are unique to individual farms. The link to the individual farms (terroir effect) is more pronounced in 5 mo aged Cheddar than in 9 mo aged Cheddar. Milk from coastal regions appears to be particularly suited for cheese production, likely due to complex NSLAB profiles and flavor development.

Key Words: milk source, cheese, flavor

NONRUMINANT NUTRITION: ENZYMES

0920 The effect of increasing *Buttiauxella* phytase dose on performance in piglets: Meta-analysis from 5 trial studies. Y. Dersjant-Li, R. M. Bold, and W. Li*, *Danisco Animal Nutrition, DuPont Industrial Biosciences, Marlborough, United Kingdom*.

The effect of *Buttiauxella* phytase on the performance of piglets was evaluated combining the datasets of five trials. A total of 234 data points (364 piglets, average initial BW 10 kg) were used in the analysis. Treatments included a nutritionally adequate positive control diet (PC), a negative control diet (NC, with an average reduction of 0.15% calcium and 0.19% phosphorus compared to the PC), and NC supplemented with *Buttiauxella* sp. phytase at 500, 1000, or 2000 phytase units (FTU)/kg feed. One FTU was defined as the amount of enzyme required to release 1 μmol of iP per minute from sodium phytate at pH 5.5 at 37°C. Piglets received the test diets (based on corn/SBM, wheat/SBM or wheat/barley and SBM) for 14 d. No grain source × phytase dose interaction was found, thus data from the 5 trials were pooled for statistical analysis (JMP 11.0, SAS). Treatment means were separated using Tukey's HSD test, trial was used as a random factor. Linear or nonlinear response was tested with increasing phytase dose from 0 (NC) to 2000 FTU/kg. Phytase dose at 1000 and 2000 FTU/kg improved ADG by 12.3 and 19.3% respectively vs. NC ($P < 0.05$), and by 3 and 9.4% vs. PC ($P > 0.05$). No significant differences were seen in feed intake. FCR was improved with phytase at 1000 and 2000 FTU/kg by 8.8 and 10.2% vs. NC ($P < 0.05$), and by 5.5 and 6.3% vs. PC ($P > 0.05$). Increasing phytase dose from 0 (NC) to 2000 FTU/kg increased ($P < 0.05$) ADG linearly and reduced FCR in a nonlinear manner. The data demonstrated that phytase at 500 FTU/kg could replace 0.19% P and 0.15% Ca. Increasing phytase dose to 1000 or 2000 FTU/kg could further improve performance of piglets fed P and Ca deficient diets, most likely due to the extra-phosphoric effects of the phytase. Cost calculation (based on feed cost and 14-d performance data) showed a net value of $0.11, 0.35, and 0.62 per pig ($11.8, 39, and 65/ton of feed) with *Buttiauxella* phytase at 500, 1000, and 2000 FTU/kg respectively compared to PC. In conclusion, increasing *Buttiauxella* phytase dose up to 2000 FTU/kg may provide production benefits in piglets.

Key Words: piglets, meta-analysis, performance

0921 Effects of dietary β-mannanase supplementation with soybean meal in the performances in weanling pigs. B. Balasubramanian*, H. M. Yun, Y. M. Kim, J. K. Kim, and I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea*.

Soybean meal (SBM) is by far the most popular protein source used for feeding livestock. The objective of the present study was to test the efficacy of supplementation of β-mannanase in diets containing de-hulled or conventional hulled SBM (44% and 48%) as well as to evaluate the interactive effects of SBM and enzyme on growth performance, nutrient digestibility, fecal microflora, and noxious gas emission in weanling pigs. In total, 140 pigs [(Landrace × Yorkshire) ×Duroc] with a initial BW of 5.97 ± 1.01 kg were used in a 6-wk feeding trial, randomly allotted in a 2 × 2 factorial arrangement, with feed consisting of hulled or de-hulled SBM with or without β-mannanase [T1 (SBM 44%), T2 (SBM 44% + 0.05% β-mannanase), T3 (SBM 48%), and T4 (SBM 48% + 0.05% β-mannanase)]. Pigs were allocated randomly to 4 treatment groups consisting of 7 replicate pens per treatment with 5 pigs per pen. Pen was the experimental unit. In this study, pigs fed diets containing 0.05% β-mannanase had greater BW, ADG, G:F, and ADFI than pigs fed diets without β-mannanase, but the differences were not statistically significant; however, interactions of SBM diets showed significant differences for ADFI ($P = 0.0334$) at the second week and showed significant effects on DM ($P = 0.0077$), N ($P = 0.0082$), E ($P = 0.0362$), P ($P = 0.0472$) at the sixth week. Furthermore, when compared with SBM, β-mannanase had effects on DM ($P = 0.0105$), N ($P = 0.0416$), P ($P = 0.0591$), but not E and Ca. There were no significant differences for serum BUN, WBC, Lymphocytes, however observed significance on RBC ($P = 0.0130$), when compared with SBM diets at the sixth week. Effects on diarrhea score ($P = 0.0469$) at d 3 and noxious gas emission were not significantly different ($P > 0.05$). The significant effects of β-mannanase supplementation with SBM on fecal microflora (*E. coli* and *Lactobacillus*) showed a significant difference at sixth week ($P < 0.05$). In conclusion, β-mannanase supplementation in a SBM diet showed positive effects on nutrient digestibility (DM, N, E, P), on feed efficiency, and for reducing *E.coli* population in weanling pigs.

Key Words: β-mannanase, soybean meal, weanling pigs

0922 Effect of a multi-enzyme component on growth performance, nutrient digestibility, carcass quality, and gas emission in broilers.
D. H. Nguyen*, H. S. Kim, S. Kathannan, S. Shanmugam, and I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea*.

A total of 480 broiler chicks (BW = 42 ± 1 g) were used in a 5-wk feeding trial in which there were two phases, starter (1 to 18 d) and finisher (19 to 35 d), to investigate the effect of dietary supplementation with multi-enzymes in broiler chickens. The chicks were randomly divided into 4 treatments with 8 replications per treatment and 15 birds per pen. Experimental diets consisted of two different levels: high-energy diet (HE) and low-energy diet (LE). The LE diet had 12.34 (starter) and 13.08 MJ ME/kg (finisher); The HE diet had 12.66 (starter) and 13.39 MJ ME/kg (finisher). Dietary treatments included 1) LCON (low-energy diet); 2) LME (LCON + 375 g multi-enzyme/ton of feed); 3) HCON (high-energy diet); and 4) HME (HCON + 375 g multi-enzyme/ton of feed). The multi-enzyme component contained protease, amylase, xylanase, glucanase, pectinase, galactosidase, debranching enzymes, and phytase. The broilers were weighed by pen and feed intake (FI), and data was recorded on d 1, 18, and 35 for calculating body weight gain (BWG) and feed conversion ratio (FCR). Fresh excreta samples were collected from each pen for the measurement of nutrient digestibility according to the procedures of AOAC (2000). All data were subjected to the GLM procedures of SAS with a 2 × 2 factorial arrangement, and probability values of $P < 0.05$ were considered to be significant. During the starter phase and overall, the effect of multi-enzymes and HE were observed to increase BWG (overall, LME and HME vs. LCON and HCON were 1,581.8 and 1,607.8 vs. 1,534.8 and 1,582.5 g/d; $P < 0.05$). In addition, the FCR improved in broilers fed with HE during d 1 to 18 and overall ($P < 0.05$). The apparent total tract digestibility (ATTD) of DM and N was improved (DM: LME and HME vs. LCON and HCON were 76.8 and 77.9 vs. 75.3 and 76.0%; N: LME and HME vs. LCON and HCON were 73.4 and 74.0 vs. 71.9 and 72.2%; $P < 0.05$) by the multi-enzymes on d 35. An increase was observed in breast muscle on carcass quality when broilers fed with HE ($P < 0.05$). Furthermore, feeding chicks with multi-enzyme supplementation reduced fecal NH_3 and H_2S concentrations ($P < 0.05$). However, no other carcass characteristics were affected by the treatments. In conclusion, dietary supplementation with a multi-enzyme component improved BWG and nutrient digestibility and reduced excreta noxious gas emission in broilers. Breast muscle was improved when broilers were fed the HE diet.

Key Words: broilers, growth performance, multi-enzymes

0923 Efficacy of dietary supplementation of protease and xylanase in plant-based diets on growth performance and health of nursery pigs at 6 to 9 wk of age.
I. Park*, H. Chen, and S. W. Kim, *North Carolina State University, Raleigh*.

This experiment was conducted to determine the supplemental effects of protease and xylanase (BRI, Durham, NC) in plant-based diets on growth performance and health of nursery pigs at 6 wk of age. One hundred and twenty pigs (60 barrows and 60 gilts at 15.5 ± 3.0 kg BW) were randomly allotted to 4 treatments with 10 pens (3 pigs per pen) per treatment, and fed the experimental diets for 3 wk in a 2 × 2 factorial arrangement. Two factors were protease (0 or 15,000 unit/kg diet) and xylanase (0 or 1400 unit/kg diet), which were supplemented to the basal diet, which included yellow dent corn (50%), soybean meal (26%), and distillers dried grains with solubles (20%) as major feedstuffs. All diets contained essential nutrients meeting the NRC requirements. Feed intake and BW were recorded weekly. At the end of the study, a pig representing median BW of each pen was selected for blood collection from jugular vein. Blood was used to obtain plasma. Plasma samples were used to measure plasma urea nitrogen (BUN), tumor necrosis factor-α (TNF-α), and immunoglobulin G (IgG). Data were analyzed using the Mixed procedure in SAS with pen as the experimental unit with treatments and sex as fixed effects and initial BW as a random effect. Statistical differences among treatment means were considered significant with $P < 0.05$. Overall, supplementation of protease did not affect growth performance of nursery pigs. Supplementation of xylanase, however, increased ($P < 0.05$) ADG (1.62 to 1.83 kg/d) without affecting ADFI and tended to increase ($P = 0.061$) G:F (0.803 to 0.860). Combinational use of protease and xylanase on growth performance did not differ among treatments. Plasma BUN and IgG were not affected by both factors, whereas plasma TNF-α was decreased ($P < 0.05$, 40.2 to 25.2 pg/mL) by supplementation of xylanase. There were no interactions of the effects of protease and xylanase in any measurements. In conclusion, dietary supplemental xylanase improved growth performance by reducing systemic inflammatory response. However, a combinational use of xylanase with protease did not enhance the effects of a single use of xylanase in nursery pigs at 6 to 9 wk of age.

Key Words: growth performance, intestinal health, nursery pigs, protease, xylanase

0924 Effects of microbial phytase on the apparent and standardized total tract digestibility of calcium in milk co-products fed to growing pigs.
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The objective of the experiment was to determine effects of microbial phytase on the apparent total tract digestibility (ATTD)

and the standardized total tract digestibility (STTD) of Ca in milk co-products fed to growing pigs. Sixty-four growing barrows (average initial BW: 15.97 ± 3.11 kg) were allotted to a randomized complete block design with 8 diets, 2 blocks, and 4 pigs per treatment in each block. A basal diet based on corn, potato protein isolate, and soybean oil was formulated. Three additional diets were formulated by adding whey powder, whey permeate, or skim milk powder to the basal diet. All diets were formulated without or with 1000 units per kilogram of microbial phytase for a total of 8 diets. All diets were formulated to contain the same concentration of Ca and total P. The basal endogenous loss of Ca was assumed to be 0.123 g/kg DMI. Feces were collected quantitatively for 5 d based on the marker-to-marker approach after a 7-d adaptation period. Results indicated that the STTD of Ca in whey powder, whey permeate, and skim milk powder were 96.18, 52.52, and 95.94% without phytase, respectively, and 94.43, 73.12, and 98.90% with phytase, respectively. Regardless of inclusion of microbial phytase, the ATTD and STTD of Ca in whey powder and skim milk powder were greater ($P < 0.05$) than in whey permeate. Inclusion of microbial phytase increased ($P < 0.05$) the ATTD and STTD of Ca in the whey permeate diet. Microbial phytase also increased ($P < 0.05$) the ATTD of P in the whey powder diet from 79.31 to 81.29%, in the whey permeate diet from 64.17 to 73.05%, and in the skim milk powder diets from 80.15 to 86.40%. Regardless of inclusion of microbial phytase, the ATTD of P was greater ($P < 0.001$) in whey powder and skim milk powder diets than in whey permeate diets. In conclusion, skim milk powder and whey powder had greater ATTD and STTD of Ca than whey permeate, but microbial phytase increase digestibility of Ca in whey permeate. The ATTD of P was also greater in skim milk powder and whey powder diets than in the whey permeate diet.

Key Words: calcium, milk co-products, pigs

0925 Effect of different levels of zinc and phytase on growth performance in weanling pigs. L. Blavi*, D. Solà-Oriol, S. M. Martín-Orúe, and J. F. Pérez, *Animal Nutrition and Welfare Service, Department of Animal and Food Sciences, Universitat Autònoma de Barcelona, Bellaterra, Spain*.

It is common to use 2500–3000 ppm Zn as ZnO to prevent post-weaning diarrhea. However, most of the dietary Zn supply is excreted, causing environmental accumulation, and recently antimicrobial resistance concerns have also increased. Phytate supplementation in most piglet diets may create insoluble salts with several divalent cations (Ca, P, Zn) inhibiting their absorption. Therefore, the objective of the present experiment was to observe the effect of the interaction between the use of therapeutic doses of Zn and phytase supplementation on growth performance in weanling piglets (0 to 35 d post-weaning). A total of 320 pigs were used in a 2 × 2 factorial arrangement, where the main factors were Zn inclusion (125 or 2500 ppm Zn) and phytase inclusion (0 and 1000 FTU). Piglets were reared in 32 pens (10 pigs/pen; 8 replicates per treatment). The pre-starter (0–14 d) and starter (14–35 d) diets contained 2520 and 2460 Kcal NE/kg, 19.65 and 19.00% CP, 1.25 and 1.23 digestible Lys, 0.35 and 0.77% Ca, and 0.33 and 0.25% P digestible, respectively. The pre-starter diet had low Ca levels (0.33%) without $CaCO_3$. Feed intake and individual BW were registered on d 0, 14, and 35 post-weaning. Performance parameters were analyzed with ANOVA by using the Mixed procedure of the statistical package SAS. There was an effect of Zn on BW at d 14 and 35 ($P < 0.05$); where pigs with no ZnO addition presented higher weights compared to pigs with ZnO (11.12 and 21.84 vs. 10.56 and 20.76 Kg, respectively). There was no phytase effect on BW, ADG, ADFI, and FCR. However, there were significant interactions on BW at d 35, ADFI 0–14 and ADG 0–35 ($P < 0.05$), where piglets without ZnO and 1000 FTU of phytase obtained better results (higher BW, ADG, and ADFI) compared to piglets with ZnO and 1000 FTU of phytase (22.2 vs. 20.19 Kg; 327.13 vs. 261.13 g/d; and 416.76 vs. 357.34 g/d, respectively), suggesting that phytase does not have the same benefits with high levels of Zn on the diet. There was also a statistical trend for the interactions on BW14 ($P = 0.08$), ADG 0–14 ($P = 0.07$), ADG 14–35 ($P = 0.06$), and ADFI 0–35 ($P = 0.06$), following the same pattern. It can be concluded that diets without therapeutic ZnO and low levels of Ca but 1000 FTU of phytase allow better growth than diets with high Zn levels.

Key Words: phytase, pigs, zinc

0926 New bacterial 6-phytase expressed in *Pseudomonas fluorescens* improved growth performance, bone parameters, and P digestibility in growing pigs. F. N. Almeida*, M. Vázquez-Añón, and J. Escobar, *Novus International, Inc., St. Charles, MO*.

A study was conducted to determine the effects of a new bacterial 6-phytase expressed in *Pseudomonas fluorescens* (CIBENZA® PHYTAVERSE®, Novus International, Inc., St Charles, MO) on growth performance, bone parameters, and P digestibility in growing pigs fed a diet deficient in standardized total tract digestible (STTD) P. A total of 144 pigs (initial BW = 44.27 ± 0.74 kg) were randomly allotted to 1 of 4 treatments with 18 replications and 2 pigs/pen. Treatments included 1) a positive control (POS) that met the requirements (NRC, 2012) for all nutrients, 2) a negative control (NEG) deficient only in STTD P (−0.10% vs. POS), 3) NEG supplemented with 250 FTU/kg phytase (NEG+250), and 4) NEG supplemented with 500 FTU/kg phytase (NEG+500). Data were analyzed using the Mixed Procedure (SAS® Institute, Cary, NC). The ADG and G:F was less ($P < 0.01$) for pigs consuming the NEG diet compared with POS (0.964 vs. 1.093 kg and 0.356 vs. 0.387, respectively). The ADG of pigs consuming NEG+250 or NEG+500 was not different ($P > 0.05$)

from that of pigs consuming POS (1.061 or 1.066 vs. 1.093, respectively). Phytase linearly ($P < 0.01$) improved the ADG of pigs fed the NEG diet. The G:F of pigs fed NEG+250 or NEG+500 was not different from pigs fed the POS. Phytase supplementation to the NEG diet tended ($P = 0.06$) to linearly improve the G:F of pigs. Bone ash weight and bone P weight were greater for pigs fed the POS diet than for pigs fed the NEG diet (6.42 vs. 4.70 g and 1.19 vs. 0.86 g, respectively). Supplementing pigs with either 250 or 500 FTU/kg, however, linearly improved ($P < 0.01$) bone ash weight compared with pigs fed NEG (4.70 vs. 5.63 or 5.99 g, respectively). Likewise, bone P weight was linearly increased ($P < 0.01$) in pigs fed NEG+250 (1.04 g) or NEG+500 (1.11 g) compared with pigs fed NEG (0.86 g). The STTD of P was greater ($P < 0.05$) for pigs fed NEG+500 (48.71%) that all other treatments, with the NEG being the least digestible (35.03%). In conclusion, this new phytase efficiently improved the growth performance, bone parameters, and STTD of P in grower pigs.

Key Words: bone, pigs, phytase

0927 Effect of timing of post-weaning supplementation of xylanase on growth performance, nutrient digestibility and fecal microbial composition in weanling pigs.

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The study was conducted to investigate the effect of timing of xylanase (Econase XT) supplementation to weanling pigs fed a corn-soybean meal based diet, and its effect on growth performance, nutrient digestibility, and gut microbial composition. A total of 128 weanling pigs ([Hampshire × Duroc] × [Yorkshire × Landrace]; barrows: gilts = 1:1; 6.2 ± 0.6 kg BW; weaning age: 21 d) were randomly assigned to 4 treatments, 8 replicate pens with 4 pigs per pen based on their BW at weaning. The 4 treatments were a combination of 2 dietary treatments (xylanase added at 0 or 16,000 BXU/kg) and 2 feeding time points [period 1 (d 0–14) and period 2 (d 14–42)]. Treatments were: xylanase-xylanase, xylanase-control, control-xylanase, and control-control. The study lasted 42 d with a 3-phase feeding program: d 0 to 14, d 14 to 28, and d 28 to 42. Chromic oxide marker was included in the diets at 0.5% from Day 28. BW and feed intake were recorded every 2 wk. On d 41, fecal samples were collected from each pig for determination of microflora diversity and apparent total tract nutrient digestibility (ATTD). Ileal digesta were also collected on d 42, for determination of apparent ileal nutrient digestibility (AID). From d 0–14, pigs had lower BW, ADG, and feed efficiency when xylanase was included in the diets. The final BW and overall ADG was higher ($P < 0.05$) when xylanase was supplied from d 14 compared with that from d 0. The AID and ATTD of DM, energy, N, and phosphorus was increased ($P < 0.05$) by xylanase and not impacted by timing of xylanase inclusion. The overall bacterial community structure was not influenced by different treatments. However, xylanase significantly decreased ($P < 0.05$) Veillonellaceae and tended to decrease ($P < 0.08$) *Megasphaera* abundance in period 2 compared to the control group. Therefore, timing of xylanase inclusion in weanling pig diets has an effect on performance in the nursery.

Key Words: weanling pigs, xylanase, digestibility, gut microbial profile

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0928 Effect of xylanase and live yeast supplementation on growth performance and gut microflora diversity of growing pigs.

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The objectives of current study were to determine the effect of xylanase and live yeast (LY) supplementation, and the timing of xylanase supplementation, on future growth performance and gut microflora diversity of pigs. In the study, 180 weanling pigs (21 ± 2 d, BW: 6.2 ± 0.16 kg) were assigned to 5 treatments in a randomized complete block design (6 replicate pens, 6 pigs per pen) from weaning to market. The 5 treatments were: control-control, control-xylanase, xylanase-xylanase, LY-xylanase, and xylanase+LY-xylanase, where the first diet was fed from weaning to 2 wk and thereafter 6 additional corn/soy/corn DDG based phases were fed until d 127. Xylanase (Econase XT) was added at 16,000 BXU/kg and LY (Vistacell) at 1 kg/t. On d 15, 2 pigs per pen were euthanized to obtain jejunal mucosa samples. Fecal samples from Days 0, 14, 43, and 127 were collected for volatile fatty acids (VFA) and microbial diversity analysis. Pigs fed with LY and LY+xylanase from d 0–15 had higher BW and ADG at d 15 compared with the control ($P < 0.05$). Overall, G:F was higher in the xylanase+LY-xylanase and control-xylanase groups ($P < 0.05$) on d 127. Additionally, glucose transporter 2 (GLUT2) mRNA expression was higher in the LY and LY+xylanase groups on d 15 compared with control ($P < 0.05$). Furthermore, intestinal alkaline phosphatase (IAP) mRNA expression was highest in the xylanase-xylanase group and lowest in the LY-xylanase group ($P < 0.05$). Fecal VFA concentration significantly increased with age ($P < 0.01$). LY supplementation significantly increased propionate acid, valeric acid, and isovaleric acid

concentrations on d 127 ($P < 0.05$). Age significantly affected microbial diversity structure ($P < 0.01$). In summary, LY supplementation with or without xylanase improved growth performance of weanling pigs in the first 2 wk after weaning. Fecal VFA concentrations and microbial community structure were significantly influenced by age, with xylanase and LY supplementation having only a minor effect.

Key Words: xylanase, live yeast, weanling pigs, growth, microbial profile

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0929 Effects of dietary supplementation of β-mannanase on digesta viscosity and intestinal health of nursery pigs. I. Park*, Y. I. Kim, and S. W. Kim, *North Carolina State University, Raleigh*.

This study was conducted to determine the effects of β-mannanase (CTC BIO Inc., Seoul, Korea) on digesta viscosity and intestinal health of nursey pigs. Pigs (36 barrows and 36 gilts at 15.5 ± 2.3 kg BW) at 45 d of age were housed individually and randomly allotted to 3 treatments (24 pens/treatment). Experimental diets had 3 levels of β-mannanase (0, 400, and 600 Unit/kg) and were fed to pigs for 10 d. Feed intake and BW were measured on d 7 and 10 to calculate growth performance. On d 10, all pigs were euthanized to obtain jejunal digesta to measure viscosity and mucosa from the duodenum and jejunum to measure tumor necrosis factor-α (TNF-α), immunoglobulin G (IgG), and malondialdehyde (MDA). Duodenal and jejunal tissues were used to measure morphology and proliferation of mucosa cells by Ki-67 immunohistochemistry. Tight junction proteins between jejunal mucosa cells were measured by the Western blot. Data were analyzed using polynomial contrasts in the Mixed procedure of SAS. Statistical differences among treatment means were considered significant with $P < 0.05$. Overall, viscosity of jejunal digesta was decreased ($P < 0.05$, 2.50 to 2.10 cP) as increasing β-mannanase from 0 to 600 Unit/kg diets. Increasing β-mannanase in the diets linearly decreased ($P < 0.05$) TNF-α (5.81 to 3.81 ng/g protein in the duodenum, 6.23 to 4.19 ng/g protein in the jejunum), IgG (1.44 to 1.07 mg/g protein in the duodenum, 1.20 to 0.80 mg/g protein in the jejunum), MDA (1.46 to 1.26 μmol/g protein in the duodenum, 1.06 to 0.69 μmol/g protein in the jejunum) and PC (7.11 to 4.22 μmol/g protein in the duodenum) of mucosa. Increasing β-mannanase in the diet linearly increased ($P < 0.05$) villus height (579 to 651 μm of duodenum, 426 to 516 μm of jejunum) and crypt depth (281 to 301 μm of duodenum, 175 to 246 μm of jejunum). Increasing β-mannanase in the diet linearly increased ($P < 0.05$) the number of proliferating cells (29.3 to 35.5%) and ZO-1 tight junction proteins (0.81 to 1.41) in the jejunum. Increasing β-mannanase in the diet, however, did not affect the growth performance of pigs during 45 to 55 d of age. In conclusion, dietary supplementation of β-mannanase (up to 600 Unit/kg diet) enhanced intestinal health by reducing the inflammatory response and oxidative stress which may be related to reduced viscosity of jejunal digesta. A 10-d feeding of β-mannanase, however, did not benefit the growth performance in nursery pigs.

Key Words: digesta viscosity, intestinal health, mannanase, nursery pig

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0930 Effects of dietary supplementation with xylanase on growth performance, ileal digesta viscosity, apparent ileal digestibility, and excreta noxious gas emission of broilers fed wheat-based diets. W. C. Liu*, J. H. Park, S. I. Lee, S. D. Upadhaya, and I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea*.

This study was conducted to evaluate the effects of dietary xylanase supplementation in wheat-based diets on growth performance, ileal digesta viscosity, apparent ileal digestibility, and excreta noxious gas emission of broilers. A total of 600 one-d-old male Ross 308 broilers were used in this 35-d growth trial. Birds with an initial average BW of 43 ± 0.6 g were randomly allotted into 4 treatments with 10 replicate pens per treatment and 15 broilers in each pen. Dietary treatments were as follows: (1) CON, basal diet; (2) T1, basal diet + 0.0125% xylanase (the concentration guaranteed 9000 U/g); (3) T2, basal diet + 0.025% xylanase; (4) T3, basal diet + 0.0375% xylanase. Broilers were weighed and feed consumption was recorded by pen on d 0, 18, and 35 to calculated BWG, ADFI, and FCR. From d 29 to 35, Cr_2O_3 was used as an indigestible marker and supplemented in the diets at a level of 2 g/kg. On d 35, 120 chicks (3 per pen and 30 per treatment) were slaughtered, and the ileal digesta was immediately collected for determining the ileal digesta viscosity and apparent ileal digestibility (AID) of nutrients. For analysis of excreta noxious gas emission, fresh excreta samples from each pen were collected in 2.6-L plastic boxes at the end of experiment. All data were analyzed by using the GLM procedure of SAS, orthogonal polynomial contrasts were used to test the linear and quadratic effects of the increasing levels of xylanase. Statements of statistical significance were based on $P < 0.05$. Dietary addition of xylanase improved (linear, $P < 0.05$) the BWG and decreased (linear, $P < 0.05$) the FCR during d 1–18 and d 0–35. Oral administration of xylanase led to a decrease (linear, $P < 0.01$) in ileal digesta viscosity. In addition, the AID of DM, CP, energy, and most amino acids, with the exception of Ile, Phe, Asp, Glu and Pro, were improved (linear, $P < 0.05$) by xylanase supplementation. Furthermore, xylanase supplementation reduced excreta NH_3 (linear, $P < 0.05$; quadratic, $P < 0.05$) and R.SH (linear, $P < 0.01$) emission. In conclusion, dietary xylanase supplementation in broilers' wheat-based diets could mitigate the detrimental effect of NSP from wheat, reduce the viscosity of gut contents, and improve nutrient digestibility, thus improving broilers' growth performance. Moreover, inclusion of xylanase not only led to more consistent and uniform performance, but it also reduced

the release of odor emissions from broiler houses.

