

**439 Fortification of fluid skim milk with conjugated linoleic acid (CLA).** W.S. Campbell\*, J. Parker, M.A. Drake, and D.K. Larick, <sup>1</sup>North Carolina State University.

Nutraceutical products make up the fastest growing segment of the U.S. food industry. Conjugated linoleic acid (CLA) occurs naturally in milk at low levels and is an anticarcinogen. Research indicates that concentrations of 1 to 3 g CLA/day would provide protective anticarcinogenic benefits. Increased levels of CLA in fluid milk would produce a nutraceutical dairy beverage. The objectives of this study were to develop a CLA fortified milk with improved nutritional properties. CLA (1 g, 2g, or 3 g /240g) and derivatized whey protein concentrate (DWPC) (0%, 0.25%, 0.5%) were added to raw skim milk prior to homogenization, HTST pasteurization and aseptic packaging. Headspace volatiles

were evaluated by purge and trap gas chromatography. Viscosity was determined using a controlled stress rheometer and visual properties ( $L^*$ ,  $a^*$ ,  $b^*$ ) were evaluated with a colorimeter. CLA fortified skim milk had minimal levels of hexanal and sensory data did not indicate substantial flavor deterioration as compared to control. The addition of CLA increased the whiteness of the milk, but did not significantly affect viscosity. Addition of DWPC at .25% in skim milk mimicked the viscosity of reduced fat milk, however, visual properties were not affected. These results indicate that skim milk may provide a vehicle for CLA consumption and that DWPC enhances the viscosity of skim milk such that it is more similar to reduced fat milk.

**Key Words:** Conjugated linoleic acid, Milk

## ASAS Nonruminant Nutrition: Alternative Ingredients (Nursery & Specialty Grain)

**440 Supplementation of  $\alpha$ -1,6-galactosidase and  $\beta$ -1,4-mannanase to improve soybean meal utilization by nursery pig.** S. W. Kim\*<sup>1</sup>, I. Mavromchalis<sup>2</sup>, and R. A. Easter<sup>2</sup>, <sup>1</sup>Texas Tech University, <sup>2</sup>University of Illinois.

Soybean meal contains 5.6%  $\alpha$ -galactoside and 1.2%  $\beta$ -galactomannans that pigs can not utilize because of they lack appropriate enzymes, resulting in gas production and flatulence. Two experiments were conducted to test a hypothesis that dietary supplementation of an enzyme mixture (carbohydrase, mainly composed of  $\alpha$ -1,6-galactosidase and  $\beta$ -1,4-mannanase) improves nutrient utilization of soybean meal in nursery pigs. In the first experiment, 108 weaned pigs (21 d; Camborough-15 x line 326, PIC, Franklin, KY) were offered three diets containing either 0% (control), 0.025%, or 0.050% of the carbohydrase for a 5-wk period in six replicates with 6 pigs per pen. Overall, growth response of pigs fed diets containing enzyme was greater ( $P < 0.05$ ) than control group (11% improvement compared to control). Average daily gain was greater ( $P < 0.07$ ) only in pigs fed a diet with 0.025% carbohydrase during the fourth wk post-weaning. There was no improvement in average daily gain in pigs fed a diet with 0.050% of carbohydrase. However, gain/feed ratio was greater ( $P < 0.05$ ) in pigs fed a diet with 0.025% of enzyme during the last 4 wk of the experiment. In the second experiment, ten cannulated female pigs (Camborough-15 x line 326, Pig Improvement Company) were used to measure the effect of the carbohydrase supplementation (0.025%) on the apparent ileal digestibility of energy and amino acids with five pigs assigned to each treatment. Ileal samples were collected for 2-d following by 5-d adjustment period during the fifth wk post-weaning. Apparent ileal digestibility of gross energy was greater (7% improvement,  $P < 0.05$ ) in the carbohydrase-supplemented diet. Also, apparent ileal digestibility of lysine, threonine, and tryptophan was greater (3% improvement,  $P < 0.05$ ) in the carbohydrase-supplemented diet. In conclusion, a carbohydrase composed of  $\alpha$ -1,6-galactosidase and  $\beta$ -1,4-mannanase can increase growth performance in nursery pigs by improving the digestibility of energy and amino acids in corn-soybean meal-based diet.

**Key Words:** Nursery pigs, Soybean meal, Carbohydrase

**441 Performance of weaned piglets fed insect-protected (MON 810) or near isogenic corn.** G. Piva\*<sup>1</sup>, M. Morlacchini<sup>2</sup>, A. Pietri<sup>1</sup>, A. Piva<sup>3</sup>, and G. Casadei<sup>1</sup>, <sup>1</sup>Istituto di Scienze degli Alimenti e della Nutrizione, U.C.S.C., Facolt di Agraria, Italy, <sup>2</sup>CERZOO, <sup>3</sup>DIMORFIPA, Facolt Medicina Veterinaria, Bologna, Italy.

