% of responses). Interestingly, despite the parturition process being the favorite topic covered, no students provided a real-life application for parturition in 2007 and only 7.0% did so in 2008. Moreover, students in both years of assessment selected hormones as the least favorite topic; however, the majority of students demonstrated the use of hormones in an applied knowledge example. It appears that students understand the practical applications of hormones but do not enjoy learning about them. Because hormones are the driving force behind reproduction, perhaps including more real-life applications involving hormones in all aspects of reproductive physiology would provide the relevance necessary to engage student motivation for appreciation of hormones in reproduction.

Key Words: hormones, reproductive physiology, teaching

362 **Conservation of livestock biodiversity: Improving awareness of the contribution of local breeds to food security and local economies.** M. Smith¹, J. R. Levey¹, N. Jackosky¹, B. Tenold¹, S. Taylor¹, J. Colletti¹, S. M. Lonergan^{1,*}, P. Boettcher², ¹*Iowa State University, Ames*, ²*Food and Agriculture Organization of the United Nations, Rome, Italy*

The overall goal of this undergraduate student project was to raise awareness of the importance of conservation of livestock biodiversity in the developed and developing world. To achieve this goal, students worked with mentors at Iowa State University and the Food and Agriculture Organization of the United Nations (FAO) to compile 30 success stories about the importance of conservation of livestock biodiversity with a particular focus on local breeds. Globally, there are diminishing numbers of local livestock breeds due to an influx of improved breeds and lines of livestock. Commercialized breeds generally perform better in modern production systems. However, they are not always adapted to adverse environmental conditions. Scientists realize that there is a need to conserve the genetic resources to utilize the benefits of the local breeds. The specific aim of this project was to highlight successful conservation efforts to use as stories to increase awareness of the roles of local breeds in local economies. To compile the stories, the literature search included utilizing scientists studying the specific livestock, the Domestic Animal Diver-

sity Information System of the FAO, and Web of Science. The current library is host to nine stories from Asia, twelve from Europe, three from North America, four from South America, and three from Africa. The collection also spans species from eleven cattle breeds, one water buffalo breed, six goat breeds, three swine breeds, one camel breed, two sheep breeds, four poultry breeds, and four different stories on Germplasm Banks. Out of the 31 stories, government action was the main driver in 21 conservation efforts. However, collaborations with nongovernment organizations, local communities, and the private sector played roles as well. These stories document the contributions of local breeds to communities. These benefits occur due to adaptations such as lower feed intake, improved capacity to tolerate heat, increased disease resistance, and low input costs when compared to the exotic breeds. Such benefits help increase food security by improving livelihood, production of textile goods, and food production. It is recommended that the library of stories be shared with the public through traditional methods and social media. The more the public understands about livestock conservation, the more research will be conducted about the breeds. The benefits of these breeds' and their products help increase food security and stimulate local economies throughout the world.

Key Words: animal genetic resources, conservation, livestock biodiversity

GRADUATE STUDENT COMPETITION—
MS ORAL I

- 363 **Influence of dietary fat source and feeding duration on pig growth performance, carcass composition, and fat quality.** E. W. Stephenson*, M. A. Vaughn, D. D. Burnett, C. B. Paulk, M. D. Tokach, S. S. Dritz, J. M. DeRouche, R. D. Goodband, J. M. Gonzalez, J. C. Woodworth, *Kansas State University, Manhattan.*

A total of 160 finishing pigs (PIC 327 × 1050; initially 45.6 kg) were used in an 84-d experiment to evaluate the effects of dietary fat source and feeding duration on growth performance, carcass characteristics, and fat quality. Pigs were blocked by sex and BW with 2 pigs per pen and 8 pens per treatment. Dietary treatments included a corn-soybean meal control diet with no added fat or a 3 × 3 factorial with main effects of fat source (4% tallow, 4% soybean oil, or a blend of 2% tallow and 2% soybean oil) and feeding duration (d 0 to 42, 42 to 84, or 0 to 84). One pig was identified in each pen on d 0, and biopsy samples of the back, belly, and jowl fat were collected on d 0, 41, and 81. On d 84, all pigs were harvested with carcass characteristics measured, and back, belly, and jowl fat samples collected. Overall, there were no differences between fat sources for growth and carcass measurements; however, pigs fed added fat diets from d 0 to 84 had improved ($P < 0.04$) G:F compared with pigs fed the control. Pigs fed added fat throughout the entire study also had improved ($P < 0.04$) ADG and G:F and heavier d-84 BW ($P < 0.01$) compared with pigs fed added fat for only period 1 or 2. Adding fat for the entire study increased ($P < 0.03$) backfat and tended to reduce ($P < 0.08$) fat-free lean index compared with pigs fed the control. Added fat also increased ($P < 0.05$) iodine value (IV) compared with pigs fed the control. Jowl fat, unlike the other two fat depots, did not show a period effect of IV when adding dietary fat. Increasing the feeding duration of soybean oil or a blend of soybean oil and tallow decreased monounsaturated and increased polyunsaturated fatty acids relative to feeding tallow (duration × fat source interaction, $P < 0.05$), with the greatest changes in C18:1 and C18:2. In conclusion, feeding added fat improved ADG and G:F; however, feeding soybean oil for an increasing duration, either alone or in a blend with tallow, negatively affected the fatty acid composition and IV of finishing pigs.

Key Words: fat source, finishing pig, iodine value

- 364 **Effects of lysine intake and divergent selection for residual feed intake on nitrogen metabolism and lysine utilization in growing pigs.** D. J. Hewitt*, C. F. de Lange², A. Gheisari¹, J. C. M. Dekkers³, A. Rakhshandeh¹, ¹*Texas Tech University, Lubbock,* ²*Department of Animal and Poultry Science, University of Guelph, Guelph, ON, Canada,* ³*Iowa State University, Ames.*

Residual feed intake (RFI) is defined as the difference between actual feed intake and that predicted on the basis of energy requirements for growth and maintenance. Little is known about the effect of divergent selection for RFI on efficiency of amino acid utilization in growing pigs. Our objective was to evaluate the effects of divergent selection for RFI and lysine (Lys) intake on nitrogen (N) metabolism and Lys utilization in growing pigs. Twenty four gilts (BW 66 ± 5 kg) were selected from generation 9 of the low RFI (LRFI; $N = 12$) and high RFI (HRFI; $N = 12$) Iowa State University Yorkshire RFI selection lines. Six pigs from each genetic line were assigned to each of two levels of Lys intake (70 and 100% of estimated requirements; NRC, 2012) from diets in which Lys was first limiting among AA. Following 5 d of adaptation, whole body N-balance and apparent fecal nutrient digestibility (AFD) was determined during a 3 d period, after which pigs were anesthetized for determining body composition using Dual-energy X-ray absorptiometry (iDXA). Pigs were then euthanized and ileal digesta was collected for measuring apparent ileal nutrient digestibility (AID). No interaction effects of line and Lys intake on N retention, AID and AFD of N, body lean and fat contents, and efficiency of Lys utilization for N retention were observed ($P > 0.05$). Line had no effect on retention, AID and AFD of N ($P > 0.05$). An increase in Lys intake improved N retention in both lines (from 15.0 to 19.6 g/d, SE 1.44, in LRFI; and from 16.9 to 19.8 g/d, SE 1.67 in HRFI pigs; $P < 0.01$). Lysine intake had no effect on AID and AFD of N ($P > 0.05$). At the low Lys intakes and when Lys clearly limited N retention the efficiency of using Lys intake (above maintenance requirements) for Lys in retained N was 77 and 86%, SE 3.1, for the LRFI and HRFI pigs, respectively ($P < 0.05$). Body lean tissue content tended to be higher in LRFI than HRFI pigs (82 vs. 76%, SE 2.7; $P < 0.09$). Collectively, these results suggest that genetic selection for low RFI is not associated with improvements in Lys utilization efficiency in growing pigs. USDA-NIFA grant number 2011-68004-30336.

Key Words: residual feed intake, lysine, pig

365 Effect of substitution of wheat for corn on growth performance and digestibility in nursing pigs. D. J. Bloxham*, C. R. Dove, M. J. Azain, *University of Georgia, Athens.*

The objective of this study was determine if wheat could substitute for corn, and if there was an optimal inclusion rate for wheat in nursery diets. A total of 144 pigs (48 pens, 3 pigs/pen) were blocked by weight and randomly assigned treatments within block. Following weaning (20 ± 3 d), pigs were fed a common phase 1 diet days 0 to 7 of the 35-d study. Phase 2 diets were fed from day 7-21d and phase 3 diets were fed from days 21 to 35. Phase 2 diets were formulated with either corn (52.9% of diet) or wheat (53.5% of diet) as the grain source. Both diets had 10% whey, 2.5% fishmeal, and 2.5% blood cells. Phase 3 diets were formulated with corn (64.3% of the diet) or wheat (65.3% of the diet) as the grain source. Diets in phases 2 and 3 were formulated to be isocaloric and isolsogenic (SID 1.35% in phase 2 and 1.23% in phase 3). All diets were formulated to meet or exceed the 2012 Swine NRC. Titanium dioxide was added as an inert marker in the diet of 0.3% to determine apparent digestibility of nitrogen, fat, and phosphorus. Within each phase the two diets were then blended in a ratio of 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100% of the corn and wheat diets respectively. Pigs were weighed and feed disappearance was determined weekly. Fecal samples were collected from 17 to 21 d and 31 to 35 d for apparent digestibility determinations. Over the 35-d study there was a quadratic effect of diet on BW (20.9, 21.3, 22.2, 21.7, 21.1, 21.2 kg, $P < 0.05$, SEM 0.39). 7-35 d there was a quadratic effect for ADG (485, 499, 532, 514, 491, 493 g/d, $P < 0.05$, SEM 14). There was no difference in ADFI among treatments. There was linear effect of diet on G:F (0.68, 0.68, 0.71, 0.71, 0.70, 0.70, $P < 0.05$, SEM 0.008) from day 7 to 35 with increasing wheat in the diet. Nitrogen and fat digestibility increased linearly from 72.5 to 83.9% for nitrogen ($P < 0.001$, SEM 0.73) and 44.9 to 63.1% for fat ($P < 0.001$, SEM 1.69) as the percent wheat increased in the diet in phase 3. There was a quadratic effect of diet on phosphorus digestibility (55.1, 56.5, 53.8, 54.6, 66.7 65.5%, SEM 1.18, $P < 0.0002$). Wheat can be fully substituted for corn, without effecting growth performance of nursery pigs. Nitrogen, fat and phosphorus digestibility increases as the amount of wheat in the diet increases.

Key Words: digestibility, growth performance, wheat

366 Evaluation of NE prediction equations for corn distillers dried grains with solubles (DDGS) for growing-finishing pigs. F. Wu*, L. J. Johnston², P. E. Urriola¹, G. C. Shurson¹, ¹Department of Animal Science, University of Minnesota, St Paul, ²West Central Research and Outreach Center, University of Minnesota, Morris.

Table 366.

Item	DDGS				Error	Bias
	A	B	C	D		
Overall G:F	0.362	0.353	0.385	0.385		
NE, kcal/kg (as-fed)						
NRC (2012) model estimates	2,377	1,924	2,612	2,513		
Illuminate estimates	2,083	2,255	2,469	2,743	259	31
EvaPig ¹						
Equation 1	2,248	2,195	2,337	2,368	216	-69
Equation 2	2,747	2,756	2,853	2,912	511	460
Equation 3	2,193	2,203	2,309	2,365	238	-89
NRC (2012)						
Equation 1-7	2,149	2,177	2,242	2,281	277	-144
Equation 1-8	2,194	2,204	2,309	2,366	237	-88

¹Crude fiber, NDF, and ADF are factors for equations 1 to 3, respectively.

Empirical equations based on analyzed chemical composition have been developed to estimate NE content of complete diets and feed ingredients, but have not been validated for use in DDGS. The objective of this study was to determine the NE content of 4 DDGS sources fed to growing-finishing pigs, and to evaluate the precision and accuracy of 5 published NE equations and NE estimates from Illuminate. A total of 432 pigs (9 pigs/pen; 12 replications/diet) were fed 4 corn-soybean meal diets containing 40% DDGS from 4 different sources. Pig growth responses were determined every 2 wk, and least square means of BW and G:F were used as factors to determine diet NE using the NRC (2012) model. Pig growth potential was defined by BW, ADFI, and protein deposition rate of 12 pens of pigs ($n = 108$) fed corn-soybean meal diets (diet NE was calculated using NRC recommended values). For each time period, diet NE was estimated by adjusting diet NE inputs until the model-predicted G:F matched the observed G:F. Next, NE of DDGS was calculated by subtracting NE content (NRC, 2012) of corn and soybean meal from diet NE, and adjusting for the percentage of DDGS in the diet. The mean NE value for each DDGS source was defined as the average among 6 periods, weighted for feed disappearance in each period. Error and bias of predicting NE compared with model estimates for the 4 DDGS were calculated for each equation. Illuminate estimates provided the least bias and moderate error, while estimated NE from EvaPig using equation 1 had the least error and moderate bias. In conclusion, these data suggest that current NE prediction equations need to be revised for better NE prediction among sources of DDGS.

Key Words: DDGS, growing-finishing pigs, NE, prediction equations

367 **Models of immune system stimulation in growing pigs: porcine reproductive and respiratory syndrome (PRRS) versus *E.coli* lipopolysaccharide (LPS).**

W. D. Stuart¹, T. E. Burkey², N. K. Gabler³, K. Schwartz³, C. F. de Lange⁴, A. Rakhshandeh¹,
¹Texas Tech University, Lubbock, ²University of Nebraska, Lincoln, ³Iowa State University, Ames, ⁴Department of Animal and Poultry Science, University of Guelph, Guelph, ON, Canada.

In recent years, there has been debate on developing a practical model of disease for studying nutrient needs of pigs during immune system stimulation (ISS). A study was conducted to compare a non-pathogenic model of ISS with the PRRSv model. Forty PRRSv-negative gilts (BW 9.4 ± 0.9 kg) were blocked by time, housed in metabolism crates, and fed-restricted (550 g/d) a corn and SBM based diet (ME 14 MJ/kg, SID Lysine 11.5 g/kg). Repeated i.m. injection of increasing amounts of LPS (initial dose of 30 µg/kg; *N* = 10), or i.m. injection of live field PRRSv (*n* = 20) were used to induce ISS. Control pigs (CON; *N* = 10) received saline injections. Blood was collected via the jugular vein at time 0 and then every 48 h after start of ISS, and assayed for hematology, metabolites, and acid-base balance. Body temperature (BT) was monitored on a daily basis. N-balances were determined during a 3 d pre-ISS period and a 3 d ISS period. Apparent ileal digestibility of dietary N was determined using the slaughter technique. No differences were observed in BT, blood parameters, N-balance, and feed intake (FI) between CON and pre-ISS period of LPS and PRRSv-treated pigs (*P* > 0.05). BT was elevated in pigs on LPS and PRRSv, by 0.7 and 0.9 °C, respectively, relative to CON (37.5°C; *P* < 0.01). Relative to CON, LPS did not reduce daily FI (*P* > 0.05). However, PRRSv-challenged pigs consumed only 55% of their daily feed allowance (*P* < 0.05). Blood glucose concentration was lower in LPS and PRRSv-treated pigs (34 and 8%, respectively, relative to 92.5 g/dl for CON; *P* < 0.05). Higher blood anion-gap (CON vs. PRRSv; 13 vs. 17 mEq/L) and lower hemoglobin (12 vs. 8 g/dl) were only observed in PRRSv-treated pigs (*P* < 0.01). Blood urea nitrogen levels and hematocrit were not affected by the treatments (*P* > 0.05). N retention was decreased in LPS and PRRSv-treated pigs (20 and 64%, respectively, relative to 11 g/d for CON; *P* < 0.03). Ileal digestibility of protein was decreased by LPS and PRRSv (16 and 26%, respectively, relative to 0.76 for CON; *P* < 0.01). These results suggest that LPS and PRRSv both reduce performance and alter metabolism of pigs. However, compared to LPS, PRRSv model elicits a more severe response with a more negative impact on performance of pigs. NPB number 13-082

Key Words: LPS, pig, PRRS

368 **Effect of diet composition and particle size on nutrient excretion of finishing pigs and the propensity to cause manure pit foaming.**

Z. Luo^{*1}, P. E. Urriola¹, B. J. Kerr², B. Hu³, G. C. Shurson¹, ¹Department of Animal Science, University of Minnesota, St. Paul, ²USDA - ARS, Ames, IA, ³Department of Bioproducts and Biosystems Engineering, University of Minnesota, St. Paul.

Manure pit foaming on commercial swine farms has been a significant problem in recent years. Changes in dietary fiber fermentability and lipid composition may alter manure composition resulting in increased manure foaming and methane production in anaerobic pits. The objective of this experiment was to measure nutrient excretion and manure foaming capability (MFC) of pigs fed 3 diets differing in the source and amount of NDF (% DM) and ether extract (EE; % DM) when ground to 2 particle sizes. Two groups of 24 growing gilts (initial BW = 119.5 ± 8.9 kg) were placed into metabolism crates and randomly allotted to 1 of 6 diets (4 replicates/treatment/group). Dietary treatments consisted of 1) corn-soybean meal (7.2% NDF, 4.6% EE; CSB), 2) CSB + 35% DDGS (13.7% NDF, 6.2% EE; DDGS), and 3) CSB + 21% soybean hulls (20.0% NDF, 6.8% EE; SBH). Diets were ground to a mean particle size of 374 ± 29 µm (Fine) or 631 ± 35 µm (Coarse) and fed for 7 wk. Excretion of DM, NDF, and EE were measured after total feces and urine collection on d 21 to d 24. Feces and urine were mixed daily and stored in simulated deep pit storage tanks. The MFC of each sample was measured in the laboratory using a column and N bubbling. Data were analyzed using the MIXED procedure of SAS, with individual pig as a random effect and diet composition, particle size, and their interaction as fixed effects. There was a diet composition × particle size interaction for MFC (*P* < 0.05). Greater (*P* < 0.05) MFC was observed for pigs fed coarse SBH compared with fine CSB and SBH, but not for fine or coarse DDGS. There was no diet composition × particle size interaction for excretion of DM, NDF, or EE. Excretion of DM and NDF were greater (*P* < 0.05) in pigs fed DDGS and SBH than in pigs fed CSB. Excretion of EE was greater (*P* < 0.01) for pigs fed DDGS than CSB or SBH. Excretion of DM, NDF, and EE was greater (*P* < 0.05) for coarse compared to fine diets. These results indicate that fiber composition in soybean hulls has a greater impact on MFC than the fiber composition in DDGS, and larger diet particle size reduces DM, NDF, and EE digestibility causing increased content in manure and MFC.

Key Words: diet particle size, fiber, finishing pigs, lipid, manure foaming, nutrient excretion

369 **Enzyme supplementation to increase value of soyhulls fed to finishing pigs.**

L. J. Schertz^{*}, P. J. Lammers, Illinois State University, Normal.

Soybean hulls are a byproduct of soybean processing, and

Table 369. Summary of finishing pig performance by dietary treatment

Soy hull, g/kg	Dietary treatment				SEM	P-value
	200	200	0	0		
Enzyme, ppm	0	1000	0	1000		
ADG kg/d	0.72	0.78	0.79	0.85	0.13	0.97
ADFI kg/d	2.04	2.05	1.94	1.99	0.52	0.97
G:F g:g	0.36	0.38	0.41	0.43	0.03	0.98

are widely available throughout the U.S. However, the high concentration of nonstarch polysaccharides in soyhulls limit a pig's ability to digest this feedstuff and thus decreases their value to pork producers. Current feeding recommendations for finishing pigs suggest limiting inclusion of soyhulls in late finishing pig diets to 10%. Exogenous enzymes with protease and carbohydrase activity are commercially available for use in pig production and the addition of these enzymes to diets containing soyhulls may enhance the utilization of otherwise wasted nutrient components. The purpose of this preliminary trial was to evaluate the individual and combined effects of feeding soyhulls and exogenous enzymes to finishing pigs. Ninety-six pigs (61.2 ± 1.4 kg) were blocked by gender (48 barrows and 48 gilts) and allotted to 8 pens (4.2 × 2.8 m) such that initial pen weight was similar. Within gender block, pens were randomly assigned to 1 of 4 dietary treatments. Experimental design was a 2 × 2 factorial with two levels of soyhull (0 or 20%) combined with two levels of exogenous carbohydrase and protease enzyme supplementation (0 or 1,000 ppm). Every 14 d, pigs, feed, and feeders were weighed to determine ADG, ADFI, and G:F. Pigs were marketed after 49 days of feeding. Treatments were arranged as a 2 × 2 factorial and data were subjected to ANOVA using JMP 11.0 (SAS Inst. Inc. Cary, NC). For all parameters a pen of 12 pigs was considered the experimental unit. Results were considered significant at $P \leq 0.05$. In this preliminary experiment, ADG, ADFI, and G:F were not impacted by dietary treatment ($P \geq 0.05$). This pre-trial was limited to a small sample size, but numeric differences between dietary treatments suggest further examination is warranted (Table 369). Increasing the nutrient utilization of soyhull inclusive diets will decrease the amount of nutrients lost to the environment while supporting growth.

Key Words: exogenous carbohydrases, nonstarch polysaccharides, protease enzymes, soyhulls

370 Effects of amino acid supplementation of reduced crude protein (RCP) diets formulated on a NE basis on belly fatty acid deposition in swine. D. G. Cook*, J. K. Apple, C. V. Maxwell, A. N. Young, D. L. Galloway, H. J. Kim, T. C. Tsai, *Department of Animal Science, University of Arkansas Division of Agriculture, Fayetteville.*

Belly fat samples ($N = 108$) from barrows and gilts were used to test the effects of crystalline AA supplementation of reduced CP diets formulated on a NE basis on fatty acid deposition of

Table 370. CP (added L-Lysine-HCL) of experimental diets for each feeding phase (% as fed)

Phase	C	RCP1	RCP2	RCP3
1	20.640 (0.350)	18.825 (0.512)	18.433 (0.549)	16.678 (0.716)
2	19.382 (0.334)	16.852 (0.558)	16.498 (0.590)	14.697 (0.763)
3	16.755 (0.285)	14.683 (0.468)	14.079 (0.523)	12.482 (0.675)
4	14.994 (0.253)	13.051 (0.424)	12.611 (0.464)	11.109 (0.607)
5	17.981 (0.300)	16.596 (0.424)	16.198 (0.462)	14.599 (0.614)

swine. Pigs were blocked by weight, and pens within each block were assigned randomly to either corn-soybean meal diets (C) or 1 of 3 RCP diets formulated with crystalline AA during each feeding phase (refer to accompanying Table 370). Paylean (10 mg/kg) was included in all diets during the last 3-wk feeding phase. After slaughter and a 24-h rapid chilling period, a 2.5-cm-thick slice was removed from the anterior end of randomly selected fresh pork bellies (3 bellies/pen). Belly slices were further dissected into the outer s.c. fat layer (OSC), middle s.c. fat layer (MSC), and all intermuscular fat (INT) for fatty acid (FA) analysis. There were no ($P \geq 0.132$) dietary treatment × fat layer interactions; however, proportions of all SFA and all MUFA increased (linear, $P \leq 0.006$), and proportions of all PUFA decreased (linear, $P = 0.010$), as CP was reduced in the diet. Also, belly fat IV decreased linearly ($P < 0.001$) with decreasing dietary CP. Total SFA were greatest (37.6%; $P < 0.05$) in the INT, and SFA percentage was greater ($P < 0.05$) in the MSC than OSC (34.8 vs. 31.9%). The OSC (45.3%) and MSC (44.8%) had greater ($P < 0.05$) proportions of all MUFA than INT (41.5%), whereas OSC (21.5%) had greater ($P < 0.05$) proportions of PUFA than MSC (19.2%) and INT (19.7%). Finally, the OSC had the greatest ($P < 0.05$) IV (74.0), and IV of the MSC was greater ($P < 0.05$) than that of the INT (70.0 vs. 68.1). Results indicate that FA composition differs greatly among the fat layers of fresh pork bellies, and SFA and MUFA composition of pork belly fat was increased by reducing dietary CP, suggesting enhanced de novo synthesis in pigs fed RCP diets supplemented with crystalline AA.

Key Words: fatty acids, net energy, reduced crude protein

371 Effects of in utero heat stress on subsequent lactational performance of gilts and transgenerational effects on offspring. J. G. Wiegert¹, R. H. Preisser¹, M. C. Lucy², T. J. Safranski², R. P. Rhoads¹, J. W. Ross³, L. H. Baumgard³, M. J. Estienne⁴, M. L. Rhoads¹, ¹Virginia Tech, Blacksburg, ²University of Missouri, Columbia, ³Iowa State University, Ames, ⁴Virginia Tech, Suffolk.

The objective of this experiment was to determine whether in utero (IU) heat stress has long-lasting and/or transgenerational effects on swine productivity. Pregnant females (F0) were housed in either thermoneutral (TN) or heat stress (HS)

Table 372.

Item	Thermoneutral		Heat Stress		SEM	Diet	Environment
	Control	Low	Control	Low		<i>P</i> -value	<i>P</i> -value
Sow FI, kg/d	5.20	5.56	4.28	4.28	0.26	0.299	0.011
Sow DBW, kg/d	-0.30	-0.63	-0.84	-0.84	0.19	0.368	0.044
Piglet ADG, g/d	263.3	279.2	236.7	235.2	9.70	0.426	0.001
Sow DBF, mm	-1.46	-2.74	-3.22	-2.17	1.01	0.680	0.445
WtE, d	7.68	7.22	7.00	5.67	1.13	0.777	0.971
HR, beats/min	69.38	69.87	89.98	91.00	7.23	0.960	0.042
RR, breaths/min	71.74	69.37	93.81	93.27	6.37	0.951	0.014
BT, °C	36.83	37.66	37.77	38.02	0.86	0.830	0.420
MUN, mg/dL	9.46	2.35	9.83	1.92	0.72	<.0001	0.979
TMP, %	4.47	4.29	4.64	4.55	4.30	0.184	0.028
Ammonia, g/d	34.2	11.2	26.8	12.9	2.9	<.0001	0.351

conditions for the duration of gestation. The female piglets from those pregnancies (F1) were therefore exposed to the effects of different environmental conditions while in utero (IUTN or IUHS). Those F1 females were retained and grown to maturity using standard management practices. Following puberty, gilts ($N = 34$ from IUTN; $N = 34$ from IUHS) were inseminated and allowed to farrow. Milk samples were collected from F1 females on lactation d 0, 7, 14 and 21 for analyses of fat, protein, lactose and solids nonfat content. Milk production was measured via weigh-suckle-weigh in a subset of gilts ($N = 15$ from IUTN; $N = 14$ from IUHS). Despite finding no difference in milk production, milk composition of IUTN and IUHS females differed. The milk from IUTN females contained more lactose (5.21 ± 0.04 vs $5.09 \pm 0.04\%$, respectively; $P < 0.05$) but tended to contain less protein (5.26 ± 0.14 vs $5.59 \pm 0.13\%$, respectively; $P < 0.15$) and solids nonfat (11.30 ± 0.11 vs $11.53 \pm 0.11\%$, respectively; $P < 0.15$) than milk from IUHS females. A portion of the offspring (F2) from the F1 IUTN and IUHS females were grown to market weight ($N = 60$) and at harvest, standard carcass measurements were collected. Live weight at slaughter of the F2 individuals tended to be greater in the offspring from IUTN females compared to offspring from IUHS females (125.8 ± 1.4 vs 122.7 ± 1.5 kg, respectively; $P < 0.15$). Carcass measurements of back fat tended to be lower (1.72 ± 0.09 vs 1.96 ± 0.10 cm, respectively; $P < 0.15$) in the offspring of IUTN females and the carcasses of the IUTN offspring were longer than those of the IUHS offspring (84.79 ± 0.43 vs 83.04 ± 0.44 cm, respectively; $P < 0.01$). There were no differences in loin eye area, meat color, firmness or marbling. The results of this experiment indicate that IUHS has both long-lasting and transgenerational effects on measurements of swine productivity. The observed effects on milk composition from the F1 females indicate that IUHS alters their physiology in a manner that persists into adulthood. The subsequent differences in offspring (F2) growth and carcass characteristics demonstrate that IUHS is capable of affecting productivity across generations, although the mechanisms are not yet understood.