Key Words: growth performance, ileal digesta viscosity, xylanase

0931 Effects of corn-expressed phytase on growth performance and gut health of nursery pigs. J. K. Lee*, H. Chen, I. Park, and S. W. Kim, *North Carolina State University, Raleigh*.

This study was conducted to determine the super-dosing effects of phytase from corn-expressed phytase (CEP, Agrivida, Inc., Medford, MA) on growth performance and gut health of nursery pigs. Pigs (16 barrows and 16 gilts; 21 d of age; 6.19 ± 0.71 kg BW) were individually housed and allotted to one of 4 dietary treatments based on a randomized complete block design with the initial BW and sex as blocks. Pigs were fed a basal diet supplemented with ground CEP to provide phytase activity at 0, 500, 1500, or 3000 FTU/kg during 2 phases (Phase 1: 10 d and Phase 2: 20 d) for a total period of 30 d. Dietary Ca and P were not reduced, with 0.83% Ca and 0.44% STTD P or 0.74% Ca and 0.36% STTD P during Phases 1 and 2, respectively. Feed intake and BW were recorded every 10 d. Plasma samples were collected on d 25 postweaning to measure cytokine tumor necrosis factor-α (TNF-α) and malondialdehyde (MDA). Pigs were euthanized on d 30 to collect tissues from the duodenum and jejunum for the evaluation of morphology, TNF- α, and MDA. Digesta were collected from the proximal jejunum to measure viscosity. Data were analyzed using polynomial contrasts in the MIXED procedure of SAS version 9.3 (SAS Inc., Cary, NC, USA). Increasing the levels of phytase increased (linear, $P < 0.05$) BW on d 20 (10.2 to 12.1 kg) and on d 30 (16.1 to 18.6 kg), increased (linear, $P < 0.05$) ADG from d 10 to 20 (0.32 to 0.49 kg/d), and tended to increase (linear, $P = 0.052$) overall ADG (0.33 to 0.41 kg/d). Increasing supplemental levels of phytase increased (linear, $P < 0.05$) villus height in the duodenum (420 to 559 μm) and jejunum (426 to 491 μm), and the villus height-crypt depth ratio (1.5 to 2.1) in the duodenum. Increasing levels of phytase tended to decrease (Con vs. $T_1 + T_2 + T_3$, $P = 0.089$) TNF- α (6.53 to 5.36 pg/mg) in the duodenum and tended to decrease (linear, $P = 0.080$) MDA (0.5 to 0.34 umol/g protein) in the jejunum. Viscosity of jejunal digesta tended to decrease (quadratic, $P = 0.078$) from 2.55 to 2.15 cP (at 1500 FTU/kg). In conclusion, super-dosing corn-expressed phytase up to 3000 FTU/kg enhanced the growth performance of nursery pigs with improved villus developments and reduced inflammatory cytokine levels and oxidative stress products.

Key Words: corn-expressed phytase, growth performance, gut health, nursery pigs

0932 Effects of xylanase and protease on gut health and growth performance of newly hatched broiler chickens. M. P. Herchler*, L. Zheng, and S. W. Kim, *North Carolina State University, Raleigh*.

This study was to investigate the effects of supplemental xylanase and protease (BRI, Durham, NC) on gut health and growth performance of broiler chickens (288-d-old, male) fed experimental diets for 28 d. Treatments were based on 2 × 2 factorial arrangement with xylanase (0 and 15,000 XU/kg) and protease (0 and 300 U/g) as 2 factors with 9 cages/treatment and 8 birds/cage. Birds and feeders were weighed weekly for calculation of ADG, ADFI, and feed:gain (F:G). On d 7 and 28, 2 birds per pen were randomly chosen to collect blood and gut tissues for immunoglobulin G (IgG), malondialdehyde (MDA), protein carbonyl, and morphology measurements. Ileal digesta were collected to determine viscosity and apparent ileal digestibility (AID). Digesta viscosity tended to decrease ($P = 0.059$) and decreased ($P < 0.05$) when both enzymes were used in wk 1 and 4, respectively, whereas it was not affected by using enzymes individually. Protease increased ($P < 0.05$) villus height (611 to 689 μm) in wk 4. Xylanase decreased ($P < 0.05$) concentrations of serum IgG (2.66 to 2.06 g/L) and ileal protein carbonyl (0.41 to 0.29 μmol/g protein) in wk 1. Protease tended to decrease ($P = 0.083$) serum protein carbonyl (0.78 to 0.66 μmol/L) in wk 1. Protease decreased ($P < 0.05$) ileal protein carbonyl (0.39 to 0.31 μmol/g protein) in wk 1, which was more effective ($P < 0.05$) with xylanase together. Protease decreased ($P < 0.05$) serum MDA (0.56 to 0.30 μmol/L) and ileal MDA (0.53 to 0.35 μmol/g protein) in wk 4. Xylanase did not affect AID, whereas protease tended to increase AID of DM ($P = 0.064$; 74.7 to 76.5%), which was more effective ($P < 0.05$) with xylanase together. In wk 1, xylanase decreased ($P < 0.05$) F:G (1.213 to 1.173) and tended ($P = 0.063$) to decrease ADFI (20.1 to 19.4 g/d), whereas protease reduced ($P < 0.05$) ADG (17.2 to 16.0 g/d) and ADFI (20.1 to 19.4 g/d). Overall, protease increased ($P < 0.05$) F:G (1.504 to 1.528) whereas tended ($P = 0.089$) to reduce ADG (51.3 to 50.2 g/d), which was more effective ($P < 0.05$) with xylanase together. Mortality was not affected ($P > 0.10$) by the treatments. In conclusion, xylanase and protease benefited gut health by decreasing digesta viscosity, enhancing gut morphology, decreasing gut oxidative stress, and increasing nutrient digestibility, whereas these benefits were not related to growth performance.

Key Words: broiler chickens, protease, xylanase

0933 Effect of supplemental enzyme on growth performance, digesta viscosity, apparent total tract digestibility of nutrients in nursery pigs. U. P. Tiwari*[1], H. Chen[2], S. W. Kim[2], and R. Jha[1], [1]*University of Hawaii at Manoa, Honolulu,* [2]*North Carolina State University, Raleigh*.

Arabinoxylans and mannans are present in high concentrations in coproducts like distillers dried grain with solubles (DDGS), which are not degraded by the endogenous enzymes of swine, increase the digesta viscosity, and subsequently reduce the digestibility of nutrients. Feed enzymes can mitigate the negative effect of fiber, thereby enhancing the utilization of relatively low-cost coproducts in swine feeding. Three enzymatic treatments (xylanase, mannanase, and xylanase + mannanase) were used in a 20-d feeding trial to evaluate the effect of supplemental enzymes on fiber degradation and nutrient digestibility in nursery pigs fed corn-soybean meal based diet with 15% DDGS. A total of 32 weaner pigs (PIC 337 × Camborough 22, initial BW 6.2 kg) were used in the study. Feed intake and BW were recorded weekly. On d 14, titanium dioxide was blended into experimental diet (0.3%) as an indigestible marker for calculation of digestibility. Fecal samples were collected over 3 consecutive days, from d 17 to 19. On d 19, pigs were fasted overnight, and exactly 4 h after refeeding on d 20 in the morning, pigs were euthanized by captive bolt followed by exsanguination. There was no significant effect of enzymes on the growth performance of pigs, as the 20-d period might not have been sufficient to show the change, as well as on the pH of jejunal, ileal, and colon digesta. Addition of xylanase reduced ($P < 0.05$) the viscosity of jejunal digesta (2.1 to 1.5 centipoise) and increased ($P < 0.05$) apparent total tract digestibility (ATTD) of acid detergent fiber (18.1 to 26.9%) and neutral detergent fiber (35.1 to 41.2%). Addition of mannanase tended to increase ($P = 0.060$) ATTD of neutral detergent fiber (35.1 to 41.4%). In conclusion, use of feed enzymes targeting fiber in coproducts degrades fiber, increases fiber digestibility, and decreases the viscosity of digesta, ultimately increasing the digestion and absorption of nutrients.

Key Words: coproducts, enzymes, fiber digestibility

0934 Effects of full fat or defatted rice bran and microbial xylanase on growth performance of weanling pigs. G. A. Casas*and H. H. Stein, *University of Illinois at Urbana-Champaign*.

The objective was to determine effects of increased concentrations of full fat rice bran (FFRB) or defatted rice bran (DFRB) in diets without or with supplementation of a microbial xylanase on growth performance and concentrations of tumor necrosis factor-α (TNF-α) and IgA in plasma of weaned pigs. A total of 532 pigs (initial BW: 9.3 ± 0.5 kg) were allotted to 14 diets in a randomized complete block design using 4 blocks and 2 replicate pens per diet in each block. A diet containing corn, soybean meal, and whey powder, and 6 diets containing corn, soybean meal, whey powder, and 10, 20, or 30% of either FFRB or DFRB were used. All diets were prepared without or with 16,000 units per kg of microbial xylanase (Econase XT-25, AB Vista, Marlborough, UK). All diets also contained 1500 units per kg of microbial phytase. On the last day of the 23-d experiment, blood samples were collected from one pig per pen to determine TNF-α and IgA. Results indicated that ADFI decreased linearly ($P < 0.05$) as inclusion of FFRB increased in diets, and that there was a tendency ($P = 0.08$) for reduced ADFI as DFRB increased in the diets. Pigs fed diets containing DFRB had greater ADFI ($P < 0.05$) than pigs fed diets containing FFRB, but ADG increased and then decreased (quadratic, $P < 0.05$) with increasing concentrations of FFRB or DFRB, in the diets. The G:F ratio was not affected by inclusion of DFRB in the diets but increased linearly and quadratically ($P < 0.05$) as the inclusion of FFRB increased, and G:F was greater ($P < 0.05$) in pigs fed diets containing FFRB than in pigs fed diets containing DFRB. There was a tendency for the concentration of TNF-α to decrease linearly ($P = 0.09$) as the inclusion of FFRB increased in the diet, but that was not the case when DFRB was added to the diets. Addition of xylanase had no effect on the variables evaluated. The concentration of IgA was not affected by inclusion of FFRB or DFRB in the diets. In conclusion, both FFRB and DFRB may be included in diets fed to weanling pigs from 2 wk post-weaning by at least 20% without compromising growth performance.

Key Words: pigs, rice bran, xylanase

935 Addition of optimal non-starch polysaccharide enzymes using in vitro method to a corn-soybean meal diet and a corn-miscellaneous meal diet for growing pigs. L. Gao, L. Chen, R. Zhong, L. Zhang, and H. Zhang*, *Institute of Animal Sciences, Chinese Academy of Agricultural Sciences, Beijing, China*.

The objectives of the present study were to evaluate the effect of optimized non-starch polysaccharide (NSP) enzymes using an in vitro digestion method on the digestibility of energy and nutrients in a corn-soybean meal diet and a corn-miscellaneous meal diet (corn–soybean meal–rapeseed meal–cottonseed meal–sugar beet pulp meal diet) of pigs. In Exp. 1, the optimal NSP enzymes (cellulase, xylanase, β-glucanase, β-mannanase, α-galactosidase, and pectinase) of the two diets were screened using a quadratic regress-orthogonal rotary design. In Exp. 2, the effects of the optimal NSP enzymes on the digestibility of energy and nutrients in the 2 diets were determined. A total of 12 ileal-cannulated pigs (initial BW = 50.9 ± 4.9 kg) were allotted to 4 treatments in an incomplete block design (4´3), 4 diets (the 2 diets with or without the addition of optimum NSP enzymes) were fed to the growing pigs. The NSP enzymes had a quadratic effect on the in vitro

dry matter digestibility (IVDMD), and the optimal enzyme combination was 534 U/kg cellulase, 9984 U/kg xylanase, 1014 U/kg β-glucanase, 4081 U/kg β-mannanase, 252 U/kg α-galactosidase, and 107 U/kg pectinase in the corn-soybean meal diet (R^2 = 0.69, P = 0.04), and 960 U/kg cellulase, 17,178 U/kg xylanase, 406 U/kg β-glucanase, 19,023 U/kg β-mannanase, 307 U/kg α-galactosidase, and 97 U/kg pectinase in the corn-miscellaneous meal diet (R^2 = 0.72, P = 0.02), respectively. Pigs fed the corn-soybean meal diet with the addition of NSP enzymes had greater ($P < 0.05$) apparent ileal digestibility (AID) of DM, NDF, and insoluble NSP, and apparent total tract digestibility (ATTD) of soluble NSP and total NSP than those fed the diet without NSP enzymes. The AID of all nutrients, with the exception of the ether extract and the ATTD of GE, DM, CP, EE, and insoluble NSP, were greater in a corn-miscellaneous meal diet with the NSP enzymes than without the NSP enzymes ($P < 0.05$). The ATTD of total NSP content had a tendency (P = 0.05) to increase with the corn-miscellaneous meal diet having the addition of NSP enzymes. In conclusion, a corn-soybean meal diet and a corn-miscellaneous meal diet with the optimal NSP enzymes using in vitro digestion method can increase nutrient digestibility of diets fed to growing pigs.

Key Words: digestibility, energy, in vitro digestion method, non-starch polysaccharide enzyme, nutrient, pig

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0936 Growth performance, bone measurements, and P digestibility in nursery pigs fed diets supplemented with increasing levels of a new bacterial 6-phytase expressed in *Pseudomonas fluorescens*. F. N. Almeida*, M. Vázquez-Añón, and J. Escobar, *Novus International, Inc., St. Charles, MO*.

An experiment was conducted to determine the effects of a new bacterial 6-phytase expressed in *Pseudomonas fluorescens* (CIBENZA® PHYTAVERSE®, Novus International, Inc., St Charles, MO) on the growth performance, bone parameters, and P digestibility in nursery pigs. A total of 280 pigs (initial BW = 6.25 ± 1.03 kg) were randomly allotted to 1 of 5 treatments with 14 replications and 4 pigs/pen. Treatments included 1) a positive control (POS) that met requirements (NRC, 2012) for all nutrients, 2) a negative control (NEG) deficient only in standardized total tract digestible (STTD) P (−0.18% vs. POS), 3) NEG supplemented with 500 FTU/kg phytase (NEG+500), 4) NEG supplemented with 1000 FTU/kg phytase (NEG+1000), and 5) NEG supplemented with 2000 FTU/kg phytase (NEG+2000). Data were analyzed using the Mixed procedure (SAS® Institute, Cary, NC). Orthogonal polynomial contrasts were used to determine linear and quadratic effects of increasing levels of phytase. ADG, ADFI, and G:F were greater ($P < 0.01$) in POS fed pigs than in NEG fed pigs. The ADG was improved (linear and quadratic, $P < 0.01$) from 0.308 (NEG) to 0.475 (NEG+2000) kg as phytase supplementation level increased. Likewise, ADFI and G:F were also improved (linear and quadratic, $P < 0.01$) by increasing levels of phytase. Bone ash and bone P content were greater ($P < 0.01$) in pigs fed POS vs. pigs fed NEG (1.159 and 0.215 g vs. 0.557 and 0.101 g, respectively). As phytase supplementation increased, bone ash and P weight also increased (linear and quadratic, $P < 0.01$) compared with NEG fed pigs. Bone ash and P weight in pigs receiving NEG+2000 were not different ($P > 0.05$) from that of pigs receiving the POS diet (1.106 and 0.192 g vs. 1.159 and 0.215 g, respectively).Phytase supplementation improved (linear and quadratic, $P < 0.01$) the STTD of P from 17.31 (NEG) to 70.74% (NEG+2000). Results from this experiment demonstrate the efficacy of this new 6-bacterial phytase to improve growth performance, bone traits, and the STTD of P.

Key Words: bone, pig, phytase

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937 Nutritive value of cold-pressed soybean cake with or without extrusion or supplementation of multi-carbohydrase for pigs. T. A. Woyengo*[1], R. Patterson[2], and C. L. Levesque[1], [1]*South Dakota State University, Brookings,* [2]*Canadian Biosystems, Calgary, AB, Canada*.

The objectives were to determine the standardized ileal digestibility (SID) of AA and the NE value of cold-pressed soybean cake (CP-SBC), and the effect of extrusion or adding multi-carbohydrase to CP-SBC diet for growing pigs. Eight ileal-cannulated pigs (initial BW = 80 kg) were fed 4 diets in a replicated 4 × 4 Latin square design to give 8 replicates per diet. Diets included a cornstarch-based diet with CP-SBC, extruded CP-SBC, and SBC plus multi-carbohydrase (1200 U of xylanase, 150 U of glucanase, 500 U of cellulose, 60 U of mannanase, 700 U of invertase, 5000 U of protease, and 12,000 U of amylase/kilogram of diet; Superzyme CS, 1 g/kg); and a N-free diet. The CP-SBC was the sole source of protein in the CP-SBC-containing diets. The ratio of cornstarch to sugar and soybean oil in CP-SBC-containing diets was identical to the N-free diet to allow calculation of energy digestibility of CP-SBC by the difference method. The evaluated CP-SBC had been produced by heating the soybean seed at 105°C for 60 min followed by pressing the heated soybean seeds at less than 42°C (barrel temperature). On a DM basis, CP-SBC and extruded CP-SBC contained 47.8 and 47.1% CP, 15.6 and 10.5% ADF, 7.23 and 8.85% ether extract, 3.11 and 3.08% Lys, and 2.25 and 3.70 TIU/mg, respectively. Extrusion increased ($P < 0.001$) the SID of AA for the CP-SBC by an average of 12%. Also, extrusion increased ($P < 0.001$) the NE value of the CP-SBC from 2743 to 2853 kcal/kg of DM. Supplementation of CP-SBC diet with the multi-carbohydrase increased ($P < 0.05$) the SID of Arg and Pro and tended to increase ($P < 0.1$) the SID of Ile and Trp. However, the multi-carbohydrase supplementation did not affect the NE value of CP-SBC. In conclusion, the CP-SBC evaluated in the

present study could be an alternative source of AA and energy in swine diets, and its nutritive value can be increased by extrusion after the cold-pressing. However, there was little additional benefit in nutritional value of the CP-SBC gained with multi-carbohydrase supplementation.

Key Words: cold-pressed soybean cake, nutrient digestibility, pig

0938 Influence of *Acacia tortilis* leaf meal-based diets on growth performance of pigs. M. Khanyile, S. P. Ndou, and M. Chimonyo*, *University of KwaZulu-Natal, Pietermaritzburg, South Africa*.

The objectives of the study were to assess the nutritive value of *Acacia* leaf meals and to determine the optimum inclusion level of *Acacia tortilis* leaf meal in finishing pigs. Five dominant leguminous leaf meals namely, *Acacia tortilis*, *Acacia robusta*, *Acacia nilotica*, *Acacia nigrescens* and *Acacia xanthophloea*, were individually hand-harvested and analyzed for their chemical and physical properties. Although the crude protein content of *A. xanthophloea* and *A. tortilis* were similar, the latter was incorporated into the experimental diets as it had the lowest water-holding capacity and swelling capacity and moderate levels of condensed tannins. *A. tortilis* was also the most abundant in the locality. Thirty finishing male F_1 hybrid (Landrace × Large White) pigs with an initial weight of 60.6 (s.d. = 0.94) kg were randomly allotted to six diets containing 0, 50, 100, 150, 200, 250 g/kg DM inclusion levels of *A. tortilis* leaf meal. Each diet was offered ad libitum to five pigs in individual pens for 21 d. Average daily feed intake (ADFI), average daily gain (ADG), and gain:feed (*G*:*F*) ratio were measured every week. There was an increase in both ADFI and ADG ($P < 0.001$) as *A. tortilis* leaf meal increased, before they started to decrease. An increase in *A. tortilis* leaf meal levels in the diets caused a quadratic decrease ($P < 0.01$) in the *G*:*F* ratio. The change in ADFI, ADG, and *G*:*F* ratio during each week of successive feeding decreased ($P < 0.05$) with incremental levels of *A. tortilis* in the diets. Using piecewise regression (broken-stick analyses), it was observed that *A. tortilis* leaf meal can be included up to 129 g/kg DM in finishing pig feeds without negatively affecting the *G*:*F* ratio. The ability with which pigs utilize leaf meal-based diets improves with duration of exposure to such diets.

Key Words: *Acacia tortilis*, condensed tannins, feed intake, pig performance

0939 Different responses of Ross 308 and 708 broiler strains in growth performance and related properties to diet treatment with or without tributyrate glycerides. A. Bedford[1], H. Yu[1], M. Hernandez[1], J. Squires[2], S. Leeson[3], Y. Hou[4], and J. Gong[*1], *[1]Agriculture and Agri-Food Canada, Guelph, ON, Canada, [2]Department of Animal Biosciences, University of Guelph, Guelph, ON, Canada, [3]Department of Animal and Poultry Science, University of Guelph, Guelph, ON, Canada, [4]Wuhan Polytechnic University, Wuhan, China*.

Within genetically similar broiler strains, there can be significant performance differences, making strain selection an important decision for producers to meet their requirements. This study has investigated the differences in growth performance, including body composition, between Ross 308 and Ross 708 birds, and compared how each strain responds to the supplementation of tributyrin. Tributyrin is a butyric acid glyceride that has been shown to have multiple positive effects on broiler performance and can be a potential alternative to in-feed antibiotics. Two hundred and forty-day-old Ross 308 and 240-d-old Ross 708 birds were divided into treatment groups and fed either a basal diet or diets supplemented with low or high levels of tributyrin for 35 d. Neither the strain nor tributyrin supplementation had an effect on overall average daily gain or feed:gain ratios ($P > 0.05$). Ross 708 control birds had significantly decreased relative abdominal fat weight at 5 wk of age compared to Ross 308 control birds ($P < 0.05$), and tributyrin supplementation further decreased relative abdominal fat weight in Ross 708 birds ($P < 0.05$). Ross 708 control birds had significantly higher fat deposition in the breast muscle compared to Ross 308 controls ($P < 0.05$), and the addition of tributyrin lowered this deposition in both strains ($P < 0.05$). Breast muscle lipid profiles were significantly different between strains, with Ross 308 control birds having decreased saturated and monounsaturated fatty acids and increased polyunsaturated fatty acids compared to Ross 708 control birds ($P < 0.05$). Significant differences in the hepatic expression of genes associated with lipid metabolism (SREBP-1 and ATPCL) were observed both between strains and with tributyrin supplementation ($P < 0.05$). These results support the modulation of lipid metabolism by tributyrin and show that even genetically similar strains can perform significantly differently at the metabolic level and respond differently to dietary supplementation of tributyrin.

Key Words: broiler, tributyrin, growth performance

0940 Immunomodulatory effects of whole yeast cells and capsicum in weanling pigs challenged with pathogenic *Escherichia coli*. S. Wojnicki[*1], V. G. Perez[2], and R. N. Dilger[1], [1]*University of Illinois, Urbana,* [2]*ADM Animal Nutrition, Decatur, IL*.

Global concerns over antibiotic resistance triggered the development of nutritional technologies to support animal health. In weaned pigs, enterotoxigenic *Escherichia coli* infections are common. In this study, we sought to quantify the combined dietary effects of whole yeast cells (WYC) and capsicum (CAP) on performance and immune indices in weanling pigs experiencing an *E. coli* infection. Weanling pigs (32 barrows and 32 gilts, 21 d of age, 5.90 ± 1.03 kg BW) were allotted to experimental treatments in a randomized complete block design based on genetics, sex, and initial BW. Four pigs were individually housed within each containment chamber and assigned to 1 of 4 dietary treatments (n = 13), which included a control diet without or with 0.2% WYC (CitriStim, ADM, Decatur, IL) or 10 ppm of CAP, provided either alone or in combination. After receiving diets for 13 d, pigs were orally inoculated with F18$^+$ *E. coli* and maintained on the same diets for an additional 10 d; a separate cohort of pigs (n = 12) receiving the control diet was sham-inoculated using PBS. Body and feeder weights were recorded, and fecal swabs collected, on 0, 5, and 10 d post-inoculation (DPI), with blood sampled at 7 DPI for clinical outcomes. Data were analyzed as a 2-way ANOVA (infected pigs only), with a separate comparison between unchallenged and challenged control-fed pigs. While no interactive effects were observed for growth performance, main effects revealed that WYC increased (P < 0.05), and CAP decreased (P < 0.05), ADFI 0–10 DPI; reciprocal effects were observed for G:F due to a lack of differences in ADG. The challenge *E. coli* strain was undetectable in fecal swabs on 0 and 10 DPI but differed between unchallenged and challenged control-fed pigs at 5 DPI. Total bacterial counts were lower (P = 0.02) at 5 DPI in pigs fed CAP-containing diet, and the combination of additives elicited higher total bacteria counts compared with either additive alone (interaction, P = 0.03) at 10 DPI. Blood leukocyte counts were increased in infected pigs receiving the combination of additives compared with infected pigs on other dietary treatments (interaction, P = 0.04), and addition of WYC increased lymphocyte counts (main effect; P = 0.01) at 7 DPI. Overall, these data indicate that WYC and CAP have different effects on ADFI and individually or in combination may affect the immune response in weaned pigs experiencing an enterotoxigenic *E. coli* infection.

Key Words: *Escherichia coli*, yeast, essential oils

0941 Comparing the effects of zinc oxide, milk hydrolysate, yeast β glucan, and combination of milk hydrolysate/yeast β glucan on growth, gut microbiota, and cytokine gene expression in weaning piglets. *A*. Mukhopadhya[*1], J. V. O'Doherty[2], N. Noronha[3], M. T. Ryan[1], and T. Sweeney[1], [1]*School of Veterinary Medicine, University College Dublin, Belfield, Dublin 4, Ireland,* [2]*School of Agriculture and Food Science, University College Dublin, Dublin 4, Ireland,* [3]*Food for Health Ireland, University College Dublin, Dublin, Ireland*.