The aim of the experiment was to compare the nutritive value for piglets of insect-protected corn (Bt) containing the Cry1A(b) protein (MON 810) with non-modified near isogenic control corn (IC), both produced on two Italian farms located in Lodi and Venezia provinces. The trial utilised 128 weaned Large White piglets weighing 8.8 (1.27) kg. Animals were divided into 4 treatments of 32 animals each (4 pens each of females and castrated males each with 4 pigs/pen). Five climate controlled rooms each containing 6 pens except the fifth room containing 8 pens were used. Treatments were blocked by sex and treatment within each room. Nutritional analytes were not different ( $P < 0.05$ ) between IC and Bt corn. Animals were fed test diets containing 33% corn for 35 days. Feed intake of pigs did not differ ( $P < 0.05$ ) among experimental diets. Feed:gain was not different ( $P < 0.05$ ) among treatments during any period on study (0-14 d, 15-35 d and 0-35 d). Overall ADG was 5.6%

higher ( $P < 0.05$ ) for Bt corn fed pigs (396 g/d) compared with IC pigs (375 g/d). Pigs fed the B.t corn had 2.8% heavier final live weights (22.6 kg) compared to the IC corn fed pigs (22.0 kg) ( $P < 0.05$ ). Differences in performance may be attributed to Bt corn having a 69% lower level of fumonisin B<sub>1</sub> than IC corn and 14.4% lower deoxynivalenol (DON). We conclude that performance of piglets fed Bt corn is at least as good as those fed IC corn.

**Key Words:** Pigs, Transgenic corn, Mycotoxins

**442 Effects of feeding blends of grains naturally-contaminated with *Fusarium* mycotoxins on growth and brain regional neurochemistry of starter pigs and the efficacy of supplemental yeast cell wall polymer in detoxification.** H.V.L.N. Swamy<sup>1</sup>, T.K. Smith<sup>1</sup>, E.J. MacDonald<sup>2</sup>, and A.E. Sefton<sup>3</sup>, <sup>1</sup>University of Guelph, Guelph, Ontario, Canada, <sup>2</sup>University of Kuopio, Kuopio, Finland, <sup>3</sup>Alltech Biotechnology Center, Nicholasville, Kentucky, USA.

Naturally-contaminated grains have been reported to be more toxic than equivalent amounts of purified mycotoxin based on chemical analysis. An experiment was conducted, therefore, to determine the effect of feeding a blend of grains naturally-contaminated with *Fusarium* mycotoxins to starter pigs and to test the efficacy of a polymer extracted from yeast cell wall as a dietary treatment for *Fusarium* mycotoxins. A total of 175 starter pigs (initial weight of 10 kg) were fed 5 diets (7 pens of 5 pigs per diet) for 21 days. Diets included a control, a blend of contaminated grains and contaminated grains + 0.05, 0.10 and 0.20% yeast cell wall polymer (MTB-100, Alltech Inc.). Diets containing contaminated grains averaged 3.85 ppm deoxynivalenol, 26.88 ppm fusaric acid and 0.4 ppm zearalenone. Weight gain of all pigs fed contaminated grains was significantly reduced compared to control especially in the first week of feeding. The feeding of contaminated grains significantly reduced concentrations of dopamine in the hypothalamus and concentrations of norepinephrine in the pons. The ratio of 5-hydroxyindoleacetic acid to serotonin was also elevated in pons. The feeding of 0.2% yeast cell wall polymer largely prevented these neurochemical changes. It was concluded that the feeding of grains naturally-contaminated with *Fusarium* mycotoxins can alter brain neurochemistry in starter pigs and that the changes can largely be prevented by the feeding of yeast cell wall polymer at the appropriate concentrations although this may not be reflected in increased growth rate.

**Key Words:** Pigs, *Fusarium*, Deoxynivalenol

**443 Influence of type of cereal and level of fiber on performance of early-weaned piglets.** G. G. Mateos\*<sup>1</sup>, A. Alcantarilla<sup>1</sup>, M. A. Latorre<sup>1</sup>, R. Lazaro<sup>1</sup>, E. Gomez<sup>2</sup>, and N. Laso<sup>2</sup>, <sup>1</sup>Universidad Politecnica de Madrid. Spain, <sup>2</sup>Centro de Pruebas de Porcino. Junta Castilla y Leon. Spain.

A trial was conducted to investigate the influence of type of cereal and level of crude fiber used in the diet on performance of early weaned piglets. There were eight treatments and eight replicates per treatment with 5 piglets (blocks 1 and 2) or 12 piglets (blocks 3 and 4) per replicate. The control diet included 8% fish meal, 15% dried whey, and 12% fullfat soy bean, and contained 52% of cooked and expanded corn. Treatments B, C, D, and E substituted 30% of the corn for 30% of cooked decorticated oats, cooked oats, cooked rice, and raw oats, respectively.