Key Words: carcass, heat stress, lactation

372 Impact of reduced dietary crude protein concentration with crystalline amino acid supplementation on lactation performance and ammonia emission of sows housed under thermo neutral and thermal heat stress environments.

D. Chamberlin¹, W. J. Powers¹, D. W. Rozeboom¹, T. M. Brown-Brandl², S. Erwin¹, C. Walker¹, N. L. Trottier¹, ¹Michigan State University, East Lansing, ²USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE.

The objective of this study was to test the hypothesis that feeding a diet containing lower dietary CP and supplemental crystalline AA compared to a diet meeting Lys requirement without supplemental AA, reduces ammonia emission, and maintains lactation performance in sows housed under thermo-neutral and thermal heat stress environments. Thirty-six, multiparous, sows were allocated to a 2×2 factorial arrangement of 2 temperatures, thermo-neutral (21°C; TN) and heat stress (31.5°C; HS), and 2 diets, 17.16 (Control) and 11.82% CP (Low), in a randomized complete block design. The HS sows were acclimated during late gestation to increasing temperature from 21 to 31.5 °C. During lactation, temperature for HS sows were incrementally changed (24 to 31.5°C and 31.5 to 24°C) from 0500 to 1500 and 1800 to 0500, respectively. Control diet met SID Lys requirement with no added CAA and Low diet contained added crystalline Lys, Thr, Trp, Val and Phe. Compared to Control, piglet ADG, sow feed intake (FI), true milk protein (TMP), weight loss (DBW), heart rate (HR), and respiration rate (RR) of Low sows did not differ. Compared to Control, MUN and ammonia emissions decreased for sows fed Low ($P < 0.0001$). Change in back fat (DBF), body temp (BT), and days post weaning to estrus (WtE) did not differ between diets. Compared to TN, DBW, HR and RR of HS sows were greater ($P < 0.05$). Compared to TN, piglet ADG of HS sows were less ($P < 0.05$). In conclusion, feeding reduced CP diet to lactating sows improved N utilization and did not impact lactation performance of sows under either thermo-neutral or thermal heat stress environments. These results indicate that reduction of dietary CP in conjunction with aggressive CAA supplementation may be implemented for lactating sows to mitigate ammonia

emissions while maintaining lactation performance.

Key Words: amino acid, ammonia emission, sow

GRADUATE STUDENT COMPETITION—MS ORAL II

- 373 **Influence of wet distillers grains produced from a novel cellulosic ethanol process utilizing corn kernel fiber on feedlot growth and carcass characteristics of steers.** E. L. Lundy*, D. D. Loy, S. L. Hansen, *Iowa State University, Ames.*

Changes in ethanol production influence the nutrient profile of distillers grains (DG) produced. One recent example of this is a secondary fermentation process involving cellulosic enzymes, yeast, and heat which partially converts corn kernel fiber into cellulosic ethanol, resulting in a novel wet DG product (C-WDG). The objective of this study was to evaluate the impact of feeding C-WDG or traditional WDG (T-WDG) on finishing cattle growth and carcass characteristics. One hundred sixty-eight crossbred steers (421 ± 23.9 kg) were stratified by source, blocked by weight to pens of 6 steers, and assigned to 1 of 4 dietary treatments fed for 94 d. Diets included a corn-based control with 13% T-WDG (CON), 30% T-WDG (TRAD), 30% C-WDG (CEL), or 18% C-WDG plus 12% condensed corn distillers solubles (CEL+CCDS). Co-products replaced corn on a DM basis. Data were analyzed as a randomized complete block design with pen as the experimental unit ($n = 7$ /treatment). Three comparisons were made: 1) CON vs. TRAD, 2) TRAD vs. CEL, and 3) CEL vs. CEL+CCDS. Data presented are LSMEANS \pm pooled SEM. Steers fed TRAD had greater ($P \leq 0.01$) ADG (1.75 ± 0.03 kg), G:F (0.166 ± 0.003), and HCW (372 ± 2.1 kg), and tended ($P = 0.07$) to have larger rib-eye areas (REA) compared to steers fed CON (ADG 1.59 kg; G:F 0.149; and HCW 364 kg). Although steers fed CEL had decreased G:F ($P = 0.02$; 0.154) due to increased DMI ($P = 0.01$; 10.9 ± 0.11 kg) compared to TRAD-fed steers (10.5 kg), no differences ($P \geq 0.16$) in ADG, HCW, or REA were observed among steers fed CEL or TRAD. Steers fed CEL had leaner carcasses ($P \leq 0.03$; YG of 2.8 ± 0.07) compared to TRAD-fed steers (YG 3.1). Steers fed CEL+CCDS had lesser ($P \leq 0.04$) DMI (10.0 kg) and ADG (1.58 kg) than CEL-fed steers (ADG 1.68), while G:F did not differ ($P = 0.50$). Subsequently, steers fed CEL+CCDS tended ($P = 0.07$) to have lesser HCW (362 kg) compared to CEL-fed steers (368 kg), likely because of the greater S contributed by the CCDS. Results from this study reiterate that T-WDG are superior to corn in energy content and establish that C-WDG produced from conversion of corn kernel fiber into cellulosic ethanol maintains significant advantage in cattle performance as a replacement for corn in feedlot diets.

Key Words: cellulosic ethanol, corn fiber, distillers grains

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- 374 **Effect of inorganic or organic selenium supplementation during gestation and lactation on feedlot performance of steer progeny.**

C. R. Muegge^{*1}, K. M. Brennan², R. P. Lemenager¹, J. P. Schoonmaker¹, ¹*Purdue University, West Lafayette,* ²*Alltech, Nicholasville, KY.*

Angus \times Simmental cows ($n = 48$, BW = 594 kg, BCS = 5.26, Age = 2.7), pregnant with male fetuses, were used to determine the effect selenium (Se) source during the last 80 d of gestation and first 105 d of lactation on progeny feedlot performance. At 203 d in gestation, cows were allotted to 1 of 3 treatments based on body weight, breed composition, and calf sire: no Se, inorganic Se, or organic Se. Diets were formulated to contain 10.4% CP and 0.90 Mcal/kg NEg during gestation and 12.1% CP and 1.01 Mcal/kg NEg during lactation. Basal diets contained 0.07 and 0.11 mg/kg Se for gestation and lactation diets; respectively. Diets were fed daily as a total mixed ration and Se was provided in a top-dress containing 0, 0.30 mg/kg Se as sodium selenite, or 0.30 mg/kg Se as Sel-Plex. Treatment diets were fed through 105 d post-partum (DPP). At 105 DPP cow-calf pairs were commingled until weaning at 210 DPP. At 28 d post-weaning, steers ($n = 47$, BW = 301 kg) were placed in individual pens and fed a diet formulated to provide 13.9% CP, 1.24 Mcal/kg NEg, and 0.10 mg/kg Se. The diet was delivered as total mixed ration once daily. Steers from cows supplemented with organic Se entered the feedlot heavier ($P = 0.02$) and tended to be heavier on d 87 ($P = 0.08$) compared to steers from cows supplemented with inorganic Se. There was no difference in ADG among treatments ($P \geq 0.76$), but steers from organic Se cows tended to spend fewer days on feed compared to steers from inorganic Se cows ($P = 0.09$). Steers from organic Se cows had a greater overall DMI compared to steers from inorganic Se cows ($P = 0.04$), but there was no difference in overall gain:feed ratio ($P = 0.82$). Dressing percentage was greater for steers from cows fed no Se compared with steers from cows fed either inorganic or organic Se ($P = 0.03$). Maternal Se source had no effect on hot carcass weight, back fat, %KPH, L. dorsi area, yield grade, marbling score, or quality grade distribution ($P \geq 0.17$) of progeny. In conclusion, maternal supplementation with organic Se appears to have a long-term benefit on intake of steer progeny and may result in improvements in growth that decreases days in the feedlot.

Key Words: feedlot, selenium, steer

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- 375 **Withdrawn.**

376 Effects of corn dried distiller's grains plus solubles supplementation to gestating cows fed low-quality forage on cow performance and feeding behavior.

V. C. Kennedy*, M. L. Bauer, K. C. Swanson, K. A. Vonnahme, *North Dakota State University, Fargo.*

To investigate the effects of corn dried distiller's grains plus solubles (DDGS) supplementation to cows fed corn stover and silage during late gestation, 27 multiparous beef cows (674 ± 17 kg) were divided randomly into 2 pens equipped with Insentec feeders. For 10 wk, both groups were fed the basal diet for ad libitum intake while one group was supplemented (SUP; $n = 12$) with DDGS at 0.3% of BW. Following parturition, all cows received the same diet for an additional 8 wk. During gestation, SUP cows consumed more forage (14.9 vs. 12.4 ± 0.61 kg; $P = 0.01$) and total ration than non-supplemented cows (CON). Time consuming forage did not differ, but SUP cows consumed forage faster than CON (67 vs. 81 ± 3.5 g/min; $P \leq 0.01$). CON cows ate more meals than SUP cows (9.5 vs. 9.3 ± 0.6 meals/d; $P = 0.06$) from d 201-218 of gestation. SUP cows consumed larger meals than CON cows (1.84 vs. 1.36 ± 0.15 kg), and spent more time eating than CON cows ($P = 0.002$). SUP cows gained BW (1.27 kg/d; $P < 0.001$) and there was no change in BCS ($P = 0.79$). CON cows tended to lose BW (-0.23 kg/d; $P = 0.06$) and lost BCS ($P < 0.001$). Calves born to SUP cows tended to be heavier than calves born to CON cows ($P = 0.06$; 43.3 vs. 40.5 ± 0.9 kg). During lactation, intake increased linearly but treatments were not different ($P < 0.01$). SUP cows spent more time eating than CON cows (186.0 vs. $193.6, \pm 10.9$ min, $P < 0.01$) after d 25 of lactation. SUP cows ate faster than CON cows until d 18 of lactation and CON cows ate faster than SUP cows from d 32 to d 56 of lactation ($P = 0.01$). Meals increased with advancing lactation and CON cows averaged more meals than SUP cows (52.3 vs. 34.9 ± 4.6 meals/d; $P \leq 0.01$). Conversely, meal size decreased as lactation advanced and SUP cows consumed larger meals than CON cows (0.6 vs. 0.9 ± 0.1 kg; $P \leq 0.05$). Time spent per meal was affected by day ($P \leq 0.02$). Finally, both groups gained ($P < 0.01$) BW with advancing lactation and CON cows appearing to realiment. DDGS supplementation influenced intake behavior during gestation and lactation as well as maintenance of maternal BW and BCS, and calf birth BW.

Key Words: beef cow, DDGS, feeding behavior.

377 Effects of zinc, chromium, and beta-agonist supplementation to feedlot steers on growth performance, carcass characteristics, and meat quality.

B. M. Edenburn^{*1}, S. G. Kneeskern¹, B. M. Bohrer¹, P. W. Rounds², D. D. Boler¹, A. C. Dilger¹, T. L. Felix¹, ¹University of Illinois at Urbana-Champaign, Urbana, ²Kemin Industries, Inc., Des Moines, IA.

Objectives were to determine effects of supplemental Zn, Cr, and ractopamine hydrochloride (RAC) on feedlot growth per-

formance, carcass characteristics, and meat quality. We hypothesized steers fed Zn and Cr, in combination with RAC, would have increased protein synthesis, or lean tissue accretion, and carcass quality, respectively, compared to steers fed RAC alone. Crossbred steers ($n = 179$; initial BW = 533 ± 94 kg) were blocked by BW and allotted to 30 pens, 10 pens per block. Pens were randomly assigned to 1 of 5 treatments: (1) control, (2) RAC, (3) Zn+RAC, (4) Cr+RAC, or (5) Zn+Cr+RAC. Steers were fed for 63 d prior to slaughter and the common basal diet contained 60% dry rolled corn, 20% corn silage, 10% distillers grains, and 10% supplement. Trace mineral (TM) treatments were included in the supplement from d 0 to 63 with targets of 1 g Zn·hd⁻¹·d⁻¹ (KemTRACE Zn-propionate; Kemin Industries, Inc., Des Moines, IA) and 3 mg Cr·hd⁻¹·d⁻¹ (KemTRACE Cr-propionate; Kemin Industries, Inc.) for Zn and Cr treatments, respectively. From d 35 to 63, RAC (400 mg ractopamine hydrochloride as Optaflexx; Elanco Animal Health, Greenfield, IN) was top dressed immediately following feed delivery. Data were analyzed using the MIXED procedure in SAS (SAS Inst. Inc., Cary, NC). A contrast statement comparing control versus all other treatments was used to evaluate the effects of RAC. There were no treatment effects ($P \geq 0.44$) on final BW, ADG, or DMI. There were also no treatment effects ($P \geq 0.32$) on LM area, 12th rib backfat thickness, marbling, KPH, USDA YG, or WBSF. However, HCW increased (trend; $P = 0.06$) 5 kg when steers were fed RAC, regardless of TM inclusion. Steaks from steers fed RAC, regardless of TM inclusion, had 2.0 percentage unit greater ($P = 0.05$) cook loss than steaks from steers fed control. Treatment affected ($P = 0.03$) L* values. Steers fed Cr+RAC had the greatest L* values (lightest appearing), while steers fed Zn+RAC had the lowest L* values; all other treatments were intermediate and not different from each other. These data suggest no improvement in growth performance, carcass characteristics, and meat quality when steers were fed Zn and Cr for 63 d in combination with 28 d RAC supplementation. Similar to previous reports, however, feeding RAC to steers for 28 d tended to increase HCW.

Key Words: beta-agonist, cattle, trace minerals

378 Post-weaning nutritional programming of ovarian development in beef heifers.

O. L. Amundson^{*1,2}, T. G. Fountain^{2,3}, E. L. Larimore¹, B. N. Richardson¹, A. K. McNeel², E. C. Wright-Johnson², D. H. Keisler⁴, R. A. Cushman², G. A. Perry¹, H. C. Freetly², ¹South Dakota State University, Brookings, ²USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE, ³Department of Animal Science, Kansas State University, Manhattan, ⁴University of Missouri, Columbia.

From weaning to breeding, the nutritional management of replacement females is critical to their lifetime productivity. Traditionally, cereal grains have been used to develop replacement heifers to enter the breeding system at a younger age. How-

ever, overfeeding heifers decreased number of calves weaned, while peri-pubertal caloric restriction increased primordial follicle numbers in the developing ovary. As the mechanisms by which this increase in primordial follicle number occurs are unknown, the objective of this study was to determine the timing of changes in primordial follicle numbers and evaluate the influence of Leptin, roundabout axon guidance receptor, homolog 4 (ROBO4) and Anti-Müllerian Hormone (AMH) genes on formation and activation of primordial follicles in beef heifers. Crossbred heifers ($N = 30$) were fed a control ration consisting of 30% alfalfa hay, 69.8% corn silage and 0.2% salt as dry matter. At eight months of age, six heifers were ovariectomized. The remaining 24 heifers were divided into two treatment groups ($N = 12$ heifers/diet). Heifers in the Stair-Step treatment ($N = 6$) received 157 kcal ME/BW, and heifers in Control treatment ($N = 6$) were offered 228 kcal ME/BW for 84 d and ovariectomized. At 84 d, the remaining heifers ($N = 6$ /diet) were fed for an additional 83 d, Stair-Step heifers received 277 kcal ME/BW and Control heifers received 228 kcal ME/BW. Heifers were ovariectomized at the end of the feeding period. Pieces of ovarian cortex were fixed in paraformaldehyde for histology or snap frozen for real-time RT-PCR. Body weight ($P = 0.13$) did not differ between treatments. Serum leptin concentrations ($P = 0.01$) were greater in Control heifers and ovarian ROBO4 mRNA abundance ($P = 0.05$) was greater in Stair-Step heifers at 11 months of age. There was a tendency for AMH mRNA abundance ($P = 0.09$) to be greater in the ovaries of Stair-Step heifers at 11 months of age. In histological sections, control heifers had more primary follicles ($P = 0.03$) at 11 months of age, while Stair-Step heifers had more primordial follicles ($P = 0.04$) at 13 months of age. There was no difference in secondary or antral follicle numbers between treatment groups or time points. In conclusion, developing heifers on a Stair-Step compensatory growth scheme decreased development costs and decreased the depletion of the ovarian reserve prior to the onset of breeding, which may have beneficial effects on increasing reproductive lifespan. USDA is an equal opportunity provider and employer.

Key Words: developmental programming, heifer, primordial follicle

379 **Effects of corn treated with foliar fungicide at various times of applications on corn silage quality and aerobic stability.** K. J. Haerr^{*1}, N. M. Lopes², J. Weems³, C. A. Bradley³, M. N. Pereira², G. M. Fellows⁴, F. C. Cardoso¹, ¹University of Illinois, Urbana, ²Federal University of Lavras, Lavras, Brazil, ³Department of Crop Sciences, University of Illinois, Urbana, ⁴BASF Corporation, Research Triangle Park, NC.

About 10 percent of the corn planted in the US is used for corn silage for dairy and beef cattle. Fungicide use on corn has been increasingly investigated within the past few years in order to increase farmers' yield and profitability. This study

utilized four 0.8 ha plots, where each plot was randomly assigned to one of four treatments, as follows; control (CON) corn received no foliar fungicide application; treatment 1 (1X) which corn received one application of pyraclostrobin foliar fungicide (Headline; BASF Corp.) at a rate of 0.11 kg a.i./ha at corn stage V5; treatment 2 (2X) which corn received 2 applications of foliar fungicides, pyraclostrobin at 0.11 kg a.i./ha at corn stage V5, and a mixture of pyraclostrobin + metconazole (Headline AMP; BASF Corp.) at 0.11 + 0.04 kg a.i./ha at corn stage R1; and treatment 3 (3X) which corn received 3 applications of foliar fungicide, pyraclostrobin at 0.11 kg a.i./ha at corn stage V5, pyraclostrobin + metconazole at 0.11 + 0.04 kg a.i./ha at corn stage R1, and pyraclostrobin + metconazole at 0.11 + 0.04 kg a.i./ha at corn stage R3. Foliar disease was evaluated two times during corn silk emergence, and scores for disease severity were assigned to 10 random plants within each plot. Corn was harvested at a dry matter of 33%, 30%, 30%, 32.5% for CON, 1X, 2X, and 3X respectively and then stored in silo bags from September 2013 until April 2014. Corn silage was sampled twice weekly for physical characteristics, major nutrients, net energy, fermentation products, mold count, yeast counts, mycotoxins, density, and aerobic stability. Statistical analysis was performed using the MIXED procedure in SAS. The average temperature for CON, 1X, 2X, and 3X post aeration was different among treatments (32.30, 33.13, 33.68, and 29.10 °C, respectively; $P < 0.01$). There was a treatment effect ($P < 0.05$) for content of sugar, fat, ADF, and soluble crude protein. The Neutral detergent fiber content was 47.32% of DM for CON and 45.28% of DM for 3X ($P = 0.05$). Total digestible nutrients, as well as net energy of lactation were higher for 3X when compared to CON ($P < 0.05$). Application of fungicide increased corn silage aerobic stability and energy content, and reduced fiber content which may contribute to a higher quality feedstuff for animals.

Key Words: aerobic stability, corn silage, foliar fungicide

380 **Impact of prebreeding vaccination with modified-live or inactivated viral vaccines on subsequent reproductive performance in crossbred beef females.** M. R. Crosswhite^{*1}, J. C. Rodgers², J. T. Seeger², B. W. Neville³, C. R. Dahlen¹, ¹North Dakota State University, Fargo, ²Zoetis, Florham Park, NJ, ³North Dakota State University, Streeter, ND.

Five hundred and fifty-nine Angus crossbred females (410 cows and 149 heifers) were used to compare pregnancy attainment and calving distributions of females administered either a killed or modified-live pre-breeding vaccine per label recommendations. Cows were stratified by days postpartum while heifers were stratified by birth date, then all females were randomly assigned to receive one of 3 treatments; 1) Sterile saline administered i.m. on d -60 and -30 relative to breeding (Control, $n = 185$), 2) Sterile saline administered

i.m. on d -60 relative to breeding and a modified-live vaccine (Bovi-Sheild Gold FP5 L5 HB, Zoetis, Inc., Florham, NJ, USA) administered i.m. on d -30 relative to breeding (MLV, $n = 188$), or 3) Killed vaccine (Vira-Sheild 6+L5 HB, Novartis Animal Health US, Inc., Larchwood, IA, USA) administered s.q. on d -60 and -30 relative to breeding (Killed, $n = 186$). All vaccines were administered according to manufacturer's label recommendations and consisted of 3 different lots and serials. All females were exposed to the 7-d CO-Synch + CIDR synchronization protocol with a single fixed-time artificial insemination (TAI) at 54 h after CIDR removal for heifers and 60-66 h after CIDR removal for cows. Clean-up bulls were placed in breeding pastures 10 d after AI and remained with females until 56 d after TAI. Presence of a viable fetus was determined at d 28, 56, and 90 relative to TAI. At parturition, date, birth weight, calf vigor, and calving ease (1 – 5 with 1 = no problem, 5 = extreme difficulty) were recorded. No differences were observed among treatments in the proportion of females pregnant (d 28: $P = 0.94$, d 56: $P = 0.36$, and d 90: $P = 0.19$). There were also no differences in calving date in the calving season ($P = 0.76$) as well as no differences in distribution of calves born in 21 day calving intervals ($P = 0.49$). More calving difficulty ($P = 0.05$) was observed in females exposed to the saline control treatment compared with females in the MLV or Killed treatments (1.09, 1.02, 1.02, control, modified-live, and killed, respectively). However, no differences were observed among treatments in calf birth weight ($P = 0.27$) or calf vigor ($P = 0.51$). When modified-live or killed pre-breeding vaccines were administered per label recommendations no impacts on pregnancy attainment or calving distribution were observed.

Key Words: modified-live, reproductive performance, vaccines

381 **Understanding interactions between diet, methane emissions and microbial community composition in growing and finishing beef cattle.** A. L. Knoell*, C. L. Anderson, A. C. Pesta, G. E. Erickson, T. J. Klopfenstein, S. C. Fernando, *University of Nebraska, Lincoln.*

At the heart of enteric methane production in ruminants is a microbial food chain. The microscale processes of this microbial food chain are greatly influenced by diet. The interactions between diet, microbial community composition and methane emissions are poorly understood. To evaluate the influence of diet on microbial community composition and methane emission, 120 animals were fed 10 different growing and finishing diets. Growing diets included high and low quality forage, with and without monensin supplementation, and different inclusions of modified distillers grain plus solubles (MDGS), and the finishing diets contained different fat sources (corn oil, tallow, and distillers) with and without monensin supplementation, and direct fed microbial (DFM). Microbial community

composition and methane emission was monitored. Methane and CO₂ concentrations of respired air were taken during feeding in an individual feeding facility utilizing 120 individual bunks equipped with the Calan gate system and an automated gas collection system. Samples were analyzed using GC methods and CO₂ was used as the internal standard. Methane:CO₂ ratio was used to measure dietary effects on methane emission. Rumen fluid was collected via esophageal tubing for microbial community analysis. The V3 region of the 16S rRNA gene was sequenced using the Ion Torrent personal genome machine (PGM). On the common diet, microbial community structure and methane levels were similar across animals but changed when fed the growing and finishing treatment diets. In growing diets, forage quality (high vs low) significantly influenced ($P < 0.05$) the CH₄:CO₂ ratio and the microbial community with cattle fed high quality forage producing lower methane per kilogram of gain. The level of methane emitted was not affected by level of MDGS supplementation but significantly changed microbial community structure. In finishing diets the source of fat, monensin supplementation and DFM had no effect on methane level. However, level of MDGS supplementation affected microbial community structure. These results indicate that dietary intervention strategies can be used to change microbial community structure and influence methane emissions in growing cattle. Identification of microbial species in high and low methane-emitting cattle under different diets would help identify dietary factors that can be used to control methane emission from cattle.

Key Words: 16S rRNA, methane, microbial community.

382 **Effects of feeding stockpiled tall fescue versus tall fescue hay during late gestation on pre-weaning calf performance.** K. N. Niederecker*¹, B. L. Vander Ley², M. C. Heller³, A. M. Meyer¹, ¹*Division of Animal Sciences, University of Missouri, Columbia,* ²*Department of Veterinary Medicine and Surgery, University of Missouri, Columbia,* ³*Department of Veterinary Medicine and Epidemiology, University of California, Davis.*

We hypothesized that cows grazing stockpiled tall fescue (STF) during late gestation have increased nutrient intake compared with cows fed summer-baled hay, which would result in improved fetal development and subsequent calf performance. Forty-eight multiparous, spring-calving crossbred beef cows (683 + 16 [SE] kg, BW) were allocated by BW, BCS, age, and expected calving date to either strip-graze endophyte-infected STF (59.7% NDF, 12.3% CP; DM basis) in 4.05 ha pastures ($n = 4$) or consume ad libitum endophyte-infected tall fescue hay (HAY; 64.9% NDF, 6.2% CP; DM basis) in uncovered drylots ($n = 4$) beginning on d 188 ± 2 of gestation. Cow BW, BCS, and 12th rib fat thickness (RF) changes were determined after 35 d (ending period 1) and at 3 d before initiation of calving (ending

period 2). Cows remained on their respective treatments until calving, but STF cows were moved to drylots at 7.0 ± 1.0 d pre-calving and fed rylage (58.6% NDF, 12.3% CP; DM basis). Within 1 wk post-partum, cow-calf pairs were moved to a single pasture for common pre-weaning management. Data were analyzed with treatment as a fixed effect; calf date of birth (cow and calf measures) and sex (calf measures) were included when $P < 0.25$. There were no differences ($P \geq 0.44$) in initial cow measures. Late gestational treatment did not affect ($P \geq 0.14$) cow BW change during period 1 or overall. During period 2, cow BW change was affected by treatment ($P = 0.02$) where cows fed HAY lost BW and STF cows gained BW. Although treatment had no effect ($P = 0.76$) on period 2 BCS change, treatment affected ($P \leq 0.02$) period 1 and overall BCS change where STF cows gained BCS and HAY cows lost BCS. Cow RF change was not affected ($P \geq 0.11$) by treatment. Calves born to STF cows tended ($P = 0.08$; 38.3 vs. 34.6 ± 1.3 kg) to weigh more at birth, suggesting fetal growth was restricted in HAY cows. This trend continued, and calves born to STF cows tended ($P = 0.07$) to have greater BW at 80 d than HAY. There were no differences in calf pre-weaning ADG ($P > 0.22$) weaning BW ($P = 0.37$), or dam age-adjusted weaning BW ($P = 0.29$). In conclusion, cow performance and calf birth weight suggest that cows grazing STF during late gestation had increased nutrient intake leading to improved fetal development.