Concerns over the usage of prophylactic antibiotics and pharmacological doses of zinc (ZnO) are driving the need to develop natural sustainable alternatives to support gut health in the piglet during the post weaning period. Our hypothesis was that a diet consisting of a combination of yeast β-glucan (YBG) and sodium caseinate hydrolysate (NaCASH) will improve gut health in weaning piglets and replace the requirement for ZnO in the diet. Thus, the objective of this experiment was to compare the effects of supplementing the weaning piglet diet with ZnO, NaCASH, YBG, and a combination of NaCASH + YBG on piglet body weight (BW), gut microbiota, and gut cytokine gene expression. Forty 21-d-old piglets (7.3 ± 0.2 kg) were weaned and assigned to either 1) control diet, 2) control diet supplemented with 3.1 g/kg ZnO, 3) 0.25 g/kg NaCASH, 4) 0.25 g/kg YBG, or 5) 0.25 g/kg NaCASH + 0.25 g/kg YBG (combination) for 12 d (n = 8). Fecal scores per pen were recorded daily and BW recorded on Days 0, 6, and 12. Following sacrifice on Day 12, caecal and colonic digesta and colonic tissues were collected. Digesta samples were used to enumerate a selected panel of bacterial colonies by 16s rRNA QPCR, while tissue samples were used to evaluate a selected panel of cytokine gene expression by QPCR. Lower fecal scores were recorded in piglets from d 6–12 supplemented with either ZnO (P < 0.01) or the combination (P < 0.05) compared to control group. Similarly, overall ADG, FI, and gain to feed ratio were improved in ZnO and combination (P < 0.05) groups compared to the control group. However, only ZnO supplementation improved BW (P < 0.05) compared to control group. In caecal digesta, *Bacteroidetes* abundance was increased by ZnO and NaCASH supplementation (P < 0.05) compared to control group, whereas YBG group had higher enteropathogenic AEEC compared to control group (P < 0.05). In colonic tissues, while *IL-1α, IL-1β, IL-8*, and *IL-17* expression were downregulated in ZnO group, only *IL-1α* expression was downregulated in NaCASH and combination diet groups compared to control group (P < 0.05). Therefore, NaCASH or YBG individually did not improve weaning piglet growth or health, yet in combination they improved growth parameters similar to ZnO supplementation. Hence, these results substantiate our hypothesis that a YBG-NaCASH combination could be a suitable alternative to

zinc oxide during the weaning period.

Key Words: gastrointestinal tract, post-weaning nutrition, inflammation

0942 Effects of a standardized blend of carvacrol, cinnamaldehyde, and capsicum oleoresin on performance of growing finishing pigs using multiple trial analysis methodology.

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The optimization of performance at limited expense in growing-finishing pigs is a constant concern of producers. Many phytomolecules have been reported to influence production efficiency of monogastric animals. The objective was to assess the effect of a standardized protected blend of cinnamaldehyde, carvacrol, and capsicum oleoresin (XT, XTRACT® 6930, Pancosma, Geneva, Switzerland) on performance and carcass quality of growing-finishing pigs. The database regrouped 14 trials organized in 7 studies (500 pigs; mean initial BW of 47.0 kg, mean duration of 69.0 d, mean XT dose of 83.5 g/t). All trials reported side-by-side comparisons of an unsupplemented control diet and the inclusion of XT in pigs. Outcomes selected were DMI, ADG, FCR, carcass yield, fat thickness in G2, and meat %. Data were analyzed using a mixed model with the TRIAL variable as a random effect and the TRT variable as a fixed effect. Mean values were calculated using the LSMEANS procedure of XLstat, weighting the data for the variance among trials. Results showed that XT increased ADG by 2.6% ($P < 0.05$) and reduced FI and FCR by. respectively. 1.1% ($P < 0.05$) and 3.8% ($P < 0.01$). For these outcomes, the lower limit of the 95% confidence interval was then used to assess the effect of XT supplementation on fattening duration or pig weight at slaughter. For a fixed slaughter weight of 120 kg, the effect of XT on performance resulted in a reduction of growing and fattening by 2.2 d. After 115 d of fattening, XT increased final BW by 1.7 kg. Finally, XT did not affect carcass yield and fat thickness G2 ($P > 0.50$) but increased meat percentage by 1.2% ($P = 0.06$). These findings suggest that the dietary supplementation of XT improves performance of growing-finishing pigs.

Key Words: multiple analysis, phytomolecules, pig performance

0943 Extracts of laminarin improve growth rate and small intestinal morphology in newborn chicks but do not influence *Campylobacter* colonization.

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Promoting growth performance while limiting the proliferation of bacteria such as *Campylobacter jejuni* is a key goal of the broiler industry. Therefore, the objective of this study was to evaluate the effects of supplementing the post-hatch diet with laminarin and fucoidan extracts on growth performance, small intestinal morphology, and *C. jejuni* colonization following an experimental challenge in 13 d old chicks. The experiment consisted of three diets: 1) basal diet, 2) basal diet + 200 ppm laminarin (LAM), and 3) basal diet + 200 ppm LAM and 160 ppm fucoidan (LAM/FUC). Day-old Ross chicks ($n = 135$) were housed in groups of three, with 15 replicates per treatment group. On Day 3, all chicks were orally gavaged with 0.1 ml × 10^6 colony forming units of *C. jejuni.* Following humane sacrifice on Day 13, caecal digesta samples were collected for enumeration of *C. jejuni* and *Lactobacillus*. Ileal tissue was also collected post-slaughter to examine small intestinal morphology. Chicks offered diets containing the seaweed extracts LAM or LAM/FUC had increased live weights (311 g, s.e. 4.14 and 302 g, s.e. 3.99, respectively, $P < 0.05$) compared to the basal diet (290 g, s.e 3.99) at the end of the experimental period (Day 13). The mean total intake for the chicks fed the LAM and LAM/FUC extracts at the end of the experiment (Day 13) were 373 g/d (s.e. 3.89), 411 g/d (s.e. 4.03), and 411 g/d (s.e 3.89), respectively, with chicks fed the basal diet having lower feed intake compared to both the LAM and LAM/FUC fed chicks ($P < 0.05$). Dietary inclusion of LAM/FUC combination increased the feed conversion ratio (FCR) (1.63 g/g vs. 1.69 g/g; s.e ± 0.02) compared to the basal diet ($P < 0.05$). Chicks offered the LAM diet had increased ileal villus height compared to chicks offered the basal diet (307 µm vs. 231 µm s.e ± 17.24, $P < 0.05$). There was no effect of LAM or LAM/FUC extracts on the proliferation of *C. jejuni* or on *Lactobacilli* numbers in the cecum. In conclusion, supplementation with LAM or LAM/FUC in the post-hatch period improved growth performance and positively modified small intestinal architecture but did not impact the extent of *C. jejuni* proliferation.

Key Words: broiler chicks, *Campylobacter jejuni*, performance, histology, seaweed

0944 Effects of defatted microalgae on nutrient digestibility and retention in broiler chicks.
T. Sun*, A. D. Magnuson, L. Tao, M. Burke, M. Barcus, and X. G. Lei, *Cornell University, Ithaca, NY*.

This experiment was to determine the impact of supplemental 10% defatted microalgae (*Nannochloropsis oceanica*, 45% CP and 3.8% ether extraction, EE) from biofuel production in a corn-soybean meal basal diet (BD) on nutrient digestibility and retention in broiler chicks. Day-old hatchling Cornish Giant cockerels were divided into two groups (5 cages/group, 4–5 chicks/cage) and fed the BD or the microalgae diet for 6 wk. Starting at wk 3, chicks were fed diets containing 0.2% chromic oxide as an indigestible marker. Total excreta of individual cages was collected daily for consecutive 5 and 3 d during wk 5 and 6, respectively. At the end of wk 6, chicks were euthanized to collect ileal digesta from 1 chick/cage. Concentration of DM, CP, EE, AA, and chromic oxide in digesta, excreta, and diets were assayed. Apparent nutrient retention was calculated based on total excreta collection and chromic oxide as an indigestible marker. The latter was also used to estimate apparent ileal digestibility of nutrients. Data were analyzed by Student *t* test. Chicks fed the two diets had similar ADFI and G:F ratio, although those fed the microalgae diet had 3–5% ($P < 0.05$) heavier BW than chicks fed the BD. Feeding the microalgae diet enhanced ($P < 0.05$) and decreased ($P < 0.05$) apparent retention and digestibility of DM by 3.3% and by 1.8%, respectively. Feeding the microalgae diet elevated (1.6 to 3.8%, $P < 0.05$) apparent retention of EE determined by the indirect method, but not by the direct method. Supplemental defatted microalgae did not affect apparent retention of CP determined by both methods at either time point except for a 17.8% decrease ($P < 0.01$) by the 5-d total collection. Feeding the microalgae diet decreased ($P < 0.05$) apparent ileal digestibilities of 8 essential AA and 6 nonessential AA, ranging from 32% for isoleucine to 7% for glutamic acid. Feeding that diet decreased ($P < 0.05$) apparent retention of 6 essential AA and 5 nonessential AA, ranging from 16% for threonine to 0.6% for leucine. In conclusion, supplementing 10% of defatted microalgae in the corn-soybean meal diet did not show consistent effect on apparent retention or ileal digestibility of DM, EE, or CP determined by the two methods at the two time-points, but the diet decreased apparent retention or ileal digestibility of a number of AA. (Supported by USDA/DOE Biomass R&D Initiative Grant and a Cornell Hatch Grant).

Key Words: algae, amino acid, broiler, digestibility, retention

0945 Defatted microalgae-mediated enrichment of n-3 polyunsaturated fatty acids in muscle of broiler chicks was not affected by supranutrition of vitamin E and(or) Se.
L. Tao, T. Sun, A. D. Magnuson, M. Burke, and X. G. Lei*, *Cornell University, Ithaca, NY*.

We previously demonstrated an enrichment of docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) in breast and thigh muscles of broiler chicks fed defatted microalgae. This study was to determine if that enrichment affected the physical quality of the meat and was enhanced by feeding less corn oil and extra vitamin E/Se. Day-old hatchling Cornish Giant cockerels (total: 216) were divided to six groups (6 replicate cages/treatment and 6 chicks/cage). The treatments included Diet 1 (control) = corn-soybean meal based diet containing 4% corn oil, 25 IU vitamin E as dl-α-tocopherol/kg, and 0.2 mg Se as sodium selenite/kg; Diet 2 = Diet 1 + 10% defatted *Nannochloropsis oceanica* (45.1% CP, 3.8% EE); Diet 3 = Diet 2 − 2% corn oil; Diet 4 = Diet 3 + 75 IU vitamin E/kg; Diet 5 = Diet 3 + 0.3 mg Se/kg; and Diet 6 = Diet 3 + 75 IU vitamin E and 0.3 mg Se/kg. The experiment lasted for 6 wk. Data were analyzed by one-way ANOVA with Bonferroni's post-hoc comparisons tests or by Student's *t* test (GraphPad Prism 6.0). Diets produced no difference in growth performance of chicks. Feeding Diet 2 enhanced ($P < 0.05$) concentrations of breast CP (14%), glycine (60%), and serine (70%) at wk 6 compared with the control. Feeding Diet 2 elevated ($P < 0.05$) DHA and EPA concentrations of both breast and thigh muscles over the control, whereas feeding Diets 3–6 did not further enhance the enrichments. Both breast and thigh muscles were cooked (175°C oven for 30 min) for texture analysis. Springiness of the thigh muscles was elevated by 23% ($P < 0.05$) in chicks fed Diet 2 than in those fed Diet 1. Chewiness of the breast muscle was elevated by 41–83% ($P < 0.05$) in chicks fed Diet 5 than in those fed the other diets. Chewiness of the thigh muscles was elevated by 79% ($P < 0.05$) in chicks fed Diet 5 than in those fed Diet 1. In conclusion, supplementation of 10% defatted microalgae in the corn-soybean meal basal diet effectively enriched DHA and EPA in breast and thigh muscles, whereas inclusions of extra vitamin E and Se or less corn oil in the diets did not enhance the enrichments. The additional Se, however, improved chewiness of the muscles. (Supported in part by a USDA/DOE Biomass R&D Initiative Grant and a Cornell Hatch Grant).

Key Words: chicken quality, DHA, EPA, microalgae, selenium, vitamin E

0946 Effect of supplementing milk during first 4 d postweaning on growth performance, energy digestibility, gut morphology, and severity of diarrhea for nursery pigs in a commercial farm.
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The experiment was conducted to evaluate the effects of supplemental milk (6.5, 8.7, 10.9, and 10.9 g DM milk/pig/d; 10% of estimated feed intake) during the first 4 d postweaning on growth performance, energy digestibility, and severity of diarrhea of nursery pigs. A total of 644 crossbred pigs, weaned at 3 wk of age (6.4 ± 1.2 kg of BW), were randomly assigned to 2 dietary treatments (12 pens/treatment, 27 pigs/pen) in a randomized complete block design with sex and initial BW as blocks. Pigs were fed pellet feed either with or without milk supplementation from d 1 to 4 postweaning (4 times daily) in a T-shaped feeder that was placed in the pens for 2 h at each feeding. All pigs had free excess to another nursery feeder with the same pellet feed during the entire nursery period in 3 phases (phase I: 10 d; phase II: 14 d; and phase III: 25 d). Fecal score was evaluated daily according to the observation of fresh feces in pens from d 1 to 4 postweaning following a scale of 1 to 3 (3 = liquid diarrheal feces). Titanium dioxide (0.3%) was added in the phase I pellet feed as an indigestible marker to measure apparent ileal digestibility (AID) of DM and GE. Jejunal tissue and ileal digesta from 1 pig/pen were collected at d 4 and 10 postweaning. Data were analyzed using the Mixed procedure of SAS. Statistical differences among treatment means were considered significant with $P < 0.05$. The results showed that milk supplementation did not affect the ADG and ADFI during the entire nursery period. However, supplementing milk tended to increase ($P = 0.073$) the G:F ratio (0.708 to 0.748) during phases I and II. The AID of DM and GE at d 10 of postweaning did not differ between treatments. Supplemental lipid milk tended to enhance ($P = 0.062$) villus height:crypt depth (2.04 to 2.15) in the jejunum at d 10 postweaning. Supplemental milk tended to reduce ($P = 0.065$) the fecal score (2.04 to 1.84) and decreased ($P < 0.05$) mortality (4.35 to 1.55%) during the entire nursery period. Collectively, supplementing milk 4 times daily for the first 4 d postweaning helped nursery pigs by enhancing feed efficiency and gut morphology with decreased severity of diarrhea and mortality during phases I and II.

Key Words: growth performance, gut health, milk, nursery pigs

0947 Effects of dietary lysophospholipid complex on apparent ileal digestibility and growth performance in nursery pigs.
L. Zheng*, A. C. Weaver, and S. W. Kim, *North Carolina State University, Raleigh*.

Two experiments were conducted to evaluate the effect of dietary lysophospholipid complex (LPC; Lipidol, Easybio System, Korea) on apparent ileal digestibility (AID) and growth performance of nursery pigs. The LPC used in this study includes lysolecithin, lysophosphatidylinositol, lysophosphatidylethanolamine, and lysophosphatidic acid (5%) with calcium silicate as a carrier (95%). In Exp. 1, 24 newly weaned pigs (12 barrows and 12 gilts at 7.2 ± 0.1 kg BW) were randomly allotted to 2 treatments in a randomized complete block design. Sex and initial BW were used as blocks. Pigs were fed a basal diet supplemented with either 0 or 0.1% LPC in 2 phases (7 and 12 d, respectively). Titanium dioxide (0.5%) was added to the diets from d 14 as an indigestible external marker. Body weight and feed consumption were recorded on d 7, 14, and 19. On d 19, jejunal digesta were collected to measure viscosity, and ileal digesta were collected to measure AID of DM, GE, lipid, and CP. In Exp. 2, 150 pigs at 6 wk of age (75 barrows and 75 gilts, 14.2 ± 0.2 kg BW) were randomly allotted to 2 treatments in a randomized complete block design. Sex and initial BW were used as blocks. Pigs were fed a basal diet supplemented with either 0 or 0.1% LPC for 3 wk. Body weight and feed consumption were recorded weekly. Blood samples were collected at the end of the study to measure the concentrations of tumor necrosis factor-α and immunoglobulin G to observe general health status of the pigs. Data were analyzed using the Mixed Model procedure of SAS. In Exp. 1, AID of lipid tended to be increased (72.7 to 84.2%, $P = 0.086$) by LPC whereas AID of DM, GE, and CP were not affected. Viscosity of jejunal digesta were not affected by LPC. Dietary LPC increased ADG (681 to 774 g/d, $P < 0.05$) and ADFI (1000 to 1089 g/d, $P < 0.05$) of nursery pigs from d 14 to 19. In Exp. 2, dietary LPC tended to increase ($P = 0.072$) ADG (664 to 708 g/d) during the 3-wk period whereas ADFI and G:F were not affected by dietary LPC. Serum concentrations of tumor necrosis factor-α and immunoglobulin G were not affected by dietary LPC. In conclusion, dietary supplementation of LPC improved the growth of nursery pigs, potentially by enhancing lipid digestibility.

Key Words: apparent ileal digestibility, growth performance, lysophospholipid, nursery pigs

0948 Effects of dietary supplementation of phytobiotics on intestinal health and growth performance of nursery pigs. I. Park*, J. K. Lee, J. Wang, and S. W. Kim, *North Carolina State University, Raleigh*.

This study was to determine the effects of dietary supplementation of phytobiotics (By-O-reg, Advanced Ag Products, Hudson, SD) on growth efficiency and intestinal development of nursery pigs. Phytobiotics included encapsulated oregano essential oil. Forty pigs (20 barrows and 20 gilts at 6.4 ± 0.3 kg BW) were randomly allotted to 4 treatments (2 × 2 factorial arrangement) with 10 pens (1 pig per pen) per treatment based on a randomized complete block design, and fed the experimental diets for 3 wk. Two factors were antibiotic growth promoter (AGP; 0 or 0.5 g/kg) and phytobiotics (0 or 0.5 g/kg diet), respectively. All diets were formulated to meet or exceed the NRC nutrient requirements. Feed intake and body weight were measured weekly. Blood samples were taken on d 20 to measure tumor necrosis factor-α (TNF-α), immunoglobulin G (IgG), IgA, and protein carbonyl (PC). On d 21, all pigs were euthanized to obtain the duodenal and jejunal mucosa and tissue. The mucosa samples were used to measure TNF-α, IgG, IgA, and PC. The tissues were used to measure morphology. Data were analyzed using the Mixed procedure in SAS with factors, interaction between factors, and sex as fixed effects and initial BW as a random effect. Interaction between factors were again analyzed using PDIFF to evaluate a different effect of each treatment. Overall, there were AGP × phytobiotics interactions ($P < 0.05$) on ADG and G:F. Among these interactions, both dietary AGP ($P = 0.071$; 627 g/d) and phytobiotics ($P = 0.057$; 624 g/d) tended to increase ADG compared with the basal diet (543 g/d) at wk 3. Dietary phytobiotics increased ($P < 0.05$) jejunal villus height (443 to 471 μm). Dietary phytobiotics decreased ($P < 0.05$) the concentrations of TNF-α (4.41 to 3.82 ng/g protein) and IgG (1.42 to 1.19 μg/mg protein) in the jejunum and PC (4.2 to 2.9 nmol/mg protein) in the plasma. Dietary AGP tended to decrease ($P = 0.063$) jejunal IgA levels (1.60 to 1.14 μg/mg protein) in the jejunum. Collectively, both dietary AGP and phytobiotics enhanced ADG only when they were used independently. A combinational use of AGP and phytobiotics had negative effects on growth performance. Dietary phytobiotics improved jejunal development by reducing inflammatory and humoral immune reaction.

Key Words: antibiotic growth promotor, growth performance, intestinal health, nursery pigs, phytobiotics

0949 Growth performance and toxic response of broilers fed diets containing unfermented or fermented cottonseed meal. J. L. Xiong[1], L. Y. Wu*[1], H. L. Zhou[2], Z. J. Wang[1], F. T. Meng[1], and L. H. Miao[1], *[1]Hubei Key Laboratory of Animal Nutrition and Feed Science, Wuhan Polytechnic University, Wuhan, China, [2]Xiangyang Engineering Research Center of Animal Medicine, Xiangyang Vocational and Technical College, Xiangyang, China.*

Cottonseed meal (CSM) is produced locally in sizeable quantities in China, but the amount of CSM used in animal diets has been limited mainly by the presence of toxic gossypol. Microbial fermentation is now known as one of the most promising detoxification techniques of CSM. Therefore, reliable evaluation of fermented cottonseed meal (FCSM) can give guidance on its appropriate dose in animal diets to ensure animal health and welfare. The objective of this study was to verify the hypothesis that the reduced free gossypol content and the improved growth performance were not the only marker factors to evaluate FCSM using in broiler diets. A total of 150 1-d-old male Cobb 400 broilers were randomly assigned to 3 dietary treatments with 5 replications of 10 birds per treatment and were fed diets with 31.0% soybean meal (SBM) (control), 15.5% SBM and 15.5% CSM, 15.5% SBM and 15.5% FCSM until 21 d of age, respectively. Birds were weighted after 12 h feed withdrawal on the end day, and then were slaughtered for measure of organ weights. Blood samples were collected through a jugular vein for analysis of serum enzyme activities on the finishing day. All data were statistically analyzed by SAS software. The level of significance was based on probability of 0.05. Fermentation decreased free gossypol from 583.40 to 191.70 mg/kg CSM, and degraded total gossypol from 5830.19 to 3882.91 mg/kg CSM. Compared with the control, the diet with 15.5% FCSM did not affect ($P > 0.05$) average daily growth and feed conversion ratio, while the diet containing 15.5% CSM decreased ($P < 0.05$) these parameters. However, the diet with 15.5% FCSM, similar with the diet containing15.5% CSM, increased ($P < 0.05$) the relative weight of liver and the activity of serum alanine aminotransferase, and decreased ($P < 0.05$) the relative weight of thymus compared with the control. In conclusion, residual gossypol or/and degradation products of gossypol in FCSM may still be hepatotoxicity and immunotoxicity, even though free gossypol and total gossypol have been markedly reduced so as not to alter adversely growth performance of broilers fed the diet with 15.5% FCSM, as half replacement of the SBM in the control.

Key Words: cottonseed meal, gossypol, fermentation, broilers

0950 Protein value of eight triticale genotypes for pigs based on standardized ileal amino acid digestibility. E. J. P. Strang[*1], M. Eklund[1], P. Rosenfelder[1], J. K. Htoo[2], and R. Mosenthin[1], *[1]University of Hohenheim, Institute of Animal Science, Stuttgart, Germany, [2]Evonik Nutrition & Care GmbH, Hanau-Wolfgang, Germany.*

The study was conducted to determine the chemical composition, physical characteristics and standardized ileal digestibility (SID) of CP and AA of 8 currently available genotypes of triticale fed to growing pigs. The experiment was conducted with 8 barrows (initial BW of 30 ± 2 kg) that were fitted with a simple T-cannula at the distal ileum. The pigs were randomly allotted to an 8 × 8 Latin square design. Diets were based on 1 of the 8 triticale genotypes each, with triticale as the sole source of CP and AA. An N-free diet was fed to determine basal ileal endogenous losses of CP and AA. Diets were supplemented with titanium dioxide as an indigestible marker, and fed at a daily intake level of 4% of pigs' average BW corresponding to about 3 times the pigs' energy requirement for maintenance (106 kcal of ME/kg of $BW^{0.75}$). Each experimental period consisted of 5 d for adaptation to the diets and 2 d for ileal digesta collection. Ileal digesta samples were collected consecutively for a total of 24 h. Data were analyzed by the Mixed Procedure of SAS with genotype and pig as fixed effects; period and period × pig were considered as random effects. The CP and non-starch polysaccharide (NSP) contents (as-fed basis) of the 8 triticale genotypes ranged from 10.5 to 11.8% and 8.5 to 10.0%, respectively. The greatest contents of NDF, ADF and ADL in the 8 genotypes amounted to 14.9, 2.9 and 0.6% (as-fed basis), respectively. Among the 8 genotypes, SID of CP, Lys, Met, Thr and Trp ranged from 81 to 85, 72 to 77, 84 to 87, 73 to 77 and 79 to 83%, respectively. The SID of CP and AA did not differ among the 8 triticale genotypes, except for SID of Arg, Glu and Gly ($P \leq 0.05$). The SID of CP and AA was not affected by NSP or NDF content due to the small variations of these fiber fractions among genotypes. Compared to SID values for triticale in current feed tables, the SID of CP, Lys, Met and Trp in the present 8 triticale genotypes was up to 4, 4, 4, and 1%-units lower, respectively, and up to 5%-units higher for Thr. These differences in SID of AA need to be accounted for in diet formulation for pigs when new genotypes of triticale are used.

Key Words: amino acid digestibility, growing pigs, triticale

0951 Effect of metabolizable energy and sulfur amino acid levels on productive performance and economic return of laying hens. C. Gallardo[*1] and E. Salvador[2], *[1]University of São Paulo, Pirassununga, Brazil, [2]National University of San Luis Gonzaga, Ica, Peru.*

One trial was conducted to evaluate the effect of metabolizable energy (ME) and sulfur amino acids (AAAS) on the productive performance and economic return of laying hens. A total of 405 ISA Brown laying hens (5 birds/pen) of 30 wk of age were distributed in a randomized experimental block design in a 3 × 3 factorial arrangement, composed of three levels of ME (2,646, 2,793 and 2,940 Mcal/Kg) and 3 levels of SAAs (0.67, 0.71 and 0.745%). Egg production, feed intake, feed conversion ratio, egg weight and egg mass, ME intake, SAAs intake, Haugh unit and feed cost (kg of egg mass), were evaluated. Significant interaction ($P < 0.05$) between ME × SAAs was observed on feed intake, feed conversion, ME intake and SAAs intake. 2,793 Mcal/kg of ME and 0.745% of SAAs propitiated higher ($P < 0.05$) feed intake, SAAs intake and better feed conversion ratio. Birds fed low-ME and SAAs diets showed low feed intake, egg production, feed conversion, egg mass, ME intake and SAAs intake. Diets providing 2,793 Mcal/kg of ME maximized ($P < 0.01$) egg production and egg mass. While Diets providing 0.745% of SAAs maximized ($P < 0.05$) egg weight and egg mass. The diet with 2,793 Mcal/kg of ME and 0.745% of SAAs had the lowest feed cost and the higher profit per kg of egg mass. Thus, the best productive performance and economic return of laying hens diet may be obtained with levels of 2,793 Mcal/kg of ME and 0.745% of SAAs.