In addition, other three extra diets (F, G, and H) were formulated in which approximately 2.6% of cooked and expanded oat hulls were added to diets A, B, and D. Convenient non-orthogonal comparisons were conducted to test the effects of supplemental fiber (ABD vs FGH), source of cooked cereal (AF vs BG vs DH), heat processing of oats (E vs C), and dehulling of oats (B vs C) on piglet performance. At the end of the trial (42 d of age), fiber inclusion did not affect feed intake, daily gains or feed conversion ( $P > 0.05$ ). Piglets fed cooked rice outperformed piglets fed any other cereal and showed the best gains and feed conversion (347, 317, 311 g/d;  $P < 0.05$  for growth, and 1.51, 1.57, and 1.63 g/g;  $P < 0.05$  for feed conversion for rice, corn, and decorticated oats, respectively). Cooking and expanding the oats improved both daily gains (303 vs 295 g/d) and feed conversion (1.55 vs 1.64 g/g) but the differences were not significant ( $P > 0.05$ ). Dehulling the cooked oats had no impact on piglet performance. It is concluded that rice is a cereal of choice in diets for early-weaned piglets. Increasing the level of fiber of the diet by adding cooked and expanded oat hulls did not impair piglet performance. Data on cost and on productive performance should be taken into account when deciding type of cereal to use in diets for early weaned piglets.

**Key Words:** Heat processing, Oat hulls, Piglets

**444 Singular and combined efficacy of two new microbial phytases in corn-soy or corn-soy-wheat diets for young pigs.** C.H. Stahl\*, J.M. Porres, K.R. Roneker, and X.G. Lei, Cornell University, Ithaca, NY.

We have expressed a heat-stable phytase from *Aspergillus fumigatus* (AP) and a catalytically-efficient phytase with low pH optimum from *Escherichia coli* (EP) in a yeast system. Two experiments were conducted to compare the efficacies of EP and AP in improving the bioavailability of phytate-P to weaning pigs in singular form and in combination with each other or with cereal phytase. In Exp. 1, 21 pigs (5-wk old, 8.11 ± .87 kg BW) were fed a corn-soybean meal basal diet containing no inorganic P (CS) supplemented with 500 U of phytase/kg of diet from AP, EP, and AP:EP (1:1) for 4 wk. In Exp.2, 36 pigs (5-wk old, 8.25 ± .79 kg BW) were used to compare the efficacy of 200 and 400 U of EP/kg of corn-soy diet containing 7.5% wheat middlings (WM, 151 U of phytase/kg of diet) with that of WM + Pi (.1%), and CS + Pi (.2%). In Exp. 1, pigs receiving CS + EP or CS + AP:EP had higher ADG (576 and 553 g,  $P \leq .05$  and .08, respectively) than the pigs receiving CS + AP (463 g) during the last week of the study. Plasma alkaline phosphatase activity (AKP) was 13% higher ( $P \leq .03$ ) in pigs fed CS + AP than those fed CS + EP diet at wk 1, and the difference became marginal at wk 4 (8%,  $P \leq .07$ ). However, there was no difference in AKP between pigs fed CS + AP:EP and the other diets. In Exp. 2., pigs fed the CS + Pi had higher ( $P \leq .05$ ) ADG than the other treatment groups. Increasing EP from 200 to 400 U/kg of diet resulted in 9% higher ( $P \leq .05$ ) plasma inorganic P concentrations at wk 2 and 3. Pigs fed the higher level of EP had plasma inorganic P concentrations similar to those of pigs fed inorganic P-supplemented diets at wk 4. In conclusion, both new phytases were effective in improving phytate-P bioavailability to young pigs, but no significantly synergistic effect was seen with the combination of AP and EP, or with EP + cereal phytase under the current dietary conditions.

**Key Words:** Phytase, *Aspergillus fumigatus*, *Escherichia coli*

**445 Effect of photoperiod on performance and energy metabolism of weanling pigs.** E.M.A.M. Bruininx<sup>1</sup>, C.M.C. van der Peet<sup>1</sup>, W.J.J. Gerrits\*<sup>2</sup>, and J.W. Schrama<sup>2</sup>, <sup>1</sup>Research Institute for Animal Husbandry, <sup>2</sup>Wageningen Institute of Animal Sciences.