Key Words: developmental programming, forage systems, pregnancy

- 383 **Performance and blood measurements by Holstein steers supplemented with or without MFP while grazing cool-season forages.** H. L. Bartimus^{1,2}, J. D. Caldwell¹, A. L. Bax¹, B. C. Shanks¹, K. P. Coffey², T. Hampton³, Y. Liang³, S. E. Bettis³, M. Vazquez-Anon³, ¹*Department of Agriculture and Environmental Sciences, Lincoln University, Jefferson City, MO*, ²*University of Arkansas, Fayetteville*, ³*Novus International, Inc., St. Charles, MO*.

Methionine is an amino acid that can limit productivity of many ruminants. Supplemental methionine may be beneficial when the major source of dietary crude protein is provided by forage and by-pass protein is provided by bacteria. Our previous research has shown supplementing with methionine hydroxy analog (MFP; Novus International) improved body weight and ADG in steers offered medium quality hay. Our objective was to evaluate the performance by steers supplemented with or without MFP while rotationally grazing cool-season forages. Holstein steers ($N = 80$; 196 ± 2.1 kg initial body weight) were stratified by body weight and allocated randomly to 1 of 2 treatments: 1) control supplement (C; 5 replications) and 2) control supplement plus MFP (MFP; 5 replications). Beginning on May 8, 2014, each replication was rotationally grazed on 3, 0.4-ha pastures of orchardgrass (*Dactylis glomerata*), alfalfa (*Medicago sativa*), and bromegrass (*Bromus inermis*)

with ad libitum access to water and shelter for a total of 71 d. A soybean hull- and wheat middling-based pelleted supplement that contained minerals and vitamins was offered at 0600 daily at 0.5% of body weight for each replication. Treatment was provided at 1.17% of supplement DM resulting in an average intake of approximately 13.5 g/d of MFP. Steers were weighed and blood was collected approximately every 21 d throughout the study. Body condition scores, body weight, gain, and ADG did not differ ($P \geq 0.22$) between treatments throughout the study. Complete blood cell counts did not differ ($P = 0.13$) between treatments. However, basophil concentrations at d 71 tended ($P = 0.07$) to be higher from C compared with MFP. Available forage tended ($P = 0.10$) to be greater from MFP compared with C. A treatment \times date interaction ($P = 0.10$) was observed for available forage with d 71 C having the lowest available forage compared with all other treatments and dates. Therefore, in this study supplementing steers on pasture with MFP did not improve gain, but resulted in less consumption of available forage at certain times of the year.

Key Words: grazing, methionine, steers

GRADUATE STUDENT COMPETITION – PHD ORAL

- 384 **Whole body and maternal protein deposition in gestating gilts at two feeding levels.** E. G. Miller^{*1}, D. Wey¹, C. L. Levesque², C. F. de Lange¹, *Department of Animal and Poultry Science, University of Guelph, Guelph, ON, Canada*, ²*South Dakota State University, Brookings*.

Whole body protein deposition (Pd) is a main determinant of amino acid and energy requirements of gestating gilts; however data on the dynamics of Pd, including its response to energy intake, is limited. In a nitrogen (N)-balance study, fifty two gestating Yorkshire gilts (initial BW and back fat [BF] at d 29 of gestation 168.1 ± 2.2 kg and 17.1 ± 0.8 mm) were used to determine the effect of feeding level on whole body N retention. Gilts were placed on high or low daily feeding level (2.54 and 1.87 kg/d) of the same diet (3.30 Mcal ME/kg, 17.8% CP, 0.82% SID Lys) from 30 to 110 d of gestation. N-balance observations, based on total urine collection with urinary catheters and fecal N digestibility using an indigestible marker, were made during 4 d periods starting at d 35, 49, 63, 85, and 106 of gestation. To correct for systematic differences between N-balance observations and Pd, the NRC (2012) nutrient requirements model was forced to be consistent with observed changes in BW and BF between 39 and 110 d of gestation; the mean ratio between modelled Pd and observed N-balance was used to adjust N-balance observations. Pregnancy-associated Pd (fetus, mammary gland, uterus, and placenta) was calculated using actual litter size and average piglet birth weight with

Table 386.

Treatment:	1	2	3	4	5	6	
d 0 to 70:	Meal	Pellet	Meal	Pellet	Rotated	Rotated	
Item, d 70 to 118:	Meal	Pellet	Pellet	Meal	Rotated	Rotated	SEM
ADG, kg ¹	0.96	0.97	0.96	0.96	0.96	0.97	0.012
ADFI, kg	2.36 ^a	2.26 ^{c,y}	2.30 ^{b,c,x}	2.28 ^{b,c}	2.30 ^b	2.29 ^{b,c}	0.024
G:F	0.407 ^c	0.430 ^a	0.421 ^b	0.422 ^b	0.420 ^b	0.423 ^b	0.002
Pigs removed/pen	0.50 ^b	1.92 ^a	1.06 ^b	0.93 ^b	0.85 ^b	0.92 ^b	0.265

^{a,b} Superscripts within a row are different ($P < 0.05$)

^{x,y} Superscripts within a row tend to be different ($P < 0.10$)

NRC (2012). Maternal Pd was calculated as the difference between total Pd and pregnancy-associated Pd. Feeding level and day of gestation affected whole body Pd and maternal Pd ($P < 0.01$), but there was no interaction ($P > 0.70$). Whole body Pd showed both linear and quadratic relationships with day of gestation ($P < 0.05$). For the five respective N-balance periods across the two feeding levels, whole body Pd was 87.1, 74.2, 90.5, 97.1, and 107.9 (SEM=7.1) g/d. Across the five N-balance periods, total (as well as maternal) Pd increased by 33.0±1.6 g/d as a result of the increased feed intake. Maternal Pd declined linearly ($P < 0.001$) with day of gestation and across the two feeding levels was 78.8, 51.1, 65.7, 57.1, and 39.2 (SEM=7.1) g/d for the five respective N-balance periods. In summary, the feeding level effect on total and maternal Pd was constant throughout gestation. The gradual decline in maternal Pd with day of gestation is in contrast to NRC (2012), and has important implications for the factorial estimation of amino acid requirements of gestating gilts. Further investigation into the physiological control of the dynamic changes in maternal Pd throughout gestation is warranted.

Key Words: gestating gilts, maternal protein deposition, nitrogen retention

385 Effects of different feeding level during three periods of gestation on sow and litter performance.

P. Ren*, X. Yang, J. Kim, D. Menon, D. P. Pangen, H. Manu, A. Tekeste, S. Baidoo, *Southern Research and Outreach Center, University of Minnesota, Waseca.*

The present study investigated the effects of different feeding level during 3 periods of gestation on sow and litter performance. A total of 113 multiparous sows (Landrace × Large White) were blocked by sow body weight (BW) and backfat (BF) after breeding and randomly allotted to 1 of 4 dietary treatments. All sows were fed the same corn-soybean meal diet with the amount of 1.0 × maintenance energy intake (100 × BW^{0.75} kcal ME/d) throughout the gestation period except 3 periods of 7 d dietary treatments imposed on d 28, d 56 and d 84 of gestation. During these 3 periods, sows were fed 1 of 4 different feeding levels based on maintenance feed intake: 1) 0.5 × maintenance level; 2) 1.0 × maintenance level; 3) 1.5 × maintenance level; 4) 2.0 × maintenance level. Results showed that with the increase of dietary feeding level, sow BW change (-5.57, -0.74, 2.81 and 8.20 kg, respectively, P

< 0.0001), BF change (-0.02, 0.98, 0.74 and 0.82 mm, respectively, $P = 0.05$), average daily gain (ADG; -0.77, -0.10, 0.39 and 1.14 kg, respectively, $P < 0.0001$) and gain to feed ratio (G:F; -0.81, -0.05, 0.16 and 0.34 kg/kg, respectively, $P < 0.0001$) during the 1st period (d 27 to 34) increased linearly. The results for sow BW and BF change, ADG and G:F during the 2nd (d 55 to 62) and 3rd periods (d 83 to 90) were consistent with the 1st period. Additionally, sow BW change (17.81, 25.37, 31.38 and 37.85 kg, respectively, $P < 0.0001$) and BF change (-0.13, 1.17, 1.43 and 2.61 mm, respectively, $P = 0.0002$) from d 27 to d 109 increased linearly with the increase of dietary feeding level during 3 periods of gestation. In contrast, sow BW change (14.67, 9.24, 7.32 and 2.78, respectively, $P < 0.0001$) reduced linearly and BF change (-0.72, -1.18, -0.74 and -1.59 mm, respectively, $P = 0.10$) and average daily feed intake (ADFI; 6.97, 6.79, 6.80 and 6.51 kg, respectively, $P = 0.10$) tended to reduce linearly during lactation period. However, there were no significant differences in litter performance in terms of number of live born and weaned piglets, litter weights at birth and weaning. In conclusion, introduction of different feeding level for 3 short periods during gestation did not affect litter performance, but greatly affected sow BW and BF change during gestation and lactation periods, which may have carry-over effects on subsequent reproductive performance.

Key Words: feeding level, litter performance, sow performance

386 Evaluating strategic pellet feeding regimens on finishing pig performance, stomach morphology, and carcass characteristics.

J. A. De Jong*, J. M. DeRouchey¹, M. D. Tokach¹, R. D. Goodband¹, S. S. Dritz¹, M. Allerson², ¹Kansas State University, Manhattan, ²Holden Farms Inc., Northfield, MN.

A total of 2,100 pigs (PIC 327 × 1050; initially 31.2 kg BW) were used in a 118-d trial to determine the effects of pellet feeding regimens on finishing pig growth performance, stomach morphology, and carcass characteristics. Pigs were allotted to 1 of 6 dietary treatments (14 pens/treatment with 25 pigs/pen). The same corn-soybean meal-based diets containing 15% dried distillers grains with solubles were used for all treatments. The 6 treatments were: 1) continuous meal feed; 2) continuous pelleted feed; 3) meal from d 0 to 70 and pellets

from d 70 to 118; 4) pellets from d 0 to 70 and meal from d 0 to 118; 5) pellets and meal rotated every 2 wk starting with meal; 6) pellets and meal rotated every 2 wk starting with pellets. On d 110, 4 pigs from each pen were harvested and a combined ulcer and keratinization score was determined for each stomach. Overall, there were no differences ($P > 0.10$) for ADG. Pigs fed meal throughout had the greatest ($P < 0.05$) ADFI, while pigs fed pellets throughout had the lowest, and all other treatments were intermediate. Pigs fed pelleted diets throughout had the greatest ($P < 0.05$) G:F, while pigs fed meal throughout had the lowest G:F, and all other treatments were intermediate. Feeding pellets throughout increased ($P < 0.05$) the number of pigs removed per pen above all other treatments. When pelleted diets were fed for the last 58 d, or for the entire trial, the incidence of ulceration and keratinization increased ($P < 0.05$) while pigs fed meal for the last 58 d had lower incidence, and all other treatments were intermediate. There were no differences ($P > 0.10$) for any carcass characteristics measured. In conclusion feeding pelleted diets improved G:F but increased removals and stomach ulceration; however, rotating pellets and meal provided an intermediate G:F response without the increase in stomach ulceration.

Key Words: finishing pig, pellet, ulcer

387 Effect of β -glucan from microalgae on the growth performance and gut health of nursery pigs.

N. E. Manzke¹, F. Castellini^{1,2}, R. L. Payne³,
S. W. Kim¹, ¹North Carolina State University,
Raleigh, ²Universidade Estadual de Sao Paulo,
Jaboticabal, Brazil, ³Evonik Corp, Kennesaw, GA.

This study was to determine the effect of β -1,3-glucan contained in algae biomass (Algamune, Algal Scientific Corp.) on the growth performance and gut health of nursery pigs. Pigs (80 gilts and 80 barrows at 6.02 ± 1.62 kg BW) were randomly allotted to 4 treatments (2×2 factorial arrangement) with 10 pens (5 barrow and 5 gilt pens) per treatment and 4 pigs per pen and feed experimental diets for 5 wk based on 3 phases (1, 2, and 2 wks for phase 1, 2, and 3, respectively). Two factors were Algamune (0.02%) and antibiotics (CTC100 and Denagard10 for Phase 1, Mecadox10 for Phase 2 and 3). Feed intake and body weight were measured weekly. Eight pigs from each treatment (1 per pen, and 8 pens per treatment) were selected for tissue sample collection. Data for each response were analyzed using MIXED procedure in SAS software (SAS Inst. Inc., Cary, NC). During the entire 5 wk period, use of antibiotics increased ($P < 0.05$) ADG (324 to 393 g/d) and ADFI (498 to 582 g/d). There were no overall effects of Algamune on ADG and ADFI during the entire 5 wk period but Algamune tended to increase ($P = 0.072$) ADG (266 to 323 g/d) when antibiotics were not supplemented during phase 2 (wk 2 to 3). Supplementation of Algamune also tended to increase ($P = 0.061$) ADFI (738 to 840 g/d) when antibiotics were not supplemented during phase 3 (wk 4 to

5). However, these effects of Algamune were not observed when antibiotics were supplemented in the feed. Both antibiotics and Algamune increased ($P < 0.05$) villus height in the duodenum of pigs at 5 wk of the study. Correctively, β -glucan extracted from microalgae could help growth and feed intake of pigs by helping gut health when antibiotics are not used.

Key Words: antibiotics, β -glucan, gut health, nursery pigs

388 Effect of altered dietary Lysine: energy ratio in gestation on gilt performance and piglet survivability. A. Ampaire*, C. L. Levesque, South Dakota State University, Brookings.

Based on the new NRC (2012) model, the increase in protein requirement in late gestation is to a greater extent than the increase in energy requirement suggesting a need for phase-feeding. To determine the effects of phase feeding Lysine: energy to gilts on piglet birth weight and survivability, 27 gilts were randomly assigned to 1 of 3 gestation feeding regimens: Control, 2.21 kg/d from breeding to d112 (0.46g Lys/MJ ME); Bump feeding (BF), the control diet at 2.21 kg/d from breeding to d89 and 2.61 kg/d from d90 to 112; Phase feed (PF), 2.21 kg/d (0.43g Lys/MJ ME from breeding to d89) and 2.61 kg/d (0.59g Lys/MJ ME from d90 to 112). All diets contained 13.5 MJ ME/kg. Gilt weights and back fat were monitored regularly. Cord blood was collected at birth for cortisol determination, birth weights were recorded and weekly piglet growth was monitored. Piglets were assigned to three weight categories according to birth weight (light weight <1.2 , average 1.21-1.6, heavy >1.61 kg). Data were analyzed using the MIXED procedure in SAS. Litter birth weight variation was assessed using a Chi-squared test. During gestation and lactation, there were no differences in mean body weight or mean back fat between the treatment groups, but there was a tendency ($P = 0.07$) for higher feed intake during lactation in the Control sows compared to BF and PF gilts ($4.35, 3.25$ and 3.53 ± 0.3 kg/d, respectively). Pigs born alive was higher ($P = 0.03$) in Control sows than the BF or PF sows ($13.5, 10.5$, and 11.9 ± 0.9 , respectively). There was no difference in mean birth weight (1.43 ± 0.07 kg) but more PF piglets ($P = 0.04$; $\chi^2=6.6$) had birth weights in the average category and a trend to more bump piglets ($P = 0.09$; $\chi^2=4.9$) in the heavy category. PF piglets had higher ($P = 0.05$) cord blood cortisol than Control and BF piglets ($88.2, 56.3$, and 64.1 ± 9.3 ng/mL, respectively). There was no difference in piglet body weight from birth to weaning; however, body weight change from birth to d 7 showed a positive correlation with cord cortisol ($r = 0.30, P = 0.003$)

Phase feeding Lysine: energy and bump feeding resulted in more piglets born at a desirable birth weight; however, only phase feeding resulted in higher levels of cord cortisol, which are associated with a higher probability for survival.

Key Words: late gestation, phase-feeding, piglet survival

389 **Effects of heat stress on adipose tissue fatty acid composition and moisture content in pigs.**

J. T. Seibert¹, M. Abuajamieh¹, M. V. Sans-Fernandez¹, J. S. Johnson¹, S. M. Lei¹, S. K. Stoakes¹, J. F. Patience¹, J. W. Ross¹, R. P. Rhoads², S. M. Lonergan¹, L. H. Baumgard¹, R. C. Johnson³,
¹Iowa State University, Ames, ²Virginia Tech, Blacksburg, ³Smithfield Farmland, Denison, IA.

Heat stress (HS) negatively impacts several production variables in swine, including carcass fat quality. Study objectives were to evaluate insulin's role (via feeding insulin sensitizing compounds) in decreasing fat quality during HS. Forty crossbred barrows (113±9 kg BW) were randomly assigned to 1 of 5 treatments during 2 experimental periods: 1) thermoneutral (TN) ad libitum feed intake control (TNAL), 2) TN pair-fed control (TNPF), 3) HS ad libitum (HSAL), 4) HS ad libitum with dietary sterculic oil (HSSO; 13 g/d), and 5) HS ad libitum with dietary chromium propionate (HSCr; 0.5 mg/d; Kemin Industries, Des Moines, IA). During period 1 (7 d), all pigs were exposed to TN conditions (23 ± 3°C, 68 ± 10% RH) and fed ad libitum. During period 2 (21 d), HSAL, HSSO, and HSCr pigs were fed ad libitum and exposed to cyclical (HS) conditions (28 to 33°C, 58±10% RH). The TNAL and TNPF pigs remained in TN conditions and were fed ad libitum or pair-fed to their HSAL counterparts (to eliminate the confounding effect of dissimilar nutrient intake), respectively. Rectal temperature (T_r), respiration rate, and skin temperature were increased (0.9°C, 37 bpm, and 2.5°C, respectively) in HS pigs. Interestingly, HSSO increased T_r relative to HSAL and HSCr (0.45 and 0.42°C, respectively) during the last week of period 2 ($P < 0.05$). HS decreased feed intake and ADG compared to TNAL (2.43 vs. 3.26 kg/d and 0.74 vs. 1.09 kg/d, respectively; $P < 0.01$) and neither variable was affected by SO or Cr supplementation. Moisture content was increased in pigs from all HS treatments compared to TNAL controls in abdominal (7.7 vs. 5.9%; $P < 0.09$) and inner subcutaneous adipose tissue (11.4 vs. 9.8%; $P < 0.06$) depots. Interestingly, TNPF pigs had increased adipose tissue moisture content in abdominal (7.3 vs. 5.9%; $P < 0.01$), inner subcutaneous (11.0 vs. 9.8%; $P < 0.07$), and outer subcutaneous (14.9 vs. 12.1%; $P < 0.01$) depots compared to TNAL pigs. HS had little or no effect on fatty acid (FA) composition of abdominal, inner, and outer subcutaneous adipose tissue depots. Feeding SO decreased the desaturase index in the abdominal (0.36 vs. 0.43; $P < 0.01$), inner subcutaneous (0.46 vs. 0.52; $P < 0.01$), and outer subcutaneous (0.51 vs. 0.55; $P < 0.01$) adipose tissue. In summary, HS did not alter FA composition in any adipose depot, but both TNPF and HS markedly increased adipose tissue moisture content.

Key Words: adipose tissue, heat stress, swine

390 **Efficacy of pea protein isolate-alginate encapsulation on viability of *Lactobacillus reuteri* in the porcine gastrointestinal tract.** J. Wang^{*1},

M. Nickerson², N. Low², T. Scott¹, A. G. Van Kessel¹,
¹Department of Animal and Poultry Science, University of Saskatchewan, Saskatoon, SK, Canada, ²Department of Food and Bioproduct Sciences, University of Saskatchewan, Saskatoon, SK, Canada.

The selection and application of probiotic bacteria is limited by the challenge of maintaining their viability in the digestive tract. Here, we hypothesized that a pea protein isolate (PPI)-alginate (AL) matrix (PPC) can improve probiotic viability during transit of the porcine gastrointestinal tract using an antibiotic resistant *L. reuteri* strain as a marker. *Lactobacillus reuteri* ATCC 53608 was selected on de Man, Rogosa and Sharpe (MRS) media containing rifampin (400 µg/mL) and streptomycin (4000 µg/mL). Early stationary phase antibiotic resistant *L. reuteri* (LRR) cultures were centrifuged, washed and either resuspended in 1 volume of 15.0% skim milk (LRR-M) or encapsulated in a 4.0% PPI:0.6% AL aqueous solution followed by extrusion and crosslinking in 5.0% CaCl₂ +1.0% Tween 80 (w/w) solution (LRR-PPC). Bacteria (LRR-M and LRR-PPC) were freeze dried and stored at -80 °C until use. Weaned piglets (age = 27d, N = 24) were divided into three treatments supplemented with either LRR-PPC or LRR-M at a level of 10⁶ cfu/g feed. The third treatment served as an unsupplemented control group. Experimental diets were prepared with a fresh aliquot of frozen probiotic each morning on experimental days 1-3. Fecal samples were collected on days 0, 2, 3 and 4. All piglets were killed on day 4 and intestinal contents were collected from the stomach, duodenum, jejunum, ileum, cecum, proximal colon and distal colon. To enumerate LRR, samples were plated on MRS agar containing 200 µg/mL rifampin and 2,000 µg/mL streptomycin.

No LRR was enumerated in feces collected on day 0. On experimental day 4, fecal shedding of LRR from LRR-PPC treatment (5.92 ± 0.10 log cfu/g feces) was significantly ($P < 0.001$) higher than the LRR-M group (5.13 ± 0.10 log cfu/g feces). Recovery of LRR in digesta varied according to treatment and location. For the LRR-M group, higher counts ($P < 0.001$) were observed in the stomach and duodenum compared to LRR-PPC, while counts in the LRR-PPC group were significantly ($P < 0.001$) higher than LRR-M in the proximal and distal colon. Homogenization of stomach contents increased viable LRR counts such that there was no significant difference between LRR-PPC (4.90 ± 0.22 log cfu/g content) and LRR-M (4.82 ± 0.20 log cfu/g content). The pattern of abundance of *L. reuteri* in the digestive tract showed that PPC disintegrated and released the probiotic in the distal small intestine permitting increased colonization in distal locations and abundance in feces. Pea protein isolate-alginate encapsulation may be effective in improving probiotic viability in the gastrointestinal tract and permit an increase in the range of

bacterial species candidates for probiotic application.

Key Words: encapsulation, *Lactobacillus reuteri*, porcine gastrointestinal tract

391 **Differential MicroRNA Expression in Sperm Cells and Seminal Plasma due to PRRSV Infection.**

S. M. Calcaterra^{*1}, D. L. Reicks², A. Feltus¹, S. L. Pratt¹,
¹Clemson University, Clemson, SC, ²Swine Vet Center,
Saint Peter, MN.

The objectives of this study were to detect differentially expressed (DE) microRNAs (miRNAs) due to PRRSV infection in sperm cells and seminal plasma and to perform functional enrichment analyses on predicted targets of these miRNAs. All animal work was performed at the Swine Veterinary Center (Saint Peter, MN) where six terminal crossbred boars were inoculated intramuscularly with 2 mL of 2×10^4 viral RNA copies/mL PRRSV strain 1-8-4 on day 0. Semen was collected two days prior to inoculation (-2 dpi) and six days post-inoculation (6 dpi). The cellular fraction was separated by centrifugation and both sperm cells and seminal plasma aliquots were flash frozen and stored at -80°C . RNA was isolated using the mirVana miRNA Isolation Kit and used in custom microarray analyses (LC Sciences, Houston, TX) based on our porcine sperm cell and seminal plasma sequencing data. Individual microarrays were performed using 3 biological replicates from -2 dpi and 6 dpi. Differential expression was determined significant by $P < 0.05$ and a fold change threshold of less than or greater than two-fold. Potential miRNA targets were predicted using miRanda 3.3a with a score threshold of 140 and energy threshold of -20 kcal/mol. Targets were then analyzed for enrichment of Gene Ontology (GO) and InterPro (IPR) terms and were considered to be enriched if $P < 0.01$ using the Bonferroni correction. Microarray analyses resulted in 83 DE miRNAs in sperm and 10 DE miRNAs in seminal plasma when comparing -2 dpi and 6 dpi. Enrichment analyses revealed that the predicted targets of 35 DE sperm miRNAs and 9 DE seminal plasma miRNAs have functions and/or conserved protein domains that are significantly enriched when compared to the pig genome. Enriched terms of the sperm transcripts included lung epithelium development, cAMP response element binding protein, lactation, lung sacculle development, regulation of cell size, positive regulation of cell adhesion, P2X7 purinoceptor, Peptidase S9B, Leucine-rich repeats, Peptidase C48, and phosphorylated immunoreceptor signaling. Transcripts from seminal plasma were enriched for ion channel activity, P2X purinoceptor, Transglutaminase, endoplasmic reticulum signal peptide binding, and Signal Recognition Particles, among others. This data is the first to report differential miRNA expression in sperm and seminal plasma due to PRRSV infection. Further studies involving qPCR of predicted miRNA targets should be performed for a greater understanding of PRRSV infection at a molecular level.

Key Words: microRNA, PRRS, semen

392 **Effects of maternal plane of nutrition during late gestation on beef calf post-weaning growth and feed efficiency, methane production, insulin sensitivity, and carcass characteristics.**

T. B. Wilson^{*},
B. C. Ramirez, L. F. Rodriguez, A. R. Green,
D. D. Boler, A. C. Dilger, T. L. Felix, D. W. Shike,
University of Illinois at Urbana-Champaign, Urbana.

Objectives were to investigate the effects of maternal plane of nutrition, during late gestation, on calf post-weaning growth and feed efficiency, methane production, insulin sensitivity, and carcass characteristics. Calves ($N = 28$; steers, $N = 17$; heifers, $N = 11$; initial BW = 251 ± 25 kg) used for this experiment were born to beef cows limit-fed for 3 planes of nutrition from 92 ± 6 to 9 ± 6 d prepartum: 100% NRC energy and protein requirement (REQ), 70% NRC requirement (70%REQ), or 130% NRC requirement (130%REQ). Calves were weaned at 199 ± 6 d of age and transitioned over 28 d to a common finishing diet. Individual DMI was recorded using GrowSafe (Airdrie, AB). At 305 ± 6 d of age, methane was collected, beginning at 3 h post-feeding, for 24 h. An indwelling venous catheter was inserted at 315 ± 6 d of age to conduct a glucose tolerance test. Plasma glucose and insulin concentrations were analyzed pre-infusion and 5, 10, 15, 20, 30, 60, 90, and 120 min post-infusion. All calves were slaughtered at 388 ± 6 d of age at an average backfat of 0.96 cm. Calf BW at the beginning and end of the transition period was not different ($P \geq 0.37$). Transition period ADG was greater ($P = 0.05$) for calves from cows fed 130%REQ than calves from 70%REQ cows, with calves from REQ cows intermediate and not different from either. There were no differences ($P \geq 0.12$) in transition period DMI or G:F. In the finishing phase, there were no differences ($P \geq 0.41$) in final BW, DMI, and ADG; however, G:F was greater ($P = 0.05$) for calves from 70%REQ cows than calves from REQ cows, with calves from 130%REQ cows intermediate and not different from either. Residual feed intake and residual gain were improved ($P < 0.01$) in calves from 70%REQ cows compared to calves from REQ and 130%REQ cows. Treatment did not affect ($P = 0.48$) methane production. Post-infusion glucose concentration was not different ($P = 0.63$); however, post-infusion insulin concentration was greater ($P = 0.01$) for calves from REQ cows than calves from 70%REQ and 130%REQ cows. There were no differences ($P \geq 0.19$) in glucose or insulin area under curve and insulin to glucose ratio. Treatment did not affect ($P \geq 0.12$) HCW, backfat, yield grade, LM area, marbling score, KPH, shear force, or intramuscular fat percentage. Calves born to 70%REQ cows were more efficient during the finishing phase, and calves born to REQ cows had greater post-infusion insulin concentrations. However, maternal plane of nutrition had no effect on final BW, methane production or carcass characteristics.