Key Words: Egg production, intake, egg mass

0952 Intestinal microbiota, microbial metabolites and carcass traits are changed in a pig model fed a high-fat/low-fiber or a low-fat/high-fiber diet. S. N. Heinritz[*1], E. Weiss[1], M. Eklund[1], T. Aumiller[1], S. Messner[1], C. M. E. Heyer[1], S. Bischoff[2], and R. Mosenthin[1], *[1]University of Hohenheim, Institute of Animal Science, Stuttgart, Germany, [2]University of Hohenheim, Department of Nutritional Medicine, Stuttgart, Germany.*

For gastrointestinal functions and health, the intestinal microbiota and its metabolites appear to be an important factor. However, further elaboration of potential relationships between nutrition, gut microbiota, and host's health by means of a suitable animal model are required. The present study was designed to examine the impact of diets high in fat or fiber content, thus rather representing an "unhealthy" or "beneficial" diet, on gut microbiota composition, microbial activity, and carcass traits by using the pig as a model for humans. Eight pigs (initial BW 28 ± 2 kg) were allotted to 2 treatments,

either fed a low fat/high fiber (LF), or a high fat/low fiber (HF) diet for 7 wk. Then, pigs were slaughtered to determine carcass and intestinal weights, as well as backfat thickness. Digesta samples of cecum and colon were taken to measure short-chain fatty acid (SCFA) concentration and gene copy numbers of total eubacteria, *Lactobacillus* spp., *Enterobacteriaceae*, *Bifidobacterium* spp., and *Bacteroides-Prevotella-Porphyromonas* (*Bacteroides* group) by use of real-time qPCR. Body weight at slaughter was 72.5 kg for the HF treatment and 77.1 kg for the LF treatment ($P > 0.05$). Carcass weight was also similar for both treatments, whereas full stomach and colon as well as liver weights were higher for the LF when compared to the HF treatment ($P < 0.05$). Gene copy numbers of total bacteria in the cecum digesta were higher in the HF compared to the LF treatment ($P < 0.05$), yet abundance did not differ in colon digesta. *Bifidobacterium* spp. occurred in higher numbers in the LF treatment, both in cecum and colon digesta ($P < 0.05$). Higher numbers in HF than in LF pigs were found for the *Bacteroides* group ($P < 0.05$) and *Enterobacteriaceae* ($P < 0.001$) in cecum and colon digesta. Total SCFA, acetate and butyrate showed higher colonic concentrations in LF than in HF pigs ($P < 0.05$), while in cecal digesta of LF only acetate and butyrate concentrations were higher ($P < 0.05$). Results confirmed the trophic action of dietary fiber on epithelium of digestive organs and revealed that the low-fat/high-fiber diet stimulated beneficial bacteria and SCFA production, especially butyrate. On the other hand, the high-fat/low-fiber diet promoted potential pathogenic bacteria. These findings are comparable to those in humans and are in support of the potential of the pig to serve as model for assessing diet-gut-microbiota interactions.

Key Words: dietary fat/fiber content, intestinal microbiota, pig model

0953 Use of zinc oxide nanoparticles as growth promoter for weanling pigs. N. C. Milani*, N. Y. Ikeda, M. Sbardella, and V. S. Miyada, *Universidade de São Paulo, Piracicaba, Brazil.*

Pharmacological levels of zinc (as ZnO) have been used in weanling pig diets for diarrhea control and growth performance improvement. Due to its low absorption, Zn-excretion has motivated environmental concerns. Thus, ZnO nanoparticles (ZnO-N) appear to be an alternative to reduce zinc oxide (ZnO) use in diets, once this form has shown higher antimicrobial activity. The purpose of this study was to evaluate the effects of dietary ZnO-N on performance and diarrhea occurrence of weanling pigs. One hundred and ninety-two 21d-weaned pigs (5.90 ± 0.83 kg BW) were used in a randomized complete block design experiment with 6 treatments, 8 replications per treatment, and 4 animals per experimental unit (pen). The treatments were: negative control (NC): basal diet (based on corn, soybean meal, dried whey and dried plasma) with 100 mg Zn (as ZnO)/kg diet; positive control (PC): basal diet with 2400 mg Zn (as conventional ZnO, 150nm)/kg diet and basal diet with 12, 24, 48 or 96 mg Zn (as ZnO-N, 70nm)/kg diet. Pigs were fed dietary treatments from 1 to 21 d feeding period followed by a common diet (same diet for all treatments) from 22 to 35 d feeding period. ANOVA and polynomial regression analysis (for levels of Zn as ZnO-N) were performed. No effects of Zn levels (as ZnO-N) were observed on performance and diarrhea occurrence (Table 1). The PC had higher ADFI and lower diarrhea occurrence compared to NC and Zn (as ZnO-N) levels during the first 21 d post-weaning period ($P = 0.0001$), without affecting ADG, G:F and BW. No residual effects of treatments were observed during 22 to 35-d period, when all pigs were fed with same diet. Therefore, ZnO-N was not effective for post-weaning diarrhea control and growth rate improvement.

Key Words: nanoparticle, performance, pigs, zinc oxide

Table 0953.

Table 1. Effects of dietary zinc oxide on the performance and diarrhea occurrence of weanling pigs

Item	Treatments						SEM	P-Value
	2,400 mg Zn/kg	Zn (as ZnO-N) levels, mg/kg						
		0	12	24	48	96		
Initial BW, kg	5.89	5.90	5.89	5.89	5.90	5.88	0.28	0.7692
1 to 21d period								
BW, kg	13.24	12.16	12.83	12.38	12.46	12.27	0.52	0.1192
ADG, g/d	349.85	298.24	330.43	309.23	312.18	303.94	17.44	0.1149
ADFI, g/d	513.27	434.45*	464.46*	440.24*	446.26*	434.88*	18.69	0.0013
Diarrhea[1],%	3.86	24.60*	22.91*	25.14*	20.68*	19.34*	3.38	0.0001
22 to 35 d period								
BW, kg	19.76	18.97	19.68	19.49	19.41	19.01	0.81	0.8632
ADG, g/d	447.35	497.21	481.6	512.58	499.61	490.15	28.70	0.5716
ADFI, g/d	804.80	891.79	799.86	857.10	843.26	825.42	25.95	0.1258
Diarrhea[1], %	5.35	3.72	6.69	6.17	8.18	6.47	2.41	0.8493

*Different from positive control (2,400 mg Zn/kg as ZnO) by orthogonal contrast test (P<0.05)
[1]Diarrhea occurrence in each period (% of days)

0954 Effect of dietary flaxseed oil on growth performance, nutrient digestibility, blood profiles, and meat quality in pigs. P. Y. Zhao*, T. S. Li, S. Shanmugam, S. Kathannan, R. X. Lan, and I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea.*

Alpha-linolenic acid (ALA) is the parent compound of the omega-3 fatty acids, which have several specific metabolic and structural roles within the body. However, ALA can't be synthesized by mammals. As flaxseed oil is rich of ALA, 2 experiments were conducted to investigate the effect of dietary flaxseed oil in pigs. In Exp. 1, 135 weanling pigs (5.50 ± 0.42 kg) were used in a 4-wk trial and were allotted to 3 treatments: 1) CON, basal diet, 2) FO0.5, CON + 5 g/kg flaxseed oil, 3) FX1, CON + 10 g/kg flaxseed oil. There were 9 replications with 5 pigs per pen. In Exp. 2, 40 finishing pigs (89.90 ± 0.41 kg) were used in a 4-wk trial and allotted to 2 treatments: 1) CON, basal diet, 2) FO0.5, CON + 5 g/kg flaxseed oil. There were 5 replications with 4 pigs per pen. Individual pig BW and the feed consumption of each pen were monitored to calculate the ADG, ADFI, and G:F. Chromium oxide (2 g/kg) was added to the diets to determine the ATTD of DM, N, and GE. Blood profiles were analyzed by using an automatic biochemistry blood analyzer. All data were subjected to the GLM procedures of SAS as a randomized complete block design (SAS Inst. Inc., Cary, NC). Tukey's range test was used to compare the means of the treatments. A $P < 0.05$ was considered to be statistically significant. In Exp. 1, no difference ($P > 0.05$) was observed on growth performance and nutrient digestibility in weanling pigs, but total cholesterol (65.29 vs. 54.14 mg/dL) and triglycerides concentrations (30.43 vs. 24.71 mg/dL) were decreased ($P < 0.05$) by 5 g/kg flaxseed oil supplemention. In Exp. 2, flaxseed oil did not affect ($P > 0.05$) growth performance and nutrient digestibility. Total cholesterol (120.42 vs. 104.11 mg/dL), LDL-cholesterol (73.69 vs. 52.18 mg/dL) and triglyceride concentrations (55.02 vs. 48.87 mg/dL) were decreased ($P < 0.05$) by 5 g/kg flaxseed oil, however, HDL-cholesterol concentration (44.43 vs. 49.64 mg/dL) was increased ($P < 0.05$). Higher ($P < 0.05$) meat pH (5.77 vs. 5.59) was observed in pigs fed 5 g/kg flaxseed oil diet. There was no difference ($P > 0.05$) in meat quality and back fat thickness in finishing pigs. In conclusion, the inclusion of 5 g/kg flaxseed oil decreased total cholesterol, LDL-cholesterol, and triglyceride concentrations, increased HDL-cholesterol concentration without any negative effect on growth performance, nutrient digestibility, and meat quality of pigs.

Key Words: blood profile, flaxseed oil and pigs

0955 The effect of three levels of unmilled rice on growth performance and digestive tract development in broilers and ducks. C. P. Villemarette*, E. Lyons, B. Chung, E. Ferguson, and F. M. LeMieux, *McNeese State University, Lake Charles, LA.*

Three experiments Exp. 1 = 144 broilers; Exp. 2 = 118 mallard *Anas platyrhynchos* ducklings; and Exp. 3 = 75 mature mallard *Anas platyrhynchos* ducks were conducted to determine the effects of 3 levels of unmilled hybrid rice on growth performance, linear measurements and weights of organs, and gastrointestinal tract. Each experiment had 3 dietary treatments: (1) corn-soybean meal (basal), (2) basal + 5% hybrid rice, and (3) basal + 10% hybrid rice. All diets were formulated to meet or exceed dietary requirements for ducks and broilers from 0 to 9 wk of age. Treatments were replicated 8 times with 6 birds per pen (Exp. 1), eight times with 4 or 5 birds per pen (Exp. 2), and 3 replications with 8 or 9 birds per pen (Exp. 3). At Day 11 (Exp. 1), and Day 14 and 21 (Exp. 2) 1 bird from each pen ($n = 24$) was randomly selected to determine linear measurements and weights of organs and gastrointestinal tract. At experiment termination 28 d and 35 d experiment 2 and 3 respectively all remaining birds $n = 70$ (Exp. 2) and $n = 75$ (Exp. 3) were euthanized for internal tract measurements. Average initial weight of the chicks and ducks was 34.8 g, 31.8 g, and 821 g in Exp. 1, 2, and 3, respectively. Final BW of the chicks and ducks was 362.1 g, 446.6 g, and 1202.0 g in Exp. 1, 2, and 3, respectively. Data was analyzed by ANOVA procedures using the GLM procedure of SAS. Tukey's Honestly Significant Difference test was used to find difference among treatments and significance was considered at ($P < 0.05$). In Exp. 1 and 2, birds fed 10% rice grew slower ($P < 0.05$) than birds fed the basal diet. In Exp. 3 the addition of rice did not affect growth, feed intake or feed efficiency. Rice addition did not affect organ length or weight ($P > 0.1$) in Exp. 1. However in Exp. 2 birds fed 5% rice had increased ($P < 0.05$) pancreas, ileum, and jejunum weights and in Exp. 3, the addition of 10% rice increased ($P < 0.05$) liver weight. These results suggest the addition of 10% unmilled rice to broiler and duck diets may decrease growth performance.

Key Words: broilers, ducks, rice

0956 Influence of zinc-methionine complex supplementation on reproductive performance and immunity of gestating-lactating sows under hot weather condition. J. M. Romo[1], J. A. Romo[2], R. Barajas[*2], H. R. Güémez[1], I. Enriquez[2], and G. Silva[1], *[1]FMVZ-Universidad Autónoma de Sinaloa, Culiacán, Mexico, [2]FMVZ-Universidad Autónoma de Sinaloa, Culiacan, Mexico.*

Thirty eight pregnant sows (Yorkshire × Landrace) were used to determine the influence of zinc-methionine complex supplementation on reproductive performance and immunity of gestating-lactating sows under hot weather condition. Thirty 5 d after be pregnant, sows were randomly assigned to treatments as follows: 1) Basal corn-soybean meal gestation diet (14.17% CP; 3.27 Mcal ME/kg) and lactation diet (17.95% CP; 3.35 Mcal ME/kg) that provided 60 mg of inorganic Zn/kg from $ZnSO_4$ (Control; CTR); and 2) Control plus 100 mg Zn/kg provided from Zn methionine complex (ZnM; ZINPRO 120, Zinpro Corp., Eden Prairie, MN). Treatments were offered since d 35 of gestation period, until Day 21 of lactation when piglets were weaned. Sows were placed in individual cages and fed ad libitum. Parametric data were analyzed by ANOVA for a completely randomized design, and percentage of piglet mortality was analyzed by Chi-square test using 2 × 2 tables. Each sow was the experimental unit. Across experiment weather means values were: air temperature 31.1 ± 1.2°C; relative humidity 68.24 ± 7.26%; and THI 82.57 ± 1.30, respectively. Sow back fat thickness (BFT) at d 35 of gestation was similar between treatments ($P = 0.93$), but in d-111 of gestation BFT was increased ($P = 0.05$) by ZnM (16.6 vs. 14.9 mm).The litter size (12.6 vs. 11.6 piglets), litter weight (12.6 vs. 12.3 kg), piglets born alive (10.4 vs. 9.4 piglets), and number of piglets weaned (7.7 vs. 8.3) were not affected by treatments ($P > 0.10$). Adjusted-21 d weaned litter weight was similar ($P = 0.32$) between treatments, with mean values of 42.3 and 45.6 kg for CTR and ZnM, respectively. Zinc methionine supplementation decreased ($P < 0.01$) piglets-mortality with mean values of 26% and 11% for CTR and ZnM, respectively. IgA in colostrums (1 682 ± 500 ng/mL) was no altered by treatments ($P > 0.10$). In piglet 14 d post weaned serum concentration of IgG (178 ± 144 ng/mL) and IgM (185 ± 101 ng/mL) were similar ($P > 0.10$) between treatments. Results suggest that ZnM supplementation to gestating-lactating sows under hot weather conditions could contribute to increase sow fat reserves and decrease mortality of piglets.

Key Words: reproductive performance, sows, zinc.

0957 Japanese quail (*Coturnix japonica*) responses to low protein diets supplemented with crystalline lysine, methionine, and threonine. C. R. Herrera Cortés[1], H. Bernal Barragán[*1], F. Sánchez Dávila[1], J. E. Hernández Quiroz[1], M. A. Montemayor Abundiz[1], and M. Cervantes Ramírez[2], *[1]Universidad Autónoma de Nuevo León, San Nicolás de los Garza, Mexico, [2]ICA- Universidad Autónoma de Baja California, Mexicali, Mexico.*

This study was conducted with the aim to determine the effect of dietary levels of lysine, methionine, and threonine on growth efficiency, environmental impact, and carcass quality of growing quails (*Coturnix japonica*). A sorghum-SBM basal diet with 21.1% crude protein, 1.08% lysine, 0.32% methionine, and 0.78% threonine (Diet 1) was formulated. Four additional diets (Diet 2 to 5) were supplemented with crystalline lysine, methionine, and threonine to contain 1.19, 1.30, 1.41, and 1.53% lysine; 0.46, 0.50, 0.54 and 0.59% methionine and 0.93, 1.02, 1.11, and 1.20% threonine, respectively. All diets were isoenergetic (2,958 kcal EM/kg feed). Ninety 14-days old quails were distributed in 30 cages, and randomly assigned to the five experimental diets ($n = 6$ replicates/treatment) during 28 d. Body weight, feed intake, average daily weight gain, and feed efficiency were monitored weekly. On the fourth week, excreta were collected during 48 h. Data were statistically analyzed with ANOVA. Final body weight, and average daily gain responded in a quadratic manner ($P < 0.05$) to incremental levels of crystalline amino acids. Birds fed Diet 5 had a body weight gain 12% higher ($P < 0.005$) than those fed the basal diet (3.26 g/d). Birds fed Diets 2 and 4 had 50 to 70% heavier thighs than birds in basal diet (16.9 vs. 9.7 g; $P < 0.05$), with no other carcass differences. On the other hand, birds receiving Diet 3 with 1.30% lysine, 0.50% methionine, and 1.02% threonine, reduced 23% ($P < 0.05$) the amount (1.17 g) of N excreted per unit of body weight gain of birds fed the basal diet. It was estimated that requirements of lysine, methionine, and threonine for growth traits of quails are 1.53%, 0.59%, and 1.20%, respectively. In conclusion, supplementing crystalline lysine, methionine, and threonine, improved growth efficiency, carcass quality, and protein utilization of growing Japanese quails fed a 21.1% CP sorghum-SBM based diet.

Key Words: Japanese quail, essential amino acids, growth efficiency

0958 Bioavailability of D-methionine relative to L-methionine for nursery pigs using slope-ratio assay. C. Kong*, J. Y. Ahn, and B. G. Kim, *Konkuk University, Seoul, The Republic of Korea.*

An experiment was conducted to determine the bioavailability of D–methionine (Met) relative to L–Met for nursery pigs using the slope-ratio assay. A total of 50 crossbred barrows with an initial BW of 13.5 kg (SD = 1.0) were used in an N balance study. A Met-deficient basal diet (BD) was formulated to contain adequate amount of all AA for 10 to 20 kg pigs except for Met. Two reference diets were prepared by supplementing the BD with 0.4 or 0.8 g L–Met/kg at the expense of corn starch, and the equivalent concentrations of D–Met were added to the BD for the 2 test diets. The pigs were adapted to the experimental diets for 5 d and then total but separated collection of feces and urine was conducted for 4 d according to the marker-to-marker procedure. Nitrogen intakes were similar across the treatments. Fecal N output was not affected by Met supplementation regardless of source, and apparent N digestibility did not change. Conversely, there was a linear response ($P < 0.01$) to Met supplementation from both Met isomers in urinary N output, which resulted in increased retained N (g/4 d) and N retention (% of intake). No quadratic response was observed in any of the N balance criteria. The estimated bioavailability of D–Met relative to L–Met from urinary N output (g/4 d) and N retention (% of intake) as dependent variables using supplemental Met intake (g/4 d) as an independent variable are 87.6 and 89.6%, respectively, but approximate 95% fiducial limits for the relative bioavailability estimates included 100%. In conclusion, with the absence of statistical significance, the present study indicated that the mean relative bioequivalence of D–Met to L–Met was 87.6% based on urinary N output and 89.6% based on N retention.

Key Words: methionine isomers, nitrogen balance, relative bioavailability, swine

0959 Energy value of bakery meal and peanut flour meal for broiler chickens determined using the regression method. F. Zhang*[1] and O. Adeola[2], *[1]Purdue University, West Lafayette, IN, [2]Department of Animal Sciences, Purdue University, West Lafayette, IN.*

The energy value of bakery meal (BM) and peanut flour meal (PFM) for broiler chickens were determined in the current experiment with Ross 708 broiler chickens from d 21 to 28 post hatching. The birds were fed a standard broiler starter diet from d 0 to 21 post hatching. 320 birds were grouped by weight into 8 blocks of 5 cages with 8 birds per cage and assigned to 5 diets. Experiment used a corn-soybean meal reference diet (RD) and 4 test diets (TD) in which test ingredients partly replaced the energy sources in the RD. The TD consisted of 200 g BM, 400 g BM, 100 g PFM, or 200 g PFM/kg, respectively. The DM of BM and PFM were 878, and 964 g/kg, respectively and the respective gross energies were 4,060, and 5,783 kcal/kg DM. The result showed that an addition of either BM or PFM to the RD did not affect the growth performance of birds from d 21 to 28 post hatching. The ileal digestible energy (IDE), ME, and MEn of both ingredients were determined by the regression method. The determined IDE values were 3,412 kcal/kg DM for BM and 4,801 kcal/kg DM for PFM; ME values were 3,176 and 4,601 kcal/kg DM for BM and PFM, respectively. And the MEn values were 3,093 kcal/kg DM for BM and 4,112 kcal/kg DM for PFM. In conclusion, the current study provides energy values for BM, and PFM, and shows that adding up to 100 g BM or PFM/kg broilers diets from d 21 to 28 did not affect growth performance.

Key Words: bakery meal, metabolizable energy, peanut flour meal

0960 Kinetics of lipid peroxidation in fats and oils as affected by lipid source, heating temperature, and length of heating. S. C. Lindblom*[1], G. C. Shurson[2], J. Moser[3], and B. J. Kerr[4], *[1]Iowa State University, Ames, [2]Department of Animal Science, University of Minnesota, St. Paul, [3]USDA-ARS, Peoria, IL, [4]USDA- ARS, Ames, IA.*

Lipid peroxidation is a chain reaction of generation and degradation of peroxidation compounds including acids, aldehydes, ketones, and polymers. However, assays used in farm animal research commonly measure 1 or 2 compounds and do not assess the change in a lipid's peroxidation status over time. Consequently, a laboratory-study was conducted to evaluate the impact of heating temperature and length of heating on the generation of lipid peroxidation products in lipids varying in fatty acid composition. Six lipids were selected based on their divergent fatty acid composition and predicted peroxidizability index (Hammond, 1954). Lipids used in this study included tallow, palm oil, soybean oil, linseed oil, menhaden oil, and a manufactured oil were heated at 4 temperatures to reflect ambient, summertime feed temperature in a bulk bin, an elevated feed processing temperature, and a frying temperature (22.5°, 45°, 90°, and 180°C, respectively). Oils (2.5 L each) were placed in a 5 L round-bottom glass flask and heated with an electric heating mantle with power controller, with bubbling air at 3 L/min. Because tallow and palm oil were solids at room temperature, they were evenly spread into a 30.5 × 45.7 cm pan to allow for air reaction to the lipid. Samples were taken at equally distributed time points within a temperature (22.5°C for 0, 6, 12, 18, 24 d; 45°C for 0, 3, 6, 9, 12 d; 90°C for 0, 18, 36, 54, 72h; and 180°C for 0, 3, 6, 9, 12h). Lipid analysis for composition, quality, and peroxidation indicators were conducted. Depending on the lipid source, heating temperature, and sampling time, peroxide value increased from 11 to 1200 mEq/kg, *p*-anisidine value from 0 to 810, hexanal from 0 to 300 mg/kg, 2,4-decadienal from 0 to 690 mg/kg, polar

compounds from 5 to 60%, polymers from 0 to 30%, and OSI from 0 to 22 h at 110°C. The data show that the peroxidizability of lipids varies greatly depending on their fatty acid profile, the degree of heating and time of sampling. Because peroxidized lipids have been shown to impact animal performance, gastrointestinal integrity, gene expression, immune competence, and metabolic oxidative status, the understanding of how and when lipid peroxidation compounds are generated and degraded, and their concentration in a lipid at specific time point is important to their use in livestock feeding programs.

Key Words: kinetics, lipid peroxidation, lipid quality

0961 Effects of feeding dried cabbage leaf residues on broiler performance, ileal digestibility and total tract nutrient digestibility. A. Mustafa, V. Higginson*, and B. Baurhoo, *McGill University, Ste-Anne De Bellevue, QC, Canada.*

A study was conducted to determine the effects of feeding dried broccoli floret residues on growth performance, apparent ileal digestibility, apparent total tract nutrient digestibility and intestinal microbial populations in broiler chickens. One thousand two hundred 1-d-old male Ross 508 broilers were randomly allotted to 4 dietary treatments and were grown over a 35-d experimental period. Dietary treatments included 4 levels of dried broccoli floret residues: 0, 3, 6, and 9%. Results showed that inclusion of dried broccoli floret residues increased body weight gain (quadratic effect, $P = 0.004$) and feed conversion ratio (quadratic effect, $P = 0.002$) with no effect on feed intake. Apparent ileal crude protein (CP, quadratic effect, $P = 0.003$) and dry matter (DM, quadratic effect, $P = 0.002$) digestibility for younger birds (25 d of age) increased as the level of dried broccoli floret residues in the diet increased. However, apparent ileal CP (linear effect, $P = 0.022$), DM (linear effect, $P = < 0.001$) and gross energy (linear effect, $P = 0.001$) digestibility for older birds (35 d of age) decreased as a result of dried broccoli residue inclusion. Nitrogen correct apparent metabolizable energy decreased (linear effect, $P < 0.001$) as the level of dried broccoli floret residues in the diet increased. However, N retention was not influenced by dried broccoli floret residue inclusion. It was concluded that incorporation of dried broccoli floret residues in broiler diet at moderate levels (i.e., 3 to 6%) may improve the growth of broiler chickens with no detrimental effects on nutrient digestibility and retention. However, at high levels (i.e., 9%), dietary dried broccoli floret residues may compromise ileal and total tract nutrient digestibility.

Key Words: Broiler, dried boccoli residues, ileal digestibility, total tract digestbility

0962 Effect of type of fibrous sources in the phosphorus-free diet on the basal endogenous loss of phosphorus in growing pigs. A. R. Son[*1] and B. G. Kim[2], [1]*Konkuk University, Seoul, South Korea,* [2]*Konkuk University, Seoul, The Republic of Korea.*

The objective of this study was to investigate the influence of fiber sources in P-free diets on the basal endogenous loss (BEL) of P in growing pigs. Eight barrows with an initial BW of 37.4 ± 2.7 kg were individually housed in metabolism crates. The pigs were allotted to dietary treatments in a replicated 4 × 4 Latin square design with 4 diets, 8 pigs, and 4 periods. Four P-free diets were formulated based mainly on cornstarch, sucrose, and gelatin, and contained 10% of cellulose, pectin, silica sand, or sawdust as a fiber source in each P-free diet. Each period consisted of a 4-d adaptation period and a 4-d period of total collection of feces according to a marker-to-marker procedure. Chromic oxide was added at 0.5% to the morning meal as an indigestible marker on d 5 and 9 in each period. The feed intake of pigs fed the sawdust diet was less ($P < 0.05$) than that of pigs fed the silica sand diet. The total fecal output of pigs fed the cellulose and silica sand diets were greater ($P < 0.05$) than that of pigs fed the pectin diet. The P concentration in the feces was greater ($P < 0.05$) in the pigs fed the pectin diet compared with the pigs fed the cellulose and silica sand diets. The total P output was not affected by the fiber sources. The BEL of P was 206, 350, 252, and 431 mg/kg DMI in the cellulose, pectin, silica sand, and sawdust diets, respectively. The BEL of P of the pigs fed the sawdust diet was greater ($P < 0.05$) than that of the pigs fed the cellulose diet. There were differences ($P < 0.05$) in the apparent total tract digestibility of DM, OM, CP, ether extract, NDF, ADF, and Ca among the experimental diets. In conclusion, the fiber sources in the P-free diet may have different effects on the BEL of P estimate and the apparent total tract digestibility of nutrients.

Key Words: basal endogenous loss of P, fiber, P-free diet

0963 Effects of feeding dried cabbage residues on performance, ileal and total tract digestibility, and selected microbial population in broiler chickens. A. Mustafa, B. Baurhoo, and V. Higginson*, *McGill University, Ste-Anne De Bellevue, QC, Canada.*

A study was conducted to investigate the effects of partially replacing corn and soybean meal with dried cabbage leaf residues (DCR) on broiler growth performance, apparent ileal nutrient digestibility and apparent total tract nutrient utilization. Dietary treatments include 4 levels of DCR (0, 3, 6, and 9%). Two hundred and twenty four 1-d old male broilers were randomly assigned to 1 of 4 groups (8 cage replicates; 7 birds/cage) and grown over a 35-d experimental period. Results showed that feeding DCR had no effects on daily body weight gain (average 53.4 g/d), daily feed intake (average 94.9 g/d), and feed

conversion ratio (average 1.78 g of feed/g of gain). Inclusion of DCR reduced apparent ileal DM (quadratic effect, $P < 0.001$), OM (linear effect, $P = 0.012$), and CP (quadratic effect, $P = 0.001$) digestibility of younger birds (d 21) while incremental levels of DCR had no effect on apparent ileal nutrient digestibilities of older birds (d 35). Apparent total tract digestibility of DM, OM, and CP increased (linear effect, $P < 0.001$) as the level of DCR increased. It was concluded that the inclusion of DCR in broiler diets up to 9% had no negative impact on bird performance and apparent ileal digestibility of older birds and improved apparent total tract nutrient digestibility.