Feed intake is an important determinant of performance that may also reflect the health status of weanling pigs. Previous studies have suggested that illumination stimulates the early development of post weaning feed intake. In a 2-wk experiment the effect of photoperiod on performance and energy metabolism of newly weaned pigs was studied. Forty 4-wk-old crossbred weanling barrows weighing 8.0 kg (SEM = 0.13) were assigned to 8 groups of 5 pigs each based on BW and litter. Groups were allotted to one of two lighting schedules: 8 h light:16 h darkness or 23 h light:1 h darkness. Each group was housed in a climate respiration chamber. Piglets had ad libitum access to feed and water. Energy and nitrogen balances, heat production, ADFI and ADG were measured weekly. Heat production, energy metabolism and performance were unaffected ( $P > 0.1$ ) by photoperiod during wk 1. However, in the second week ADFI (420 vs. 304 g/d) and ADG (381 vs. 240 g/d) were

higher ( $P < 0.05$ ) for pigs at the 23:1 h lighting schedule than at the 8:16 h schedule. Furthermore, total energy retention, energy retained as protein and as fat were higher ( $P < 0.05$ ) during week 2 in pigs at the 23:1 h lighting schedule (+131, +41, and +414% respectively) than at the 8:16 h schedule. Moreover, during wk 2 metabolizability of energy tended to be higher ( $P < 0.1$ ) and energy requirements for maintenance were lower ( $P < 0.05$ ) for pigs at the 23:1 h schedule compared with the 8:16 h schedule ( $P < 0.1$ ). Heat production was unaffected by photoperiod during wk 2. In conclusion, exposing pigs to a longer period of light post-weaning stimulated ADFI and ADG. In addition to the feed intake, the high ADG is due to an improved metabolizability of energy and a reduced energy requirement for maintenance. The results from this study suggest that lighting schedule can be used as a tool to stimulate feed intake post weaning.

**Key Words:** Photoperiod, Metabolism, Pigs

**446 Diets containing high quality animal proteins increase growth of early-weaned pigs.** F. R. Dunshea\*, P. J. Eason, D. J. Kerton, and T. Moyes, Agriculture Victoria, Victorian Institute of Animal Science, Werribee, Australia.

This study was conducted to compare the performance of early weaned pigs fed diets containing freeze dried bovine colostrum and porcine plasma with that of pigs fed diets containing conventional protein sources. Four male pigs per sow were weaned at 14 d of age from 24 sows and randomly allocated to one of four diets formulated to contain 15.5 MJ DE/kg, 0.95 g available lysine/MJ DE and 23.8% CP. All diets contained fishmeal (10%) and bloodmeal (3%) with the remaining supplemental protein being provided as skim milk (animal protein (A)), skim milk and soyabean meal (7%) (vegetable protein (V)), skim milk and plasma meal (plasma (P)) and skim milk and colostrum (colostrum (C)) The inclusion level of colostrum and plasma were reduced from 6 to 2.5% after 1 wk. Pigs fed P and C diets grew more quickly than pigs fed diets containing more conventional ingredients. However, the performance of pigs fed the A diet was only marginally less than the performance of pigs fed the diets containing immunoglobulins (Ig, C and P). Pigs fed the V diet ate less and grew more slowly than pigs fed any of the other diets, particularly over the first 2 wks after weaning. These data demonstrate that pigs fed bovine colostrum perform similarly to pigs fed freeze dried porcine plasma. While there was little benefit of feeding complex protein sources over feeding a predominantly animal protein diet, inclusion of even a moderate level of soyabean meal in the diet of early weaned pigs reduced performance over the first 2 wks post-weaning. Supported by the Pig Research and Development Corporation.

Age	Dietary A	Dietary V	Treatment C	Treatment P	Within sed	IG vs non-Ig	Within non-V	V vs non-V
Daily Gain (g/day)								
14-21d	63	14	65	87	13	0.055	0.017	0.47
21-28d	247	205	270	233	22	0.049	0.11	0.26
28-35d	403	414	415	423	30	0.90	0.62	0.79
Feed Intake (g/day)								
14-21d	128	92	134	142	13	0.032	0.002	0.56
21-28d	280	237	305	300	22	0.15	0.006	0.49
28-35d	480	466	491	503	32	0.83	0.30	0.78

**Key Words:** Pigs, Early-weaned, Protein

**447 Potential for egg protein as a protein source for phase 1 nursery diets.** J. F. Jaen\*<sup>1</sup>, C. V. Maxwell<sup>1</sup>, Z. B. Johnson<sup>1</sup>, D. C. Brown<sup>1</sup>, S. Singh<sup>1</sup>, M. E. Davis<sup>1</sup>, K. J. Touchette<sup>2</sup>, J. A. Coalson<sup>2</sup>, and R. E. Musser<sup>3</sup>, <sup>1</sup>University of Arkansas, Fayetteville, <sup>2</sup>Merrick's, Inc., Middleton, WI, <sup>3</sup>The Pork Group, Inc., Rogers, AR.