Key Words: feed efficiency, fetal programming, insulin sensitivity

393 Influence of feed efficiency ranking on diet digestibility and performance of beef steers.

J. R. Russell^{*1}, N. O. Minton², W. J. Sexten²,
M. S. Kerley³, S. L. Hansen¹, ¹Iowa State University,
Ames, ²Division of Animal Sciences, University of
Missouri, Columbia, ³University of Missouri, Columbia

The study objective was to determine effects of growing phase (GP) diet, GP feed efficiency (FE), and finishing phase (FP) diet on diet digestibility and FP feed efficiency. Two groups, totaling 373 steers, were fed at the University of Missouri (70-d GP), shipped to Iowa State University (ISU) for finishing, and fed in GrowSafe bunks during both phases. During GP, steers received whole shell corn (G-Corn) or roughage-based (G-Rough) diets. Within each group, the 12 greatest and 12 least feed efficient steers from each GP diet ($n = 96$ total; 488 ± 5 kg) were selected. At ISU, steers were fed 10 g titanium dioxide (TiO_2) daily in receiving diets similar to GP diets for 14-d, followed by 2-d fecal collection to determine diet DM digestibility during GP (GDMdig). For FP, steers were transitioned to corn (F-Corn) or byproduct-based diets (F-Byp). Optaflexx was fed for 28-d prior to harvest and the TiO_2 protocol was repeated immediately before Optaflexx introduction to determine FP diet digestibility (FDMdig). The 96 steers were ranked by growing phase G:F and categorized as the 24 greatest (HFE) or 24 least (LFE) feed efficient steers from each GP diet. Data were analyzed using PROC MIXED of SAS with group as a random effect. The HFE steers tended to have greater GDMdig than LFE (69.1% vs 65.5%; $P = 0.13$), but FDMdig did not differ due to FE ($P = 0.9$). A positive correlation between GDMdig and FDMdig ($R = 0.39$, $P < 0.01$) was driven by positive correlations for digestibility between feeding phases in G-Corn-F-Corn steers ($R = 0.49$, $P = 0.02$) and G-Rough-F-Byp steers ($R = 0.68$, $P < 0.01$). Despite greater finishing G:F in HFE versus LFE steers ($P = 0.04$), there was no correlation for overall G:F between phases ($P = 0.2$) and a negative correlation for G:F between phases in G-Rough-F-Corn steers ($R = -0.57$, $P < 0.01$). Growing phase G:F and digestibility tended to be positively correlated ($R = 0.2$, $P = 0.07$); however, finishing G:F and digestibility were negatively correlated ($R = -0.35$, $P < 0.01$). In this study, digestibility was positively correlated between feeding phases when steers were grown and finished on similar diets. Feed efficiency was negatively correlated between phases when steers were roughage-grown and corn-finished, reinforcing the idea that cattle should be FE tested using diets similar to the production environment of interest.

Key Words: cattle, digestibility, feed efficiency

394 Evaluation of a feed additive mixture of pre- and probiotics, enzymes and yeast on in vitro true digestibility of feeds. H. Larson^{*}, N. Kenney-Rambo, A. DiCostanzo, University of Minnesota, St. Paul.

Two in vitro experiments were conducted to determine effects of feeding a proprietary formula containing pre- and probiotics, enzymes and yeast (FORMULA) for 21 d (ADAPTED) and/or incubating with or without FORMULA inclusion (ADDITIVE) on in vitro true digestibility (IVTD) of forage (Experiment 1) and concentrate (Experiment 2) samples. Two cannulated lactating dairy cows underwent a 21-d adaptation period consisting of daily intra-cannula dosing of either 2 g of FORMULA (ADAPT) or dried distillers grains with solubles (DDGS; NADAPT). Feed samples (8) representing mature (MGH) and late-bud (LBGH) grass hay, and fresh range grass (FRG; Experiment 1) or corn silage (CS), dry rolled corn (DRC) and DDGS (Experiment 2) were incubated in ANKOM F57 filter bags for 48 h in each of four incubator jars in two replicate incubations (ANKOM DAISY¹¹) within experiment. Proportion of non-NDF (100 – NDF) fraction remaining in bags after 48 h represented IVTD. Rumen fluid from either ADAPT or NADAPT was mixed with buffer at a 1:4 ratio, and filter bags containing 0.5-g samples were suspended in each incubator. While preparing incubations, FORMULA (ADD) or DDGS (NADD) was added at 0.02 g/incubator. Therefore, all possible combinations of rumen fluid source and additive inclusion were represented for a 2×2 split plot factorial (ADAPTED \times ADDITIVE) experiment where ADDITIVE effect was nested within ADAPTED. Incubating forage samples in ADAPT led to greater ($P < 0.05$) IVTD in MGH (34.0 vs 37.2%) and FRG (56.0 vs 59.0%) but not ($P > 0.05$) in LBGH (64.6 vs 64.9%). Adding FORMULA the day of incubation of forage samples resulted in greater ($P < 0.05$) IVTD (52.0 vs 53.3%). When concentrate samples were incubated in ADAPT, IVTD was greater ($P < 0.05$) regardless of concentrate sample (84.3 vs 87.8%). In vitro evaluation of effects of long-term ruminal adaptation to FORMULA on digestibility demonstrated potential to improve digestibility of forages and concentrates in vivo. Specific situations for which digestibility improvements may not occur need to be determined in additional studies. Future in vitro studies must be conducted using rumen fluid of cattle adapted to FORMULA for at least 21 d.

Key Words: concentrate, forage, in vitro digestibility

**UNDERGRADUATE STUDENT
COMPETITION – ORAL**

395 The effects of high-stress versus low-stress cattle handling at the time of shipping to slaughter on physiological responses in cattle fed ractopamine hydrochloride. J. A. Hagenmaier^{*1}, S. J. Bartle¹, C. Reinhardt¹, D. Rethorst¹, M. J. Ritter², G. J. Vogel³, C. A. Guthrie², D. Thomson¹, ¹Kansas State University, Manhattan, ²Elanco Animal Health, Greenfield, IN, ³Elanco Animal Health, Canyon, TX.

Feedlot cattle ($n = 80$; $BW = 668 \pm 36$ kg) were used to measure the effects of handling at the time of shipping on physiological response, blood parameters, and carcass quality in cattle fed ractopamine hydrochloride during the summer in a Kansas commercial feedlot. Eight phenotypically similar steers were selected from 10 pens. Within each pen, cattle were stratified by weight and randomly assigned to 1 of 2 handling treatments: 1) Low-stress handling (LSH) or 2) High-stress handling (HSH). For the LSH treatment, 4 penmates were walked a course of 1,600 meters. Penmates from the HSH treatment were kept at a minimum of a trot over the 1,600 m course. Rectal temperature (RT), heart rate (HR), and respiratory rate (RR) were recorded prior to handling (baseline) and post-handling. Blood samples were collected at baseline, post-handling, and during exsanguination at the abattoir. Steers on the HSH treatment had higher HR than LSH cattle post-handling (100.4 vs. 86.7 beats/min; $P = 0.01$). There was no difference between treatments on post-handling RR (76.7 vs. 75.7 ± 2.6 breaths/min, $P = 0.80$) or RT (40.5 vs. 40.3 ± 0.09 °C, $P = 0.17$). Blood pH, bicarbonate, and base excess were all decreased post-handling in the HSH cattle ($P < 0.0001$). Blood lactate was greater in the HSH cattle post-handling (15.1 vs. 5.2 ± 1.93 mmol/L, $P = < 0.0001$), while the LSH handled cattle tended to have greater blood lactate at exsanguination (12.2 vs 11.0 ± 0.43 mmol/L; $P = 0.06$). High-stress handled cattle had greater post-handling levels of plasma epinephrine ($2,408$ vs. $1,598 \pm 232.8$ pg/mL, $P = 0.02$), norepinephrine ($3,434$ vs. $2,010$ pg/mL ± 523.4 ; $P = 0.0004$), and cortisol (136 vs. 114 ± 16.7 nmol/L; $P = 0.01$) than LSH cattle. However, no differences were observed in these hormones at exsanguination ($P > 0.05$). High-stress handled cattle had greater serum glucose post-handling (260 vs. 102 ± 10.3 mg/dL; $P < 0.0001$) than LSH cattle, however there was no difference at exsanguination (137.9 vs. 155.8 mg/dL; $P = 0.30$). There was no effect of handling treatment on blood creatine kinase at post-handling or exsanguination ($P > 0.05$). No differences in carcass quality were observed between treatments ($P > 0.05$). High-stress handling increased HR and stress hormones, also causing exhaustion of the respiratory system resulting in acute acidosis. However, HSH cattle recovered and no differences were seen in blood parameters at exsanguination.

Key Words: Beta-agonists, cattle-handling, lactate

396 **Digestibility in steers fed modified distiller grains with solubles and corn silage to partially replace corn in finishing diets.** S. E. Gardine*, D. B. Burken, J. L. Harding, M. J. Jolly-Briethaupt, T. J. Klopfenstein, G. E. Erickson, J. C. MacDonald, B. L. Nuttelman, *University of Nebraska-Lincoln, Lincoln.*

A digestibility experiment evaluated partially replacing corn with corn silage and modified distiller grains with solubles (MDGS) in finishing diets. Six ruminally fistulated steers

were used in a 5×6 Latin rectangle design. Treatments were organized in a $2 \times 2 + 1$ factorial arrangement. Factors included 15 or 45% corn silage and 20 or 40% MDGS, plus a 95% corn silage diet. Steers were assigned randomly to dietary treatment using 21-d periods with 15-d adaptation and 6-d collection. Steers were dosed twice daily with titanium dioxide 7 days before and during the collection period. Fecal grab samples were collected thrice daily, composited by day, freeze dried, and composited by steer within period. Fecal samples were analyzed for NDF, OM, and titanium concentration. Ruminant pH was recorded every minute using wireless pH probes. Rumen fluid samples were collected five times throughout day 21 of each period and were analyzed for volatile fatty acids (VFA). In situ bags containing corn bran, corn (ground to 6 mm), or corn silage, with four replicates of each ingredient, were incubated in each of the six steers for 24 or 36 h to determine impact of dietary treatment on ruminal fiber digestion. Corn bran and corn silage were evaluated for in situ NDF disappearance while corn was evaluated for DM disappearance. Total tract digestibility, ruminal VFA, and in-situ data were analyzed using the mixed procedure of SAS. Ruminant pH data were analyzed as a repeated measure using the GLIMMIX procedure. No silage \times MDGS interactions were observed for DMI, total tract digestibility, ruminal pH measurements, acetate:propionate ratio (A:P), or in-situ disappearance data ($P > 0.31$). Greater corn silage inclusion increased DMI, NDF intake, ruminal pH, A:P, NDF disappearance of corn bran, and DM disappearance of corn ($P < 0.09$) and decreased DM and OM digestibility ($P < 0.03$). As MDGS increased in the diet, NDF intake, total VFA concentrations, and NDF disappearance of corn bran ($P < 0.03$) increased, with no differences in any other tested variables ($P > 0.13$). The 95% corn silage diet had the lowest DMI and digestibility, and total VFA concentration ($P < 0.03$), while ruminal pH was the greatest ($P < 0.01$) compared to all other treatments. These results indicate that increased inclusion of corn silage in distillers grains diets can increase ruminal pH and improve ruminal fiber digestion.

Key Words: corn silage, digestion, distillers grains plus solubles

397 **Effect of trace mineral injection and ractopamine hydrochloride on growth performance and carcass characteristics of finishing cattle.** E. K. Niedermayer^{*1}, O. N. Genter-Schroeder¹, C. A. Clark², S. L. Hansen¹, ¹*Iowa State University, Ames,* ²*Armstrong Memorial Research and Demonstration Farm, Iowa State University, Lewis.*

The objective of this study was to determine how trace mineral (TM) injection, 96 and 28 d prior to harvest, and the β -agonist ractopamine hydrochloride impact growth and carcass characteristics of finishing beef cattle. Two-hundred sixty-four crossbred steers (428 ± 29.6 kg, SD) consuming a common

grain-based diet were assigned to one of 6 pens ($n = 44$ steers/pen) and randomly assigned to receive a 5-mL injection of TM (MM) or physiological saline (SAL; $n = 132$ per treatment; 22 per pen) on d 0. On d 68 steers were randomly assigned within treatment to receive a second injection of MM or SAL and 3 of the 6 pens were randomly assigned to receive 300 mg·steer⁻¹·d⁻¹ of ractopamine hydrochloride for 28 d (RAC), or no ractopamine hydrochloride supplementation (CON). Data were analyzed as a $2 \times 2 \times 2$ factorial, with fixed effects of initial injection, second injection, and RAC supplementation, and steer was the experimental unit. Trace mineral injection did not affect ADG prior to RAC supplementation ($P \geq 0.78$); however, there was an interaction between initial injection and RAC on ADG ($P = 0.0003$). Within steers that received SAL initially, those supplemented with RAC had the greatest ADG ($P < 0.001$), and those without RAC had the least ADG ($P = 0.03$), while within those receiving MM initially, ADG was not affected by RAC supplementation ($P = 0.15$). The second injection did not affect ADG ($P \geq 0.22$). However, within CON cattle, MM steers had greater ADG than SAL steers ($P = 0.03$). An interaction between initial injection and RAC affected ribeye area ($P = 0.03$), where SAL+CON steers had the smallest ribeye area. Ribeye area was smaller in animals that received MM as their second injection ($P = 0.04$) compared with SAL. There was an interaction between initial and second injection ($P = 0.01$) where steers that received either MM or SAL at both time points had greater marbling scores ($P \leq 0.05$) than SAL+MM steers. Another interaction between initial injection and RAC was found in yield grade (YG; $P = 0.01$), where SAL+CON and MM+RAC steers tended to have greater YG than SAL+RAC and MM+CON steers ($P \leq 0.10$). Overall, TM injection 96 d prior to harvest may improve growth and carcass characteristics when ractopamine hydrochloride is not used, although TM injection 28 d prior to harvest appears to have no additional benefit.

Key Words: cbeta-agonist, attle, trace mineral

398 **Differential expression of genes in the jejunum of steers with extreme feed efficiency phenotypes.**

A. R. Butler^{*1}, A. K. Lindholm-Perry², H. C. Freetly²,
¹North Carolina State University, Raleigh, ²USDA, ARS, US MARC, Clay Center, NE.

The small intestine is an important site of digestion and absorption of nutrients in cattle, and has the potential to significantly impact feed efficiency. We hypothesized that the differences in feed efficiency phenotypes of beef cattle can be partially explained by the differences in gene expression in the small intestine. The objective of this study was to determine whether cattle feed intake or growth phenotypes are related to the transcript abundance of genes expressed in the jejunum. Individual DM intake (DMI) and BW gain were measured on 248 steers for 84 d. BW gain was regressed on DMI and steers were assigned to 4 Cartesian quadrants. The

four most extreme steers from each quadrant were identified and selected for jejunum sampling and analysis. RNA was extracted from the jejunum samples and the RNA samples were quantified and analyzed for integrity. The difference in RNA transcript abundance between the groups was measured using the Affymetrix GeneAtlas Microarray System with the Bovine Gene 1.1 ST Array Strips. The data were analyzed using the Affymetrix Transcriptome Analysis Console. Genes differentially expressed in steers with high intake/high gain phenotypes were in networks involved with lipid metabolism and small molecule biochemistry (CYSTM1, CRYAB, EDIL3). Genes with expression unique to animals with low intake/high gain phenotypes were related to proteolysis and hydrolase functions (USP18, MMP14, LYZ). Genes uniquely expressed in low intake/low gain animals were related to stress responses (HSPH1, HSPA6, DNAJB1), and genes differentially expressed in high intake/low gain animals were involved in cell-mediated immune response (IL1RN, CCL8). These results suggest that the differential expression of genes in the jejunum of steers may affect feed efficiency. USDA is an equal opportunity provider and employer.

Key Words: beef cattle, feed efficiency, microarray

399 **Characterization of microbial community structure during Shiga toxin-producing Escherichia coli (STEC) shedding in beef cattle.**

M. Klosterman*, N. D. Aluthge, C. L. Anderson, G. E. Erickson, T. J. Klopfenstein, S. C. Fernando, *University of Nebraska, Lincoln.*

A rich microbial community inhabits the gastrointestinal intestinal tract of ruminants, and cattle are a principle reservoir of the pathogen *Escherichia coli* O157:H7. This food borne pathogen produces shiga toxins that cause worldwide disease with their main route of entry to the environment is through cattle feces. Previous studies have shown that the level and frequency of shiga toxin producing *E. coli* (STEC) varies widely between individual animals. Some animals shed very high concentrations of the pathogen and therefore may be responsible for a majority of transmission of the STECs among individuals and into the environment. In this study, we hypothesize that dysbiosis of the gut microbiota will result in STEC colonization in beef cattle and subsequent shedding of STEC in beef animals. Using selective microbiological culture methods and molecular methods, STEC high-shedders and low-shedders were identified among 170 beef steers over 3 time periods. Based on shedding numbers 48 high-shedders ($>10^4$ STEC cfu/g of feces) and 48 low shedders ($<10^2$ cfu/g of feces) were phenotyped for gut microbial composition using 16s rRNA based amplicon sequencing. A total of ~525,000 high-quality DNA sequences generated through 454-pyrosequencing was used to evaluate microbial community composition. Bioinformatic analysis of the sequences from high-shedders and low-shedders indicated significant variations in mriobiome composition between

Table 400.

	Husk	4 Row	8 Row	SE	P-value
DM Intake, %BW	1.39%	1.36%	1.39%	0.10	0.9173
DMD	68.14% ^a	50.74% ^b	48.66% ^b	2.0	<0.01

high and low shedders. It was revealed that members of the phylum *Bacteroidetes* were more abundant in the low-shedders, while members of the phylum *Proteobacteria* were more abundant in the high-shedding animals. Furthermore, at the family level, *Prevotellaceae* were represented more in the low-shedders than in the high-shedders. Further analysis showed that 9 operational taxonomic units (OTUs) were significantly more abundant in low-shedders than in high-shedders. Most of these OTUs represented members of the genus *Prevotella*. These results provide new insight into bacterial populations that are present in the feces of shedding cattle.

Key Words: STEC, 16S microbial community

400 Effect of corn residue composition on DMD of crossbred wether lambs. L. J. McPhillips*, J. J. Updike, J. C. MacDonald, T. J. Klopfenstein, J. L. Harding, M. J. Jolly-Briethaupt, *University of Nebraska-Lincoln, Lincoln.*

This project was conducted to determine the digestibility of corn residue from different harvest methods. Modern harvest technologies allow the corn plant residue to be deposited in a windrow at the rear of the combine. The residue includes the husks, cobs, and some leaves that pass through the combine plus 2 to 8 rows of the stems that are cut and windrowed. In this study 4 or 8 rows of stems were windrowed, and husks were obtained from seed corn harvest. These residues were fed to 18 crossbred wether lambs (BW 26.1 kg SD 4.48 kg) over three 15 d periods. Lambs were divided into 3 blocks in a 6x3 row-column transformation with 6 treatments, 3 periods, and 3 independent squares ($N = 9$). Lambs were fed treatment diets in an 8 d adjustment period, and total fecal collections were completed over 7 d. DM, OM, and NDF were determined for both the fecal composite of each lamb and diet components of each period. The corn stem is known to be less digestible and the corn husk most digestible relative to other plant parts. It was hypothesized that the husk would have greater dry matter digestibility (DMD) than both 4 row and 8 row residues. It was further hypothesized that the 4 row would have greater DMD than the 8 row due to lower amount of corn stem gathered in the 4 row residue. A mixture of Sweet Bran, brome grass hay, and sheep supplement was used in all diets to supplement protein and increase palatability. During period 4, only the SB, brome, and supplement mixture was fed. Residue DMD could then be determined by difference. Husks were 17.4 percentage units more digestible than 4 row. This demonstrates that the harvest method that increases the amount of husk will increase

the digestibility. The small numerical difference between 4 row and 8 row digestibility supports the hypothesis that stem decreases digestibility and husk increases digestibility. However, this was not confirmed statistically.

Key Words: corn residue, digestibility, lambs

401 The effects of cutting height and plant maturity on yield and nutritional value of smooth brome forage over a two year period. M. A. Woolsoncroft*, S. R. Duncan, A. J. Sexten, A. K. Sexten, *Kansas State University, Manhattan.*

Some forage quality must be sacrificed to achieve sustainable yields. The purpose of this study was to determine the combination of cutting height and stage of plant maturity that optimizes quality and yield. A brome pasture was divided into 27 plots (3.05 m × 4.57 m) in a completely randomized block design with a 3 × 3 factorial treatment arrangement to determine the effect of cutting height (2.54 cm, 7.62 cm, or 12.7 cm) and plant maturity (boot, bloom, seed) on yield and nutritional value. A strip of forage (0.91 m × 3.05 m) was harvested from each plot and weighed to determine yield. A grab sample from each harvested strip was collected and dried. Ground grab samples were analyzed for DM, Ash, NDF, ADF, and N. Treatments were applied to the same pasture over a two year period. In both years, yield was greater ($P \leq 0.01$) when brome was cut at 2.54 cm compared to the 7.62 cm and 12.7 cm. In year 1, cutting height had no effect on any of the nutritional parameters measured. In year 2, NDF content tended ($P = 0.06$) to increase as cutting height was reduced. Yield was greatest ($P < 0.05$) for brome that was in the seed stage of maturity, followed by bloom then boot which produced the lowest yield. In both years, dry matter content was greatest ($P \leq 0.01$) in the seed stage, but lower in bloom and boot stages. In year 1, ash content was similar between the boot and bloom stages with both having a greater ($P = 0.002$) ash content than seed stage. In year 2, ash content was higher in seed and boot while being lower in bloom stage. In both years, NDF and ADF increased with plant maturity, with seed and bloom stages having a greater ($P < 0.01$) fiber content than boot stage. Crude protein, estimated from N content, was greatest ($P < 0.01$) in boot, followed by bloom, than seed stage which contained the lowest CP content. Reducing cutting height produced a greater yield; however, NDF tended to increase in year 2. More mature brome produced greater yields; however nutritional value was decreased with increasing maturity. Cutting brome at a reduced cutting height in a younger stage of maturity can lead to better yields, but may lead to an increase in fiber content with consecutive years of reduced cutting height.

Key Words: cutting height, forage yield, plant maturity

Table 402.

Item AMMC:	Control		DON Contaminated			SEM	Prob-ability, $P <^1$
	---	0.50%	---	0.25%	0.50%		
Analyzed DON, mg/kg	<0.5	<0.5	6.6	6.7	6.4		
d 0 to 28							
ADG, g	533	516	420	403	421	14.2	0.001
ADFI, g	782	784	686	693	726	23.2	0.003
G:F	0.683	0.658	0.614	0.585	0.583	0.021	0.002
CV, d 28 BW	0.136	0.121	0.166	0.152	0.147	0.015	0.05

¹ No effects observed for AMMC ($P > 0.20$).

402 Effects of an algae-modified montmorillonite clay and deoxynivalenol on nursery pig performance. J. A. Erceg*, H. L. Frobose, M. D. Tokach, J. M. DeRouchey, S. S. Dritz, R. D. Goodband, J. L. Nelssen, *Kansas State University, Manhattan.*

A total of 280 barrows and gilts (PIC 327 × 1,050; initially 9.9 ± 1.5 kg) were used in a 28-d growth study to evaluate the effects of an algae-modified montmorillonite clay (AMMC; Olmix S.A., Brehan, France) on the growth performance of nursery pigs fed diets contaminated with deoxynivalenol (DON). Pigs were allotted to 1 of 5 treatments by initial weight, gender, and weaning age in a completely randomized design in a 2 × 2 + 1 factorial arrangement. There were 8 replicate pens per treatment and 7 pigs per pen. Naturally DON-contaminated wheat (10.7 mg/kg) replaced non-contaminated wheat to incorporate DON into test diets. Basal ingredients were tested for mycotoxin and amino acid content prior to diet manufacturing. The 5 experimental diets, fed in pellet form, included a control (<0.5 ppm DON) without or with 0.50% AMMC and a DON contaminated diet (5 ppm DON) without or with 0.25 or 0.50% AMMC. Following diet manufacturing, analyzed DON averaged <0.5 mg/kg for control diets and 6.6 mg/kg for DON contaminated diets. Data were analyzed using mixed model. There were no interactions between DON and AMMC ($P > 0.10$). Overall (d 0 to 28), pigs fed diets containing DON had reduced ($P < 0.01$) ADG (411 vs. 524 g), ADFI (689 vs. 783 g) and G:F (0.600 vs. 0.671) and increased ($P < 0.05$) variation in final BW (15.9 vs. 12.8%) compared with pigs fed diets without DON. The addition of AMMC had no effect ($P > 0.10$) on growth performance. In conclusion, dietary DON reduced pig performance as expected; however, adding AMMC (0.25 or 0.50%) did not mitigate the negative effect.

Key Words: deoxynivalenol, mycotoxin, nursery pig

403 The effects of an algae-modified montmorillonite clay on nursery pig growth performance in diets contaminated with deoxynivalenol. S. Q. Fowler*, H. L. Frobose, R. D. Goodband, S. S. Dritz, J. C. Woodworth, J. M. DeRouchey, M. D. Tokach, *Kansas State University, Manhattan.*

A total of 360 barrows (PIC 1,050; initially 11.4 kg and 45 d of age) were used in a 21-d growth experiment evaluating the effects of an algae-modified montmorillonite clay (AMMC; Olmix S.A., Brehan, France) in nursery pig diets naturally-contaminated with deoxynivalenol (DON). Pigs were allotted to pens by BW, and randomly assigned to 1 of 9 dietary treatments in a 3 × 3 factorial arrangement with dietary DON levels (0, 1.5, and 3 mg/kg) and AMMC inclusion (0, 0.15, and 0.50%) as main effects. There were 8 replicate pens per treatment and 5 pigs per pen. Mycotoxin analyses were conducted on the main ingredients at LDA Labs (Ploufragan, France) and the NDSU Veterinary Diagnostic Laboratory (Fargo, ND). Naturally contaminated wheat (6 mg/kg DON) replaced non-contaminated wheat in diets to achieve desired dietary DON levels. All diets were fed in meal form and pig BW and feed disappearance were measured weekly. Analyzed dietary DON concentrations generally matched formulated levels (1.7 and 3.2 mg/kg DON, respectively). No DON × AMMC interactions were detected ($P > 0.09$) for nursery pig growth or BW. As dietary DON level increased, ADG (555, 500, and 484 g/d) and final BW (23.1, 21.9, and 21.6 kg) decreased (quadratic, $P < 0.05$), driven by poorer (quadratic, $P < 0.01$) ADFI (829, 749, and 685 g/d) and feed efficiency (0.674, 0.670, and 0.616). At both 1.5 and 3 mg/kg DON, reductions in ADG were most severe during d 0 to 7 (15 and 22%, respectively), lessening over time to only 6 and 4% during the final period. The addition of AMMC to diets with or without DON had no effect ($P > 0.12$) on nursery pig growth with ADG of 520, 507, 513 g/d and G:F of 0.662, 0.655, and 0.643 for pigs fed 0, 0.15, and 0.50% AMMC, respectively. The results of this study suggest that even at low dietary concentrations, DON reduces performance, and the inclusion of AMMC in diets did not alleviate DON-associated effects on nursery pig growth.