Key Words: broilers, dried cabbage residues, ileal digestbility, total tract digestibility

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0964 Effect of different levels of zinc and calcium on growth performance in weanling pigs. L. Blavi*, D. Solà-Oriol, S. M. Martín-Orúe, and J. F. Pérez, *Animal Nutrition and Welfare Service, Department of Animal and Food Sciences, Universitat Autònoma de Barcelona, Bellaterra (08193), Spain.*

High Zn levels (2,500 to 3,000 mg/kg ZnO) are widely used to prevent diarrhea in piglets after weaning. The NRC recommendations of Ca levels after weaning are defined at 0.85 to 0.80% to piglets 5 to 11 kg. In a previous study we observed that piglets with low Ca in pre-starter diet (0.35% Ca) had higher BW than piglets with high levels (0.95%). Therefore, the objective of this trial was to observe the effect of Ca with addition of therapeutic ZnO or not on growth performance during pre-starter phase (0–14 d). A total of 320 pigs were used in a 2 × 2 factorial arrangement, where the main factors were: Zn levels (125 or 2,500 ppm Zn) and Ca levels (0.35% and 0.95%). Piglets were reared in 32 pens (10 pigs/pen; 8 replicates per treatment). From Day 14 onward, the Ca level was fixed at 0.77% for all diets. The pre-starter (0 to 14 d) and starter (14 to 35d) diets contained 2,520 and 2,460 Kcal NE/kg, 19.65 and 19.00% CP, 1.25 and 1.23 digestible Lys, and 0.33 and 0.25% P digestible, respectively. Feed intake and individual BW were registered on d 0, 14, and 35 post-weaning. Performance parameters were analyzed with ANOVA by using the mixed procedure of the statistical package SAS. There were a significant effect of the level of Ca and Zn on BW at d 14 and 35 ($P < 0.05$); where pigs with low Ca (0.35%) and also pigs with 125 ppm Zn showed the highest weights (values from Ca effect: 10.87 vs. 10.33 Kg d 14 and 21.20 vs. 20.37 Kg d 35; values from Zn effect: 10.97 vs. 10.24 Kg d 14 and 21.67 vs. 19.90 Kg d 35, respectively). A significant interaction was observed on average daily feed intake (ADFI) from 0 to 14d ($P = 0.04$), where piglets with 0.35% Ca and 125ppm Zn in the diet presented higher consumption compared to piglets with 0.35% Ca and 2,500 ppm Zn (327.13 vs. 261.20 g/d, respectively). In addition, an statistical trend for the interaction in FCR during pre-starter phase (0 to 14d; $P = 0.097$), where piglets with 0.95% and 2,500ppm Zn showed the highest ratios. There was no significant effect of the experimental treatments on the FCR of the starter phase (14 to 35d). It can be concluded that lower levels of Ca and Zn allow better growth of weaned piglets, suggesting that mineral supplementation has an important role on growth performance.

Key Words: calcium, pigs, zinc

0965 Evaluation of cold pressed soybean meal and pea protein as alternative amino acid sources in swine diets. J. Koepke*, *South Dakota State University, Brookings.*

Cold pressed soybean meal (CP-SBM) and a processed pea product (PP, 55% crude protein) were evaluated as potential alternative ingredients for use in swine diets. CP-SBM was produced from regular full fat soybeans that had been heat treated before cold-pressing to reduce trypsin inhibitors. 907 kg of heated soybeans produced approximately 775.6 kg of high oil (8%) meal and 131.5 kg soybean oil. Unlike solvent extracted SBM, CP-SBM can be produced on-farm and the oil byproduct sold as high commodity product. The PP was harvested from yellow peas that were mechanically milled and a portion of the dehulled split cotyledons was processed. A digestibility trial was conducted to determine the standard ileal digestibility (SID) of protein and amino acids in CP-SBM and PP in comparison to solvent extracted SBM. Six ileal-cannulated barrows (29.25 ± 1.5 kg BW) were used in crossover design with 4 collection periods of 7 d each (5 d acclimation and 2 d ileal collection of 12h/d). Pigs were randomly assigned, within period, to one of four experimental diets (CP-SBM, PP, SBM, and nitrogen-free) where CP-SBM, PP and SBM were included as the sole protein sources, respectively. Feed allowance per period was provided at 3 × maintenance energy requirement (197 kcal x $BW^{0.60}$/d) based on measured body weight at the beginning of each period. The SID of lysine (94.4 vs. 77.2 ± 1.9), arginine (96.7 vs. 83.2 ± 2.7), valine (89.3 vs. 73.6 ± 3.3), leucine (91.3 vs. 75.7 ± 2.9), isoleucine (90.9 vs. 77.4 ± 2.4) and threonine (88.3 vs. 67.0 ± 4.4) were higher ($P < 0.02$) in PP than CP-SBM. The SID of isoleucine (84.6 vs. 77.4 ± 2.4; $P = 0.107$), asparagine (82.3 vs. 72.6 ± 3.0, $P = 0.075$) and glutamine (85.9 vs. 77.4 ± 2.8, $P = 0.099$) tended to be higher in SBM compared to CP-SBM. There was no difference in SID between PP and SBM in any of the essential AA measured. Based on SID, both CP-SBM and PP may be used as an alternative amino acid source in swine diets while PP appears to be superior alternative than CP-SBM.

Key Words: cold-pressed soybean meal, pea protein, growth performance

0966 The effects of feeding low trypsin inhibitor soybean meal to broilers on growth performance. G. Hosotani*, B. Freitas, M. S. Kerley, and M. C. Shannon, *Division of Animal Sciences, University of Missouri, Columbia.*

A 21-d experiment was conducted to compare soybean meal (SBM) from low trypsin inhibitor to parent soybean cultivars on growth performance of broilers. One hundred and fifty 1-d-old male broilers (Ross 308) were randomly placed in battery cages and allocated to 6 dietary treatments with 5 replicates and 5 birds per replicate in a factorial arrangement of 3 SBM sources, solvent extracted conventional SBM (SOLV), cold-pressed conventional SBM (CON), and cold-pressed low trypsin inhibitor SBM (LTI) by laboratory-scale mechanical extraction. All SBM sources were either non-heated or heated in a forced-air oven at 120°C for 20 min. Diets were formulated to meet or exceed NRC (1994) and Aviagen nutrient requirements. Broilers were weighed and feed disappearance measured on d 7, 14, and 21. Statistical analyses were performed as a randomized complete block design using PROC GLM of SAS with significance level set at $P \leq 0.05$. Feeding sources of SBM resulted in differences in ADG, ADFI, and feed conversion ratio (FCR) in all measurements ($P < 0.05$). Overall, chicks fed LTI had intermediate ADG (36 g; $P < 0.0001$) compared to CON and SOLV (30 and 50 g, respectively), and FCR (1.38 vs. 1.54, and 1.19, respectively; $P < 0.0001$). Chicks fed LTI or HTI had lower ADFI compared to SOLV (49, 46, and 59 g, respectively; $P < 0.0001$). Heating SBM improved FCR on wks 1 and 2, resulting in overall improvement from 1.40 to 1.34 FCR ($P = 0.0017$). Interaction between SBM sources and heat treatment was not significant throughout the experiment. In conclusion, feeding LTI improved growth performance of broiler chicks compared to CON by 20% in ADG and 10% in FCR. We hypothesized that feeding LTI to broilers would result in similar growth performance of broilers fed SOLV. However, feeding either heated or non-heated LTI to broilers did not have similar growth performance as broilers fed SOLV, decreasing ADG by 28% and impairing FCR by 16%, most likely due to other anti-nutritional factors or nutritional characteristics that impaired growth performance of broiler chicks.

Key Words: broiler, performance, soybeans

0967 Nutritive value of cold-pressed camelina cake with or without supplementation of multi-carbohydrase in pig diets. T. A. Woyengo*[1], R. Patterson[2], and C. L. Levesque[1], [1]*South Dakota State University, Brookings,* [2]*Canadian Biosystems, Calgary, AB, Canada.*

Cold-pressed camelina cake (CPCC), a fibrous co-product of camelina seed pressing, is available for livestock feeding. However, information is also lacking on the effect of supplementing fiber-degrading enzymes (carbohydrases) to CPCC-based diets on nutrient utilization by pigs. Thus, the objectives were to determine the standardized ileal digestibility (SID) of AA and DE value of cold-pressed camelina cake (CPCC), and the effect of adding Multi-Carbohydrase to a CPCC-based diet for pigs. Six ileal-cannulated barrows (average initial BW = 36 kg) were fed 5 diets in 5 × 5 Latin square design with 1 added column to give 6 replicates per diet. A corn-soybean meal-soybean oil-based diet and the basal diet with corn, soybean meal, and soybean oil replaced by 25% CPCC in a 2 × 2 factorial arrangement with or without Multi-Carbohydrase (1,200 U of xylanase, 150 U of glucanase, 500 U of cellulose, 60 U of mannanase, 700 U of invertase, 5,000 U of protease, and 12,000 U of amylase/kilogram of diet; Superzyme CS, 1 g/kg). The fifth diet was N-free. The ratio of corn, SBM, and soybean oil in the basal diet was identical to the CCPC-containing diets to allow calculation of nutrient digestibility of CPCC by the difference method. On a DM basis, CPCC contained 42% CP, 10.5% ether extract, 12.2% crude fiber, 2.07% Lys, 0.73% Met, 1.64% Thr, and 0.51% Trp. The SID of Lys, Met, Thr, and Trp for CPCC were 43.5, 70.7, 44.8, and 55.3%, respectively. The DE value for CPCC was 3783 kcal/kg of DM. Multi-Carbohydrase supplementation did not affect the SID of AA and DE value for the CPCC-based diet. In conclusion, CPCC evaluated in the current study could be an alternative source of AA and energy in swine diets. However, Multi-Carbohydrase supplementation did not result in an additional benefit in nutritional value of the CPCC.

Key Words: pig, cold-pressed camelina cake, nutrient digestibility

0968 Optimization of alkali hydrolysis conditions to increase antioxidant availability in corn distillers grain. A. Daramola* and B. Min, *University of Maryland Eastern Shore, Princess Anne.*

Corn is one of the most abundant sources for antioxidants, such as phenolic compounds, among crops and they are well-concentrated into corn distillers grain (CDG) products without degradation. However, more than 70% of phenolics in CDG exist in the insoluble from bound to cell-wall-matrix, which could not be absorbed to exert their health benefits. The objective of this study was to evaluate combinations of alkali hydrolysis condition variables and determine the best combination of the variables to maximize amounts and antioxidant capacity of available phenolics in CDG for absorption. Wet distillers grains (WDG) were alkali-hydrolyzed using factorial combinations of the condition variables: NaOH concentration (0 (control), 0.6, 1.5, and 3.0 mol/kg WDG), incubation temperature (25, 50, and 80°C) and time (0.5, 2, and 4 h). WDG were mixed with NaOH solution at the ratio of 1:3 (w/v) and incubated in a temperature-controlled shaker. After incubation, the mixture was neutralized with HCl and centrifuged. Supernatants were extracted with ethyl acetate and precipitates were freeze-dried and extracted with 80%

ethanol to obtain soluble (FREE) phenolics. Residues were alkali-treated and extracted with ethyl acetate for matrix-bound (BOUND) phenolics. Antioxidant potentials (total phenolic and flavonoid contents and antioxidant capacity measured as oxygen radical absorbance capacity [ORAC]) of FREE and BOUND phenolics were evaluated. Data were analyzed by ANOVA and least square means were compared using PDIFF. Response surface analysis was used to determine the best combination of the condition variables. The antioxidant potential of FREE and BOUND phenolics in control without NaOH were not affected by incubation temperature and time ($P > 0.05$). As the condition variables increased, the antioxidant potentials increased significantly ($P < 0.05$). The biggest increases in antioxidant potentials of FREE phenolics were observed when NaOH concentration increased from 0.6 to 1.5 mol/kg WDG, incubation temperature from 50 to 80°C, and incubation time from 0.5 to 2 h, respectively ($P < 0.05$). When WDG was incubated with NaOH solution at 3.0 mol/kg WDG at 80°C for 4 h, FREE phenolics accounted for over 98% of the total amounts and antioxidant capacity in alkalized WDG. In addition, response surface analysis showed the best combination of alkali hydrolysis condition variables as NaOH concentration (2.55 mol/kg WDG), incubation temperature (69°C) and time (3.0 h) for producing alkalized WDG with maximally available bioactive phenolics, which could contribute to the improvement of farm animal health and productivity.

Key Words: corn distillers grain, alkali hydrolysis, antioxidants

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0969 Effects of high protein canola meal on digestibility of phosphorus and growth performance of weanling pigs. Y. She[*1], H. H. Salgado[2], D. Li[3], and H. H. Stein[1], *[1]University of Illinois at Urbana-Champaign, Urbana, [2]Laval Univ., Quebec City, QC, Canada, [3]CAU, Beijing, China.*

Two experiments were conducted to evaluate the nutritional value of high-protein canola meal (CM-HP) and conventional canola meal (CM-CV) in diets fed to weanling pigs. Experiment 1 was designed to compare the apparent total tract digestibility (ATTD) and the standardized total tract digestibility between CM-HP, CM-CV and soybean meal (SBM). Forty eight growing barrows (initial BW: 16.8 ± 1.18 kg) were placed in metabolism crates and allotted to a randomized complete block design using a 2 × 3 factorial arrangement with 8 replicate pigs per diet. Diets were based on CM-HP, CM-CV, or SBM, and 0 or 500 units of microbial phytase. Diets were provided for 12 d with total collection of feces over the final 5 d. Results indicated that as phytase was added to the diets, the ATTD and STTD of P increased ($P < 0.01$) from 41.9 to 57.5% and 45.1 to 60.8%, respectively, in CM-HP; from 40.8 to 60.5% and 44.5 to 64.3%, respectively, in CM-CV; and from 61.0 to 74.2% and 66.7 to 80.5%, respectively, in SBM. There were no difference in ATTD or STTD of P between CM-HP and CM-CV, but ATTD and STTD of P was greater ($P < 0.05$) in SBM than in CM-HP and CM-CV. In Exp. 2, 405 pigs (initial BW: 10.07 ± 1.41 kg) were randomly allotted to 9 dietary treatments with 9 replicate pens per treatment. There were 4 to 6 pigs per pen. The control diet was a corn-SBM diet. Four additional diets were formulated by adding 10, 20, 30, or 40% of either CM-HP or CM-CV to the control diet. Results indicated that increased inclusion rate of CM-CV increased (quadratic, $P < 0.05$) ADG of pigs. Increased inclusion rate of CM-HP or CM-CV decreased (linear, $P < 0.05$) ADFI, but increased (linear, $P < 0.05$) G:F. Pigs fed CM-CV had greater ($P < 0.05$) ADG and G:F than pigs fed CM-HP. In conclusion, there is no difference in the ATTD or STTD of P between CM-HP and CM-CV, and inclusion of up to 40% CM-HP or CM-CV has no negative effects on growth performance of weaned pigs from 2 wk post-weaning.

Key Words: canola meal, phytase, pigs

0970 Effect of heat stress on the apparent and standardized ileal digestibilities of amino acids in growing pigs. A. Morales[1], M. Perez[1], P. Castro[1], N. O. Ibarra[1], E. Avelar[1], L. H. Baumgard[2], and M. Cervantes[*1], *[1]ICA- Universidad AutÃ³noma de Baja California, Mexicali, Mexico, [2]Iowa State University, Ames.*

The exposure of pigs to heat stress (HS) impairs the small intestine digestive and absorptive capacities affecting in turn the AA digestibilities. A two 7-d periods experiment was conducted with 8 pigs (30 kg initial BW) surgically fitted with T-type cannulas at the terminal ileum to analyze the effect of HS on both the apparent (AID) and the standardized ileal digestibility (SID) of AA in pigs fed a wheat-SBM diet. A thermometer was placed inside the ileal lumen (IL) of all pigs to register the temperature at 15 min intervals. After recovery from surgery, all pigs were adapted to the diet and trained to consume the same amount of feed twice a day for 7d under thermal neutral (TN) conditions (22 ± 2°C). Following, the pigs were divided into 2 groups (4 pigs each); one was kept under TN conditions and the other group was exposed to natural HS (24 to 45°C) for 7d (period 1). In period 2, the ambient temperature conditions of the two groups were switched. Ileal digesta was continuously collected during 12 h on d 7 of each period. Chromic oxide was used as indicator of the intestinal digesta flow. The IL temperature was around 1.6°C higher in HS pigs ($P < 0.001$). The AID of AA (%) for the TN and HS pigs were: Arg, 90.6, 88.1; His, 88.7, 85.9; Ile, 84.8, 83.9; Leu, 86.9, 84.1; Lys, 86.8, 86.2; Met, 89.8, 89.1; Phe, 86.0, 84.8; Thr, 75.7, 74.1; Val, 82.8, 81.7, respectively. The SID (%) of AA for the TN and HS pigs were: Arg, 94.0, 92.0; His, 92.5, 90.2; Ile, 89.5, 88.1; Leu, 90.1, 88.6; Lys, 91.0, 90.1; Met, 94.4, 93.6; Phe, 90.4, 88.9; Thr, 86.0, 83.7; Val, 88.1, 86.5;, respectively. The AID of Arg and His was lower ($P <$

0.01) in HS pigs, and the SID of Arg and His, as well as Leu, was also lower in HS pigs. Neither the AID nor the SID of the remaining essential AA was affected by HS. In summary, these data show that ileal temperature increases in HS pigs, and that the digestibilities of essential AA are differentially affected in pigs exposed to natural HS conditions. Special attention should be given to Arg and His when formulating diets for growing pigs under HS conditions

Key Words: pigs, heat stress, amino acids, digestibility

0971 Effect of methionine sources and graded levels of sulfur amino acids on the growth performance of post-weaning piglets. F. Molist[*1], P. Buttin[2], M. Bouwhuis[1], and P. J. van der Aar[1], *[1]Schothorst Feed Research, Lelystad, The Netherlands, [2]Novus International, Brussels, Belgium.*

The aim of the experiment was to evaluate the effects of graded levels of sulfur amino acids (SAA) in the diet of weaned piglets, and to compare the effects of the source of added free-methionine (Met). The experiment was set up according to a 2 × 4 factorial arrangement, with two Met sources (DL-2-hydroxy-4(methylthio) butanoic acid, HMTBa; Novus Europe SA/NV, Belgium vs. DL-methionine, DL-Met; Adisseo, France) and four graded levels (−6, 0, +6, +12% of the requirement) of Met. All the diets were formulated to meet 2008 CVB requirements for weaning piglets for energy (NE 9.37 MJ/kg) and slightly limiting in standardized ileal digestible (SID) Lys (11 g SID Lys/kg). The basal diet (0%) was formulated at 0.6 SID SAA/SID Lys, and the different levels were obtained by the inclusion of the Met source on molar content of HMTBa compared to DL-Met in the commercial products. In total 480 piglets (Tempo × Topigs 20, Topigs Norsvin; boars and gilts) with an average BW of 7.35 ± 0.70 kg and an average age of 26 ± 1 d old entered the trial at the day of weaning. The piglets received a standard diet during the first 7 d. The experimental diets were fed ad libitum from d 7 post-weaning during 4 wk. Body weights (BW) were measured at weaning, on 7, 21, and 35 d post-weaning, and ADG, ADFI, and FCR were calculated accordingly. Data were analyzed as a 2 × 4 factorial arrangement in a randomized block design by analysis of variance (ANOVA), using GenStat® for Windows (17th edition). During d 7–21 of the trial, neither ADG nor ADFI were affected by the treatment. During d 21–35 of the trial, and overall (7–35 d), piglets supplemented with HMTBa showed a greater ADFI ($P = 0.046$), ADG ($P = 0.037$), and final BW ($P = 0.043$) with no effect of level nor interaction. In conclusion, there was no effect of level of Met or SAA on growth performance suggesting that SID Met and SID SAA were above the piglets' requirements. Piglets supplemented with HMTBa showed greater feed intake and subsequent growth than piglets receiving diets containing DL-Met.

Key Words: methionine, piglets

0972 Digestible calcium requirement for 100 to 130 kg pigs. L. A. Merriman[*1], C. L. Walk[2], C. M. Parsons[3], and H. H. Stein[3], *[1]University of Illinois, Urbana-Champaign, [2]AB Vista, Marlborough, United Kingdom, [3]University of Illinois at Urbana-Champaign, Urbana.*

An experiment was conducted to determine the digestible calcium requirement by pigs from 100 to 130 kg. Ninety pigs (average initial BW = 99.89 ± 3.34 kg) were randomly allotted to 15 experimental diets. Each diet was fed to 6 replicate pens using a randomized complete block design. Fifteen corn and soybean meal-based diets were formulated and all diets had the same concentrations of phytate and Na. Diets were formulated using a 3 × 5 factorial design with diets containing 0.11, 0.21, or 0.31% standardized total tract digestible (STTD) P and 0.12, 0.29, 0.46, 0.61, or 0.78% total Ca (0.08, 0.18, 0.29, 0.38, or 0.49% STTD Ca). The P concentrations ranged from 48 to 152% of the STTD P requirement and the Ca concentrations ranged from 27 to 173% of the total Ca requirement. Experimental diets were fed for 28 d and pigs were individually housed. Pig and feeder weights were recorded at the beginning and at the conclusion of the experiment to calculate ADFI, ADG, and G:F. On d 28, all pigs were euthanized and the right femur was extracted. Ash, Ca, and P concentrations were determined from the de-fatted, dried femurs. Results indicated that as dietary concentrations of STTD Ca increased, the ADFI and ADG decreased (main effects of Ca, $P < 0.05$), regardless of the dietary concentration of P. Models to predict ADFI [ADFI = 3.6782– 1.2722 × STTD Ca (%); $P = 0.001$] and ADG [ADG = 1.2141– 0.6230 × STTD Ca (%); $P = 0.008$] were dependent only on the concentration of STTD Ca, but not on the STTD of P. There were no effects by STTD Ca or STTD P on G:F indicating that the negative effects of STTD Ca on ADG was a result of reduced ADFI. Linear increases were observed for bone ash, bone Ca, and bone P as dietary concentrations of STTD Ca increased for all levels of STTD P (interaction, $P < 0.001$). In conclusion, results from the experiment support the current requirements (NRC, 2012) for Ca and STTD P, and feeding beyond the requirements for Ca (0.46% total Ca; 0.29% STTD Ca) or STTD P (0.21) is detrimental to growth performance of pigs.

Key Words: bone ash, calcium, pigs, phosphorus

0973 Effects of inclusion of canola meal in weanling pig diets containing different concentrations of energy. T. F. Pedersen[*1], Y. Liu[2], and H. H. Stein[3], *[1]Aarhus University, Aarhus, Denmark, [2]University of California, Davis, Davis, [3]University of Illinois at Urbana-Champaign, Urbana.*

The objective of the experiment was to determine effects of diet NE and addition of an exogenous enzyme on growth performance and physiological parameters of weanling pigs fed a corn-soybean meal (SBM) diet or diets containing high protein canola meal (CM-HP) or conventional canola meal (CM-CV). In total, 492 pigs (initial BW: 9.15 ± 0.06 kg) were used in a randomized complete block design with 9 replicate pens per treatment. A control diet based on corn and SBM and 4 diets containing 20 or 30% CM-HP or CM-CV were formulated; inclusion of choice white grease (CWG) was adjusted to maintain constant NE among diets. Four additional diets containing 20 or 30% CM-HP or CM-CV were formulated without adjusting CWG and NE in these diets was, therefore, reduced compared with the control diet. Three diets that were similar to the control diet and the diets containing 30% CM-HP or CM-CV without adjusted CWG were formulated, but a carbohydrase was included in these diets. Pigs were fed experimental diets for 22 d. Results indicated that ADG and G:F decreased (linear, $P < 0.05$) as CM-HP was included in diets with constant energy, but that was not the case if CM-CV was included in the diet or if diets were not formulated to a constant NE. There were also no differences in G:F or in final BW among pigs fed the control diet and pigs fed canola meal diets. Only minor and inconsistent effects of CM-HP or CM-CV on intestinal weight, gut fill, digesta pH, cecal VFA concentrations, and serum concentrations of urea N, total N, or albumin were observed. However, thyroid gland weight increased ($P < 0.05$) or tended to increase ($P < 0.10$) as the concentration of canola meal increased. Serum concentrations of IgG and total tract digestibility of GE were reduced (linear, $P < 0.05$) if CM-HP or CM-CV was included in the diets. No major effects of the carbohydrase were observed. In conclusion, up to 30% CM-HP or CM-CV may be used in diets fed to weanling pigs from 2 wk post-weaning without impacting growth performance and NE in diets containing canola meal does not have to be similar to that in corn-SBM diets.

Key Words: canola meal, energy concentration, pigs

0974 Effect of increasing concentrations of digestible calcium and digestible phosphorus on apparent total tract digestibility of calcium and phosphorus by pigs. J. C. González-Vega[*1], C. L. Walk[2], M. R. Murphy[1], and H. H. Stein[1], *[1] University of Illinois at Urbana-Champaign, Urbana, [2]AB Vista, Marlborough, United Kingdom.*

Two experiments were conducted to determine effects of increasing concentrations of digestible Ca and digestible P on apparent total tract digestibility (ATTD) of Ca and P in diets fed to pigs. In Exp. 1, 6 diets were formulated to contain 0.36% standardized total tract digestible (STTD) P and 0.32, 0.40, 0.48, 0.56, 0.64, or 0.72% STTD Ca, by including increasing quantities of calcium carbonate at the expense of cornstarch. Two additional diets contained 0.72% STTD Ca and 0.33% or 0.40% STTD P. A total of 80 pigs (initial BW: 13.12 ± 1.79 kg) were placed in metabolism crates and randomly allotted to the 8 diets with 10 replicate pigs per diet in a randomized complete block design. Results indicated that the ATTD of Ca and the ATTD of P decreased (linear, $P < 0.001$) as dietary STTD Ca increased. However, increasing dietary STTD P did not affect ATTD of Ca, but the ATTD of P increased (linear, $P < 0.05$) as dietary STTD P increased. In Exp. 2, 20 corn-soybean meal based diets were formulated with diets containing 4 concentrations of STTD P (0.15, 0.31, 0.39, or 0.47%) and 5 concentrations of STTD Ca (0.13, 0.27, 0.42, 0.57, or 0.72%). A total of 120 pigs (initial average BW: 29.45 ± 2.15 kg) were placed in metabolism crates and randomly allotted to the 20 diets in 6 blocks with 1 pig per diet in each block. Results indicated that ATTD of Ca in diets linearly increased ($P = 0.009$) as concentration of STTD Ca increased, but was not affected by the concentration of STTD P. However, the ATTD of P linearly decreased ($P < 0.001$) as the concentration of STTD Ca increased, but linearly increased ($P < 0.001$) as the concentration of STTD P increased. In conclusion, for pigs between 11 and 50 kg, the ATTD of Ca varies by the concentration of STTD Ca in diets, but is not affected by the concentration of STTD P. However, the ATTD of P is negatively affected by increasing concentration of STTD Ca, but increases as concentration of STTD P increases.