An off-site trial using 216 weanling barrows was conducted to determine the efficacy of pasteurized (60°C for 1 hr) or non-pasteurized egg product to replace spray dried plasma (SDP) in the phase 1 (d 0 to 10) diet of nursery pigs. Pigs (The Pork Group, Inc.; 20 ± 2 d of age; 5.6 kg BW) were assigned by initial weight to one of six treatments in a randomized complete block designed experiment. There were six blocks with six pigs/pen. Six diets were fed during phase 1: 1) a negative control diet devoid of egg product and SDP, 2) a positive control diet containing 5% SDP added at expense of soybean meal 48%, 3) as 2 with pasteurized egg product replacing 50% of the SDP, 4) as 2 with pasteurized

egg product replacing 100% of SDP, 5) as 2 with non-pasteurized egg product replacing 50% of SDP, 6) as 2 with non-pasteurized egg product replacing 100% of SDP. All diets were formulated to contain 1.5% lysine. Upon completion of the phase 1 diet, a common phase 2 diet (1.35% lysine) was fed from d 10 to 24 after weaning, and upon completion of phase 2, a common phase 3 diet (1.20% lysine) was fed from d 24 to 38 after weaning. In phase 1, source of egg product (pasteurized or non-pasteurized) had no effect on ADG ( $P > 0.1$ ). However, egg product added at the 50% inclusion level resulted in greater ADG and ADFI than when supplemented at the 100% inclusion level (158 and 241 vs. 134 and 189 g/d, respectively;  $P < 0.05$ ). Pigs fed non-pasteurized egg product had greater G:F than pigs fed pasteurized egg product (0.763 vs. 0.637, respectively;  $P < 0.05$ ). The results of this experiment indicate that non-pasteurized egg product can successfully replace 50% of SDP in nursery diets when SDP was included at 5%.

**Key Words:** Egg product, Diet, Nursery pigs

**448 Performance of growing pigs fed wheat-based diets added with low levels of inorganic phosphorus.** M. Cervantes\*, A.B. Araiza, N. Torrentera, S. Espinoza, and M. Cervantes, *Universidad Autnoma de Baja California, Mexicali, Mxico.*

An experiment was conducted to evaluate the performance of growing pigs fed wheat-based diets, added with low levels of inorganic phosphorus (P). Thirty crossbred (Landrace x Yorkshire x Duroc) pigs (27.2 kg initial body weight) were assigned to 5 dietary treatments according to a randomized complete block design. Treatments T1, T2, T3, and T4 were wheat-based diets added with .20, .50, .70, and .90% dicalcium phosphate (DP), respectively; T5 was a wheat-soybean meal, control diet, formulated to meet the requirement of total P for the 20-50 kg pigs. Wheat was the sole source of dietary protein, energy, and organic P in the test diets. Inorganic P in the test diets was provided as dicalcium phosphate. Organic (wheat and soybean meal) and inorganic P were assumed to be 50, 23, and 100% available, respectively. Diets were formulated to contain .22, .28, .31, .35, and .43% available P. Feed and water were provided ad libitum. Regression analysis including treatments T1 to T4 were performed; also, the positive control was contrasted against the average of treatments T1 to T4. Daily weight gain, feed intake, feed/gain ratio, and intakes of lysine, threonine, total P, and available P were: 842, 884, 836, 878, 856 g/d; 1.93, 1.94, 1.87, 1.94, 1.76 kg/d; 2.68, 2.66, 2.6, 2.57, 2.31; 16.0, 16.1, 15.5, 16.1, 15.2 g/d; 9.7, 9.7, 9.3, 9.7, 10.9 g/d; 7.9, 9.1, 9.3, 10.5, 8.6 g/d; 4.2, 5.4, 5.8, 8.8, 7.6 g/d. Intake of both total and available P increased ( $P < .01$ ) as the supplementation level of inorganic P increased. However, none of the performance variables (daily gain, feed intake, feed/gain ratio) was affected ( $P > .10$ ) by the supplementation level of inorganic P. The supplementation level of inorganic P did not affect either lysine or threonine intakes. These data indicate that organic P from wheat can replace significant amounts of P from inorganic sources, reducing the cost of the diet and the P pollution. These results also show that formulating diets on the basis of available P reduce the need for inorganic P without affecting pig performance.

**Key Words:** Pigs, Wheat, Available phosphorus

**449 Growth performance and carcass characteristics of grow-finish pigs fed increasing levels of distiller's dried grains with solubles.** M. H. Whitney\*<sup>1</sup>, G. C. Shurson<sup>1</sup>, L. J. Johnston<sup>2</sup>, D. Wulf<sup>3</sup>, and B. Shanks<sup>3</sup>, <sup>1</sup>University of Minnesota, St. Paul, MN, <sup>2</sup>University of Minnesota, Morris, MN, <sup>3</sup>South Dakota State University, Brookings, SD.