Key Words: deoxynivalenol, mycotoxin, nursery pig

404 Immune system stimulation by repeated lipopolysaccharide injection alters liver cytoplasmic protein profile in pigs. A. C. Outhouse*, J. K. Grubbs¹, C. K. Tuggle², N. K. Gabler¹, A. Rakhshandeh³, S. M. Lonergan¹, ¹*Iowa State University, Ames*, ²*Bioinformatics and Computational Biology Program, Department of Animal Science, Iowa State University, Ames*, ³*Texas Tech University, Lubbock.*

Defining the changes in the liver protein profile of pigs in response to immune system stimulation (ISS) will provide insight into how animals handle immunological stress. Therefore, the purpose of this study was to investigate and define the effects of ISS and selection for residual feed intake (RFI) on the liver protein profile of pigs. Pigs divergently selected for low RFI (10 generations) are more efficient than their high RFI contemporaries (5 generations), providing a model to study the biology underpinning feed efficiency. Six (3/line) of 12 gilts

Table 404.

Protein	Coverage (%)	Change (%) *with LPS stimulation	P-value
Heat Shock Protein 60	6	27	0.019
Heat Shock Protein 70	7	20	0.0026
Peroxiredoxin-2	15	-42	0.00021

* A positive value indicates an increase in protein abundance in LPS-stimulated pigs; a negative value indicates a decrease in protein abundance in LPS-stimulated pigs.

(BW 63 ±4 kg) were injected intramuscularly every 48 h, for 7 d, with increasing amounts of *E.coli* lipopolysaccharide (LPS). Remaining six pigs were injected with saline (3/line). Pigs were then euthanized and liver tissue collected. The liver cytoplasmic protein fraction was isolated and two-dimensional difference in gel electrophoresis (2D-DIGE) was utilized to determine changes in the protein profile. A total of 563 protein spots were resolved on the 2D-DIGE gel. Seventy-eight protein spots were different in response to ISS ($P < 0.05$). Thirty-six protein spots were different between RFI selection lines ($P < 0.05$). Twenty-two spots from the two analyses were selected for identification through MALDI-TOF mass spectrometry. Three proteins affected by LPS were heat shock protein (HSP) 60, HSP70, and Peroxiredoxin (PRDX) 2 (Table 404). Identities of these proteins were independently confirmed through two-dimensional western blots. In this experiment, the identified proteins were not influenced by RFI line. Heat shock proteins 60 and 70 are known for their cytoprotective effects during stress. We predict the oxidative stress incurred during ISS causes HSP60 and HSP70 to increase in abundance due to their innate responsibilities to protect cells during times of stress. Peroxiredoxin-2 has been shown to eliminate peroxides during times of stress. A decrease in PRDX2 in the liver could indicate consumption, depletion or movement of PRDX2 throughout the body during an ISS. These data show that ISS altered cytoplasmic protein profile in the liver, specifically with a response by cellular rescue proteins.

Key Words: 2D-DIGE, heat shock protein, immune system stimulation, protein profile

- 405 **Exogenous glucagon-like peptide 2 and epidermal growth factor are important trophic factors associated with enhanced intestinal tissue repair and barrier function in a piglet model of intestinal failure.** J. Koepke^{*1}, D. Lim², P. W. Wales³, P. Wizzard², D. Sigalet⁴, J. Li⁵, J. M. Turner², C. L. Levesque¹, ¹*South Dakota State University, Brookings*, ²*University of Alberta, Edmonton, AB, Canada*, ³*University of Toronto, Toronto, ON, Canada*, ⁴*University of Calgary, Calgary, AB, Canada*, ⁵*University of Guelph, Guelph, ON, Canada*.

The digestive tract of newly weaned pigs undergoes rapid and substantial adaptation to multiple stressors, as such, specific

ingredients are included in early diets to aid in gut adaptation and promote gut health. Recent cautionary use of blood and intestinal products in early weaned pig diets has emphasized the need to understand what factors may play an important role in intestinal adaptation. This study assessed the efficacy of 2 gut trophic factors (exogenous GLP-2 and EGF, alone and in combination) on ileal gut adaptation using a piglet model of intestinal failure. Neonatal piglets (age 3-5 days) received one of 4 treatments [saline ($N = 7$), GLP-2 ($N = 5$), EGF ($N = 4$) and GLP-2+EGF ($N = 6$)] for 7 days after surgical modification (75% mid-intestinal resection). Pigs were fitted with venous and gastric catheters and daily nutrient supply was provided using a combination of parenteral (80% of daily nutrient requirements) and enteral (20% of daily nutrient requirements) nutrition. The GLP-2 and EGF were provided in the parenteral and enteral solutions, respectively. Expression of genes related to tissue repair (trefoil factor 3, TFF3), cell proliferation (ki-67), differentiation (cdx2), and apoptosis (caspase 3), digestive enzymes (intestinal alkaline phosphatase, IAP), and tight junction proteins (claudin 7 and 15) were assessed. Statistical analysis was completed using a two-way ANOVA. Expression of TFF3 increased 2.7, 2.5, and 2.5 fold ($P < 0.01$) in pigs provided GLP-2, EGF, or the combination, respectively. The combination therapy tended to increase ($P = 0.09$) IAP expression 1.7-fold. GLP-2 and EGF alone tended to increase ($P < 0.07$) claudin-7 expression 1.4-fold but GLP-2 and the combination increased ($P < 0.05$) claudin-15 expression 2.7- and 2.4-fold, respectively. There was no effect of treatment on expression of ki-67, cdx2, or c3. Intestinal adaptation with exogenous GLP-2 and EGF therapy is enhanced through mechanisms of tissue repair, as well as, digestive and barrier function rather than cell proliferation or apoptosis. The combination therapy provided little additional benefit.

Key Words: intestinal adaptation, piglets, trophic factors

- 406 **Water administration of glucose and amino acids attenuates changes in intestinal structure and lesion scores in PRRSv and PEDv co-infected pigs.** A. S. Clifton^{*1}, W. P. Schweer¹, S. C. Pearce¹, D. M. McKilligan², K. Schwartz¹, K. J. Yoon¹, N. K. Gabler¹, ¹*Iowa State University, Ames*, ²*TechMix LLC, Stewart, MN*.

Porcine epidemic diarrhea virus (PEDv) infection causes enterocyte loss and villus atrophy, which results in reduced performance and, if severe enough, mortality. Therefore, our objective was to examine whether water delivery of nutrients (glucose and amino acids) could alleviate changes in intestinal structure and function in growing pigs co-infected with Porcine Reproductive and Respiratory Syndrome virus (PRRSv) and PEDv. Thirty gilts (16.6 ± 1.8 kg BW) were allocated to one of three treatments for 21 d. Treatments included: 1) Control, healthy, PRRSv, and PEDv naïve gilts ($N = 6$), 2) PRRSv+PEDv co-

infection ($N = 12$; PRP) and 3) PRRSv+PEDV co-infection + water delivery of nutrients ($N = 12$; PRPD). Treatments 2 and 3 were inoculated with a live PRRSv at d 0, then with PEDV at 14 dpi. Water supplementation which consisted of glucose syrup, monosodium glutamate, betaine, glycine and alanine was delivered at 15-30 g/d solids for 21 d. At d21 all pigs were euthanized, jejunum samples were collected and histological samples were assessed for lesions, including villus atrophy, crypt depth, inflammation, and brush border digestive enzyme activities. Control pigs remained negative for PEDV and PRRSv by qPCR and as expected, the challenged pigs were positive for both PEDV and PRRSv. PRP and PRPD treatments reduced villus height versus the control (264, 289 and 422 μm , $P < 0.001$, respectively). Crypt depth tended to be altered due to treatment (280, 317 and 255 μm ; control, PRP and PRPD respectively, $P = 0.056$). Irrespective of challenge, villi:crypt ratio was reduced compared to the control ($P < 0.05$). However, PRPD gilts tended to have a higher villi:crypt ratio compared to the PRP treatment ($P = 0.10$). Histologic lesions were scored on a scale of increasing severity from 1-5. Compared to the control (0), the jejunum lesion scores were increased ($P < 0.01$) with PRP treatment (4.42). However, compared to the PRP, PRPD numerically attenuated this score (3.58, $P > 0.05$). Brush border digestive enzyme activities for sucrase and aminopeptidase were not altered by treatment. However, both the PRP and PRPD treatments reduced maltase and lactase activities by 50% compared to the control ($P < 0.05$). Overall, nutrient supplementation by supplemented water during a PRRSv and PEDV co-infection reduced jejunum lesion scores, but did not influence digestive enzymes.

Key Words: co-infection, intestinal function, intestinal structure

407 **Effect of Vitamin E injection pre-farrowing on antioxidant enzymes and performance of nursery pigs following a PEDV outbreak.** J. T. Gebhardt¹, G. M. Hill¹, J. E. Link¹, R. Becerra¹, R. L. Stuart², ¹Michigan State University, East Lansing, ²Stuart Products Inc, Bedford, TX.

Due to the impact of porcine epidemic diarrhea virus (PEDV) on swine production, it is hypothesized that supplementation of vitamin E following an outbreak may be beneficial by reducing oxidative stress in young pigs. Therefore, the objective of our study was to evaluate the effect of a 5 ml i.m. injection of Vital E Repro (300 I.U. Vitamin E, 200,000 I.U. Vitamin A, and 100,000 I.U. Vitamin D₃) on day 107 of gestation on litter performance and antioxidant status. Twelve barrows, 6 from sows that received the vitamin E injection, and 6 from sows that received a saline injection, were bled at 4.7 ± 1.2 days of age, at weaning (d 24.7 ± 1.2), and after three weeks in the nursery (d 45 ± 1.2). Assays for plasma ceruloplasmin (CP), vitamin E (E), and red cell superoxide dismutase (SOD), and glutathione peroxidase (GSH-Px) were performed using com-

mercially available kits. At weaning, the pigs were allotted into 4 pens by genetics and treatment to evaluate performance while fed a commercial starter diet. Overall ADG and ADFI were greater for pigs from sows receiving the E injection (0.43 vs. 0.30 kg/day, $P = 0.05$; 0.50 vs. 0.39 kg/day, $P = 0.02$; E vs. saline, respectively). There was no difference in G:F (0.86 vs. 0.77, $P = 0.16$) E vs. saline, respectively. Ceruloplasmin activity increased ($P < 0.0001$) over time (0.075, 0.240, and 0.281 U/ml for d5, d 25, and d 45, respectively) regardless of treatment. The GSH-Px activity was greater on d 45 than d 25 regardless of treatment ($P = 0.009$). There was a treatment * time interaction ($P = 0.01$) for GSH-Px activity (1,702 vs. 2,886 nmol/min ml⁻¹) for d 25 vs. d 45 in the saline treatment. The SOD activity was increased ($P < 0.0001$) between d 5 and d 45 (281 vs. 438 U/ml) and between d 25 and d 45 (296 vs. 438 U/ml) regardless of treatment. Plasma E concentration was greatest on d 5 then decreased ($P < 0.0001$) on d 25 and d 45 (5.4 vs. 3.1 vs. 0.9 ppm), respectively. Observed changes over time in antioxidant activity could be due to age or dietary changes, thus further investigation is necessary. With a limited number of observations, it appears nursery pig performance may benefit from injecting sows with E prior to farrowing.

Key Words: antioxidant enzymes, nursery pigs, vitamin E

408 **Survival and mitigation strategies of porcine epidemic diarrhea virus (PEDV) in complete feed.** M. P. Trudeau¹, H. Verma², F. Sampedro², P. E. Urriola¹, G. C. Shurson¹, S. M. Goyal², ¹Department of Animal Science, University of Minnesota, St. Paul, ²Veterinary Population Medicine, University of Minnesota, St. Paul.

Infection with PEDV causes severe diarrhea, vomiting, enteritis, and high mortality in young pigs and is a serious problem for the US swine industry. Contaminated feed can be a source of PEDV transmission and may be affected by feed storage time and chemical composition. Combinations of organic acids have been used to control pathogens such as *Salmonella*. However, there are no data measuring kinetics of virus survival and the effect of organic acids on PEDV survival in complete feed. The objectives of this study were to 1) measure wild virus survival kinetics in complete feed and 2) determine if organic acids are effective in reducing infectivity of cell culture adapted virus. In Exp. 1, jejunal mucosa scrapings of PEDV infected pigs were diluted in 0.5mL of PBS and utilized to infect 5 g of feed. Infected feed was stored for 0, 7, 14, and 28 d at 22°C. At the end of each storage time, 10 d old pigs were inoculated with an extract of the contaminated feed. Results demonstrated that PEDV was capable of infecting naïve pigs in wet feed stored for 28 d, but only 7d in dry feed. In Exp. 2, 5 g of feed were weighed into vials and mixed with either 15 mg Nutriad's Ultracid P (orthophosphoric, citric, fumaric, and malic acid), 20 mg Novus' Activate DA (organic acids and 2-hydroxy-4-methylthio buta-

noic acid), 10 mg Kemin Agrifoods' KEM-GEST (phosphoric, fumaric, lactic, and citric acid), or 10 mg AgriNutrition's Acid Booster (phosphoric, citric, and lactic acid). We modified the concentration of sugar (20 mg) and salt (20 mg) in additional vials as methods of modifying the composition and water activity of the diets. A paired control sample was incubated without additives. We added 1 mL of PEDV (3.2×10^4 TCID₅₀/mL) to each vial and vortexed. Vials were stored at 22°C for 0, 1, 3, 5, 7, 14, and 21 d. Virus was eluted and inoculated in Vero-81 cells to calculate TCID₅₀/mL. Virus inactivation kinetics were tested with log-linear or Weibull models. Data fitted the Weibull model better. There were no differences in the inactivation kinetics (Delta, d) of PEDV between the control samples and the samples treated with Nutriad (18.9) or salt (14.6). The acidifiers that produced the faster inactivation kinetics were Novus (0.4) followed by Kemin (1.8). Addition of some organic acids can reduce the survivability of PEDV in feed, but complete inactivation took up to 14 d.

Key Words: feed additives, inactivation kinetics, Porcine Epidemic Diarrhea Virus

409 **Evaluation of Environmental Sampling Methods for PED.** R. Bardot*¹, T. Fangman², ¹University of Missouri-Columbia, Columbia, MO, ²Boehringer-Ingelheim Vetmedica Inc. Ames, IA.

The ability to detect PEDV (Porcine Epidemic Diarrhea Virus) via the environment as a proxy for herd health status post break would bring great benefits to the swine industry. The cost effectiveness of using a Swiffer or gauze sponge to pick up the virus is a less invasive sampling method (as compared to rectal swabs/bleedings) to the pigs and reduces personal labor costs. The purpose of this evaluation is to assess the ability of the Swiffer compared to a gauze sponge to pick up PEDV in a commercial swine environment. The ability of a gauze sponge soaked in PBS and Swiffer pad in transport media was demonstrated to detect PEDV in breed to wean sites following sanitation and overnight drying. Breed to wean sites ($n = 6$) of a large Midwest swine production system containing PED were identified as High Prevalence ($N = 3$) and Low Prevalence ($N = 3$). High PED prevalence sites were determined to be 7 ± 1 week post break from the sampling dates. Low PED prevalence sites were determined to be 12 ± 2 weeks post break. Historical piglet PED ($n = 30$ piglets at 21 d intervals) testing data from each site was provided as supplemental information. Before sampling was performed, farrowing rooms were disinfected by current disinfection protocols. A high prevalence power calculation suggested stalls ($n = 12$) for each sampling method ($n = 2$). At each site, 12 farrowing stalls were randomly selected to be swabbed with the Swiffer pad and transport media, while another 12 were randomly selected to be swabbed with gauze sponge and PBS. The back third of each selected stall was swabbed starting from left wall, the flooring, and to the right wall, ending with swabbing the railings and the back

door. After swabbing, the Swiffer pad or gauze sponge was put back into their respective bag with media ($N = 50$ mL) and labeled at each site. Once all 24 stalls were swabbed, each liquid specimen was transferred into a test tube ($N = 5$ mL). Each test tube was labeled and shipped to Boehringer Ingelheim's Health Management Center in Ames, IA for PEDV PCR testing. There was no discernable difference ($P > 0.05$) in PED detection with either collection method, however further study is needed to understand if the genetic material found following disinfection is infectious or noninfectious.

Key Words: environmental, PED, sampling

410 **The effects of uric acid supplementation during oocyte maturation on the in vitro fertilization of pigs.** K. J. Jaciuk*, C. Streaker, B. D. Whitaker, University of Findlay, Findlay, OH.

High incidences of polyspermic penetration in pig oocytes during in vitro fertilization (IVF) continue to challenge researchers. The objective of this study was to reduce the incidence of polyspermic penetration by supplementing uric acid during the later stages of oocyte maturation. Oocytes ($N = 160$) were supplemented during the last 24 h of maturation with 0.02, 0.04, or 0.06 mM uric acid. The oocytes then experienced IVF and were evaluated for penetration, polyspermic penetration, and male pronuclear formation rates. The remaining embryos were evaluated for cleavage and blastocyst formation rates at 48 and 144 h after IVF, respectively. Supplementation of 0.04 and 0.06 mM uric acid were significantly toxic ($P < 0.05$) to the oocytes and removed from the remainder of the study. To determine the effects of uric acid supplementation on oocyte maturation, oocytes ($N = 135$) were supplemented with 0.02 mM uric acid during the last 24 h of maturation and catalase and superoxide dismutase activities were determined. The remaining oocytes were analyzed for DNA fragmentation using an oocyte microgel electrophoresis assay. There were no significant differences between the 0.02 mM uric acid supplemented oocytes or those that were not supplemented with uric acid when comparing IVF kinetics, embryonic development rates, catalase activity, or DNA fragmentation. Oocytes supplemented with 0.02 mM uric acid has significantly higher ($P < 0.05$) levels of superoxide dismutase activity (5.81 ± 0.28 units/oocyte) compared to the oocytes not supplemented with 0.02 mM uric acid (1.26 ± 0.45 units/oocyte). These results indicate that supplementing 0.02 mM uric acid to pig oocytes during the later stages of maturation is not detrimental to fertilization or embryonic development success and increases the levels of superoxide dismutase activity in the maturing oocyte.

Key Words: IVF, oocytes, polyspermy

411 **Withdrawn.**

GRADUATE STUDENT COMPETITION – MS POSTER

- 412 **Prevalence of loin bruising and tail lesions in Irish slaughter pigs.** N. van Staaveren^{*1,2}, D. L. Teixeira², A. Hanlon¹, L. A. Boyle², ¹*School of Veterinary Medicine, University College Dublin, Belfield, Dublin 4, Ireland*, ²*Pig Development Department, Teagasc Animal and Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork, Ireland.*

Loin bruising and tail lesions are potential welfare indicators to record during meat inspection. Loin bruising is associated with increased costs because it necessitates trimming and therefore downgrading of the loin. Tail biting is a well-known problem in the pig industry and even mild tail lesions have been associated with pathologies, reduced carcass weight and increased risk of carcass condemnation/trimming. Potential welfare and economic implications of loin bruising and tail lesions make it imperative to get an accurate picture of the scope of the problem. Visits to two factories in the Republic of Ireland were conducted in summer 2014. Two observers scored each carcass after scalding/dehairing on the slaughterline and recorded sex, herd, loin bruising (0 to 2) and tail lesion scores (0 to 5). Scores were collapsed into two levels for loin bruising (none/mild, severe) and 3 levels for tail lesions (none/mild, moderate, severe). Prevalence and their range were determined on herd level. Effects of factory and sex were analyzed by SAS V9.3 PROC GENMOD. In total, 13,133 carcasses were inspected. Severe loin bruising was present in 4.0% of the pigs. Herd level prevalence for severe loin bruising ranged from 0 – 6.0% in factory A and 0 – 21.7% in factory B. Pigs had a higher odds of severe loin bruising in factory B (OR=4.5, 95%CI 3.58 – 5.79) than A. Sex had no effect on loin bruising. Moderate and severe tail lesions were present in 27.3% and 1.0% of the pigs, respectively. Herd level prevalence for severe tail lesions ranged from 0 – 7.9% in factory A and 0 – 9.7% in factory B. For moderate tail lesions this was 16.0 – 66.8% and 4.0 – 40.0%, respectively. Pigs in factory B had significantly lower odds for moderate (OR=0.2, 95%CI 0.19 – 0.23) and severe tail lesions (OR=0.6, 95%CI 0.39 – 0.79) than in factory A. Males had a higher odds of moderate (OR=1.4, 95%CI 1.30 – 1.54) and severe tail lesions (OR=4.2, 95%CI 2.68 – 6.54) than females.

Tail lesions are more common and the larger variation between herds suggests that this is a more suitable welfare indicator than loin bruising which might be affected by slaughterhouse processes (e.g. scalding/dehairing). Tail lesions recorded at meat inspection could provide valuable feedback to producers to inform their herd health/welfare plans.

Key Words: loin bruising, pigs, tail lesions

- 413 **Seasonal and cryopreservation impacts on semen quality in boars.** M. M. Krautkramer^{*1}, J. J. Parrish¹, T. M. Loether¹, J. R. Miles², L. A. Rempel², ¹*University of Wisconsin, Madison*, ²*USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE.*

Seasonal boar infertility occurs worldwide and contributes to economic loss to the pork industry. The current study evaluated cooled versus cryopreserved semen quality of 11 Duroc boars collected in June (cool season) and August 2014 (warm season). Semen was cooled to 16°C (cooled) or frozen over liquid nitrogen (frozen-thawed). Quality evaluation included: % motile sperm using CASA, % viable sperm by Sybr14/propidium iodide staining, and sperm nuclear shape of Hoechst 33342 stained sperm by Fourier harmonic analysis (FHA) amplitudes 0 to 5 (HA0-5; in microns). Data were evaluated with ANOVA and MANOVA using a mixed model with collection season (June or August), preparation (cooled or frozen-thawed), and season X preparation interaction as fixed effects. Boar effect and associated interactions were considered random. An interaction of season and preparation for motile sperm ($P < 0.01$) existed with June better than August for cooled semen (80 vs. 43%; $P < 0.05$) but not different for frozen-thawed semen (8 vs. 8%; $P > 0.05$). The % viable sperm was greater for cooled vs frozen-thawed semen (72 vs. 22%, $P < 0.001$) but no interaction or main effect of season was present ($P > 0.05$). Analysis of sperm nuclear shape was first evaluated with MANOVA using the composite HA0-5 measurements together. An interaction of season by preparation ($P < 0.0006$) associated with nuclear shape. Individual HA measures were evaluated using ANOVA. HA0 had an interaction of season and preparation with a decrease in cooled semen from June to August (2.834 vs. 2.778; $P < 0.001$) but an increase for frozen-thawed semen (2.740 vs. 2.825; $P < 0.001$). Similarly, HA2 had an interaction of season and preparation with cooled semen decreasing in HA2 from June to August (1.075 vs. 1.065; $P < 0.05$) but increased for frozen-thawed semen (1.076 vs. 1.092; $P < 0.01$). Main effects of season influenced HA3-5 ($P < 0.05$). In summary sperm nuclei were decreased in overall size and length for cooled semen from June to August, but the opposite was true for frozen-thawed sperm. Seasonal changes of cooled semen for compensable semen traits of motility and viability and the uncompensable trait of FHA are similar to previous studies but the impacts of season on frozen-thawed sperm are novel. Reduced motility and viability of cryopreserved semen does indicate a need for improvement of cryopreservation techniques, which is currently overcome by high sperm concentration. USDA is an equal opportunity provider and employer.

Key Words: boar, seasonal, semen

414 Weight-shifting and locomotion scoring as measures of lameness in dairy cows: Repeatability and correlation.

N. A. Olson^{*1}, B. H. Manning², S. A. Wagner¹, ¹*North Dakota State University, Fargo*, ²*Zoetis Inc., Kalamazoo, MI*.

This study investigated the repeatability of two measures of lameness in dairy cows: locomotion scoring and rear leg weight-shifting. Correlations between these two measures and the presence or absence of hoof lesions also were explored. Data were obtained from 11 dairy cows classified as “lame” (locomotion score of ≥ 3 on a 5-point scale) and 11 dairy cows classified as “sound” (gait score $< 3/5$). Each cow was weighed for 5 consecutive days on a scale that measured the weight borne on each leg 11-14 times per second. Each weighing session consisted of 2 to 3, 5-minute sub-sessions of data recording. Prior to weighing on days 1 and 5, video recordings were made of the cows walking; these videos were used to assign locomotion scores on a 5-point scale (1 = not lame, 5 = severely lame). On days 1, 3, 4, and 5 each animal had one weighing session; day 2 consisted of 4 weighing sessions at approximately 3 hour intervals. The standard deviation of weight borne over time was calculated for each foot at each weighing session and used as a measure of weight shifting. For lame and sound cows, mean locomotion scores and weight shifting did not differ within the group over the test period (score: $P = 0.85$; shifting: 0.70). Increased shifting of weight borne on the rear legs was correlated with higher locomotion scores ($P = 0.003$). In addition, the presence of a lesion on the right rear hoof (the most common location) was correlated with increased weight shifting of the right rear leg ($P = 0.027$). Repeatability of weight-shifting measures and their correlation to both locomotion scores and hoof lesions validates weight-shifting behavior as an objective measure of lameness and hoof pain.