Key Words: calcium, phosphorus, pigs

0975 Trans-generational effect of feeding genetically modified mCry1Ac corn to laying hens and offspring on offspring growth and health. L. Chen*, R. Zhong, L. Zhang, L. Gao, and H. Zhang, *Institute of Animal Sciences, Chinese Academy of Agricultural Sciences, Beijing, China.*

The experiment was to assess the chronic effect of the transgenic corn lines containing the *mCry1Ac* gene from *Bacillus thuringiensis* strain (BT) to White Leghorn laying hens for 12 wk and their offspring from 1 d to 36 wk on offspring growth

and health. Healthy hens (n = 72 placed in cages; 3 hens/cage) were randomly assigned to 1 of 3 corn-soybean meal dietary treatments (8 cages/treatment) formulated with the following corn: 61.7% nontransgenic near-isoline control corn (CT), BT corn, and commercially available nontransgenic reference corn (RF) for 12 wk. After 12 wk, fertile eggs were collected daily and hatched for 21 d. A total of 240 offspring pullets were assigned to 3 dietary treatment for 36 wk, i.e., 1) CT corn-fed parental hens/CT corn-fed offspring pullets (CT/CT); 2) BT corn-fed parental hens/BT corn-fed offspring pullets (BT/BT); and 3) RF corn-fed parental hens/RF corn-fed offspring pullets (RF/RF). Each dietary treatment was assigned to 10 replicates with 8 offspring pullets per replicate for a total of 80 pullets per treatments. Body weight and egg quality of pullets were determined weekly. Offspring hens were harvested at the end of 36 wk (n = 8/treatment), and carcass yield and organ weights (heart, liver, spleen, lung, kidneys and ovary) were recorded; organs and intestines were sampled for histological analysis. Analysis of serum biochemistry parameters, hematology, and hormone were performed. Immune cell phenotypes of spleen and peripheral blood mononuclear cells were determined. No differences in body weight, egg quality and function of reproductive organs were observed between hens consuming the CT/CT diet and hens consuming the BT/BT diet. Intestinal histology and health were similar between the control and test groups. The relative weight of lung and kidneys of hens fed the BT/BT treatment was less than hens fed the CT/CT treatment ($P < 0.05$). Liver and kidney histology and health were not affected by the diet treatment. Offspring hens from the BT/BT treatment had greater duodenal goblet cells/villus ($P < 0.05$) and jejunal villus height/crypt depth ratios ($P = 0.06$). Similar organosomatic indices, serum biochemistry parameters, hematology, and hormone parameters did not indicate the characteristics of organ dysfunction. Immune response was not affected by the trans-generation feeding BT/BT diet. These results indicate that trans-generational consumption of the BT corn diets is not detrimental to hen growth and health.

Key Words: *Bacillus thuringiensis*, genetically modified, hen, *mCry1Ac* gene corn, trans-generational effect

0976 Effects of methionine or arginine supplementation and environmental temperature on performance, carcass traits and meat quality of finishing pigs. J. K. Htoo[*1], C. A. Garbossa[2], H. Silveira[2], L. G. Amaral[2], N. A. Barbosa[3], and V. S. Cantarelli[2], *[1]Evonik Nutrition & Care GmbH, Hanau-Wolfgang, Germany, [2]Federal University of Lavras, Lavras, Brazil, [3]Evonik Industries do Brazil, São Paulo, Brazil.*

A 46-d study was conducted to determine the effects of methionine (Met) or arginine (Arg) supplementation in a thermal-neutral (24°C) or heat stressed (32°C) environment on performance, carcass characteristics and meat quality of finishing pigs. Seventy-two mixed-sexed pigs (PIC × DanBred; initial BW of 69.1 ± 0.11 kg) were assigned to 6 diet regimes using a 2 × 3 factorial arrangement with 3 dietary treatments [a basal diet (BD), the BD + 0.15% DL-Met or the BD + 0.40% L-Arg], and 2 environmental temperatures (24°C or 32°C) having 6 pen replicates (2 pigs/pen) per treatment. Diets were formulated based on corn, soybean meal and corn gluten meal using the analyzed ingredient AA contents and published standardized ileal digestible (SID) coefficients to meet AA requirements for both finisher 1 (0.76% SID Lys; 70–90 kg) and finisher 2 (0.69% SID Lys; 90–112 kg) phases. Pigs were fed the finisher 2 diets until they reached a predetermined market weight (115 kg). At slaughter, 36 pigs (6 pigs/treatment) were selected for carcass assessment. Samples of longissimus dorsi (LD) muscle were used for meat quality assessments. Data were analyzed using the MIXED procedure of SAS. There was no diet × temperature interaction for any variables ($P > 0.05$). Compared with 24°C, ADFI, ADG and G:F were lower ($P < 0.001$) under 32°C temperature during each phase and the overall 46-d period, except for the ADFI during finisher 2 period ($P = 0.056$). Overall, supplementing with 0.15% DL-Met or 0.40% L-Arg reduced ADFI ($P = 0.033$) and increased G:F ($P = 0.012$). Compared with 24°C, 32°C temperature increased ($P < 0.05$) chilled carcass yield and 24 h pH of carcass but decreased ($P < 0.05$) drip loss after 24 and 48 h and the number days to reach 115 kg BW. The 24 h pH of carcass tended to increase ($P = 0.053$) by 0.15% DL-Met addition but all other measured carcass parameters including lean percentage and backfat thickness were not affected by dietary treatments. The concentrations of cortisol and heat shock protein 70 (HSP70) in plasma and concentrations of thiobarbituric acid reactive substances and hydrogen peroxide in LD muscle were not affected by the dietary treatments or the environment temperature. These results indicate that heat stress reduces pig performance and may affect carcass quality. Additional L-Met or L-Arg supplementation in finisher pig diets may improve feed efficiency.

Key Words: arginine, methionine, temperature

0977 A protective effect of IGF-activated plasma protein (CTCgrow) on lipopolysaccharide-induced intestinal dystrophy in rats. M. Kwak[*1], J. Kim[1], J. M. Lee[2], S. W. Jung[2], and K. Y. Whang[1], *[1]Korea University, Seoul, The Republic of Korea, [2]CTC BIO, Seoul, The Republic of Korea.*

In livestock industry, dietary plasma protein has shown the improved growth performance of weaned animals and it seems to be more than nutrient content itself. The exact mechanism of plasma protein on enhancing growth performance is not fully understood yet, but dietary insulin-like growth factors (IGFs) in plasma protein might have an important role. But it has been also suggested that IGFs with binding protein

might attenuate the growth-promoting effects of IGFs. Therefore, we conducted an experiment to determine the protective effects of commercially available IGF-activated plasma protein product (by de-binding with protein, CTCgrow) on intestinal dystrophy induced by lipopolysaccharides (LPS). Forty-two rats (4 wk-old) were allotted into six treatments in a 2 × 3 factorial design. One factor was dietary supplementation (CON, control; PP, 50 g/kg of plasma protein; and aIGFPP, 3.4 g/kg of IGF-activated plasma protein) and the other factor was LPS-challenge (PBS or LPS). Basal diet was formulated based on NIH-31 diet. During 4 wk of feeding period, rats were allowed to the diets ad libitum and growth performance was recorded weekly. On Day 28, rats were injected with either LPS or PBS and growth performance was recorded every day for 3 d. At Day 3 post-injection, rats were sacrificed and gut morphological change was investigated in jejunum samples. Before LPS-challenge, body weight and feed intake of aIGFPP group were numerically higher than those of other groups. After LPS-challenge, aIGFPP alleviated the weight loss induced by LPS-challenge and showed significantly higher feed efficiency than PP ($P < 0.05$). In non-challenged groups, there were significantly higher villus height (VH) and VH:CD ratio and lower crypt depth (CD) in aIGFPP than other groups ($P < 0.05$). And the number of goblet cells per villus was also significantly higher in aIGFPP than other groups ($P < 0.05$). And there was a tendency that LPS-challenged groups showed lower VH and higher CD than non-challenged groups in respective dietary treatment groups. In LPS-challenged groups, VH and VH:CD ratio were numerically higher in CON and aIGFPP than PP. The number of goblet cells per villus was significantly higher in LPS-challenged aIGFPP than other LPS-challenged groups ($P < 0.05$). These results indicated that aIGFPP had a growth-promoting effect by improvement of intestinal morphology before LPS-challenge. Also aIGFPP demonstrated a protective effect on gut mucosal injury induced by LPS.

Key Words: rats, intestine, gut morphology, IGF, plasma protein

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0978 Effects of α-Galactosidase supplementation on the energy value of soybean meal and growth performance of weanling pigs. C. D. Espinosa*, *University of the Philippines Los Baños, Laguna, Philippines; University of Illinois at Urbana-Champaign, Urbana-Champaign.*

Two experiments were conducted to determine effects of supplementing diets with an α-galactosidase enzyme complex on the energy value of soybean meal (SBM), apparent total tract digestibility (ATTD) of nutrients in corn-SBM diets, and growth performance of weanling pigs. In Exp. 1, 40 barrows (PIC 337 × C24; initial BW 9.9 ± 1.9 kg) were randomly allotted to 5 dietary treatments with 8 pigs per diet. A basal diet consisting of 94.89% corn (as-fed basis) and 4 diets containing 70% of the basal diet and 30% (as-fed basis) SBM supplemented with 0, 100, 200, or 400 mg/kg of an α-1,6-galactosidase enzyme complex were formulated. Pigs were individually housed in metabolism crates that allowed for the total, but separate, collection of urine and fecal materials from each pig. Results indicated that addition of increasing concentrations of α-1,6-galactosidase enzyme complex increased (linear, $P < 0.05$) DE, and tended (linear, $P = 0.09$) to increase ME of SBM by approximately 300 kcal/kg (as-fed basis). The enzyme complex also improved ($P < 0.05$) the ATTD of ash and tended ($P < 0.10$) to improve the ATTD of DM, hemicellulose, OM, and crude fat. In Exp. 2, 378 pigs (PIC 337 × C24; initial BW 4.5 ± 1.8 kg) were randomly allotted to 1 of 3 dietary treatments with 21 pigs per pen and 6 pen replicates per treatment. The experiment lasted 10 d. Treatments included 2 diets (without or with the enzyme complex) formulated with the assumption that SBM contained 3344 kcal ME/kg (as-fed basis). The last diet was formulated assuming that the SBM contained 3644 kcal ME/kg if 100 mg/kg of the enzyme complex was also included in the diet. Inclusion of SBM was 18% in all diets. Results indicated that regardless of the presumed ME in SBM, addition of the enzyme improved ($P < 0.05$) total BW gain, tended ($P = 0.09$) to improve ADG, and tended ($P = 0.10$) to improve caloric efficiency when compared with the diet containing no enzyme. The cost of feed/kg of gain also tended ($P = 0.10$) to be reduced by addition of the enzyme complex to the diet. In conclusion, the α-1,6-galactosidase enzyme complex used in these experiments improved the energy value of SBM and the ATTD of nutrients, which may result in reduced cost of production per unit of gain.

Key Words: α-galactosidase, soybean meal, weanling pigs

0979 Use of crystalline amino acids in meal feeding does not affect nitrogen retention in growing pigs compared to protein-bound amino acids. S. A. Lee* and B. G. Kim, *Konkuk University, Seoul, The Republic of Korea.*

The present study was conducted to test the hypothesis that the supplementation of crystalline AA (CAA) affects the N retention for growing pigs in the meal feeding. Ten pigs with initial BW of 53.6 kg (SD = 2.7) were individually housed in metabolism crates. The pigs were allotted to 2 experimental diets according to a crossover design with 10 animals and 2 periods. Two experimental diets were formulated. A diet was mainly based on corn and soybean meal as N sources (protein-bound form-diet, PBD), and the CAA were supplemented to the PBD at the expense of 14.2% soybean meal (CAA-supplemented diet, CD). The supplementation levels of CAA were determined based on the standardized ileal digestible AA in the SBM. The daily amount of feed allowance per pig was determined as 3 times the maintenance energy of pigs within similar BW and an equal amount of the feeds was provided at 0730

and 1630 h. Total but separate collection of feces and urine was performed according to marker-to-marker and time-to-time methods, respectively. The amounts of excreted and retained N were determined based on the analyzed N contents in the fecal and urinary samples. Nitrogen intake of pigs fed the PBD and CD were 52.4 and 46.2 g/d ($P < 0.001$), respectively. The fecal N excretion (7.52 and 6.23 g/d, $P = 0.014$), digested N (44.9 and 39.9 g/d, $P < 0.001$), and retained N (24.9 and 22.2 g/d, $P = 0.014$) in the pigs fed the PBD were greater than in the pigs fed the CD. However, the apparent total tract digestibility of N and retention of N did not differ among the pigs fed 2 experimental diets. In conclusion, the use of CAA in the meal feeding did not affect the N retention in growing pigs compared to the protein-bound AA from the SBM.

Key Words: free amino acid, nitrogen retention, protein-bound amino acid

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0980 Effects of SILOHealth 104 supplementation on the growth performance of Ross 308 broiler chickens.

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Global consumption of poultry products has consistently increased over the past 30 yr, requiring producers to maintain chicken production to meet the demands. With the rising concern regarding the inclusion of antibiotics in feed, developing a viable alternative for poultry production is of a significant interest. Butyric acid, a short chain fatty acid, is the primary energy source for colonocytes and has shown potential as an alternative to in-feed antibiotics, including its antimicrobial activity and positive effects on production performance traits of broiler chickens. SILOHealth 104 (SILO S.P.A., Florence, Italy) is a commercial butyrate product mainly containing mono- and di-glycerides of butyrate with a small portion of mono- and di-glycerides of propionic, caprylic, capric, and lauric acids. Its effects on broiler performance have yet to be evaluated. Four hundred and eighty day old male Ross 308 birds were divided into different treatment groups with equal starting weights and fed a basal diet, or basal diet including 500, 1,000, 2,000, or 3,000 ppm of SILOHealth 104 for 35 d. There were no significant differences in overall average daily gain or feed:gain ratio with the addition of SILOHealth 104 to the diets ($P > 0.05$). At 5 wk of age, abdominal fat weight was reduced in birds supplemented with SILOHealth 104 in a dose responsive manner ($P < 0.05$), while breast muscle weight increased with supplementation up to 2000 ppm, with significant increases in 1000 ppm and 2000 ppm birds compared to controls ($P < 0.05$). Expression of both Forkhead box protein O4 and myostatin, two factors that can inhibit protein synthesis, were found to be significantly decreased in the breast muscle of all SILOHealth 104 birds compared to control birds ($P < 0.05$). These data suggest that the components of SILOHealth 104 can positively impact the deposition of muscle, while reducing abdominal fat deposition in broiler chickens.

Key Words: broiler, butyrate glycerides, breast muscle

0981 Effect of increasing *Buttiauxella* phytase dose to 2000 FTU/kg on phytate degradation and ileal AA digestibility in weaned pigs.

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This study determined the effect of increasing *Buttiauxella* phytase dose on phytate degradation and ileal AA digestibility in weaned pigs. Six treatments were tested including a nutritionally adequate positive control (PC); a negative control (NC) with reduction of 0.1% Ca, 0.14% digestible P and 35 kcal/kg ME vs. PC; NC supplemented with a *Buttiauxella* sp. phytase at 250, 500, 1,000 or 2,000 phytase units (**FTU**)/kg feed. One FTU was defined as the amount of enzyme required to release 1 µmol of iP per minute from sodium phytate at pH 5.5 at 37°C. Male pigs (Topigs × Pietrian, barrows, 20kg BW) were randomly allocated in metabolism crates (1 pig per crate) in 2 runs, 24 pigs in each run with a total of 8 replicates per treatment. Pelleted diets based on mixed grain (wheat, corn and barley) were fed for 9 d with 3 d adaptation, 5 d collection of feces and urine (for measuring apparent total tract digestibility [ATTD]) and 1 d to collect ileal digesta (for measuring apparent ileal digestibility [AID], TiO_2 as marker). The diets were supplied at 2.5 times energy requirement for maintenance in 2 equal meals per day, water was freely available. Treatment means were compared using Tukey's HSD, linear or nonlinear responses were determined using JMP 11 (SAS). Phytase at 2,000 FTU/kg showed greater ($P < 0.05$) nutrient digestibility vs. NC or PC for most of the parameters. Increasing phytase dose from 0 (NC) to 2,000 FTU/kg linearly improved ($P < 0.05$) ATTD of P, retainable P, Ca, DM, N, ME as well as AID of P, N, Lys, Met, Cys, Thr, Val, Ile, Leu and mean essential AA. While AID of Ca and Trp increased in a nonlinear manner. AID of phytate was 36, 39, 54, 67, 76, and 83%, respectively, for PC, NC, phytase at 250, 500, 1,000 and 2,000 FTU/kg feed ($P < 0.05$). The AID of phytate was linearly correlated with mean AID of AA ($P < 0.05$). In conclusion, increasing *Buttiauxella* phytase dose increased the level of phytate degradation, resulting in improved digestibility of AA and other nutrients. This demonstrated that increasing *Buttiauxella* phytase dose to 2,000 FTU/kg can lead to both phosphoric and extra-phosphoric effects.

Key Words: pigs, phytate degradation, AA digestibility

0982 Influence of dietary crude protein and phosphorus levels on the utilization of crude protein and phosphorus in growing pigs. P. Xue*[1] and O. Adeola[2], [1]*Purdue University, West Lafayette, IN,* [2]*Department of Animal Sciences, Purdue University, West Lafayette, IN.*

A study was conducted to determine the response of total tract utilization of CP and P to different CP and P levels in growing pigs. A total of 72 growing pigs (initial BW 20.9 ± 0.8 kg) were used in a randomized completely blocked design, with 9 treatments and four 10-d experimental periods giving 8 replicates per treatment. The pigs were blocked by BW and allotted to 9 treatments with a 3 × 3 factorial arrangement consisted of 3 CP levels (5.5, 9.7, or 13.9%) and 3 apparent total tract digestible P (ATTDP) levels (0.11, 0.19, or 0.27%). The CP level and ATTDP levels were adjusted using SBM and mono-calcium phosphate (MCP), respectively. Limestone was included to maintain the Ca: ATTDP ratio across diets. There was a 5-d adjustment period followed by a 5-d total collection period. Chromic oxide and ferric oxide were used as markers to time the initiation and termination of fecal collection, respectively. The daily feed intake was adjusted to 4% of the average BW of each block, in 2 equal daily feeding regimen at 0730 and 1730 h. Data was analyzed using PROC MIXED of SAS (9.4) and contrasts were used to test the linear and quadratic effects of increasing levels of P within each CP level, or vice versa. Digested P (g/d) was regressed against P intake (g/d) for each CP level to determine the true total tract digestibility (TTTD) of P in MCP. Digested P (g/d) increased linearly along with the increasing level of CP ($P < 0.05$). The determined TTTD of P in MCP for 5.5, 9.7, and 13.9% CP diets were 80.5, 82.6, and 87.9%, respectively. There were no statistical differences among the three TTTD estimates. In the nitrogen utilization results, increasing dietary P level decreased the urine nitrogen output ($P < 0.05$). In conclusion, the results indicated that dietary CP deficiency may limit total tract P digestion.

Key Words: crude protein, phosphorus, total tract digestibility

0983 Effects of Dakota gold and high fat commodity DDGS in a complete diet on pellet quality. A. D. Yoder*, *Kansas State University, Manhattan.*

Inclusion of dried distillers grains with solubles (DDGS) in pelleted feed is limited because of pellet quality. Including a reduced-fat DDGS instead of a higher fat DDGS may mitigate these negative effects. Thus, the objective of this experiment was to evaluate pellet quality when 2 different sources of DDGS were used in a pelleted complete feed. The experiment was set up as a 2 × 2 × 2 × 4 factorial arrangement with 2 sources of DDGS (reduced and high-fat DDGS), 2 pellet temperatures (65.6°C and 82.2°C), 2 inclusion rates (15% and 30%) and 4 Pellet Durability Methods (Standard Pellet Durability Index (PDI; ASABE S269.4, 2007), Modified PDI (three 19-mm hex nuts), Holmen NHP 100 for 60 s, and Holmen NHP 200 for 240 s) in a typical complete feed formulated for a finishing swine diet. Reduced-fat DDGS (Dakota Gold) was sourced from POET, LLC and high-fat DDGS was sourced from a local feed mill. Feed was pelleted on a 1 ton per hour pellet mill (CPM Model PM 1012–2) equipped with a 4.0 mm × 32 mm die. Throughput was held constant at 680 kg/hour. Each treatment was replicated 3 times. Data were analyzed using the GLIMMIX procedure of SAS. There was no interaction between any 2 variables of the experiment. The addition of Dakota Gold improved pellet quality by 5.2% points ($P < 0.05$). The PDI results were 88.0% and 82.8% for the Dakota Gold and 8% fat commodity DDGS, respectively. Inclusion level ($P = 0.71$) or conditioning temperature ($P = 0.103$) had no effect on PDI. The PDI method of analysis had the greatest effect on the results ($P < 0.05$). The result of Standard PDI, Modified PDI, Holmen NHP 100, and Holmen NHP 200 were 95%, 91%, 89%, and 67%, respectively. The NHP 200 method produced the lowest values primarily due to the long run time of the method. The feed industry should select the method that best models their feed manufacturing and delivery processes. The results of this experiment indicate that the addition of lower fat DDGS improves pellet quality, and the PDI method of analysis can significantly impact the results reported in the industry.

Key Words: pellet, DDGS, pellet durability index

0984 Oregano essential oil supplementation in gestation and lactation shortened birthing interval in primparous and multiparous sows. M. Renken, R. C. Thaler, and C. L. Levesque*, *South Dakota State University, Brookings.*

A total of 15 gilts and 26 sows (parity 2 to 5) were used to assess the impact of oregano EO (By-O-Reg, Advanced Ag Products) supplementation in gestation and lactation on farrowing characteristics (duration and birth interval), and sow and piglet performance. Females were assigned to 1 of 2 dietary treatments at breeding [0 or 2 g/d oregano EO supplementation]. Experimental diets were fed throughout gestation and lactation (21 d). Diets were offered once daily in gestation and twice daily in lactation, and oregano EO was added as a top dress with the AM feeding. Diets were formulated to meet or exceed nutrient requirements for sows/gilts in gestation (0.6% SID Lysine and 3280 kcal ME/kg) and lactation (0.9% SID Lysine and 3280 kcal ME/kg). Control sows (0 g/d EO) received soy hulls (the carrier for the EO) at 2 g/d. Assessment of sow performance included body weight and backfat (breeding, d 110 of gestation, d 1 of lactation, and at weaning), and lactation feed intake. Piglets were weighed at birth and at weaning. All farrowings were attended by a trained technician and farrowing duration was determined as the time between birth of the first and last piglets and piglet birth interval was

recorded. Data was analyzed as a RCB design with sow as the experimental unit. Sow performance was not affected by EO supplementation: mean body weight was 180.0 ± 8.9 kg and 233.7 ± 5.3 kg at breeding and d110, respectively and lactation feed intake was 7.09 ± 0.35. Gestation length tended to be shorter ($P = 0.11$) in EO supplemented sows (115.0 vs. 115.7 ± 0.3). Farrowing duration (3.5 ± 0.5 h) was not influenced by EO supplementation but birthing interval tended to be shorter ($P = 0.10$) in EO fed sows (14.0 vs. 20.2 ± 2.8 min/pig). Born alive (12.8 vs. 11.9 ± 0.8), stillborns (0.26 vs. 0.40 ± 0.17), piglet birth weight (1.33 vs. 1.36 ± 0.03 kg) and piglet weaning weight (7.38 vs. 7.26 ± 0.16 kg) were not influenced by maternal EO supplementation. Subsequent rebreeding interval tended to be increased ($P = 0.06$) in EO fed sows (4.7 vs. 4.5 ± 0.1 d). Oregano EO supplementation had little impact on sow and piglet performance but appeared to positively impact birthing interval and gestation length. A shorter birthing interval may reduce the risk of stillborns and limit the need for farrowing assistance.

Key Words: birthing interval, essential oil, sow

0985 Effects of casein on digestibility of amino acids in distillers dried grains with solubles fed to pigs.

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The objective of this experiment was to determine the true ileal digestibility (TID) of CP and AA in casein and to determine the effects of inclusion of casein in experimental diet on apparent ileal digestibility (AID) and standardized ileal digestibility (SID) of CP and AA in corn distillers dried grains with solubles (DDGS) fed to pigs. Eighteen barrows with an initial BW of 50.5 ± 4.5 kg were surgically fitted with T-cannula at the distal ileum and individually housed in metabolism crates. Pigs were allotted to triplicate 6 × 3 incomplete Latin square design with 6 dietary treatments and 3 periods. The 6 dietary treatments consisted of 3 diets formulated to contain 6, 10, or 14% casein; 2 diets prepared to contain 48% DDGS or 30.8% DDGS and 6% casein; and one nitrogen-free diet to determine the basal ileal endogenous losses of CP and AA. Each period lasted 7 d consisted of 5 d of adaptation period and 2 d of ileal digesta collection period. The AID of CP and all AA in casein were linearly increased ($P < 0.01$) with increasing dietary casein. The estimated TID of CP, Lys, Met, Thr, and Trp were 101% (SE = 3.2), 99.9% (SE = 2.12), 99.2% (SE = 1.17), 97.0% (SE = 3.23), and 98.8% (SE = 3.30), respectively. The AID and SID of Arg, Lys, Phe, and Trp in diet containing DDGS were less ($P < 0.01$) than those in diet containing DDGS and casein. There were no differences between the AID of CP, His, Ile, Thr, and Val in diet containing DDGS and those in diet containing DDGS and casein. However, the SID of CP, His, and Ile in DDGS diet were less ($P < 0.05$) than those in DDGS and casein diet. In conclusion, improving protein quality in experimental diets by inclusion of highly digestible protein sources such as casein may affect the SID of CP and AA in test ingredients of lower protein quality.