Currently, the recommended maximum inclusion rate of distiller's dried grains with solubles (DDGS) in grow-finish swine diets is 10%. However, previous studies conducted at the University of Minnesota have shown that DDGS produced from new ethanol plants in the MN-SD region has higher nutrient levels and digestibility than reported in NRC (1998). Therefore, we conducted a growth performance and carcass evaluation study to re-evaluate the recommended maximum inclusion rate of DDGS in grow-finish diets when formulated on a total amino acid basis. A total of 240 (28.4 .8 kg) crossbred pigs were randomly assigned to one of 4 dietary treatment sequences in a 5-phase grow-finish feeding program (24 pens, 10 pigs/pen, 6 reps/trt). Dietary treatments consisted of corn-soybean meal diets containing 0, 10, 20, or 30% DDGS. All diets were formulated to contain equivalent total lysine, ME, Ca, and P levels

within each phase. Pigs were weighed and feed disappearance was determined bi-weekly. Time of changing to the subsequent diet phase was based on average pen weight within dietary treatment sequence. Pigs were slaughtered and carcass data collected when average pen weight reached 115 kg. Pigs fed the 20 or 30% DDGS diets had reduced ADG ( $P < .10$ ) compared to 0 or 10% DDGS, but ADFI was unaffected by dietary treatment ( $P > .10$ ). Feed/gain increased when pigs were fed 30% DDGS ( $P < .10$ ) compared to 0, 10, and 20% DDGS inclusion levels. Dressing % decreased linearly ( $P < .03$ ) with increasing dietary DDGS level, but slaughter weight was also lower for pigs fed 20 or 30% DDGS ( $P < .05$ ). Loin depth was lower in pigs fed the 30% DDGS diets ( $P < .10$ ), but backfat depth and % lean did not differ between treatments ( $P > .10$ ). Results from this study suggest that when grow-finish diets are formulated on a total amino acid basis, less than 20% DDGS should be included in the diet for optimal performance and carcass composition. Dietary inclusion levels of 20% or greater may provide satisfactory performance and carcass composition if diets are formulated on a digestible amino acid basis.

**Key Words:** Pigs, Distiller's Dried Grains with Solubles, Growth

**450 Availability of phosphorus in distiller's dried grains with solubles for growing swine.** M. H. Whitney\* and G. C. Shurson, *University of Minnesota, St. Paul, MN.*

A total of 42 growing barrows (20.1 1.3 kg initial BW) were used in a slope-ratio assay to determine the availability of P in distiller's dried grains with solubles (DDGS) produced from ethanol plants in the MN-SD region. Barrows were randomly allotted by weight and ancestry to one of seven dietary treatments. Pigs were housed in individual metabolism cages and fed either a corn starch-soybean meal control diet (.29% total P) or one of six diets containing increasing levels of total P from either dicalcium phosphate (DCP) or DDGS (.34, .39, and .44% total P). Pigs were fed at a level equivalent to 2% of their initial body wt twice daily, and were allowed a 7 d adjustment period prior to a 5 day collection period. Total feces and urine were collected for each pig and analyzed for total P. Phosphorus retention was calculated as the difference between P intake and excretion. Actual P intake ranged from 2.33 g/d (control diet) to 3.91 g/d (DDGS diet with .44% total P). Urinary and fecal P excreted and total P retained increased linearly ( $P < .01$ ) with increasing P intake, regardless of P source. However, P retention (% of intake) was not different between dietary treatments ( $P > .10$ ). A linear regression analysis was conducted for P excreted and P retained relative to P intake for each dietary treatment separately. The slope ratios of the regression lines from each P source were used to determine P availability. Availability of P in DCP was assumed to be 100%. Slopes for P excreted and retained were .354 and .646 (DCP,  $R^2 = .42$  and  $.72$ ) and .405 and .595 (DDGS,  $R^2 = .55$  and  $.73$ ), respectively. Availability of P was 87.5 % and 92.2 %, based on P excretion and P retention, respectively. These results suggest that DDGS from the MN-SD region is an excellent source of available P for growing swine, and that P availability is higher than listed in NRC (1998).

**Key Words:** Pigs, Distiller's Dried Grains with Solubles, Available Phosphorus

**451 Feeding value of hullless and hulled barley in grower pig diets.** A.N. Fenton\*, J.S. Radcliffe, A.F. Harper, M.J. Estienne, D.E. Brann, and C.A. Griffey, *Virginia Polytechnic Institute and State University.*

Ninety-six crossbred pigs (initial BW=38kg) were used in a 6-wk experiment to investigate the feeding value of hulled or hullless barley in pelleted grower pig diets. Pigs were randomly allotted to four dietary treatments, with six replicate pens of each. Diets 1, 2 and 3 were formulated to contain 0.95% Lys, 0.23% available P, 0.60% Ca and 3,446 kcal/kg DE. Diet 1 was corn-soybean meal (SBM) based. Diets 2 and 3 contained 25% corn and a combination of SBM and 46% hullless barley (Diet 2) or 42% hulled barley (Diet 3). Diet 4 was identical to Diet 2 except hulled barley replaced hullless barley on an equal weight basis. Therefore, this diet was lower in CP, energy and mineral content. Pigs had ad libitum access to feed and water. Individual BW and pen feed consumption were recorded weekly. During wk-6, fresh fecal samples were collected six times from at least three out of the four pigs in each pen. Fecal and feed samples were analyzed for Ca, P, Cr, N, DM and energy. The Duncan procedure of SAS (1994) was used to compare treatment means, with pen serving as the experimental unit. Diet type