Key Words: behavior, dairy, lameness

415 Effect of dietary lysine on plasma amino acid profile of finishing pigs.

N. Regmi^{*}, T. Wang, M. A. Crenshaw, B. J. Rude, S. F. Liao, *Mississippi State University, Mississippi State*.

Muscle growth requires constant amino acid (AA) supply from the blood and, therefore, the profile of plasma AAs is a critical parameter to manage in order to maximize the lean gain of pigs. This research was conducted to study how dietary lysine affects plasma AA profile in finishing pigs. Eighteen crossbred (Yorkshire \times Landrace) finishing pigs (9 barrows and 9 gilts; initial BW 92.3 ± 6.9 kg) were individually penned in an environment controlled barn. Pigs were assigned to 3 dietary treatments according to a Randomized Complete Block Design with sex as the block and pig as the experiment unit (6 pigs/treatment). Three corn and soybean-meal based diets were formulated to contain three levels of total lysine for the three treatments, which were 0.43, 0.71, and 0.98%

lysine (as-fed basis) for Diets I (lysine deficient), II (lysine adequate), and III (lysine excess), respectively. After 4 weeks on the trial, jugular vein blood was collected and the plasma samples were obtained by centrifugation. The concentrations of 24 AAs were determined using appropriate HPLC methods. Five distinct patterns of plasma AA concentration alteration were observed: (1) The plasma lysine level followed the same trend as the dietary lysine level and there were significant differences ($P < 0.05$) among the three treatments. (2) The plasma asparagine concentration was increased ($P < 0.05$) with Diet III, but it was not with Diet I, when compared with Diet II. (3) There was no difference between Diets II and III in the plasma concentration of alanine, glutamic acid, glycine, or leucine, but the concentrations of these AAs were reduced with Diet I ($P < 0.05$). (4) The concentrations of arginine, histidine, citrulline, threonine, valine, isoleucine, or phenylalanine were increased with Diet I when compared to Diet II ($P < 0.05$), but there was no difference in the concentrations of these AAs between Diets III and II. (5) There were no differences ($P > 0.05$) among the three diets in the plasma concentrations of aspartic acid, -alanine, cystine, glutamine, methionine, ornithine, proline, serine, taurine, tryptophan, or tyrosine. These five distinct patterns of plasma AA concentrations indicated complex metabolic interactions between dietary lysine and other AAs. Thorough understanding of these interactions will assist swine nutritionists to manage plasma AA profile via dietary AA supply. This research was supported by USDA-NIFA Hatch/Multistate Project 233803.

Key Words: amino acid profile, dietary supply, lysine, plasma, swine

416 Effects of diet form and distillers dried grains with solubles (DDGS) on growth performance, carcass characteristics, and visceral weights of growing-finishing pigs.

M. F. Overholt^{*}, J. E. Lowell, I. M. Grossman, H. H. Stein, A. C. Dilger, D. D. Boler, *University of Illinois, Urbana-Champaign, Urbana*.

Objectives were to determine growth performance, carcass characteristics, and visceral weights of barrows and gilts fed a pelleted or mash diet, without or with 30% DDGS. A total of 192 pigs were used in 2 blocks, each block consisted of 96 pigs. Pigs were randomly allotted to 1 of 4 dietary treatments, with 12 replicate pens per diet and 2 barrows and 2 gilts per pen. Data were analyzed as a 2×2 factorial arrangement with main effects of diet form (pellet or mash) and DDGS inclusion (0 or 30%) in a randomized complete block design. Pellet-fed pigs were heavier (114.34 kg vs. 111.40 kg; $P < 0.01$) and gained 0.03 kg/day more BW ($P = 0.001$) than mash-fed pigs after a 91 d feeding period. Pigs fed a mash diet with DDGS were 2.72% less efficient ($P < 0.03$) than pigs fed a mash diet with no DDGS, efficiency differences were not present when diets were pelleted ($P > 0.42$). Feed intake did not differ among treatment groups, but mash-fed pigs with DDGS

consumed at least 0.81 kg/d more ($P < 0.05$) feed than pigs fed all other diets (interaction $P < 0.01$). There were no differences ($P = 0.41$) in intestinal mass as a percentage of BW between pelleted and mash-fed pigs. Pelleted-fed pigs had 0.92 kg less ($P < 0.001$) gut-fill than mash-fed pigs. The difference in gut fill can be attributed to pelleted-fed pigs losing 1.54 percentage units more ($P = 0.02$) BW during lairage than mash-fed pigs. Pelleted-fed pigs produced carcasses that were 2.5 kg heavier ($P < 0.001$) and 1.6 mm fatter ($P < 0.001$) at the 10th rib than mash-fed pigs. There were no differences ($P = 0.84$) in LEA between pelleted and mash-fed pigs. Therefore, pelleted-fed pigs had estimated carcass lean values that were 1.79 percentage units less ($P = 0.04$) than mash-fed pigs. Inclusion of DDGS increased ($P < 0.01$) intestinal mass and gut fill ($P < 0.01$), and decreased ($P = 0.01$) HCW by 2.11 kg and dressing percentage ($P < 0.001$) by 0.66 percentage units, regardless of diet form. There were no differences in fresh loin color, marbling, firmness, ultimate pH, or drip loss among any dietary treatments ($P > 0.15$). Overall, pelleted-fed pigs grew faster, were more efficient, and were heavier than mash-fed pigs. There were no differences, in meat quality between pellet-fed pigs and mash-fed pigs.

Key Words: growth, pelleting, pig, pork, viscera

417 Effects of dry acidulant coating of commercial pet food on *Salmonella* contamination.

A. M. Jeffrey^{*1}, C. K. Jones¹, C. G. Aldrich¹, A. R. Huss¹, C. Kneuvens², ¹Kansas State University, Manhattan, ²Jones Hamilton, Walbridge, OH.

Salmonella is currently a concern in the pet food industry. One potential method of *Salmonella* mitigation is through the use of acidifiers to reduce pH to inhibit growth of bacteria. The objective of this experiment was to determine if coating pet food with a dry acidulant, sodium bisulfate (SBS, Jones-Hamilton, Co., Walbridge, OH), would reduce *Salmonella* growth over time in pet food of varying surface area, bulk density and piece density. A total of 10 commercial extruded pet foods were utilized in nested design with two food types: cat vs. dog, and three SBS concentrations within food type: 0, 0.6, or 0.8% SBS for cat and 0, 0.2, and 0.4% for dog foods. Samples were analyzed for surface area, bulk density, and piece density. Samples were dry inoculated with *Salmonella* cocktail on d 0 and analyzed for *Salmonella* counts on d 0, 1, 2, 7, and 14 by direct plating to Xylose Lysine Deoxycholate (XLD) agar. Piece density was correlated with *Salmonella* counts ($P = 0.001$, correlation coefficient = 0.47), but not bulk density or surface area ($P = 0.16$ and 0.68, respectively). Food type, SBS concentration, and time, as well as their interactions, all significantly impacted *Salmonella* counts ($P < 0.05$). *Salmonella* in the non-coated control decreased in both cat and dog food over the 14-d period ($P < 0.05$; 1.0 log reduction and 1.5 log reduction in cat and dog food, respectively). Coating pet foods with SBS further decreased ($P < 0.05$) *Salmonella* by

Table 417.

SBS Concentration, %:	Cat food			Dog food		
	0.0	0.6	0.8	0.0	0.2	0.4
<i>Salmonella</i> , log ₁₀ cfu/g						
d 0	4.43	4.41	4.29	4.84	4.93	4.95
d 1	3.73	3.22	3.16	3.56	3.64	3.61
d 2	3.01	2.56	2.63	3.64	2.67	2.51
d 7	3.21	1.88	1.38	3.20	2.22	2.05
d 14	3.47	1.31	1.01	3.36	2.09	1.92

Food type: $P = 0.04$, SEM = 0.125; Time: $P < 0.0001$, SEM = 0.115; SBS concentration (food type) $P < 0.0001$; SEM = 1.146.

d 1 through d 14, but the lowest tested concentration offered adequate reduction at most time points. In conclusion, piece density and time can influence *Salmonella* quantity in extruded pet foods, and a moderate inclusion of a dry acidulant may further reduce contamination.

Key Words: commercial pet food, *Salmonella*, sodium bisulfate

418 Influence of algae meal as a replacement of corn in feedlot lamb diets on nutrient digestibility.

R. S. Stokes^{*}, D. D. Loy, M. L. Van Emon, S. L. Hansen, Iowa State University, Ames.

Recent advances in technology support use of heterotrophic microalgae for the production of oils for bioenergy. Oil is extracted and the resultant coproduct includes a combination of de-oiled microalgae and soyhulls, resulting in an algae meal with a unique profile of protein, fiber, and fat. To determine the effects of algae meal (ALG) on diet and nutrient digestibility and N retention, 10 whiteface cross wethers (33.71 ± 0.55 kg) were used in a replicated 5 × 5 Latin square. There were 5 periods, each with 10 days of diet adaptation followed by 5 days of total fecal and urine collection. Sheep ($n = 2$ sheep-diet⁻¹·period⁻¹) received one of 5 diets: a corn-based control (CON), 15% algae meal (15ALG), 30% algae meal (30ALG), 45% algae meal (45ALG), and 60% algae meal (60ALG). Algae meal replaced corn on a DM basis. Data were analyzed using Proc Mixed of SAS and LSMEANS and pooled SEM are reported. Dry matter intake was lesser ($P = 0.01$) for CON (1.04 kg/d) than ALG-fed lambs (1.15, 1.29, 1.19, and 1.25 ± 0.271 kg/d for 15ALG, 30ALG, 45ALG, and 60ALG, respectively). Dry matter digestibility linearly ($P < 0.001$) decreased as ALG inclusion increased (75.1, 73.3, 69.8, 68.0, and 67.5 ± 0.70% for CON, 15ALG, 30ALG, 45ALG, and 60ALG, respectively). Digestibility of NDF and ADF were lesser ($P ≤ 0.01$) for CON than ALG-fed sheep. However, there was a cubic effect ($P < 0.03$) of ALG inclusion on NDF and ADF digestibility, with lesser digestion in CON, intermediate and similar digestion across 15ALG, 30ALG, and 45ALG, and greater digestion in 60ALG. Ether extract digestibility was lesser ($P = 0.002$) for CON than ALG, with a linear ($P = 0.002$) increase as ALG inclusion increased (83.5, 87.0, 87.9, 87.9, and 89.5 ± 1.20% for CON, 15ALG, 30ALG, 45ALG,

and 60ALG, respectively). There was a cubic ($P = 0.03$) effect for N digestibility with 45ALG and 60ALG being lesser and CON being greater than all other treatments. Nitrogen balance did not differ ($P = 0.22$) between CON and ALG. Results of this study suggest ALG is readily consumed by lambs at up to 60% of diet DM and in relation to commonly available concentrate feeds offers a comparable digestibility. Algae meal could potentially replace portions of corn or soyhulls, serving as a viable component of feedlot diets.

Key Words: algae, digestibility, sheep

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- 419 **Impact of managing cow-calf pairs on pasture or in a dry lot during a 10 day synchronization period on reproductive performance and weight change in cows and their calves.** D. N. Black^{*1}, M. R. Crosswhite¹, B. W. Neville², C. R. Dahlen¹, ¹North Dakota State University, Fargo, ²North Dakota State University, Streeter, ND.

The objective of this project was to determine the effects of moving cow-calf pairs from summer pastures in early- to mid-July into dry lots for a 10 day estrus synchronization and breeding period on reproductive performance and weight change in cows and their calves. Cow-calf pairs ($n = 427$) were stratified by calf sex and days postpartum and randomly assigned to one of two treatments: 1) pairs were removed from summer pastures and managed in dry lots during a 10 day synchronization and breeding window (DL, $n = 212$), 2) pairs remained on summer pasture for the synchronization and breeding period, and were gathered for each of 3 separate handling events to facilitate AI (CON, $n = 215$). The DL group was provided ad libitum grass hay, while the CON group had ad libitum access to native range pastures with both groups having equal access to a vitamin/mineral supplement. All cows were exposed to 7-d CO-Synch + CIDR protocol with fixed-time AI (d 10) at 60-66 h after CIDR removal. Single day, unshrunk BW of cows and calves were recorded on day -10 and d 0 relative to breeding, with additional calf BW collected on d 35 and 88 and cow BW on d 95. Presence of a viable fetus was determined in cows on d 35 and 95 via transrectal ultrasonography. Both cows and calves in the DL group had reduced ($P \leq 0.04$) weight gain during the 10 day synchronization window compared with the CON group. No differences ($P \geq 0.36$) were observed between treatments for pregnancy rate at d 35 (49.5% and 52.3% for CON and DL, respectively) or d 95 (91.1% and 89.6% for CON and DL, respectively), or cow BW on d 95. However, calves in the DL treatments were 6.8 kg lighter ($P \leq 0.003$) on d 35 and 8.5 kg lighter on d 88 (weaning) compared with calves in the CON group. Managing cow-calf pairs in the dry lot for a 10 day estrus synchronization and breeding period did not affect final pregnancy rates, but did have a negative impact on calf weaning weights.

Key Words: beef cattle, breeding management, calf performance

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- 420 **Effects of dietary inclusion of direct-fed microbials on growth performance and carcass traits of finishing pigs.** A. L. Sevarolli^{*}, I. Park, F. Castellini, S. W. Kim, North Carolina State University, Raleigh.

This study was to determine the effect of direct-fed microbials (DFM, PrimaLac, Star Labs, Clarksdale, MO) on the growth performance and carcass traits of finishing pigs. PrimaLac includes *Lactobacillus acidophilus* (2.5×10^7 cfu/g), *Lactobacillus casei* (2.5×10^7 cfu/g), *Bifidobacterium thermophilum* (2.5×10^7 cfu/g), and *Enterococcus faecium* (2.5×10^7 cfu/g). Sixty pigs at 88.5 ± 0.6 kg BW were housed in pens (3 pigs/pen) and allotted to 2 dietary treatments (0 or 0.05% DFM) in a randomized complete block design with sex and initial BW as blocks. There were 5 gilt pens and 5 barrow pens per treatment. Pigs were fed experimental diets which had corn, DDGS, and soybean meal as major ingredients meeting the NRC nutrient requirements (2 phases and 2 wk each). Body weight and feed intake were measured weekly. At the end of the study, pigs were moved to a local packing plant to process the carcass. Cold carcass (24 hr after processing) was used to measure backfat thickness at 1st, 10th, and last ribs. Loin was removed, weighed, and the middle part was removed for the determination of loin color (Minolta colorimeter), marbling score (1 to 5, NPPC scale), drip loss (48 hr), and chemical composition. Data were analyzed using Proc Mixed of SAS with treatment and sex as fixed effect and initial body weight blocks as a random effect. Pigs with DFM had greater ($P < 0.05$) ADFI (2.79 and 2.56 kg/d) and ADG (0.89 and 0.79 kg/d) than pigs without DFM during 4 wk feeding period. Loin tended to be heavier ($P = 0.100$) for pigs with DFM (7.55 kg/side) than pigs without DFM (6.64 kg/side). There was no difference in backfat thickness between treatments. Chemical composition (dry matter, crude protein, ether extract, and crude ash) and drip loss did not differ between treatments. Loin samples from DFM treatment tended to be lighter ($P = 0.054$, 53.9 vs. 51.9 L* value). Collectively, growth performance of pigs was enhanced by dietary supplementation of DFM without affecting loin quality.

Key Words: direct fed microbials, finisher pigs, growth performance, loin

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- 421 **Effects of amino acid supplementation of reduced crude protein (RCP) diets formulated on a NE basis on the fatty acid composition of the LM and jowl subcutaneous fat.** D. G. Cook^{*}, J. K. Apple, C. V. Maxwell, A. N. Young, D. L. Galloway, H. J. Kim, T. C. Tsai, Department of Animal Science, University of Arkansas Division of Agriculture, Fayetteville.

Samples ($n = 108$) of pork LM and jowl s.c. fat were used to test the effects of crystalline AA supplementation of reduced CP diets (formulated on a NE basis) on fatty acid composi-

Table 421. CP (added L-Lysine-HCL) of experimental diets for each feeding phase (% as fed)

Phase	C	RCP1	RCP2	RCP3
1	20.640 (0.350)	18.825 (0.512)	18.433 (0.549)	16.678 (0.716)
2	19.382 (0.334)	16.852 (0.558)	16.498 (0.590)	14.697 (0.763)
3	16.755 (0.285)	14.683 (0.468)	14.079 (0.523)	12.482 (0.675)
4	14.994 (0.253)	13.051 (0.424)	12.611 (0.464)	11.109 (0.607)
5	17.981 (0.300)	16.596 (0.424)	16.198 (0.462)	14.599 (0.614)

tion. Pigs ($n = 216$) were blocked by BW, and pens (6 pigs/pen) within each block were assigned randomly to either corn-soybean meal diets (C) or 1 of 3 RCP diets supplemented with crystalline AA to meet SID AA ratios during each of the 5 feeding phases (23 to 41, 41 to 59, 59 to 82, 92 to 104, and 104 to 127 kg BW). Paylean (10 mg/kg) was included in all diets during the last 3-wk feeding phase. After slaughter and chilling, jowls and whole pork loins were collected from randomly selected carcasses (3 carcasses/pen). Jowl s.c. fat and LM samples were freeze-dried and analyzed for fatty acid composition. Proportions of palmitic acid (16:0) increased (linear, $P = 0.014$) in jowl fat with decreasing CP, but percentages of stearic acid (18:0; $P \geq 0.265$) and total SFA ($P \geq 0.117$) in LM and jowl fat were similar among treatments. Percentages of all MUFA, especially oleic acid (18:1c9), increased with decreasing dietary CP in the LM (linear, $P < 0.001$) and jowl fat (linear, $P \leq 0.014$). Total PUFA percentages were decreased (linear, $P < 0.001$) with decreasing dietary CP. More specifically, decreasing dietary CP reduced (linear, $P \leq 0.001$) weight percentages of linoleic (18:2n6) and linolenic (18:3n3) acids in samples of LM (26.8 and 39.5%, respectively) and jowl fat (10.4 and 32.0%, respectively). The resulting IV for both the LM and jowl s.c. fat was decreased (linear, $P < 0.001$) as CP decreased in the diets. Results indicate that the fatty acid composition of pork lean and fat were altered by reducing dietary CP, and the pattern of increased MUFA composition, particularly in jowl s.c. fat, may imply enhanced de novo synthesis in pigs fed RCP diets supplemented with crystalline AA.

Key Words: fatty acids, net energy, reduced crude protein

422 Effects of Cr supplementation during gestation on beef cow performance and the interaction with Cr during finishing on progeny growth performance and carcass characteristics. S. G. Kneeskern*, A. C. Dilger, S. C. Loerch, D. W. Shike, T. L. Felix, *University of Illinois at Urbana-Champaign, Urbana.*

Objectives were to determine effects of supplemental Cr-propionate (Cr) during cow gestation on cow milk production and performance, and the interaction of supplemental Cr during cow gestation and feedlot finishing on progeny growth performance, intramuscular fat, and other carcass characteristics. Spring-calving, mature cows ($n = 66$; initial BW = 508 ± 100 kg) were fed 1 of 2 supplements from mid- through late gestation (128 d): 1) 1.81 kg pelleted corn fortified with 3 mg Cr-d

¹, or 2) 1.81 kg pelleted corn with no supplemental Cr. There was no effect ($P \geq 0.10$) of treatment on cow BW and BCS change. Supplementation with Cr did not affect milk production at 90 d ($P = 0.20$) or 180 d ($P = 0.89$). There was no effect of treatment on calf birth BW ($P = 0.40$) or weaning BW ($P = 0.56$). Steer progeny ($n = 34$) were used in a 2×2 factorial arrangement of treatments: with the first factor being gestational Cr and the second factor being 0 or 3 mg Cr-d⁻¹ supplementation during the finishing phase. Steers were slaughtered at a targeted 1.27 cm backfat. There was an interaction ($P < 0.01$) of dam and feedlot treatment on days on feed (DOF). Steers from dams fed Cr that also were fed Cr in the feedlot were fed the longest, while steers from dams fed Cr that were not fed Cr in the feedlot had the fewest DOF; steers from dams not fed Cr were intermediate and different from both. Steers from dams fed Cr gained 0.12 kg-d⁻¹ less (trend; $P = 0.09$) than steers from dams not fed Cr during gestation, regardless of feedlot treatment. Proportion of carcasses grading Low Choice and above was fewest (trend; $P = 0.10$) for steers receiving Cr during fetal development and finishing, but greatest for steers receiving Cr only once; steers never receiving Cr were intermediate and different from both. Steers fed Cr during finishing had the greatest ($P = 0.01$) dressing percentage, regardless of gestational supplementation. Supplementation with Cr during gestation did not alter cow milk production or BW and BCS. Supplementation of Cr during both fetal development and finishing increased DOF and tended to decrease proportion of Low Choice and above carcasses, when compared to other treatments. Steers from dams fed Cr tended to gain less in the feedlot, while steers fed Cr only in the feedlot had the greatest dressing percentage.

Key Words: beef, chromium, fetal programming

423 Determining energy value of oil-extracted corn co-products in feedlot diets. A. A. Hohertz*, C. C. Zellmer, A. DiCostanzo, *University of Minnesota, St. Paul.*

A dataset derived from 15 manuscripts containing 85 means for treatments comparing a control diet with diets containing various concentrations of low-, reduced- or full-fat dried, modified wet and wet distillers grains with solubles (DGS) and condensed distillers solubles (CDS) in growing and finishing beef cattle experiments was subjected to a meta-analysis to determine impact of oil extraction in DGS or CDS on performance and energy value. In all instances, DGS or CDS substituted grain or grain and protein supplement source at a given percentage of diet DM without regard to impact on caloric, lipid, protein or dry matter concentrations of dietary treatments. Using a mixed model approach, continuous and discrete independent variables were evaluated through stepwise regression on performance variables (DMI, ADG, feed-to-gain, FTG, analyzed as gain-to-feed, GTF, final BW, and observed ME). Feeding CDS resulted in greater feed conver-

sion efficiency due to greater ADG ($P = 0.02$) at similar DMI ($P = 0.93$). This resulted in greater ($P < 0.04$) observed dietary ME concentration for cattle fed CDS. No differences ($P > 0.24$) were detected in ADG or GTF for cattle fed DGS or control diets. Therefore, observed ME concentration derived from iterating ADG and DMI for cattle fed DGS or a Control diet did not differ ($P = 0.50$). With the exception of impact on DMI, ether extract content, or a measure thereof, proved to be a significant effect on performance with P-values ranging from 0.005 (observed ME) to 0.12 (ADG). In all instances, modeled effects of ether extract on ADG, GTF or observed ME were positive indicating that as ether extract concentration of co-product increases, performance response improved. Effect of co-product ether extract was significant ($P = 0.05$) and reflected an impact of 0.06 Mcal observed ME/1% change in co-product ether extract content. At an average 7.25% ether extract concentration for DGS modeled in this analysis (3.12 Mcal ME/kg DM), the expected ME concentration of full-fat DGS (12% ether extract) would be 3.42 Mcal ME/kg DM. Equivalent NE_g concentrations for DGS containing 12%, 7.25% or 3.5% ether extract, corresponding to average concentrations for full-, reduced- and low-fat DGS, would be 1.66, 1.46 or 1.30 Mcal NE_g /kg DM, respectively. Results of this meta-analysis demonstrated that reducing oil content of corn co-products reduced energy value of co-products.

Key Words: distillers grains, energy value, growing cattle

GRADUATE STUDENT COMPETITION – PhD POSTER

- 424 **Effects of standardized ileal digestible lysine and added tribasic copper chloride on growth performance and carcass characteristics of finishing pigs.** K. F. Coble^{*1}, S. S. Dritz¹, J. L. Usry², M. D. Tokach¹, J. M. DeRouchey¹, R. D. Goodband¹, J. C. Woodworth¹, ¹Kansas State University, Manhattan, ²Micronutrients, Social Circle, GA.

A total of 1,267 pigs (PIC 337 × 1,050; initially 26.4 kg) were used in a 120-d experiment to determine the effects of standardized ileal digestible (SID) Lys and added tribasic copper chloride (TBCC; Intellibond C, Micronutrients, Indianapolis, IN) on growth performance and carcass characteristics of finishing pigs. Pens of pigs were allotted to 1 of 8 dietary treatments in a randomized complete-block design with 26 to 27 pigs per pen and 6 pens per treatment. Treatments were arranged in a split-plot design. Whole-plot treatments included 2SID Lys levels at 92.5 or 100% of the estimated requirement. Within each Lys level, there was a 2 × 2 factorial arrangement of treatments with either 0 or 150 ppm Cu from TBCC with 2 feeding durations (60 or 120 d). All diets were corn-soybean

Table 424.

SID Lys,%	Early TBCC	Late TBCC	ADG,kg	G:F	Yield,%	HCW,kg	Carcass ADG,kg
92.5	-	-	0.88	0.365	75.06	97.8	0.65
	+	-	0.89	0.365	76.11	99.1	0.66
	-	+	0.89	0.369	75.74	99.9	0.67
	+	+	0.88	0.366	76.74	100.3	0.67
100	-	-	0.90	0.373	75.89	100.5	0.67
	+	-	0.91	0.378	75.35	100.8	0.68
	-	+	0.90	0.371	75.60	100.2	0.67
	+	+	0.91	0.373	75.76	101.1	0.68

meal-based with 30% dried distillers grains with solubles (DDGS) and contained 17 ppm of Cu from copper sulfate ($CuSO_4$) provided by the trace mineral premix. There were no 3-way interactions or 2-way interactions for early TBCC × SID Lys, late TBCC × SID Lys, or early TBCC × late TBCC. Overall (d 0 to 120), TBCC did not affect growth performance; however, pigs fed 100% of the SID Lys requirement had increased ($P < 0.05$) ADG, G:F, and final BW compared with those fed 92.5% of the estimated requirement. A significant TBCC × SID Lys interaction ($P < 0.05$) was observed for carcass yield and backfat depth. Hot carcass weight and carcass ADG were improved ($P < 0.05$) when pigs were fed 100% SID Lys compared with those fed 92.5%, and tended ($P < 0.10$) to improve in pigs fed TBCC compared with those not fed TBCC. In conclusion, feeding TBCC did not affect whole body growth performance, but increased HCW and carcass ADG. Also, there was a TBCC × Lys interaction for carcass yield and backfat. Increasing SID Lys from 92.5 to 100% of the estimated requirement resulted in increased ADG, HCW, carcass ADG, and improved G:F.

Key Words: copper, finishing pigs, lysine

- 425 **Effect of dietary lysine on carcass dressing percentage and lean cut yield in late finishing pigs.** T. Wang^{*}, N. Regmi, M. A. Crenshaw, J. R. Blanton, S. F. Liao, *Mississippi State University, Mississippi State.*

Although the lysine requirement of pigs at late finishing stage is lower than that of younger pigs, it is the last production stage for producers to provide optimal levels of dietary lysine to maximize carcass yield and quality. The objective of this study was to evaluate the effect of dietary lysine on growth performance and carcass characteristics of late finishing pigs. A total of 9 crossbred barrows (Yorkshire × Landrace; initial BW 94.4 ± 6.7 kg) were randomly allotted to 3 treatments, and each treatment consisted of three pen replicates with one pig per pen. Three corn and soybean-meal based diets were formulated according to the NRC (2012) requirements for nutrients except for lysine. The total lysine concentrations were 0.43, 0.71, and 0.98% (as-fed basis) for Diets 1 (D1, lysine-deficient), 2 (D2, lysine-adequate), and 3 (D3, lysine-excess), respectively. The feeding trial lasted 5 weeks, during which time the pigs were allowed ad libitum access to the respective

diets and water. Pigs receiving D1 had lower ADG than those receiving D2 or D3 ($P < 0.05$), but no difference was found between the D2 and D3 pigs. Although there were no significant differences ($P > 0.08$) in the hot carcass weights among the 3 treatment groups, the loin eye area of the D1 group was reduced by 15% (6.2 cm²) when compared to the D2 group ($P < 0.05$), but no difference ($P = 0.77$) were detected between the D3 and D2 groups. Both the trimmed and untrimmed ham weights of the D1 group were decreased by approximately 17% (4.0 kg) compared to the D2 or D3 group ($P < 0.05$). The dressing percentage and the total lean cut weight were both linearly increased ($P < 0.05$) with the dietary lysine concentrations. The carcass shrinkage, the back-fat thickness, and the visual scores for loin color, loin marbling, and ham color were not affected by dietary lysine level ($P > 0.15$). In conclusion, while the lysine-deficient diet reduced the loin eye area and the ham weights, the lysine-excess diet linearly increased the dressing percentage and the total lean cut weight. Data from this study confirmed the importance of dietary lysine supply for the overall carcass yield and quality of late finishing pigs and indicated that there is still some room for improving dressing percentage and lean cut yield via more dietary lysine supply. This research was supported by USDA-NIFA Hatch/Multistate Project 233803.