Key Words: digestibility, nutrient, swine

0986 Investigations of marker and fiber effects on energy and nutrient utilization in growing pigs.

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An experiment was conducted to investigate whether the apparent ileal and total tract digestibility of nitrogen and energy, and excretion patterns of indigestible markers were influenced by the type of marker and dietary fiber. Twenty barrows surgically fitted with T-cannula at the end of ileum were used in two experimental periods consisting of a 7-d adjustment period followed by a 3-d total fecal collection period and a 3-d ileal digesta collection period. Three diets were identically formulated except for 10% of the cornstarch (CS), corn bran (CB) or oat bran (OB). All three diets contained three index markers (5 g/kg chromic oxide [Cr_2O_3], 5 g/kg titanium dioxide [TiO_2], and 20 g/kg acid-insoluble ash [AIA]). Pigs were fed at 0800 h and 1600 h with 2 equally sized meals during the experimental period. The ileal digesta were collected every 3 h from 0900 h to 1700 h with 4 time periods (TP) on ileal digesta collection days. For all 3 markers, the marker concentration of CS diet was greater than OB diet, which had greater marker concentration than CB diet ($P < 0.001$). The marker concentration of the first ileal collection day (Day1) was significantly lower than the third day (Day3) for Cr_2O_3 ($P = 0.05$), TiO_2 ($P < 0.001$) and AIA ($P < 0.01$), respectively. The 3 markers were excreted in a similar pattern over 4 TPs for ileal digesta. The highest marker concentration appeared at the second TP (1200 h to 1500 h). The apparent ileal digestibility of energy (AIDE) and nitrogen (AIDN) of CB and OB diets was not affected by markers. For all 3 diets, the apparent total tract digestibility of energy (ATTDE) and nitrogen (ATTDN) determined by total collection method was greater ($P < 0.05$) than those determined by using inert digestibility markers. The ATTDE and ATTDN of CB diet calculated based on Cr_2O_3 were lower ($P < 0.05$) than those determined by TiO_2, but for OB diet, the ATTDE and ATTDN determined by AIA were greater ($P < 0.05$) than those determined by TiO_2. In conclusion, the marker distribution varied over time periods and was affected by fiber type, and the marker type may affect the estimate of total tract but not ileal digestibility of energy and nitrogen.

Key Words: markers, fibers, digestibility

0987 Evaluation of ileal energy digestibility of diets based on different grain species fed to growing pigs. P. Rosenfelder*, H. K. Spindler, E. J. P. Strang, E. DeGiorgi, M. Eklund, and R. Mosenthin, *University of Hohenheim, Institute of Animal Science, Stuttgart, Germany.*

It is well accepted that feed energy digested until the end of the ileum is more efficiently utilized by the pig than energy fermented microbially in the hindgut. Thus, ileal rather than fecal energy digestibility values may be closer to the actual energy available for maintenance and production, but data on ileal energy digestibility of cereal grains are scarce. The objective of the present study was to determine in growing pigs the ileal energy digestibility of diets based on 8 different genotypes of barley, rye, triticale, and wheat each. Therefore, 4 experiments were conducted with 8 or 9 ileally cannulated growing pigs (initial BW of 24 to 32 kg) each. The assay diets were formulated to contain 1 of the 8 genotypes of each grain species at an inclusion level of 95% (on as-fed basis). All diets were supplemented with plant oil, minerals and vitamins, and titanium dioxide as an indigestible marker. The experiments were either arranged as a row-column design with 8 periods of 6 d each and 9 pigs (for barley and wheat), or according to an 8 × 8 Latin square design with 8 periods of 6 (rye) or 7 d (triticale) and 8 pigs. Experimental periods comprised 4 (barley, rye, and wheat) or 5 d (triticale) for adaptation, followed by 2 d for ileal digesta collection. The daily feed intake amounted to 4% of pigs' average BW, corresponding to about 3 times the animals' energy requirement for maintenance (106 kcal of ME/kg of $BW^{0.75}$). On average, ileal energy digestibility amounted to 65, 67, 78, and 73% for barley, rye, triticale, and wheat diets and was different between grain species ($P < 0.05$). Ileal energy digestibility was different within the 8 rye diets ($P < 0.05$) with values ranging between 66 and 70%, but there were no differences in ileal energy digestibility within barley, triticale, or wheat diets. Differences in ileal energy digestibility within rye diets reflect variations in contents of fiber fractions of the rye genotypes, as higher contents of NDF, ADF, and different non-starch polysaccharide fractions resulted in a linear decrease in ileal energy digestibility ($P < 0.01$). In conclusion, triticale is superior in ileal energy digestibility compared to the other grain species.

Key Words: cereal grains, ileal energy digestibility, growing pigs

0988 The relationship between the expression of genes regulating appetite control and feeding behavior in pigs divergent in feed efficiency. S. Vigors[1], J. V. O'Doherty[2], A. K. Kelly[2], and T. Sweeney*[1], [1]*School of Veterinary Medicine, University College Dublin, Belfield, Dublin 4, Ireland,* [2]*School of Agriculture and Food Science, University College Dublin, Dublin 4, Ireland.*

More efficient pigs eat less than their less efficient counterparts, however the regulation of appetite and feeding behavior in the hypothalamus and intestine has not been well researched. Therefore, the objective of this study was to examine the association between residual feed intake (RFI) and feeding behavior with both hypothalamic and gut peptides involved in appetite control. Seventy-five male pigs (initial BW 22.4 kg [SD = 2.03]) were fed a standard finishing diet (13.8 MJ DE/kg and 9.5 g standard ileal digestible [SID] lysine/kg) during a 42 d period for the purpose of calculating RFI and evaluating feeding behavior. Following the calculation of RFI on Day 112, 8 high RFI (HRFI) and 8 low RFI (LRFI) pigs (average weight 85 kg, sem 2.8 kg), were slaughtered (115 d.o). Tissue was collected from the hypothalamus and small intestine to analyze the gene expression of neuropeptides and gut peptides associated with appetite control. Behavioral analysis confirmed that LRFI pigs ate less ($P < 0.0001$), spent less time eating per day ($P < 0.05$), had smaller meals ($P < 0.05$), and spent less time eating each meal than the HRFI pigs ($P < 0.10$). In the jejunum and ileum, the HRFI pigs had increased expression of glucagon-like peptide 1 receptor (*GLP-1R*) ($P < 0.05$), with no changes in the other measured gut or hypothalamic peptides ($P > 0.10$). While RFI was unrelated to neuropeptide gene expression, the amount eaten per feeder visit was positively correlated with cocaine and amphetamine related transcript gene expression (*CART*) in the periventricular nucleus ($r = 0.63$; $P < 0.01$). The expression of pro-opiomelanocortin (*POMC*) was negatively correlated with eating rate ($r = -0.62$; $P < 0.011$). In the duodenum the amount eaten per visit was positively correlated with the expression of cholecystokinin (CCK; $r = 0.56$) and *GLP-1R* ($r = 0.54$). In conclusion HRFI pigs had increases in activity related to feeding behavior and increased gene expression of *GLP-1R.* This study identified strong relationships between feeding behavior traits and the gene expression of the hypothalamic neuropeptides *CART, POMC* and the gut peptide *CCK* suggesting these neuropeptides are important in the control of feeding behavior in pigs.

Key Words: gut peptides, neuropeptides, pigs, residual feed intake

0989 Ileal amino acid digestibility in broiler chicken fed rice bran with or without carbohydrase and phytase. C. Gallardo*, J. C. Dadalt, J. C. da Silva Maciel de Souza, and M. A. D. T. Neto, *University of São Paulo, Pirassununga, Brazil.*

Exogenous enzymes improve feedstuffs used by poultry but information on amino acid digestibility is still limited. Apparent ileal digestibility (AID) and standardized ileal digestibility (SID) of amino acids (AA) in broiler chicks fed rice bran (RB) with or without multi-carbohydrase (MC; 35 U/g α-galactosidase, 110 U/g galactomannanase, 1,500 U/g xylanase and 1,100 U/g β-glucanase) and Phytase (Phy; 10,000 FTU/g) supplementation was investigated. A total of 245 male broilers (7 birds/pen) were fed with one low-protein diet and four corn-starch-based diets containing 30% of RB as sole source of protein in 2 (MC; 0 or 200 mg/kg) × 2 (Phy; 0 or 50 mg/kg) factorial arrangement. Low-protein diet (5% casein) was used to estimate endogenous AA losses. All diets contained Chromium (0.3%) as an indigestible marker. All birds were slaughtered on 21st for ileal digesta collection. Data were analyzed using the GLM procedure of SAS (Statistical Analysis System, version 9.2) for enzyme effects and probable interaction on digestibility. Compared to diet without enzymes, single inclusion of MC or Phy showed effect ($P < 0.05$) on AID and SID of AA. Absolute increases on AID and SID of AA, from MC + Phy supplementation, exceeded the single sum of the increases from MC or Phy supplementation. Averages of 17 AA from AID and SID were: 63.03% and 74.08% for RB without enzyme; 63.73% and 75.11% for RB with MC, 64.22% and 75.41% for RB with Phy, and, 64.65% and 75.98% for RB with MC + Phy, respectively. Interaction ($P < 0.05$) from MC × Phy was observed on AID for Arg, His, Thr, Val, Glu and Ser; and SID for Arg, His, Leu, Val, Asp, Glu and Ser; and a trend on AID for Asp ($P = 0.072$), and SID for Thr ($P = 0.051$) and Pro ($P = 0.080$). The beneficial effects from MC combined with Phy may be an effective strategy to improve AID and SID of AA in RB for broiler chicks.

Key Words: apparent, standardized, enzyme

0990 Effect of dietary net energy and digestible lysine levels on performance of weaned and starter pigs fed low protein-amino acids fortified diets. J. K. Htoo*[1] and J. Morales[2], [1]*Evonik Nutrition & Care GmbH, Hanau-Wolfgang, Germany,* [2]*PigCHAMP Pro Europa, Segovia, Spain.*

Two experiments were conducted to evaluate the effect of dietary NE and standardized ileal digestible (SID) Lys levels on performance of 7 to 10 kg pigs (Exp. 1) and 9 to 17 kg pigs (Exp. 2). In Exp. 1, 288 mixed-sex pigs (PIC; initial BW of 7.0 ± 0.45 kg) were assigned to 6 diet regimes using a 2 × 3 factorial design with 2 levels of SID Lys (1.35 or 1.42%) and 3 NE levels (10.00, 10.35 or 10.70 MJ/kg) for 14 d. In Exp. 2, 288 mixed-sex pigs (PIC; initial BW of 9.2 ± 0.39 kg) were assigned to 6 diet regimes using a 2 × 3 factorial design with 2 levels of SID Lys (1.22 or 1.32%) and 3 NE levels (9.75, 10.10 or 10.45 MJ/kg) for 21 d. For both studies there were 6 pen replicates (3 barrows and 3 gilts/pen) per treatment, and diets were based on corn, soybean meal and whey powder using the analyzed ingredient AA contents to meet requirements. There was no NE x SID Lys interaction for any measured parameter ($P > 0.05$) in both Exp. 1 and 2. In both Exp. 1 and 2, ADFI was not affected ($P > 0.05$) by SID Lys or NE levels. The amount of SID Lys (g/kg of gain) was not affected ($P > 0.05$) by the treatments in both studies. In Exp. 1, pig performance seemed to maximize at 1.42% SID Lys and 10.35 MJ NE. However, ADG and G:F were not affected by the NE level. Compared with 1.35% SID Lys, 1.44% SID Lys increased G:F (0.782 and 0.833; $P = 0.035$) but did not affect ADG (233 and 244 g/d; $P > 0.05$). In Exp. 2, pig performance seemed to maximize at 1.32% SID Lys and 10.10 MJ NE. The dietary NE level did not affect ADG and G:F. Increasing dietary SID Lys from 1.22 to 1.32% increased ADG (388 and 420 g/d; $P = 0.014$) but did not affect G:F (0.592 and 0.616; $P = 0.105$). These results indicate that performance of 7 to 10 kg pigs maximized when the diet contains 1.42% SID Lys and 10.35 MJ/kg NE (SID Lys:NE of 1.37 g/MJ). For 9 to 17 kg pigs, performance maximized at the dietary SID Lys of 1.32% and NE of 10.10 MJ/kg (SID Lys:NE of 1.31 g/MJ).

Key Words: lysine, net energy, performance

0991 Relationship between the microbiota in different sections of the gastrointestinal tract, and the body weight of broiler chickens. J. Lee* and C. Kong, *Konkuk University, Seoul, The Republic of Korea.*

In the poultry industry, many efforts have been undertaken to improve the growth performance of broiler chickens and identification and modulation of body weight (BW)-related bacteria could be one of the strategies to improve productivity. However, studies regarding the relationship between BW and microbiota are scarce. The objective of the present study was to investigate the relationship between BW and microbiota in different sections of the gastrointestinal tract (GIT), and explore the BW-related bacterial groups in broiler chickens. A total of twenty 18-d-old Ross 308 male broiler chickens were selected based on BW, and samples were collected individually from the 3 different sections of the GIT, which included the crop, ileum and cecum. Bacterial genomic DNA was extracted from the samples, and the V4 region of 16S rRNA gene was amplified. All the amplicons were then sequenced on Illumina MiSeq, and microbial communities were analyzed by using QIIME. In principal coordinate analysis, bacterial communities were clustered into three groups, based on the sections of GIT. Several BW-related bacterial groups were identified from linear regression analysis with R statistical package (version 3.0.3). At the genus level, *Streptococcus*

in the ileum ($r = -0.81$, $P < 0.001$) as well as *Akkermansia* in ileum ($r = -0.51$, $P = 0.023$) and cecum ($r = -0.55$, $P = 0.022$), were negatively related to BW, whereas *Bifidobacterium* in the ileum ($r = 0.49$, $P = 0.029$) and *Lactococcus* in the cecum ($r = 0.59$, $P = 0.006$) showed a positive correlation. The results from the present study showed that particular bacterial communities in the GIT were related to BW, and the study has broadened the understanding of the intestinal microbial ecosystem in broiler chickens.

Key Words: broiler chickens, gastrointestinal tract, microbiota

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0992 Nutrient profile and in vitro digestibility of cassava silages in swine. U. P. Tiwari*, and R. Jha, *University of Hawaii at Manoa, Honolulu, HI.*

Exploring and evaluating alternative feedstuffs to develop cost-effective and sustainable feeding program is of utmost need when market availability and price of conventional feedstuffs are variable. Cassava (*Manihot esculenta*) is a starchy tuber with high energy content while its leaves are rich in protein; thus combined parts of cassava can be a potential feedstuff for swine. Ensiling cassava parts may enhance its utilization in swine. Two independent studies were performed with cassava silages. First study evaluated different combinations of tubers and vines while second study evaluated different combinations of vines and molasses. In first study, 2 different lines of cassava (L_1 and L_2) and 2 sample types (100% tubers, T_{100} and 50% tubers and 50% vines, T_{50}) were ensiled over 3 periods (fresh [M_0], ensiled for 2 [M_2] and 3 [M_3] months). In second study, 2 different lines of cassava (L_1 and L_2) and 3 sample types (100% vines, V_0; 95% vines and 5% molasses, V_5; and 90% vines and 10% molasses, V_{10}) were ensiled for 2 mo. Nutrient profile of samples was analyzed using standard methods and digestibility was determined using an in vitro method (3 step enzymatic assay). With increasing the proportion of vine in the silage mix, ADF, NDF, and CP content increased ($T_{50} > T_{100}$) while starch decreased. However, ensiling resulted in a reduction of the CP, NDF, ADF and starch contents compared to the fresh samples. The CP content of L_2 (V_0M_0, V_5M_2, $V_{10}M_3$) was higher (15–18%) than L_1 (12–13%). The DM digestibility of $L_2T_{100}M_0$ (91%) and $L_1T_{100}M_0$ (86%) was higher ($P < 0.05$) than $L_2T_{50}M_0$ (76%) and $L_1T_{50}M_0$ (74%). Energy digestibility of $L_2T_{100}M_3$ (92%) and $L_1T_{100}M_3$ (87%) was higher ($P < 0.05$) than $L_1T_{50}M_3$ (69%) and $L_2T_{50}M_3$ (61%). Nutritional value of cassava silages decreased with increase in proportion of vines in the sample. However, digestibility was still at reasonable level. Thus, ensiling the combination of tubers and vines of cassava can be useful strategy to supply enough amount of feed for swine. However, ensiling period needs to be considered with combination of tubers and vines. Also, the pH of silage decreased with increase in ensiling period; feeding silage may provide gut health benefit, in addition to providing energy and other nutrients to swine.

Key Words: cassava silage, digestibility, swine

0993 Amino acid digestibility in feed ingredients fed to pigs. S. A. Lee*[1], J. Y. Ahn[2], A. R. Son[3], and B. G. Kim[1], *[1]Konkuk University, Seoul, The Republic of Korea, [2]Jeongeup, The Republic of Korea, [3]Konkuk University, Seoul, South Korea.*

The objective was to determine the standardized ileal digestibility (SID) of CP and AA in the cereal grains and various byproducts fed to growing pigs. Ten feed ingredients used in this study were barley (9.32% CP), lupin kernels (LK, 31.1% CP), and wheat (11.3% CP) as the cereal grains, and 2 sources of corn gluten feed [CGF 1 (21.6% CP) and 2 (24.6% CP)], corn gluten meal (CGM, 65.3% CP), lupin hulls (LH, 11.6% CP), rice bran (RB, 14.5% CP), soybean meal (SBM, 44.8% CP), and wheat bran (WB, 15.4% CP) as the byproducts. Eleven experimental diets were formulated to contain each ingredient as a sole source of N and an N-free diet was also prepared to estimate the basal endogenous losses of CP and AA. All diets also contained 0.5% chromic oxide as an indigestible index. The ileal digestibility of AA in the test ingredients was determined at 2 different locations. An incomplete 11 × 5 Latin square design was employed for each of 2 locations with 11 dietary treatments, 5 periods, and 11 animals. Eleven barrows with an initial BW of 62.1 ± 5.8 (location 1) and 66.7 ± 3.5 kg (location 2) were equipped with a T-cannula in the distal ileum. An experimental period consisted of a 4-d adaptation and a 2-d collection periods. Least square means were presented for the SID values. Values for the SID of CP in the barley, LK, wheat, CGF 1 and 2, CGM, LH, RB, SBM, and WB were 84.7, 90.5, 90.4, 77.4, 74.6, 89.5, 90.4, 74.4, 86.9, and 63.4% (SEM = 5.3, $P = 0.006$), respectively. Respective values for the SID of Lys were 75.5, 88.4, 83.9, 74.7, 62.4, 80.3, 83.9, 78.5, 88.0, and 71.2% (SEM = 3.3, $P < 0.001$), and the respective values for the SID of Met were 83.6, 88.7, 89.4, 85.7, 78.3, 88.9, 89.4, 85.3, 91.1, and 77.0% (SEM = 2.4, $P < 0.001$). In conclusion, the SID of Lys and Met in the barley, LK, wheat, CGF 1, CGM, LH, and RB did not differ compared to the SBM.

Key Words: amino acid, alternative feed ingredient, digestibility

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0994 Evaluation and development of the prediction equation for the gross energy in feed ingredients. A. R. Son*[1] and B. G. Kim[2], *[1]Konkuk University, Seoul, South Korea, [2]Konkuk University, Seoul, The Republic of Korea.*

The objective of this study was to evaluate the accuracy of a previously published equation and to develop novel prediction equations for the GE concentration in feed ingredients. Data from 297 corn, 550 corn gluten feed, 148 copra expellers, 222 copra meal, 486 palm kernel expellers, 102 rapeseed meal, and

130 soybean meal samples were used. The mean values of the feed ingredients were 10.4 ± 2.4%, 19.8 ± 9.6%, 4.44 ± 2.71%, 5.19 ± 2.17%, and 4230 ± 265 kcal/kg on an as-is basis for the moisture, CP, ether extract, ash, and GE concentrations, respectively. The predicted GE concentration of each ingredient was calculated using the published equation based on the chemical composition. To test the accuracy of the predicted GE concentrations, the regression analysis of the determined minus predicted GE concentration against the predicted GE concentration was conducted, which was able to verify the bias in the predicted values. The correlation and multiple regression procedures of SAS were used to generate the novel prediction equations. According to the results of regression analysis for the accuracy of the published equation, the intercept (−230.3; SE = 4.8 and $P < 0.01$) and slope (0.062; SE = 0.031 and $P < 0.05$) was different from 0. The recommendable regression equations for the GE concentration (kcal/kg on an as-is basis) in the feed ingredients were: Eq. 1 = 4598– (51.6 × moisture) + (37.7 × ether extract) with root mean square error = 181, R^2 = 0.537, and $P < 0.001$; Eq. 2 = 4537– (54.2 × moisture) + (11.0 × CP) + (46.5 × ether extract)– (32.6 × ash) with root mean square error = 166, $R^2 = 0.612$, and $P < 0.001$. All independent variables are in % on an as-is basis. In conclusion, the previously published equation may overestimate the GE concentrations in the feed ingredients used in this study. On the basis of the novel prediction equations, the moisture and ether extract concentrations can be good independent variables to estimate the GE concentration in the feed ingredients.

Key Words: feed ingredient, gross energy, regression equation

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0995 Effect of supplemental citrulline on thermal and production parameters during heat stress in growing pigs.

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Heat stress (HS) compromises intestinal barrier function, and citrulline improves gut health in rodent models. Therefore, objectives were to characterize effects of citrulline supplement (CIT) on physiological and production responses during HS. Supplements were fed twice daily at 0600 and 1800 h and consisted of 20 g of cookie dough without citrulline (CON) or with 0.13 g/kg BW L-citrulline (CIT; 99.3% purity; MP Biomedicals, Santa Ana, CA). Forty crossbred gilts (30 ± 2 kg) were assigned to 1 of 5 supplemental-environmental treatments: 1) thermoneutral (TN; 23.6 ± 0.1°C) ad libitum fed (AL) with CON (TN-AL; $n = 8$), 2) TN pair-fed (PF) with CON (PF-CON; $n = 8$), 3) TN PF with CIT (PF-CIT; $n = 8$), 4) HS AL with CON (HS-CON; $n = 8$), and 5) HS AL with CIT (HS-CIT; $n = 8$). Acclimation lasted 4d while all pigs received the CON supplement. During period 1 (P1; 7d), pigs were kept in TN and fed AL their respective diets. During period 2 (P2; 60 h), HS-CON and HS-CIT animals were fed AL and exposed to cyclical HS (33.6 to 38.3°C) while TN-AL, PF-CON, and PF-CIT remained in TN and were fed either AL or PF to their HS counterparts to negate the effect of dissimilar nutrient intake. Feed intake was measured daily and BW was obtained 1 d before P1, d7 of P1, and at P2 conclusion. Rectal temperature (Tr), skin temperature (Ts), and respiration rate (RR) were obtained once daily at 1800 h during P1 and thrice daily at 0600, 1200, and 1800 h during P2. Pigs exposed to HS had increased Tr (0.8°C), Ts (4.7°C), and RR (47 bpm) relative to TN pigs ($P < 0.01$). HS-CIT pigs had decreased RR (7 bpm, $P = 0.04$) and a tendency for decreased Tr (0.1°C, $P = 0.07$). Feed intake decreased ~15% in HS relative to TN-AL pigs ($P < 0.01$) and did not differ between HS and PF pigs ($P > 0.10$). P2 ADG decreased 18 and 62% in HS and PF pigs, respectively, relative to TN-AL pigs. PF-CIT pigs tended to have increased (0.12 kg/d; $P = 0.09$) ADG compared to PF-CON pigs. Gain:feed was similar between TN-AL and HS pigs but decreased 30% in PF relative to TN-AL pigs ($P < 0.01$). No effects of CIT on production variables during HS were detected. In summary, CIT modestly affected the thermal response but had no effect on production parameters during HS, but tended to increase ADG during limit-feeding.

Key Words: heat stress, citrulline

0996 Effect of microencapsulated blends of organic acids on growth performance, nutrient digestibility, and fecal microflora in pigs.

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The microencapsulated blend of organic acids (MO) allowed slow-release of active ingredients and prevented the immediate disappearance of compounds on exiting the stomach. A total of 90 pigs [(Landrace × Yorkshire) × Duroc] with an average initial BW of 6.47 ± 0.27 kg (21 d) were used in a 154-d trial. Pigs were allotted to 3 treatments with 6 replicates/treatment and 5 pigs/pen. Dietary treatments included: 1) CON, basal diet, 2) MO1, CON + 0.1% MO (weanling phase) and 0.025% MO (growing-finishing phase), 3) MO2, CON + 0.2% MO (weanling phase) and 0.05% MO (growing-finishing phase). Individual pig BW and the feed consumption of each pen were monitored to calculate the ADG, ADFI, and G:F. Chromium oxide (2 g/kg) was added to the diets to determine the ATTD of DM, N, and GE. All data were analyzed using the GLM procedures of SAS (SAS Inst. Inc., Cary, NC). Orthogonal comparison was conducted using polynomial regression to measure the linear and quadric effects. Tukey's range test was used to compare the means of treatments, and $P < 0.05$ was considered to be significant. Pigs BW was higher ($P < 0.05$) in MO2 than CON on d 21 (14.39 vs. 13.94 kg), d 42 (25.98 vs. 27.05 kg), and d 154 (109.32 vs. 114.09 kg). From d 0 to 21, 22 to 42, 0

to 42, and 0 to 154, pigs in MO2 had higher ($P < 0.05$) ADG (377 vs. 356 g, 603 vs. 573 g, 490 vs. 464 g, 699 vs. 667 g) than CON. Increased ($P < 0.05$) G:F was detected in MO2 compared with CON from d 84 to 154 (0.369 vs. 0.343) and d 0 to 154 (0.430 vs. 0.408). Linear effect ($P < 0.05$) was observed on BW, ADG, and G:F at the same time. Pigs in MO2 had higher ($P < 0.05$) ATTD of DM (83.67 vs. 81.82%, 76.63 vs. 72.29%) than CON on d 21 and 42. Linear effect ($P < 0.05$) was also observed on the ATTD of DM on d 21 and 42. Fecal *Lactobacillus* concentration (7.70 vs. 7.45 $\log_{10}$cfu/g) was increased ($P < 0.05$) by MO2 compared with CON on d 42. Linear and quadratic effects ($P < 0.05$) were also observed on *Lactobacillus* concentration on d 42. In conclusion, the inclusion of 0.2% MO can increase BW, ADG, the ATTD of DM, and fecal *Lactobacillus* counts in weanling pigs, in addition, 0.05% MO can increase G:F in finishing pigs.

Key Words: growth performance, microencapsulation, pigs

0997 Effect of multispecies probiotic supplementation source on growth performance and meat quality traits in growing-finishing pigs.

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In South Korea, using antibiotics as growth promoters in animal feeds has been forbidden since 2011. Probiotics have received considerable attention as suitable alternatives of antibiotics to promote growth in pig industry. The study was conducted to investigate the effects of multispecies probiotic (*B. coagulance* [1×10^9 cfu/g], *B. lichenformis* [5 × 10^8 cfu/g], *B. subtilis* [1 × 10^9 cfu/g], and *Clostridium butyricum* [1 × 10^8 cfu/g]) supplementing with corn based meal on growth performance and meat quality traits in growing-finishing pigs. A total of 75 pigs ([Landrace × Yorkshire] × Duroc) with initial body weight (BW) of (23.3 ± 1.42) kg. Pigs were randomly allocated to the three treatment groups with 5 replicate pens per treatment, 5 pigs (3 barrows, 2 gilts) per pen. The following three treatments were used: CON (Basal diet), T2 (CON + 0.01% multispecies probiotic), and T3 (CON + 0.02% multispecies probiotic). These dietary treatments were given as Phase I (Week 6), Phase II (Week 12), and Phase III (Week 16) to analyze growth performance. Orthogonal polynomial contrast was conducted to measure the linear and quadratic effects for increasing the multi-species probiotic levels on all measurements. Statistical significance was considered when P value was less than 0.05. Higher level of (0.02%) multispecies probiotic supplementation had linearly increased effects on BW ($P = 0.030$) at wk 16 and also significant differences on average daily gain and gain:feed ($P < 0.05$) without effects of average daily feed intake ($P > 0.05$) in treatments with probiotic supplementation at entire experiment. Significant effects ($P < 0.05$) were observed on increased apparent total tract digestibility of dry matter (DM, $P = 0.004$), nitrogen (N, $P = 0.012$), energy (E, $P = 0.055$) at wk 16 in diets with probiotic supplementation, 0.02% multispecies probiotic inclusion in diets showed reduced level of *E. coli* ($P = 0.011$, 0.013) and increased significant difference on *Lactobacillus* counts ($P = 0.004$, 0.005) respectively at wk 6 and 16, live meat quality traits of back fat thickness ($P = 0.004$, at wk 16) and lean meat percentage ($P = 0.006$, at wk 12), blood glucose ($P = 0.028$, at wk 6) level, RBC ($P = 0.013$, at wk 16) levels, NH_3 emission ($P = 0.010$, at wk 16) and sensory evaluation of color ($P = 0.001$), firmness ($P = 0.031$). These results suggested improving effects of dietary multispecies probiotic on growth performances, apparent total tract digestibility, balancing the management of desired fecal micro biota, reduced NH_3 gas emission, and sensory evaluation of meat quality in growing-finishing pigs.