had no effect ( $P>0.10$ ) on ADG or feed intake over the 6-wk experiment. However, due to numerical differences in feed intake and ADG, feed efficiency was improved ( $P<0.05$ ) for pigs fed Diet 3. There was no effect ( $P>0.10$ ) of diet type on Ca digestibility. Phosphorus, DM, CP and energy digestibilities were lowest ( $P<0.05$ ) for pigs fed Diet 4. The digestibility of P was similar for pigs fed Diets 1, 2 and 3. Pigs fed Diet 2 had a higher DM digestibility compared to pigs fed Diet 1 ( $P<0.05$ ), but were similar to those fed Diet 3. Pigs fed Diet 3 had a higher CP digestibility than those fed Diets 1 or 2 ( $P<0.05$ ). However, pigs fed Diet 3 had a slightly lower energy digestibility than pigs fed Diets 1 or 2 ( $P<0.05$ ). The results of this study indicate that hullless or hulled barley can be incorporated into swine diets at levels of at least 40% and yield performance similar to corn-SBM based diets, if diets are formulated to the same nutrient specifications.

**Key Words:** Pig, Barley, Digestibility

**452 Energy and nitrogen balance of pigs fed four corn grains.** R.W. Fent\*, S.D. Carter, M.J. Rincker, and B.W. Senne, *Oklahoma State University, Stillwater.*

Six sets of four littermate barrows (27.5 kg) were used to evaluate four corn grains (A, B, C, and D) in an energy and nitrogen balance experiment. Corns A and B were nearly isogenic with A being normal corn, while B was a high-oil variety. Corns C and D were also normal varieties. Pigs were housed individually and allotted to four dietary treatments based on weight and litter. Experimental diets (1.0% Lys) consisted of corns A, B, C, or D (90.48%) with casein (5.04%), crystalline amino acids, and a vitamin/mineral source. Pigs had ad libitum access to water and an effort was made to equalize feed intake within replicate. A 7-d adjustment period to the diets was followed by a 5-d collection of feces and urine. Data are reported on a DM basis unless otherwise noted. GE concentration and CP content of corns A, B, C, and D were: 4,462, 4,761, 4,594, and 4,601 kcal/kg and 8.73, 9.14, 9.47, and 9.02%, respectively. GE intakes for pigs fed diets containing A, B, C, and D were 5,452, 5,291, 5,387, and 4,965 kcal/d. However, fecal and urine GE excretions (kcal/d) were similar ( $P>0.10$ ) across all treatments. The DE for the diets containing A, B, C, and D were 3,924, 4,186, 4,061, and 3,990 kcal/kg while ME were 3,868, 4,127, 4,006, and 3,935 kcal/kg, both varying ( $P<0.04$ ) depending on source of corn. However, no differences ( $P>0.10$ ) were seen in DE:GE (.886, .887, .894, and .885) or ME:GE (.874, .875, .882, and .873). Nitrogen absorption and retention were not affected by corn source. Previously, we determined the ME

of casein to be 4,560 kcal/kg and, thus, the casein in the diet (5.04%) supplied 230 kcal/kg. Subtraction of the ME provided by casein from the ME of the diets resulted in ME concentrations of 3,600, 3,842, 3,660, and 3,625 kcal/kg (as-fed basis) for corns A, B, C, and D. This correction resulted in slight differences ( $P<0.10$ ) in ME:GE (.901, .905, .909, and .890) for the corn grains. These results indicate that although ME concentrations varied for the four corn grains, the differences observed were attributed to initial variation in GE concentration.

**Key Words:** Corn, Metabolizable energy, Pigs

**453 Swine digestible energy evaluations of Bt (MON810) and Roundup Ready® corn compared with commercial varieties.** A.M. Gaines\*, G.L. Allee, and B.W. Ratliff, *University of Missouri-Columbia.*