Key Words: dressing percentage, late finishing pigs, lean cut yield, lysine

426 Feeding vitamin E may reverse sarcoplasmic reticulum membrane instability caused by feeding wet distillers grains plus solubles to cattle.

M. D. Chao*, K. Domenech-Perez, C. R. Calkins,
University of Nebraska-Lincoln, Lincoln.

Feeding wet distillers grains plus solubles (WDGS) in beef feedlot diets increases polyunsaturated fatty acid (PUFA) concentration in the sarcoplasmic reticulum (SR) membrane, thereby altering membrane integrity, resulting in more rapid post-rigor calcium leakage and improving tenderness through early activation of calcium dependent proteases. Supplementation with antioxidants may mitigate such effects. One hundred and sixty cross-bred steers were finished on either corn or 30% WDGS with 4 antioxidant treatments [none – control; vitamin E (VitE) at 450 mg (1,000 IU)/hd/d; Agrado Plus (Ag) at 3 g/hd/d (215 ppm of feed); a combination of 225 mg (500 IU)/hd/d of VitE and 3 g/hd/d of Ag]. Ten strip loins from each treatment ($N = 80$) were aged for 2, 7, and 14 d. Steaks from each aging period were placed under retail display conditions for 0, 4, and 7 d. Discoloration, tenderness (WBSF), free calcium concentrations, lipid oxidation, sarcomere lengths, proteolysis, and SR lipid, phospholipid and fatty acid profiles were measured. Feeding VitE was effective in reducing ($P < 0.01$) lipid oxidation for all three display periods in beef from cattle fed corn and was effective in maintaining color stability after 6 d of retail display ($P < 0.01$) in beef from both corn and

WDGS diets. Without antioxidant supplementation, there were no differences in discoloration scores between the two dietary treatments for any of the aging and display periods, but steaks from corn-fed steers had higher lipid oxidation values at all three display periods compared to steaks from steers fed 30% WDGS. Feeding WDGS decreased ($P < 0.01$) total saturated fatty acids in the SR membrane, tended to decrease ($P = 0.09$) total monounsaturated fatty acids, and increased ($P = 0.01$) total PUFA. Furthermore, steaks from steers fed WDGS had more ($P < 0.05$) phosphatidylcholine in the SR membrane, but less ($P < 0.05$) phosphatidylethanolamine compared to steaks from steers fed corn or WDGS supplemented with VitE. There were no differences in tenderness, sarcomere length, or free calcium concentrations among steaks from steer in any of the treatments, aging and display periods. At 2 d postmortem, steaks from steers fed WDGS had more proteolysis compared to steaks from steers fed corn only or WDGS supplemented with VitE. These results suggest that the alteration of SR fatty acid profile in WDGS fed cattle may affect the ratio of SR membrane phospholipids, and thus contribute to differences in proteolysis. Feeding VitE mitigates such effects.

Key Words: distillers grains, fatty acids, sarcoplasmic reticulum

427 Oral administration of amino acids as energy sources for newborn piglets. N. E. Manzke*^{1,2},

G. C. Hoch³, B. Gomes¹, M. Kutschenko⁴,
E. G. Xavier⁵, G. J. M. M. De Lima⁶, E. Nogueira⁴,

¹Universidade Federal de Pelotas, Pelotas, Brazil,

²North Carolina State University, Raleigh,

³Universidade Federal do Pampa, Uruguaiana,

Brazil, ⁴Ajinomoto do Brasil/Ajinomoto Animal

Nutrition, S_o Paulo, Brazil, ⁵Universidade Federal de Pelotas (UFPEL) - Brazil, Pelotas, Brazil,

⁶Embrapa, Concordia, Brazil.

Amino acids may be a readily available source of energy, especially to young animals, promoting beneficial effects on performance, health and immune status. The objective of this study was to evaluate the effects of glutamine (Gln), glutamic acid (Glu), AminoGut (Amg) and Arginine (Arg) supplementation on performance and blood parameters. Fifty litters, selected based on genotype and parity, were distributed according to a Latin square. Within each litter, five piglets were chosen with body weights close to litter average. Treatments consisted of two intragastric applications of doses containing one of the following: Control: no supplementation; Gln: 2.89 g L-glutamine + 7 mL of water; Glu: 3.14 g L-glutamic acid + 10 mL of water; Amg: 3.19 g of the commercial mixture of L-glutamine and L-glutamic acid + 7 mL of water; Arg: 2.94 g L-glutamic acid + 8 mL of water. Doses were calculated based on energy needs of 10.95 kcal/pig/day (unpublished data). Piglets were supplemented with the first dose provided just after colostrum consumption and the second dose 24 h

Table 427. Growth performance of piglets

BW (kg)	Control	Amino acid			SEM	P-value
		Glutamine	Acid Glutamic	Amino- Gut		
Birth	1.41	1.39	1.40	1.40	1.40	0.01 0.575
7 days	2.80 ^{ab}	2.68 ^{bc}	2.82 ^{ab}	2.86 ^a	2.52 ^c	0.06 <0.01
Weaning	5.54 ^a	5.38 ^a	5.59 ^a	5.76 ^a	4.87 ^b	0.15 <0.01

^{a,b,c} Values within row with different superscripts differ, $P < 0.05$.

after. Data from each response was analyzed using MIXED procedure in SAS software. Arg supplementation reduced ($P < 0.05$) piglet's body weight at 7 d and weaning. Other treatments did not affect the performance of piglets, even though piglets fed AminoGut numerically increased 4% weight weaning. Mortality was not affected by treatments. There were no treatment effects ($P > 0.05$) in plasmatic levels of glucose, creatinine, urea, triglycerides, aspartate transaminase and alanine transaminase. Amino acid supplementation did not show significant variation in blood parameters and performance of newborn born piglets. Future studies should be conducted for the purposes of studying the supplementation of functional amino acids for newborn piglets.

Key Words: arginine, glutamic acid, glutamine

428 Differential microRNA expression in sperm cells and seminal plasma due to PRRSV infection.

S. M. Calcaterra^{*1}, D. L. Reicks², A. Feltus¹,
S. L. Pratt¹, ¹Clemson University, Clemson, SC,
²Swine Vet Center, Saint Peter, MN.

The objectives of this study were to detect differentially expressed (DE) microRNAs (miRNAs) due to PRRSV infection in sperm cells and seminal plasma and to perform functional enrichment analyses on predicted targets of these miRNAs. All animal work was performed at the Swine Veterinary Center (Saint Peter, MN) where six terminal crossbred boars were inoculated intramuscularly with 2 mL of 2×10^4 viral RNA copies/mL PRRSV strain 1-8-4 on day 0. Semen was collected two days prior to inoculation (-2 dpi) and six days post-inoculation (6 dpi). The cellular fraction was separated by centrifugation and both sperm cells and seminal plasma aliquots were flash frozen and stored at -80°C . RNA was isolated using the mirVana miRNA Isolation Kit and used in custom microarray analyses (LC Sciences, Houston, TX) based on our porcine sperm cell and seminal plasma sequencing data. Individual microarrays were performed using 3 biological replicates from -2 dpi and 6 dpi. Differential expression was determined significant by $P < 0.05$ and a fold change threshold of less than or greater than two-fold. Potential miRNA targets were predicted using miRanda 3.3a with a score threshold of 140 and energy threshold of -20 kcal/mol. Targets were then analyzed for enrichment of Gene Ontology (GO) and InterPro (IPR) terms and were considered to be enriched if $P < 0.01$ using the Bonferroni correction. Microarray analyses resulted in 83 DE miRNAs in sperm and 10 DE miRNAs in seminal plasma when

comparing -2 dpi and 6 dpi. Enrichment analyses revealed that the predicted targets of 35 DE sperm miRNAs and 9 DE seminal plasma miRNAs have functions and/or conserved protein domains that are significantly enriched when compared to the pig genome. Enriched terms of the sperm transcripts included lung epithelium development, cAMP response element binding protein, lactation, lung saccule development, regulation of cell size, positive regulation of cell adhesion, P2X7 purinoceptor, Peptidase S9B, Leucine-rich repeats, Peptidase C48, and phosphorylated immunoreceptor signaling. Transcripts from seminal plasma were enriched for ion channel activity, P2X purinoreceptor, Transglutaminase, endoplasmic reticulum signal peptide binding, and Signal Recognition Particles, among others. This data is the first to report differential miRNA expression in sperm and seminal plasma due to PRRSV infection. Further studies involving qPCR of predicted miRNA targets should be performed for a greater understanding of PRRSV infection at a molecular level.

Key Words: microRNA, PRRS, semen

UNDERGRADUATE STUDENT COMPETITION – POSTER

429 Effects of age and time of day on standing behavior between commercially-housed ewes and their lambs. M. S. Palmer*, T. W. Harris, K. M. Hoelting, J. D. Allen, Northwest Missouri State University, Maryville.

The purpose of this study was to determine the behavioral patterns of 2 groups of commercially-housed ewes and their pre-weaned lambs in a 30 day period. Behavioral data was collected from 7 Suffolk ewes and their respective cross-bred lambs ($N = 10$; 4 singlets and 3 sets of twins) utilizing HOB0 Pendant G data loggers (Onset Computers, Bourne, MA) fitted on the rear cannon bone of each animal and set to record every minute. Data was analyzed as a completely randomized design, with the sheep being the experimental unit. Daily standing time was greater ($P < 0.01$; 737.5 vs. 485.1 ± 23.82 min/d, respectively) for the ewes compared to the lambs. Contrarily, the lambs had more ($P < 0.01$; 36.1 vs. 22.9 ± 1.25 bouts/d, respectively) total standing bouts throughout the day than the ewes; however, standing bout durations were greater ($P < 0.01$; 33.3 vs. 14.4 ± 1.14 min/bout, respectively) in the ewes than lambs. No difference was observed ($P > 0.10$) between single lambs and lamb twins in standing time and number of standing bouts during the day. Also, the duration of standing bouts were similar ($P > 0.10$) between single lambs and lamb twins. Overall, the ewes were more likely ($P > 0.01$; 49.7 vs. 32.6 ± 2 percent/day, respectively) to be standing at a given time compared to lambs. Overall likelihood of an animal standing increased ($P < 0.01$) as age of the lamb (day of trial) increased. Percent likelihood to

stand was greatest for both ewe and lamb ($P > 0.10$; 68.6 and 43.8 \pm 1.58 percent, respectively) in the late afternoon (1200 to 1800 h). Results indicate that sheep standing behavior is affected by age of animal and time of day.

Key Words: behavior, daily activity, sheep

430 **Effect of different light sources on discoloration of fresh ground beef.** J. Cooper^{*1}, B. R. Wiegand², A. B. Koc², L. Schumacher², C. L. Lorenzen², ¹Oklahoma State University, Stillwater, ²University of Missouri, Columbia.

Color of fresh meat has a distinct impact on consumer purchasing habits. If a product shows signs of discoloration this can cause purchase discrimination by many consumers, thus leading to discounted prices or spoilage causing significant profit loss to the meat industry. This study was conducted to analyze the effects of two different lighting sources [fluorescent (FLO) and light emitting diode (LED)] used in retail settings on the rate of discoloration of fresh ground beef. Fresh, never frozen beef was ground and fat added to achieve approximately 30% fat. Sixty three, 113.4 g patties were packaged on Styrofoam trays, overwrapped with oxygen permeable film, and divided into three light treatments: LED, FLO, and dark (DRK; used as a control). Patties were then placed into their respective lighting chambers in the cooler that was approximately 1.1 °C. Over the next seven days, three patties were removed each day from each lighting chamber for surface temperature, L*, a*, b* readings, oxymyoglobin content (OMB₂) and fat and moisture percentage analyses. Data showed that surface temperatures ranged from 0.39 to 5.39 °C. FLO patties were warmer ($P < 0.05$) than DRK and LED patties. Patty temperatures under LED treatment were midrange of those of DRK and FLO. Redness of patties faded over time ($P < 0.05$) as evidenced by a* values with FLO treated patties having substantial fading after day three while LED treated values did not have a substantial decline until day five. Oxymyoglobin values revealed FLO treatment had the lowest amount of OMB₂ ($P < 0.05$). Overall, data indicates that patties under LED lighting may increase shelf life by two days in a retail setting.

Key Words: color, ground beef, LED, light source

431 **Differences in forage quality when comparing novel and endophyte-infected fescue over the grazing season.** M. E. Bloemer^{*}, M. Srinivasan, F. A. Ireland, D. W. Shike, T. L. Felix, *University of Illinois at Urbana-Champaign, Urbana.*

Objectives were to compare forage characteristics and in situ digestibility of novel and endophyte-infected tall fescue over the growing season. Tall fescue is widely used for grazing beef cattle predominantly in the Southeastern United States. Endophyte-infected tall fescue (KY-31) possesses many positive agronomic qualities, but can depress cattle growth due

to ergot alkaloid-producing endophytes. Novel endophyte-infected tall fescue (MaxQ) combines the agronomic advantages of KY-31 with improved cattle performance. However, comparison of forage quality between MaxQ and KY-31 is lacking. We hypothesized MaxQ would have greater in situ digestibility than KY-31, in part due to decreased ADF and NDF concentrations when compared to KY-31. Samples were taken at 10 d intervals over 70 d, beginning May 28. Clipped samples were collected from randomly selected locations in 4 different paddocks per cultivar at each time point. Forages were analyzed for DM, NDF, and ADF. Composite samples were incubated in ruminally fistulated steers ($n = 2$) for 12 and 24 h to determine in situ DM disappearance (DMD) and NDF disappearance (NDFD). Data were analyzed using the MIXED procedures in SAS (SAS Inst. Inc., Cary, NC) with repeated measures. There were interactions of cultivar by d collected for ADF ($P = 0.03$) and NDF ($P < 0.01$). On d 20, 30, 50, and 60 of collection, paddocks of KY-31 had 2.5 to 7.8 percentage units greater NDF than paddocks of MaxQ. Similarly, on d 20, 30, 50, 60, and 70 of collection, paddocks of KY-31 had 3.0 to 6.2 percentage units greater ADF than paddocks of MaxQ. There were no interactions ($P \geq 0.16$) of cultivar, incubation time, or week sampled for DMD. As expected, the 24-h in situ DMD was greater ($P < 0.01$) than the 12-h in situ DMD. Over the course of the growing season, DMD of both MaxQ and KY-31 decreased ($P < 0.01$). There was an interaction ($P = 0.05$) of incubation time and sampling d on NDFD. From d 10 through d 40, 24-h NDF digestibility was greater than 12-h NDF digestibility; however, from d 50 through d 70, there was no difference in 12 versus 24-h in situ NDF digestibility. Although forage quality differed over the growing season, lack of difference in in situ DMD and NDFD between MaxQ and KY-31 suggest that improved forage quality is not the mechanism for increased performance of cattle grazing MaxQ compared to those grazing KY-31.

Key Words: cattle, fescue, forage quality

432 **Impact of porcine respiratory and reproductive virus on behavior and welfare of growing pigs.** H. Wooten^{*1}, J. Mcglone¹, W. D. Stuart¹, K. Schwartz², N. K. Gabler², C. F. de Lange³, T. E. Burkey⁴, A. Rakhshandeh¹, ¹Texas Tech University, Lubbock, ²Iowa State University, Ames, ³Department of Animal and Poultry Science, University of Guelph, Guelph, ON, Canada, ⁴University of Nebraska, Lincoln.

The Porcine respiratory and reproductive virus (PRRSv) is one of the leading causes of negative pig welfare and substantial loss of profits in the US swine industry. Little is known about the effect of PRRSv on the sickness behavior of growing pigs. Therefore, in the current study we investigated the effects of PRRSv on the behavior and welfare of growing pigs. A total of 20 PRRS negative gilts (BW 9.4 \pm 0.9 kg) from a commercial line were fed restricted (550 g/d) a

corn and SBM based diet, individually housed in metabolism crates and then inoculated intramuscularly with a live PRRSV (d 0). Blood samples were collected via the jugular vein at 0, 2, 4, 6, 8, and 9 days post inoculation (dpi), and assayed for blood urea nitrogen (BUN), glucose (Glu), creatinine, hematocrit (Hct), hemoglobin Hb, anion gap (AGap) and serum viral load. A video monitoring system was used to collect behavior data before (pre-challenge, d -3 to 0 dpi) and after the PRRSV challenge (post-challenge, d 0 to 9 dpi). Eye temperature of pigs was measured on a daily basis using an infrared imaging technique. All pigs became PRRSV-positive within 2 to 4 dpi as assessed by qPCR titers. Serum viral load was highest at 4 dpi and remained elevated until 9 dpi. Relative to d 0, the 9 d PRRSV challenge increased eye temperature from 37.7 to 38.7 °C (SE 0.12), AGap (from 13 to 17 mEq/L, SE 0.7), and creatinine concentrations (from 0.7 to 0.8 mg/dl, SE 0.03). However, PRRSV infection decreased the levels of blood Glu (from 93 to 85 mg/dl, SE 6.0) and Hb (from 12 to 8 g/dl, SE 0.9; $P < 0.05$). No effect of PRRSV was seen on BUN and Hct ($P > 0.05$). During the post-challenge period pigs displayed an increase in lying frequency (pre- vs. post-; 77 vs. 85% of time, SE 3.3; $P < 0.05$), a decrease in eating and drinking frequency (11 vs. 7%, SE 1.1; $P < 0.05$), and a tendency to decrease overall activity (13 vs. 9%, SE 2.5; $P < 0.09$) compared to the pre-challenge period. During the post-challenge period pigs consumed 55% of their daily feed allowance ($P < 0.05$). Collectively, these results suggest that the porcine respiratory and reproductive virus alters physiology and directly impacts the behavior and welfare of growing pigs. NPB project #13-082

Key Words: behavior, pig, PRRS

433 Prediction of primal cut weights in pigs using a non-linear mixed procedure. C. A. Hegg¹, F. A. Cabezon¹, A. P. Schinckel¹, A. C. Kloth², C. Northington², E. B. Sheiss², A. W. Duttlinger², ¹Purdue University, West Lafayette, ²Indiana Packers Corporation, Delphi, IN.

The objective of this trial was to model the relationships of carcass measurements and primal cut weights to carcass weight and estimate the residual variation. Data from 558 pigs (94.16 ± 7.6 kg of hot carcass weight, HCW) were collected at a pork processing plant. To get an accurate representation of a normal production day, several suppliers were chosen based on their relative participation on the total pigs provided to the plant. Hot carcass weight, loin depth (LD), backfat depth (BF) and percent lean (PL) were recorded for each pig during the slaughter process. Primal cut belly, butt, picnic, sparerib, ham and loin weights were recorded for each carcass side. To linearize the allometric function ($Y = AX^B$), natural logarithm to natural logarithm transformation was performed ($LN Y = LNA + B LN X$). To evaluate which combination of explanatory variables were best, different models were tested. For all cut weights, a model that included LNHCW, SIDE,

Table 433. Estimates for predicting cut weights using an overall equation.

Weight, kg	A Estimate	B		b ₁ -BF Est.	b ₂ -LD Est.	b ₃ -SIDE Est.	Residual Variance
		Est.	SE				
Belly	0.054	1.074	0.04	0.041			0.35
Butt	0.066	0.919	0.04	-0.037			0.15
Ham	0.149	0.947	0.02	-0.047		0.090	0.41
Loin	0.206	0.881	0.02	0.039	0.012	0.294	0.37
Picnic	0.084	0.892	0.02	-0.021		-0.047	0.09
Sparerib	0.013	1.092	0.04	-0.013		-0.083	0.04

All b₁-BF estimates ($P < 0.001$)

b₂-LD estimate ($P < 0.001$)

All b₃-SIDE estimates ($P < 0.001$)

SUPPLIER and LNHCW*SUPPLIER interaction was used, then LD and BF were added. A non-linear mixed procedure (SAS) was used to fit the model for cut weight which was: cut weight = A*(HCW)^B + b₁(BF -19.65) + b₂(LD - 62.37) + (b₃*SIDE). The effect of SIDE was significant for estimating sparerib, ham, picnic and loin weights ($P < 0.001$). Also LD was significant for the estimation of loin weight ($P < 0.001$). For belly and picnic cuts, SUPPLIER was significant ($P < 0.05$). Estimates for an equation to predict belly and picnic weights for each supplier were performed. Pork primal cut weights can be estimated using a non-linear mixed model.

Key Words: primal cut, non-linear mixed procedure, allometric function.

434 Effects of different applications of pyrethrin/pyrethroid insecticides on bull reproductive parameters. C. L. Timlin*, J. L. Stewart, F. A. Ireland, C. F. Shipley, V. L. Jarrell, D. W. Shike, T. L. Felix, University of Illinois at Urbana-Champaign, Urbana.

Objectives of this experiment were to evaluate the long-term effects of pyrethroid and pyrethrin sprays, in combination with ear tag and pour-on insecticides, on bull semen quality and serum testosterone concentrations. There are concerns in the beef industry over the impacts of pyrethrins on fertility. Short-term (9 wk) studies have shown no effects of pyrethrin and pyrethroids on sperm quality in beef bulls, but one study reported reduced serum testosterone concentrations at wk 9. Therefore, we hypothesized that exposing bulls to the fog and premise sprays, in combination with the fly tag and pour-on treatments, would reduce semen quality and decrease serum testosterone over an extended time (18 wk), compared to no treatment or fly tag and pour-on. Angus, Simmental, and Angus x Simmental bulls ($n = 28$) were randomly assigned to 1 of 3 treatment groups: (1) no exposure to pyrethrin applications (CONT; $n = 10$), (2) fly tags and pour-on (TAG+POUR; $n = 9$), or (3) fly tags, pour-on, premise spray and fog spray (TAG+POUR+SPRAY; $n = 8$). Bull BW, semen, and blood were collected every 3 wk during the 18 wk trial. Semen was collected via electroejaculation and assessed, using computer-assisted semen analysis, for overall and progressive motility, and morphology. Blood was collected from the tail vein and

serum testosterone concentrations were analyzed. Data were analyzed using the MIXED procedures in SAS (SAS Inst. Inc, Cary, NC) with repeated measures for motility, morphology, serum testosterone, and BW. There was a treatment \times wk interaction ($P < 0.01$) for sperm with primary defects. At wk 18, CONT bulls had a greater ($P = 0.01$) percentage of sperm with primary defects than bulls treated with insecticides. Insecticide treatment did not affect overall motility ($P = 0.84$), progressive motility ($P = 0.68$), percent normal sperm ($P = 0.43$), or percent of sperm with secondary defects ($P = 0.38$). However, over time, overall and progressive motility, and normal morphology of sperm samples decreased ($P < 0.01$). There was no treatment \times wk effect ($P = 0.81$) or treatment effect ($P = 0.25$) on serum testosterone concentrations. However, serum testosterone decreased ($P < 0.01$) over time. Bull BW, BCS, and scrotal circumference were not affected ($P \geq 0.14$) by treatment. The use of pyrethrin and pyrethroid based insecticides, regardless of application, did not negatively impact reproductive parameters in beef bulls.

Key Words: beef bulls, insecticides, reproduction

435 **Role of exogenous estrogen in initiation of estrus and induction of an LH surge.** C. L. Mogck¹, C. A. Madsen^{1,2}, T. W. Geary², G. A. Perry¹, ¹South Dakota State University; Department of Animal Sciences, Brookings, ²USDA ARS Fort Keogh, Miles City, MT.

Among cattle the Luteinizing Hormone (LH) surge that causes ovulation occurs shortly after the onset of a spontaneous estrus. In addition an injection of 100 mg of Gonadotropin Releasing Hormone (GnRH) can induce an LH surge capable of inducing ovulation. We hypothesized that different preovulatory estradiol profiles would result in different ovulatory LH surges, and that an injection of GnRH (100 mg) would induce a secondary LH surge among cows that exhibited standing estrus prior to the GnRH injection. In order to establish the importance of estradiol on initiating an LH surge, ovariectomized multiparous cows ($N = 26$) received estradiol cypionate (ECP), estradiol benzoate (EB) or no treatment (CON) to mimic a preovulatory period. Prior to treatment, all cows received a progesterone-releasing device (CIDR) for 7 d, 25 mg injection of prostaglandin-F₂α (PGF) at CIDR removal (d -2), and an injection of GnRH (100 μg; d 0 h 0) 2 d later to mimic the follicular phase. Utilizing a 3 \times 3 Latin Square design, cows received either ECP 36 h before GnRH injection, EB 12 h before GnRH injection, or no estradiol (CON). Blood samples were collected every 4 h from h -36 to GnRH and every 30 min from GnRH until h 2.5. Peak LH concentration and interval from GnRH to peak LH was analyzed using the GLM procedure in SAS. Circulating concentrations of LH were analyzed as repeated measures using the MIXED procedure in SAS. There was an effect of treatment on peak concentration of LH with EB treated cows having a greater ($P < 0.01$) peak LH concentrations (20.5 ± 3.0 ng/mL) than

ECP (9.9 ± 3.0 ng/mL) or CON (10.6 ± 3.1 ng/mL). In addition, there was a difference in the interval from GnRH to peak LH concentration with ECP treated cows reaching peak LH concentrations 638.3 \pm 41.8 min before GnRH and EB and CON cows reaching peak LH concentrations after GnRH (83.3 ± 41.8 and 35.3 ± 43.0 min, respectively). There was an effect of treatment, time, and a treatment by time interaction ($P < 0.01$) on circulating concentrations of LH, with ECP treated cows having increased concentrations of LH at hour -16, -12, -8, and -4 compared to EB and CON. However, EB had greater concentrations of LH than ECP at 30, 60, 90, 120, and 150 min after GnRH and CON having greater concentrations of LH at 30 and 60 min after GnRH compared to ECP. In summary, exogenous estradiol influenced timing and peak concentrations of an LH surge.

Key Words: estradiol, gonadotropin releasing hormone, luteinizing hormone

436 **Effects of diet form and distillers dried grains with solubles (DDGS) on stomach morphology and ulceration scores in growing-finishing pigs.**

I. M. Grossman*, M. F. Overholt, J. E. Lowell, H. H. Stein, E. K. Arkfeld, A. C. Dilger, D. D. Boler, University of Illinois, Urbana-Champaign, Urbana.