Two digestible energy experiments were conducted to compare nutritional value of insect protected (containing CryIA (b) protein, Bt) corn, glyphosate-tolerant (Roundup Ready, RR) corn (containing maize EP-SPS protein), their near-isogenic parents (BtC and RRC) and three commercial corn hybrids (C1, C2, and C3). Twenty crossbred barrows (26.4±2.8 kg) were placed in metabolism crates allowing for separate collection of feces in two collection periods. Pigs were assigned to one of the five dietary treatments in a complete randomized design. Fecal matter was collected and feed disappearance recorded for the five-day periods. Both fecal material and feed were analyzed for dry matter and gross energy values to determine digestible energy coefficients for each of the experimental hybrids. There were significant differences ( $P\leq.05$ ) in digestibility coefficients (88.1%, 87.7%, 86.2%, 87.3%, and 87.6% for Bt, BtC, C1, C2, and C3, respectively). However, Bt was not different than its near-isogenic parent (BtC). Twenty additional crossbred barrows (25.5±2.9 kg) were placed in metabolism crates in two collection periods and assigned to one of the five dietary treatments in a complete randomized design. Fecal matter was collected and feed disappearance recorded for the five-day periods. There were significant differences ( $P\leq.05$ ) in digestible energy coefficients (87.3%, 88.4%, 86.0%, 88.6%, and 88.0% for RR, RRC, C1, C2, and C3, respectively). However, RR was not different from its near-isogenic parent (RRC). In conclusion, Bt and RR corn digestible energy coefficients values are not different from their near isogenic parents; however, there were differences among the other three commercial corn hybrids tested.

**Key Words:** Corn, Energy, Swine

**ASAS/ADSA Breeding and Genetics: Quantitative Methods**

**454 Use of matrix exponentials to enforce the positive definite constraint of covariance matrices.** S.D. Kachman\*, *University of Nebraska.*

Restricted maximum likelihood estimates of covariance matrices must be positive definite. Enforcing the positive definite constraint for unstructured covariance matrices is a challenge. Matrix exponentials provide a means of reducing the positive definite constraint to a symmetry constraint. An unstructured covariance matrix  $\mathbf{V}$  can be written as the exponential of a matrix  $\mathbf{A}$ . A matrix exponential is defined as  $\mathbf{V}=\exp(\mathbf{A})=\sum_{i=1}^{\infty} \frac{\mathbf{A}^i}{i!}$ . Provided that  $\mathbf{A}$  is symmetric and finite the covariance matrix  $\mathbf{V}=\exp(\mathbf{A})$  is positive definite. By taking a spectral decomposition of  $\mathbf{A}=\mathbf{P}\mathbf{D}\mathbf{P}'$  and iterating on  $\mathbf{D}$  as opposed to  $\mathbf{A}$ , the required derivatives are dramatically simplified. The partial derivative of  $\mathbf{V}$  with respect to  $\delta_{ij}$ , element  $ij$  of  $\mathbf{D}$ , is  $\mathbf{P}\Delta_{ij}\mathbf{P}'$  where  $\Delta_{ij}$  is matrix of zeros except for elements  $ij$  and  $ji$  which are equal to  $[\exp(\delta_{ii})-\exp(\delta_{jj})]/[\delta_{ii}-\delta_{jj}]$ . The derivative reduces to  $\exp(\delta)$  when  $\delta_{ii}=\delta_{jj}=\delta$ .

**Key Words:** Mixed Model, REML

**455 Use of partial augmentation to improve the Monte Carlo sampling of variance components.** R.A.A. Torres Jr and Richard L. Quaas, *Animal Science Department - Cornell University.*

The use of Gibbs Sampling (GS) to estimate variance components ( $\Sigma$ ) for some highly parameterized mixed linear models (animal models) results in chains with very slow mixing. Sampling all location parameters ( $\theta$ ) together may not be enough to overcome the slow mixing. Procedures to sample from the marginal distribution of dispersion parameters have

been suggested but they can be too computationally burdensome for certain applications. Sampling from the marginal distribution of variance components involves evaluating the likelihood as in derivative-free REML estimation, where the determinant of the mixed model equations is obtained using factorization techniques for sparse matrices. This factorization involves reordering the system of equations and results in an arrow shaped system ( $\mathbf{C}$ ). This shape is the useful feature exploited here. The upper left-hand block ( $\mathbf{C}_{11}$ ), corresponding to the tail of the arrow, is usually very large and very sparse and its determinant can be computed at a much lower cost than that for the entire system. Our approach is to sample  $\Sigma$  from its distribution marginal with respect to location parameters at the tail of the arrow ( $\theta_1$ ), but conditional to those at the head of the arrow ( $\theta_2$ ). To do so, we compute  $\pi(\Sigma-\theta_2, \mathbf{y})$  which is proportional to the target distribution and requires the Cholesky factor of  $\mathbf{C}_{11}$  only and use it in a Metropolis-Hastings (MH) algorithm to obtain a sample of  $\Sigma$ . For a system of 255,325 equations, 75,699 were avoided by combining additive and cow effects for non-parents, what is possible as we use MH for sampling  $\Sigma$ .  $\mathbf{C}_{11}$  was assigned 168,000 equations as a high increase in computation resulted if more equations were included. This resulted in augmenting only with 11,626 parameters, which is about 4.5% of the number of augmented parameters in the usual implementation of the GS. Such approach is a compromise between marginal sampling and full conditional sampling of dispersion parameters. It is capitalizes on the shorter chain needed with full conditional sampling (lower autocorrelations) and the computational ease of marginalization.

**Key Words:** Markov Chain Monte Carlo, Covariance function, Test-day model