As particle size decreases in swine diets, growth efficiency of pigs increases, but the occurrence of stomach ulcers can also increase. In addition to being an animal health concern, stomach ulcers can reduce the value of pig stomachs as by-products. On average, the stomach of a finisher pig weighs 0.60 kg and is valued at approximately \$0.67/kg. The total value of by-products (drop value) of a pig is currently \$10 to \$15; the stomach represents between 2.5 and 4% of drop value. Therefore, an increase in stomach ulcerations has economic implications for the meat industry. The objectives of this study were to determine differences in stomach morphology and ulceration scores of barrows and gilts fed pelleted or mash diets without or with 30% distillers dried grains with solubles (DDGS). Pigs ($N = 192$) were randomly allotted to 1 of 4 dietary treatments, with 12 replicate pens per diet, and 2 barrows and 2 gilts per pen. The 4 dietary treatments were: pelleted diet with 0% DDGS, pelleted diet with 30% DDGS, mash diet with 0% DDGS, and mash diet with 30% DDGS. A subset of 96 pigs (the heaviest barrow and gilt from each pen) were selected for stomach evaluation. Stomach weight, absolute and as a percentage of live weight, was recorded. Stomachs were scored using a 10 point scale where 0 represented a normal, healthy stomach and 10 represented a stomach with one or more bleeding ulcers and an esophagus opening diameter less than 2 mm. Data were analyzed as a 2 \times 2 factorial arrangement in a randomized complete block design with pen as the experimental unit. For all stomach traits, the interaction of diet form and DDGS inclusion was not significant ($P > 0.44$). Absolute stomach weight was not different among

treatments ($P \geq 0.25$). Stomach weight as a percentage of live weight tended to be increased ($P = 0.07$) 0.02 percentage units in pelleted-fed pigs compared with mash-fed pigs, but was not affected by DDGS inclusion ($P = 0.36$). Pelleting diets increased ulceration scores from 1.27 to 1.79 ($P < 0.01$), but there was no difference in ulceration score between DDGS treatments ($P > 0.10$). Overall, all stomachs in this study were considered healthy, but packers should be aware of potential economic impacts on the value of stomachs as by-products due to dietary particle size of swine diets.

Key Words: pelleting, pigs, ulcers

437 **Effects of a low-protein, high-fiber supplement on performance, blood metabolites, and first-service AI conception rate in beef cows grazing lush pasture.** M. Jarboe*, K. Doungkamchan, W. T. Meteer, W. P. Chapple, D. W. Shike, *University of Illinois at Urbana-Champaign, Urbana.*

The objective of this study was to evaluate the effects of a dry, low-protein, high-fiber supplement on performance, blood metabolites, and first-service AI conception rates. Spring-calving, lactating Simmental and Simmental-Angus cows ($n = 117$) were stratified by breed and BW and allotted to 6 pastures. Pasture groups were randomly assigned to 1 of 2 treatments: control (CTRL, no supplement), and supplement (SUP, 1.8 kg supplement·cow⁻¹·d⁻¹). Supplement contained 45% ground corn cobs, 45% soybean hulls, and 10% dried molasses. Cows grazed tall fescue, orchard grass, red clover, and white clover mixed pasture for 70 d (April 28 to July 7, 2014). Clip samples were collected from new pastures as groups were rotated. Cows were bred via timed AI on d 10. Serum from d 0, 7, and 18 was pooled by pasture group within d and analyzed for NEFA, beta-hydroxybutyrate (BHBA), and blood urea nitrogen (BUN) concentrations. Conception rate was determined via palpation and ultrasound on d 45. Data were analyzed using the MIXED procedures in SAS (SAS Inst. Inc, Cary, NC) with repeated measures for CP, ADF, NDF, DM, NEFA, BHBA, and BUN. There were no treatment by time interactions ($P \geq 0.63$), nor treatment effects ($P \geq 0.07$) for pasture composition. Over time, CP decreased ($P < 0.01$); however, ADF ($P < 0.01$) and NDF ($P < 0.01$) increased. Over time, DM did not differ ($P = 0.20$). Treatment did not affect final BCS ($P = 0.97$) and BW ($P = 0.77$). There was no difference ($P = 0.83$) in percentage of cows cycling prior to estrus synchronization between treatments (CTRL, 68%; SUP, 69%). There were no treatment by time interactions ($P \geq 0.45$) for NEFA or BUN. Treatment did not affect ($P = 0.80$) serum NEFA concentrations. Serum concentration of BUN tended ($P = 0.09$) to be greater in CTRL cows compared to cows fed SUP. There was a treatment by time interaction ($P = 0.02$) for BHBA. On d 10, serum concentrations of BHBA were greater ($P < 0.01$) for cows fed SUP compared to CTRL cows; however, on d 18, there were

no differences ($P = 0.66$) between treatments. There was no difference ($P = 0.64$) in conception rate between treatments (CTRL, 38.5%; SUP, 51.7%). In conclusion, a low-protein, high-fiber supplement did not affect BW and BCS, or significantly improve first-service AI conception in cows grazing lush pasture in early spring.

Key Words: beef cow, reproduction, supplementation

438 **Are porcine epidemic diarrhea virus (PEDv) exposed gilts and sows farrowing problems improved by vitamin E?** R. Becerra^{*1}, J. E. Link¹, K. C. Turner², J. T. Gebhardt¹, R. L. Stuart³, G. M. Hill¹, ¹Michigan State University, East Lansing, ²Michigan State University, Okemos, MI, ³Stuart Products Inc, Bedford, TX.

Porcine Epidemic Diarrhea Virus (PEDv) is a coronavirus that infects epithelia cells lining the small intestine of pigs. Producers and veterinarians believe that sows exposed to PEDv have longer farrowing times and an increased number of mummies and pigs born dead especially when more than 10 piglets are farrowed in a litter. Since vitamin E (E) is important in reducing oxidative stress and improving immunity, the objective of our research was to determine if E increases survivability of offspring and reduces farrowing time in PEDv exposed sows. Following confirmation of pregnancy, 22 PEDv exposed sows and gilts were given a 5 ml i.m. injection of Vital E Repro (300 I.U. E, 200,000 I.U. Vitamin A, 100,000 I. U. Vitamin D₃) or saline 7 days before farrowing. Sows were observed during farrowing and weighed before and after. Pigs were weighed at birth and weaning. Sow parity, body condition score, pre- and post-weaning weights did not differ between treatments ($P \geq 0.32$). However, farrowing time was reduced ($P = 0.05$) for sows injected with E vs. saline (190 vs. 287 min), respectively. Number of pigs born to sows given the E injection was not different ($P = 0.10$) than those injected with saline (11.6 vs. 13.5). Similarly, number of live births was not different (10.5 vs. 12.0, $P = 0.10$). Number of pigs weaned from sows given the E injection did not differ from pigs born to sows given saline (9.7 vs. 11.6; $P = 0.06$), respectively. The mean litter weight at birth did not differ between the E and saline injected sows (13.5 vs. 15.1 kg, $P = 0.32$) nor did litter weaning weight differ (57.5 vs. 59.1 kg, $P = 0.81$), respectively. The plasma E concentrations of the pigs at 3 d (5.00 vs. 5.25 ppm, $P = 0.61$), 21 d (3.15 vs. 3.05 ppm, $P = 0.10$), and 42 d (1.03 vs. 0.73, $P = 0.10$) did not differ by sow's treatment with E or saline, respectively. With the limited number of observations, the vitamin E injection did not affect number of pigs born or their weight but did reduce farrowing time and tended to prevent a reduction in circulating vitamin E concentrations.

Key Words: nursery pig, sow, vitamin E

439 Influence of forage inclusion level on growth performance and feeding behavior in finishing steers.

M. C. Ruch*, T. C. Gilbery, S. R. Underdahl, M. L. Bauer, K. C. Swanson, *North Dakota State University, Fargo.*

Forty-four steers (452 ± 4.6 kg) predominately of Angus and Simmental origin were used in a randomized block design to determine the effects of forage inclusion level on growth performance and feeding behavior in finishing steers. Steers were fed dry-rolled corn based diets which included a mixture of hay and corn silage as the forage source. Dietary treatments were 5%, 10%, 15%, or 20% forage. Diets were fed for 84 days. Feed intakes and feeding behavior were measured using the Insentec system. A visit was defined as each time the Insentec system detected a steer at a bunk. A meal was defined as eating periods which may include short breaks separated by intervals not longer than 7 min. Animals were weighed the first 2 days, then every 28 days after, and finally the last two days of the study. Steers were slaughtered with an average weight of 625 kg. There was a linear decrease ($P \leq 0.02$) in DMI intake, ADG, and G:F as forage inclusion increased. Number of visits and meals per day and eating time per visit, per meal, and per day were not affected by forage inclusion. Feed DMI per visit did not differ between treatments but eating rate per meal decreased linearly ($P < 0.001$) with increasing forage inclusion. Eating rate (g/min) responded quadratically ($P = 0.04$) with the greatest eating rate observed in the 10% forage treatment. Hot carcass weight and dressing % decreased ($P = 0.02$) linearly as forage inclusion increased. These results indicate that a decrease in forage inclusion in a finishing diet will increase DMI, ADG, and G:F as well as increase DMI per meal.

Key Words: behavior, finishing steers, forage, growth

440 Evaluation of further processing methods for soybean meal in diets for nursery pigs.

A. M. Jeffrey*, H. L. Frobose, M. D. Tokach, R. D. Goodband, S. S. Dritz, J. C. Woodworth, J. M. DeRouchey, *Kansas State University, Manhattan.*

A total of 296 mixed sex pigs (PIC 327 \times 1,050; 6.5 ± 1.4 kg BW and 21 d of age) were used in a 31-d experiment evaluating the effect of further processing methods for soybean meal on nursery pig growth performance. There were 11 replicate pens per treatment with 6 or 7 pigs per pen. At weaning, pigs were allotted to pens by initial weight to 1 of 4 treatments in a completely randomized design. A 3-phase diet series was used with experimental diets fed during phase 1 (d 0 to 7) and phase 2 (d 7 to 20), and a common diet fed during phase 3 (d 20 to 30). Experimental treatments were: 1) Negative control (NC: 38.5% SBM and 25% dried whey), 2) Fermented soybean meal processing method 1 (FSBM1; Nutraferma, Sioux City, IA), 3) Fermented soybean meal processing method

Table 440.

	NC	FSBM1	FBSM2	ETS	SEM	<i>P</i> <
d 0 to 7						
ADG, g	76 ^{ab}	74 ^{ab}	96 ^b	64 ^a	11.7	0.07
ADFI, g	172	162	162	141	16.5	0.32
G:F	0.415 ^a	0.457 ^a	0.604 ^b	0.445 ^a	0.050	0.03
d 0 to 31						
ADG, g	360	351	362	358	12.4	0.81
ADFI, g	541	526	530	525	16.7	0.76
G:F	0.664	0.665	0.680	0.678	0.013	0.46

Table 441.

	NC	Plasma A	Plasma B	Nutri-Gold	SEM	<i>P</i> <
d 0 to 10						
ADG, g	82 ^a	129 ^c	125 ^c	102 ^b	5.0	0.001
ADFI, g	124 ^a	156 ^c	141 ^b	123 ^a	3.0	0.001
G:F	0.660 ^b	0.832 ^a	0.885 ^a	0.821 ^a	0.029	0.001
d 0 to 24						
ADG, g	234 ^a	252 ^b	257 ^{bc}	242 ^{ab}	4.7	0.01
ADFI, g	299 ^a	324 ^b	321 ^b	304 ^a	5.7	0.01
G:F	0.785	0.778	0.802	0.798	0.009	0.19

^{a,b,c} Means without a common superscript differ $P < 0.05$.

2 (FSBM2; Nutraferma, Sioux City, IA), and 4) Enzymatically treated soybean meal (ETS; Hamlet Protein, Findlay, OH). Diet formulation was based on a common SID Lys level (1.35%). Diets 2, 3 and 4 contained 28.5% SBM and 25% dried whey and specialty soybean meal sources were added at 5% in both phase 1 and 2. Feed was pelleted in phases 1 and 2, while the phase 3 common diet was fed in meal form. From d 0 to 7, pigs fed FSBM2 had increased ($P < 0.05$) ADG and d 7 BW compared to pigs fed ETS, and increased G:F ($P < 0.05$) compared to all treatments. No other differences ($P > 0.10$) were observed for growth or pig BW during phase 2, phase 3 or for the overall experiment. In summary, further processed soybean meal sources did not improve nursery pig growth compared to traditional soybean meal.

Key Words: fermented soybean meal, nursery pig, protein sources

441 Evaluation of bovine plasma source and whole dried milk in nursery pig diets on growth performance.

C. D. Evans*¹, H. L. Frobose¹, D. W. Dean², M. D. Tokach¹, R. D. Goodband¹, S. S. Dritz¹, J. C. Woodworth¹, J. M. DeRouchey¹, ¹*Kansas State University, Manhattan*, ²*International Ingredient Corp, Fenton, MO.*

A total of 360 barrows and gilts (PIC 359 \times C29; initially 6.2 ± 1.4 kg BW and 19 d of age) were used in a 24-d experiment evaluating different specialty ingredients on nursery pig growth performance. This experiment was conducted in a commercial environment (Cooperative Research Farm Nursery; Sycamore, OH). At weaning, pigs were allotted to pens by initial BW to 1 of 4 treatments in a completely randomized design. There were 9 replicate pens per treatment with 10 pigs per pen. Experimental diets were fed from d 0 to 10 with a

Table 442.

Variable	Treatments					Contrasts			
	16%CP	14.9%CP +EAA	14.9%CP	13.5%CP +EAA	13.5%CP	16 vs 14.9	16 vs 13.5	14.9 vs 14.9 + EAA	13.5 vs 13.5+ EAA
Leucine									
Artery, uM	122.92	104.39	109.74	119.64	107.98	0.0613	0.0432	NS	0.1150
Fractional removal ¹ , %	35.36	41.91	38.05	44.59	40.67	NS	0.2031	NS	NS
Mammary uptake:milk output	1.14	1.11	1.11	1.21	1.15	NS	NS	NS	NS
Methionine									
Artery, uM	25.92	37.94	23.11	49.08	23.98	NS	NS	0.0003	<0.0001
Fractional removal, %	43.38	27.32	43.32	24.24	40.43	NS	NS	0.0011	0.0014
Mammary uptake:milk output	1.14	1.01	1.01	0.97	0.96	0.0657	0.0171	NS	NS

¹Fractional removal = arterio-venous difference/arterial concentration

common diet fed from d 10 to 24. Experimental diets were: 1) Negative control (NC; 5% fish meal), 2) NC + 5% bovine plasma A (AP920, APC Inc.; Ankeny, IA), 3) NC + 5% bovine plasma B (Promax; Protena, Nicaragua), and 4) NC + 5% dried whole milk (NutriGold; International Ingredients Corporation Inc., St. Louis, MO). All diets were balanced on SID Lys and lactose and were fed in pellet form. From d 0 to 10, pigs fed Plasma A and Plasma B had greater ($P < 0.01$) ADG and ADFI than pigs fed the NC or NutriGold diets. Pigs fed NutriGold also had increased ($P < 0.01$) ADG relative to pigs fed the NC diet. Also, G:F was greater ($P < 0.001$) for plasma and NutriGold containing diets compared to the NC. During the common period (d 10 to 24), there were no differences for ADG or ADFI, but pigs previously fed NC had greater (0.810 vs. 0.765; $P < 0.01$) G:F compared to those previously fed Plasma A. Overall (d 0 to 24), pigs fed Plasma A and B had greater ($P < 0.02$) ADG and ADFI than NC pigs. Furthermore, pigs fed Plasma B had increased ($P < 0.04$) ADG relative to pigs fed NutriGold. In summary, both plasma sources increased intake and growth with no differences between sources. NutriGold also improved performance compared to the NC.

Key Words: animal plasma, milk products, nursery pig

442 **Effect of amount and profile of amino acid supply on mammary amino acid metabolism.** B. M. Dado^{*1}, M. A. C. Danes¹, G. A. Broderick², M. A. Wattiaux¹, ¹University of Wisconsin, Madison, ²Broderick Nutrition & Research, LLC, Madison, WI.

Amino acids function not only as protein building blocks but also as signaling molecules that affect milk protein synthesis and mammary metabolism. In an attempt to expose the mammary gland to different amounts and profile of AA in the arterial blood, ten Holstein cows were blocked by DIM into two 5x5 Latin squares and fed 5 treatments: (1) positive control (16% CP), formulated to meet metabolizable protein requirements; 14.9% CP with (2) or without (3) EAA infusion; or 13.5% CP diet with (4) or without (5) EAA infusion. The AA solutions were prepared according to AminoCow to provide all limiting EAA in each diet and were infused continuously

into the abomasum. On the last day of each 14-d period, blood samples were taken from the coccygeal vessel and the mammary vein simultaneously, at four time-points equally spaced between two milkings. Plasma samples were analyzed for AA by GC-MS. Data was analyzed using Proc Mixed, significance was declared at $P < 0.10$ and trend at $P < 0.20$. Contrasts and LS-means are reported in Table 442. All AA are analyzed and responded differently to the treatments. Methionine and Lysine are presented as examples of the two groups of AA according to their post-absorptive metabolism. The changes in AA arterial concentrations were smaller than we attempted to achieve. Nonetheless, some effects were observed. Decreasing dietary CP decreased leucine arterial concentration but fractional removal was numerically increased relative to the positive control, indicating that the mammary uptake process might not be driven by mass action alone. For methionine, fractional removal decreased with AA infusions, even though methionine arterial concentrations were increased. Mammary uptake to milk output ratio was affected by CP levels for methionine, suggesting responses within the mammary gland.

Key Words: amino acid, mammary gland

443 **Novel cecum cannulated pig model to investigate the human microbiota through inter species transfer of gut microbiota from humans to pigs.** M. E. Kaiser^{*}, C. L. Anderson, N. D. Aluthge, T. E. Burkey, P. S. Miller, D. E. Hostetler, S. C. Fernando, University of Nebraska, Lincoln.

Recent studies of the human microbiome have helped understand how changes in the microbial community affects human health and physiology, yet they fail to identify the mechanisms and signals underlying how the microbiota impacts human physiology and health. This is mainly because of the lack of a good animal model to investigate the human microbiome over time. The main goal of this research project was to develop a new cecum-cannulated humanized pig model through fecal transplants from humans to pigs to identify the signals of the microbiome that affects the obese phenotype. To this end, we derived 15 germ-free pigs and performed inter- intra-

species fecal microbiota transplantation experiments to demonstrate that a human gut associated microbiota can colonize and be maintained within the gnotobiotic pig. The pigs derived through cesarean sectioning were divided into 3 treatment groups and were inoculated with either an obese human gut microbiota, lean gut microbiota, or a conventional pig microbiota. The pigs with an obese donor microbiota were fed a 40% fat and carbohydrate diet and the pigs that received a lean or conventional pig microbiota was maintained on a 5% fat and carbohydrate diet. Fecal samples were collected weekly to monitor establishment of the gut microbial community. At 7 wk of age, 2 pigs from each treatment were cecum cannulated to evaluate the effect of cannulation on the microbial community structure. The pigs were maintained for an additional 2 wk before euthanization. Microbial community was evaluated using 16S rRNA sequencing using an ION Torrent Personnel Genome machine. This pilot study demonstrated that germfree piglets receiving the human microbiota developed a donor like microbial community each similar to the respective obese or lean donor (PERMANOVA $P < 0.05$) with minimal animal-to-animal variation. Comparison of the microbiotas of humans, germfree pig recipients of (obese, lean, and conventional), revealed that the microbiota of germfree piglets receiving human microbiota was more similar to human donor microbiota than conventionally raised pigs suggesting the establishment of a human gut flora within the pig (PERMANOVA, $P < 0.05$). The humanized pig model has potential to help understand structure function relationships of the human microbiome. With the cecum cannulation, longitudinal sampling can be performed at the site of microbial action allowing the investigation of microbial gene expression. This model will provide an opportunity to better understand how microbial gene expression effects host gene expression and in turn host physiology.

Key Words: 16S human microbiota, microbiota transplantation, pig model

444 **Gross morphology, morphometric characteristics, and sequential changes in digesta fiber fractions of gastrointestinal tract segments from high postpartum piglet mortality extensively reared swine.** S. N. Carr*, Q. S. Baptiste, *Berea College, Berea, KY.*

The gross morphology, morphometric characteristics, and sequential changes in digesta fiber fractions of gastrointestinal tract segments harvested from high postpartum piglet mortality (21.79%) of extensively reared swine were investigated. Swine had access to forage with moderately high NDF (50 to 60%) and ADF (30 to 43%) throughout this study and consumed a basal diet of corn and soybean with added minerals. Harvested stomach was dissected and emptied of its content (900 g of digesta) via a 4cm incision in the cardiac/oesophageal region. Stomach volume was 4,540 mL and its empty weight (579.14 g) was below that reported for concentrate fed

intensively reared swine (0.64% vs. 1.20% of BW). In addition, a conspicuous 6.5 cm long fingerlike sacculation and segmentation of the fundus was visible both externally and along the inner walls of the dissected stomach. The length of the small intestine (18.69 m) was equivalent to average values reported for adult swine (18 m). The large intestine length (455 cm) was greater than 50% of the value reported for adult swine (750 cm). Stomach, caecum (proximal, medial and distal regions), and colon digesta were sampled and analyzed for DM, NDF and ADF content. Stomach digesta NDF and ADF (24.53 and 12.98%) reflected the values expected for extensively reared swine consuming soybean meal and corn concentrate. NDF and ADF values of caecum proximal (32.47 and 16.67%), medial (35.98 and 19.24%), and distal (31.78 and 16.69%) regions were higher than those of a composite colon digesta sample (25.47 and 13.06%). The DM values of caecum proximal (14.70%), medial (16.10%), and distal (19.44%) regions were lower than those of a composite colon digesta sample (23.19%). Hence, extensively reared swine display intestinal morphology and morphometric characteristics which indicate the need for caecal digestion and colon absorption of nutrients. However, even these modifications may be inadequate to meet nutrient requirements of gestating extensively reared swine, as evidenced by high early postpartum piglet mortality rates of this study's herd.

Key Words: GIT, morphology, mortality

445 **Effects of detoxifying agents on growth performance of nursery pigs fed deoxynivalenol-contaminated wheat.** H. L. Frobose*, E. W. Stephenson¹, M. D. Tokach¹, J. M. DeRouchey¹, R. E. Musser², S. S. Dritz¹, R. D. Goodband¹, J. C. Woodworth¹, J. L. Nelssen¹, ¹*Kansas State University, Manhattan,* ²*NUTRIQUEST, Mason City, IA.*

A total of 238 barrows and gilts (PIC 327 × 1,050; initially 13.4 ± 1.8 kg) were used in a 21-d study to evaluate the effects of detoxifying agents on the growth performance of nursery pigs fed diets contaminated with deoxynivalenol (DON). Pens of pigs were allotted by BW to 1 of 5 treatments in a completely randomized design with a 2 × 2 + 1 factorial arrangement, with main effects of DON (4 mg/kg) and Product D (Nutriquest, Mason City, IA). A fifth treatment was included to confirm the effectiveness of 1.0% sodium metabisulfite (SMB; Na₂S₂O₅) in DON-contaminated diets. There were 6 or 7 replicate pens/treatment and 7 pigs/pen. Naturally DON-contaminated wheat (6 mg/kg) replaced non-contaminated wheat in diets to achieve desired dietary DON concentrations. Basal ingredients were tested for mycotoxin and amino acid content prior to diet manufacturing. Diets were pelleted at 85°C with a 45 s conditioning time. Analyzed DON levels were 92% lower when pelleted with SMB, but otherwise DON matched formulated levels, although low levels of fumonisin (<1 mg/kg) were also present. Overall (d 0 to 21),

Table 445.

Formulated DON, mg/kg:	<0.5	<0.5	4.0	4.0	4.0	
Additive:	None	Product D	None	Product D	SMB	SEM
Analyzed DON, mg/kg	0.04	0.06	4.10	4.23	0.35	
d 0 to 21						
ADG, g	498	510	404	363	543	13.2
ADFI, g	798	805	702	639	772	18.3
G:F	0.625	0.634	0.576	0.567	0.704	0.011
Final BW, kg	23.9	24.2	22.1	21.1	24.8	0.30

a DON × Product D interaction was observed for ADG ($P < 0.05$) with a tendency for an interaction for ADFI ($P < 0.06$). As anticipated, DON reduced ($P < 0.001$) ADG and ADFI by 20 and 12%, respectively, but the interaction was driven by poorer growth performance when Product D was incorporated into DON diets. Additionally, pigs fed DON diets had 9% poorer G:F ($P < 0.001$). Deoxynivalenol-associated reductions in ADG were most distinct (89%) during the initial period (39 vs. 329 g from d 0 to 3), and least marked (18%) during the final period (497 vs. 607 g from d 14 to 21). Adding SMB increased ($P < 0.01$) ADG, ADFI and G:F compared to pigs fed DON-contaminated diets, and also increased ($P < 0.02$) ADG and G:F compared to pigs fed DON-free diets. Overall, Product D was not effective in DON-contaminated diets. While SMB appears promising to restore performance in pelleted DON-contaminated diets, additional research is necessary to clarify the response.

Key Words: deoxynivalenol, mycotoxin, sodium metabisulfite

446 Characterization of microbial community structure during *Salmonella* shedding in beef cattle.

M. Muller*, N. D. Aluthge, C. L. Anderson, A. L. Knoell, C. J. Bittner, G. E. Erickson, S. C. Fernando, *University of Nebraska, Lincoln.*

Food animals are a major reservoir for zoonotic transmission of *Salmonella* through contaminated foods. In particular, asymptomatic carriers play an important role in *Salmonella* propagation in cattle and in contaminated foods because they are not easily identified and isolated. Minimizing the number

of such animals would have a significant impact on lowering incidence of *Salmonella* contamination in beef in a production setting. Depending on the serotype and other unknown factors, *Salmonella* can cause either a symptomatic infection in cattle or the organism can colonize the animals asymptotically, converting the animal to a carrier state where the organism can be dispersed quite efficiently throughout the environment. We hypothesize that competition between pathogens and non-pathogens for nutrient resources is important for limiting disease incidence and pathogen colonization. Therefore, competitive exclusion may be a viable strategy to reduce or control pathogenic *Salmonella* populations. However, our knowledge about the fecal microbial community is limited as 99% of the bacteria in the rumen or feces have not been cultured or isolated, hindering the opportunity to identify competitor. As a first step toward identifying competitor microbial species, we used selective microbiological culture methods and molecular methods to identify *Salmonella* high-shedders and low-shedders among 225 beef steers over 4 time periods. Based on shedding numbers 48 high-shedders ($>10^3$ *Salmonella* cfu/g of feces) and 48 low shedders ($<10^2$ cfu/g of feces) were phenotyped for gut microbial composition using 16s rRNA based amplicon sequencing. A total of ~10,000,000 high-quality DNA sequences generated through Ion Torrent semi-conductor based sequencing was used to evaluate microbial community composition. Bioinformatic analysis of the sequences from high-shedders and low-shedders indicated significant variations in microbiome composition between high and low shedders. It was revealed that members of the phylum *Bacteroidetes* were more abundant in the high-shedders, while members of the phylum *Firmicutes* were more abundant in the low-shedding animals. Furthermore, the analysis showed that 8 operational taxonomic units (OTUs) were significantly more abundant in low-shedders than in high-shedders. These OTUs represented candidate members of the microbiome that can be used as direct fed microbials (DFM) to reduce *Salmonella* shedding. These results provide new insight into bacterial populations that are present in the feces of *Salmonella* shedding cattle.

Key Words: 16S bacterial community, dysbiosis, *Salmonella*

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