Key Words: *Bacillus* spp., *Clostridium butyricum*, pig performances

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0998 Effects of dietary red ginseng on growth performance, nutrient digestibility, blood profile, meat quality, and carcass grade in growing-finishing pigs.

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This study was conducted to determine the effect of dietary red ginseng on growth performance, nutrient digestibility, blood profile, meat quality, and carcass grade in growing-finishing pigs. A total of 120 crossbred pigs ([Landrace × Yorkshire] × Duroc) with an average body weight of 21.77 ± 1.88 kg were used in 22 wk experimental period. Pigs were randomly assigned to 3 treatments with 8 replications (5 pigs per replication). Dietary treatments included: 1) CON, basal diet; 2) TRT1, CON + 0.1% fermented red ginseng; 3) TRT2, CON + 0.2% fermented red ginseng. All data were analyzed as a randomized complete block design using mixed procedures of SAS. In the current study, no significant difference was observed on average daily gain (ADG), average daily feed intake (ADFI), and gain to feed ratio (G/F) among treatments at 10th, 18th and 22th weeks. However, pigs fed with TRT1 diet (657 g) had higher ADG ($P < 0.05$) than those fed with CON diet (634 g) at sixth week. Overall, a significant increase ($P < 0.05$) in ADG was observed in TRT1 treatment (550 g) compared with CON treatment (542 g), and no effect was observed on ADFI, FCR, and G/F. Apparent total tract digestibility (ATTD) of dry matter (DM) in TRT1 treatment (81.46) was higher ($P < 0.05$) than that of CON treatment (78.03). In addition, ATTD of nitrogen (N) in pigs fed with TRT1 diet (81.89) was higher ($P < 0.05$) compared with pigs fed with CON diet (76.08) and TRT2 diet (77.37). No significant difference was observed in the ATTD of energy (E) among treatments at sixth

and 10th weeks. Supplementation of red ginseng in TRT1 treatment significantly decreased ($P < 0.05$) drip loss at d 1 (1.38), d 5 (4.60) and d 7 (7.01) post slaughter. On d 9, drip loss of CON treatment (13.92) was considerably lower than TRT1 treatment (8.68) and TRT2 treatment (11.12). Meantime, drip loss of TRT2 treatment (11.12) was significantly higher than TRT1 treatment (8.68). In conclusion, results of the present study indicated that supplementation of red ginseng enhanced growth performance, nutrient digestibility and decreased meat drip loss, with no significant effect on blood profile and carcass grade in finishing pigs.

Key Words: growing-finishing pigs, growth performance, red ginseng

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0999 Effect of protected organic acid blend with medium chain fatty acid on growth performance, nutrient digestibility, blood profiles, meat quality, fecal micro flora and fecal gas emission in finishing pigs. D. H. Nguyen*, T. S. Li, S. D. Upadhaya, H. N. Tran, and I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea.*

A total of 105 finishing pig ([Yorkshire × Landrace] × Duroc) with an average BW of 51.0 ± 3.33 kg were used in 10 wk trial to evaluate the effect of protected organic acid blend on finishing pigs. Pigs were randomly allotted to one of three dietary treatments (7 replication pens with 5 pigs per pen) in a randomly complete block design based on their initial BW. Dietary treatments were: 1) CON (basal diet); 2) MC1 (CON + 0.1% protected organic acids); 3) MC2 (CON + 0.2% protected organic acids). Protected organic acids contained 17% fumaric acid, 13% citric acid, 10% malic acid and 1.2% medium chain fatty acid (capric and caprylic acid). BW and feed were recorded at the beginning, on week 5 and week 10 of the experimental period to calculate ADG, ADFI and G:F. Fresh fecal samples were collected at sixth week and 12th week for calculation of DM, N, and energy digestibility by adding 0.2% chromium oxide before 1 wk. All data were subjected to the GLM procedures of SAS and differences among treatments were separated by Tukey's multiple range test with a $P < 0.05$ indicating a significance. In the current study, overall, the inclusion of MC1 and MC2 led to greater ADG (861, 864 vs. 827 g/d; $P < 0.05$). Administration of MC2 improved G:F compared with CON treatment (0.354 vs. 0.337; $P < 0.05$). However, no difference ($P > 0.05$) was observed in ADFI of pigs fed MC1 and MC2 compared with CON. Pigs fed MC1 and MC2 diets led to higher ($P < 0.05$) IgG concentration at the end of 5 wk. At the end of 10 wk higher concentration of IgG was seen in MC1 treatment compared with CON treatment ($P < 0.05$). Administration of MC1 and MC2 treatments led to higher *Lactobacillus* counts and lower *E.coli* counts compared with CON ($P < 0.05$). During the end of the experiment, a decrease in fecal ammonia emission was observed with MC2 treatment ($P < 0.05$). Supplementation of protected organic acid increased ($P < 0.05$) the drip loss at d5 and d7 of meat evaluation. In conclusion, protected organic acid supplementation enhanced growth performance, reduce ammonia gas emission and improve gut microbial population in finishing pigs.

Key Words: finishing pig, growth performance, protected organic acids

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1000 Effect of dietary melamine concentrations on performance and tissue melamine residue in male broiler chickens. J. H. Kim[1] and D. Y. Kil[*2], [1]*Chung-Ang University, Anseong-si, The Republic of Korea,* [2]*Chung-Ang University, Anseong-si, South Korea.*

We investigated the effect of dietary melamine concentrations on performance and tissue melamine residue in male broiler chickens. A total of 504 1-d-old male broiler chicks were housed in 42 battery cages for a 5-wk feeding trial. Birds were randomly allotted to 1 of 7 dietary treatments with 6 replicated cages. Dietary melamine concentrations were set to 0, 250, 500, 750, 1,000, 5,000, or 10,000 mg/kg by adding purified form of melamine ($\geq$ 99.0%) at the expense of the sand. At the end of the experiment, 3 birds from each treatment were euthanized. Kidney and breast samples were collected for melamine residue analysis. Results indicated that the BW and BW gain for birds fed diets containing 10,000 mg/kg melamine were less ($P < 0.01$) than those fed diets containing 0, 250, 500, 750, 1,000, or 5,000 mg/kg melamine. There were no differences in feed efficiency and mortality among treatments. Kidney melamine residue for 10,000 mg/kg treatment group was greater ($P < 0.01$) than for 0, 250, 500, 750, or 1,000 mg/kg treatment groups. The 10,000 mg/kg treatment group had greater ($P < 0.01$) melamine residues in breast muscle than other treatment groups. Orthogonal polynomial contrast test revealed that increasing melamine concentrations of diets decreased BW, BW gain (linear and quadratic, $P < 0.05$), and feed intake (linear, $P < 0.01$). Increasing melamine concentrations of diets increased (linear, $P < 0.01$) melamine residues in the kidney and breast. According to food safety issue (WHO), melamine concentrations of human food should be limited less than 2.5 mg/kg. Thus, based on linear regression analysis between dietary melamine concentrations and breast melamine residue ($y = 0.0071x - 1.7956$, $R^2 = 0.89$), the upper limit of melamine concentrations of diets for male broiler chickens was estimated to be 605 mg/kg. In conclusion, 10,000 mg/kg melamine is toxic to male broiler performance. Dietary melamine concentrations for male broiler chickens should be limited approximately less than 600 mg/kg in terms of human food safety.

Key Words: dietary melamine, male broiler chicken, tissue melamine residue

1001 Effect of dietary melamine concentrations on performance and tissue melamine residue in female broiler chickens. J. H. Kim[1] and D. Y. Kil[*2], [1]*Chung-Ang University, Anseong-si, The Republic of Korea,* [2]*Chung-Ang University, Anseong-si, South Korea.*

An experiment was conducted to investigate the effect of dietary melamine concentrations on performance and tissue melamine residue in female broiler chickens. A total of 504 1-d-old female broiler chicks were housed in 42 battery cages for a 5-wk feeding trial. Birds were randomly allotted to 1 of 7 dietary treatments with 6 replicated cages. Dietary melamine concentrations were set to 0, 250, 500, 750, 1,000, 5,000, or 10,000 mg/kg by adding purified form of melamine ($\geq$ 99.0%) at the expense of the sand. At the conclusion of the experiment, 3 birds from each treatment were euthanized by CO_2, and then kidney and breast samples were collected for melamine residue analysis. Results indicated that the BW, BW gain, and feed intake (FI) for birds fed diets containing 10,000 mg/kg melamine were less ($P < 0.01$) than those fed diets 0, 250, 500, 750, 1,000, or 5,000 mg/kg melamine. There were no differences in feed efficiency and mortality among treatments. Kidney and breast melamine residue for 10,000 mg/kg treatment group were greater ($P < 0.01$) than other treatment groups. Orthogonal polynomial contrast test revealed that increasing melamine concentrations of diets decreased (linear and quadratic, $P < 0.05$) BW, BW gain and FI (linear, $P < 0.01$). Increasing concentrations of melamine in diets from 0 to 10,000 mg/kg decreased (quadratic, $P < 0.05$) feed efficiency. Increasing melamine concentrations of diets increased (linear and quadratic, $P < 0.01$) melamine residues in the kidney and breast. According to food safety issue (WHO), melamine concentrations of human food should be limited less than 2.5 mg/kg. Thus, based on linear regression analysis between dietary melamine concentrations and breast melamine residue ($y = 0.0054x - 1.3291$, $R^2 = 0.94$), the upper limit of melamine concentrations of diets for female broiler chickens was 709 mg/kg. In conclusion, 10,000 mg/kg melamine is toxic to female broiler performance. Dietary melamine concentrations for female broiler chickens should be limited approximately less than 700 mg/kg in terms of human food safety.

Key Words: dietary melamine, female broiler chicken, tissue melamine residue

1002 A plant extract with manganese, Vali MP®, decreased adipogenesis in 3T3-L1 pre-adipocytes by modulating adipogenic gene expression and cellular energy level. S. W. Choi[*1], J. Kim[1], S. W. Jung[2], and K. Y. Whang[1], [1]*Korea University, Seoul, The Republic of Korea,* [2]*CTC BIO, Seoul, The Republic of Korea.*

As animals grow, the rate of fat deposition increases and results in a decreased feed efficiency. To improve lean growth, dietary modulation (low energy and high protein) and metabolic modulator are applied for finishing pigs. One of successful metabolic modulators is a β-adrenergic agonist, which increases leanness by improving protein synthesis. However, the use of β-adrenergic agonist for pork production are banned in many counties due to bio-safety issue. Vali MP® is a natural product consisting of plant extracts and manganese and showed improved lean growth and decreased fat deposition when supplemented in finishing pig diet. However, direct effect on adipogenesis is not fully understood. We investigated effect of Vali MP® on adipogenesis by using 3T3-L1 mouse pre-adipocytes. Murine pre-adipocytes (3T3-L1) were differentiated into adipocyte by switching media (DMEM with 10% FBS, 1% antibiotics, 10 μM cortisone, 0.5 mM methylisobutylxanthine, and 1.0 ug/mL insulin) for 2 d, and then media was changed adipocyte maintenance medium (DMEM with 10% fetal bovine serum, 1% antibiotics and 1.0 μg/mL insulin) for another 2 d. Cells were maintained in DMEM with 10% fetal bovine serum and 1% antibiotics) for 4 more days. After a total of 8 d differentiation, cellular triglyceride (TG) content was determined by Oil Red-O staining, cDNA was constructed for quantitative real-time PCR and cell lysates were prepared for immunoblotting. During differentiation, Vali MP® (10% in PBS) solution was added to the final concentration of 0, 0.05, 0.10, and 0.2% through the adipocyte differentiation. TG accumulation was not affected at 0.05% Vali MP® supplementation, however 0.10% and 0.20% Vali MP® supplementation decreased TG accumulation by 25% and 90%, respectively. At 0.05% Vali MP® supplementation, gene expression level of SREBP1C was not changed, but PPAR-γ and CEBPα, and fatty acid synthase were increased ($P < 0.05$). As Vali MP® concentration was increased (0.10% and 0.20%), these gene expression levels were decreased at dose dependent manner ($P < 0.05$). Protein expression level of AMPK (cellular energy gauge) was not affected by Vali MP® supplementation, but phosphorylated AMPK was increased and resulted in increased phosphorylated acetyl-coA carboxylase (inactive form; $P < 0.05$). Collectively, these data indicate Vali MP® decreases adipogenesis by affecting adipogenic gene expression and cellular energy status (AMPK). The results suggest a possible molecular mechanism of lean growth promoting effects of Vali MP® in finishing pigs. However, the molecular mechanism of Vali MP® on myogenesis should be addressed.

Key Words: ValiMP(*R*), anti-adipogenesis, 3T3-L1

1003 Effects of dietary lysophospholipids (LipidolTM) on intestinal morphology and gene expression of inflammatory cytokines in weaned rats.

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Weaning is a stressful condition for animals and negatively affects growth performance by increasing dystrophy of intestinal villi. This intestinal dystrophy attenuates nutrient absorption and barrier function. Lysophospholipids (LPLs), biosynthesis metabolites, are glycerophospholipids in which one acyl chain is lacking and thus only one hydroxyl group of the glycerol back bone is acylated. LPLs can diffuse rapidly into the lipid parts of membrane due to the relatively small hydrophobic part and increase permeability of membrane by altering fluidity of membrane. Therefore, we hypothesize that supplementation of LPLs products (Lipidol^{TM}) can modulate nutrient absorption and barrier function of intestine, and an experiment was conducted to investigate relieving effects of LPLs against weaning stress. Twenty-one rats (4 wk-old) were allotted into 3 dietary treatments (Control, NIH-31 diet; LEC, NIH-31 diet with 2 g of lecithin/kg of feed; and LPL, NIH-31 diet 2 g of LPLs/kg of feed). After 4 wk of feeding period, jejunum samples were collected and gene expression of inflammatory cytokines (IL-1, IL-4, IL-6, IL-10, IL-12β, and TNF-α) and tight junction proteins (β-catenin and ZO-1) were determined by qRT-PCR. Body weights and feed intakes were measured weekly. Serum biochemical markers (triglyceride, total cholesterol, and blood urea nitrogen) were measured. And jejunum morphology (villus heights, crypt depths, and the number of goblet cells) was also observed. Growth performance (body weight, average daily gain, average daily feed intake, and feed efficiency) was not affected by dietary treatments. There were numerically lower triglyceride and higher total cholesterol in LPL than other groups but no difference was found in blood urea nitrogen among 3 treatments. There were no differences in levels of IL-1, IL-4, IL-6, IL-10, IL-12β, and TNF-α, and ZO-1 expression among 3 treatments. But β-catenin expression was increased in LPL than other treatments ($P < 0.10$). Jejunal villus height were also numerically higher in LPL and villus heights:crypt depths ratio was significantly higher in LPL than other groups ($P < 0.05$). The number of goblet cells per villus was also significantly higher in LPL than other groups ($P < 0.05$). The results of this experiment demonstrated LPLs improved the gut health in villus heights and villus heights:crypt depths ratio after weaning. Also gut barrier function was improved with higher number of mucous producing cells. The healthier intestine should be able to absorb more nutrients with better efficiency, thus a reduced weaning-related growth check is expected.

Key Words: rats, intestine, gut morphology, lysophospholipids

1004 Effect of protected sodium butyrate and nutrient concentration on early phase of broilers.

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The study was conducted to compare the effect of sodium butyrate protected with PFAD sodium salt (GUSTOR N'RGY) with three different nutrient concentration diets on growth performance. A 3 × 2 factorial design was used with a basal diet based on wheat, barley and soybean meal with three different nutrient concentrations and with or without additive. The tested treatments were: CON (3,000 kcal AMEn/kg, 22.02% CP and 11.6 g/kg dig Lys) and CON-1 (CON with a reduction of 60 kcal AMEn/kg and 2.3% of amino acids), CON-2 (CON with a reduction of 120 kcal AMEn/kg and 4.6% of amino acids), N'RGY (CON diet with GUSTOR N'RGY at 1kg/t), N'RGY-1 (CON-1 diet with 1 kg of N'RGY/t) and N'RGY-2 (CON-2 diet with 1 kg of N'RGY/t). A total of 252 Cobb 1-d-old males broiler chickens were used in the study. Birds were housed in 36 floor pens of seven animals, such that there were 6 replicates/treatment. The treatments were randomly distributed among the pens. Mash feeds and water were offered ad libitum. The study lasted 21 d and the weight of animals and feed from each pen were recorded at d 0 and at d 21. Data were analyzed by ANOVA using the GLM procedure of SAS. Both nutrient concentration and feed additive inclusion affected the performance variables. There were no differences between CON and CON-1 on BW, ADG and FCR. However, CON-2 had lower BW than CON-1 (BW: 831 g ab, 860 g a and 805 g b, $P = 0.03$; ADG: 37 g/day ab, 39 g/d a and 36 g/d b, $P = 0.03$) and worst FCR than CON and CON-1 (1.51 b, 1.52 b and 1.57 a, $P = 0.007$). Animals fed diets with the addition of N'RGY had higher BW (850 g vs. 813 g, $P = 0.03$), ADG (38 g/d vs. 36 g/d, $P = 0.03$), ADFI (52 g/d vs. 51 g/d, $P = 0.01$) and better FCR (1.51 vs. 1.56, $P = 0.003$). It can be concluded that the reduction of energy and amino acids reduce animal performance on its second step, and that the use of GUSTOR N'RGY is able to improve the results of performance in the early phase of chickens.

Key Words: protected sodium butyrate; nutrient concentration; broilers

1005 Use of aromatics plants in the diet on performance of broilers in Colombia. L. Bernal*, *La Salle University, Bogotá, Colombia.*

Poultry production has major challenges to streamline animal productivity, improve intestinal health, create safe and of good nutritional quality protein for human consumption. Plant diversity of Colombian tropical plant species has not evaluated in animal feed and which may have beneficial antiseptic properties in the productive parameters and intestinal health of chickens. The aim of this study was to evaluate the inclusion of the leaves of two plants from Choco, Santa Maria (*Piper peltatum*) and basil (*Ocimum basilicum*) on performance of broilers Ross 308 line in Colombia. The experiment was conducted in the San José de Guausa farm, located in the municipality of Chia, Cundinamarca Department. Two hundred chickens Ross 308 commercial line a day were used. Birds were evaluated for an experimental of 42 d. Four treatments were evaluated. Control (CON, basal diet): animals were fed a diet of corn-soybean meal without aromatics plants; treatment two, animals that received the control diet with the inclusion of 0.05% basil leaves (ABH); treatment three, animals fed with 0.05% leaves of Santa Maria (SMB) and treatment four diet by including 0.025% (ABH) and 0.025% (SMB). The production parameters evaluated were feed intake (g), weekly weight (g), feed conversion and weight gain (g). The experimental design was completely random, distributed in four treatments, five replicates per treatment, and 10 animals per repetition. Data variables were asked ANOVA, and to detect between treatment means the Tukey test was employed in the SAS statistical package. As a result of this study, significant difference ($p < 0.05$) was found between treatments for the weekly weight, bird average daily gain and feed conversion, ABH was the treatment with the best results in week seven for the weight (2362 vs. 2155, 2297, 2346 g), weight gain (79 vs. 59, 71, and 76 g) and feed conversion (2.079 vs. 2.23, 2.42, 3.74). These results suggest that the diet with the addition of 0.05% of ABH can benefit the productive parameters of chickens level weight, weight gain and feed conversion, which favors animal productivity.

Key Words: aromatics plants, growth performance, feed conversion

1006 Dietary antioxidants, chromium and betaine supplementation can improve lactation performance of sows during summer. J. J. Cottrell[1], F. Liu[1], D. J. Henman[2], K. O'Halloran[2], and F. R. Dunshea*[1], *[1]Faculty of Veterinary and Agricultural Sciences, The University of Melbourne, Parkville, Australia, [2]Rivalea Australia Pty Ltd, Corowa, Australia.*

Heat stress (HS) causes considerable losses to the global pig industry with lactating sows being particularly sensitive. There is strong evidence that nutritional supplements may provide means of ameliorating HS and so the aim of the present study was to investigate the effects of some dietary additives on lactational performance of lactating sows during summer. Eighty seven multiparous sows were fed either a wheat-based control (CON, $n = 31$) or a supra-nutritional antioxidant diet (AO, $n = 56$) for an 18 d lactation period during summer in southern Australia. All sows were housed in lactation stalls within open-sided lactation sheds. The CON diet contained NRC recommendations for all nutrients including selenium (0.15 mg/kg) and Vitamin E (44 IU/kg) while the AO diet was fortified with selenized yeast (0.4 mg/kg Se), Vitamin E (95 IU/kg), chromium picolinate (400 ppm Cr) and betaine (2 g/kg). All of these nutritional supplements have been demonstrated to ameliorate some of the physiological responses to HS in sheep and/or pigs in our laboratory. The daily temperatures during this summer study were from 15.8 ± 3.67°C to 31.9 ± 5.00°C. Sow weight and backfat were measured from 9 d before farrowing and at weaning, and individual piglet and litter weight were measured at farrowing and weaning. When the outside temperature exceeded 30°C, the respiration rate of all sows was measured in the afternoon. Appropriate blocking ensured there was no dietary effect on initial weight (301 ± 27.7 kg) on entry into the facility. Sows fed the AO diet lost less backfat (4.1 vs. 2.2 mm for CON and AO, $P = 0.047$) and live weight (−41.6 vs. −33.4 kg, $P = 0.021$) between entry into the facility and weaning than those sows fed the CON diet despite there being no effect on feed intake (5.63 vs. 5.87 kg/d, $P = 0.20$). There was also no dietary effect on litter weight at weaning (82.7 vs. 83.2 kg, $P = 0.91$) or number of piglets at weaning (10.2 vs. 9.9 piglets, $P = 0.42$) although average piglet weight at weaning tended to be greater for the sows fed the AO diet (8.05 vs. 8.47 kg, $P = 0.078$). Respiration rate increased by 4.0 breaths per min for every degree above 30°C ($P = 0.001$) but was unaffected by diet ($P = 0.88$). In conclusion, dietary Se, Cr, betaine and Vitamin E supplementation can reduce backfat and live weight loss of lactating sows during summer.

Key Words: antioxidants, lactating sow, heat stress

1007 Effects of dietary melamine on growth performance, organ weight, and blood melamine concentrations in pigs. K. R. Park* and B. G. Kim, *Konkuk University, Seoul, The Republic of Korea.*

The objective of current experiment was to determine the effects of dietary melamine on growth performance, organ weights, and blood melamine concentration for pigs. Twelve barrows with an initial BW of 19.8 kg (SD = 2.2) were randomly allotted to 4 dietary treatments in a completely randomized design. Four experimental diets were prepared to contain 0, 1, 2, or 4% of melamine based on the commercial corn and soybean meal based diet. The pigs were individually housed in metabolism crates and fed the experimental diets during 21 d of trial. Body weight and feed intake were recorded on d 7, 14, and 21. The daily feed allowance was approximately 2.7 times the estimated energy requirement for maintenance and divided into 2 equal meals at 0700 and 1600 h. The blood samples were obtained on d 7, 14, and 21 from each pig to analyze the melamine concentration. To exclude the effects of feed intake, blood melamine concentration relative to ADFI was calculated in each pig. At the end of the experimental period, all pigs were euthanized for collecting heart, kidneys, liver, and lungs. The collected organs were weighed and the organ weight relative to BW was calculated to exclude effects of BW. From d 0 to 7, the ADG, ADFI, and G:F linearly decreased ($P < 0.05$) as dietary melamine concentration increased. From d 7 to 14, linear decrease ($P < 0.05$) of ADG and ADFI and quadratic decrease ($P < 0.05$) of ADG was observed with increasing dietary melamine concentration. However, there were no linear and quadratic effects of dietary melamine concentration on G:F from d 7 to 14. During the overall period, the ADG, ADFI, and G:F linearly decreased ($P < 0.05$) as dietary melamine concentration increased. The weight of organs relative to BW was not affected by the concentration of dietary melamine. The blood melamine concentration relative to ADFI linearly increased ($P < 0.05$) as dietary melamine concentrations increased on d 7, 14, and 21. In conclusion, increasing levels of melamine in diets fed to pigs linearly decreased the growth performance and increased blood melamine concentration.

Key Words: blood, melamine, organ

1008 Effects of dietary melamine on growth performance and blood and urinary melamine concentrations in pigs. K. R. Park* and B. G. Kim, *Konkuk University, Seoul, The Republic of Korea.*

The objective of current experiment was to determine the effects of dietary melamine on growth performance and melamine concentration in blood and urine for pigs. Nine barrows with an initial BW of 35.9 kg (SD = 2.1) were randomly allotted to 3 dietary treatments in a completely randomized design. Three experimental diets were mainly based on wheat and soybean meal and were formulated to contain 0, 1, and 2% of melamine. The pigs were individually housed in metabolism crates and fed experimental diets during 12 d of trial. Body weight and feed intake were recorded at the end of the experimental period. The pigs had free access to feed and water. Blood samples were obtained on d 12 from each pig to analyze the melamine concentration. Urine was collected from 1100 h on d 7 to 1100 h on d 9, and urinary melamine concentration and average daily urinary melamine excretion were determined. To exclude effects of feed intake, melamine concentration in the blood samples, urinary melamine concentration, and average daily urinary melamine excretion relative to ADFI were calculated. The ADG and G:F were not affected by increasing dietary melamine concentrations. However, ADFI linearly decreased ($P < 0.05$) and tended to quadratically decrease ($P = 0.081$) with increasing dietary melamine concentration. The melamine concentration in the blood samples relative to ADFI linearly increased ($P < 0.05$) as dietary melamine concentration increased. The urinary melamine concentration, urinary melamine concentration relative to ADFI linearly and quadratically increased ($P < 0.05$), and the daily melamine excretion relative to ADFI linearly increased ($P < 0.05$) and tended to quadratically increase ($P = 0.071$) with increasing dietary melamine concentration. In conclusion, the addition of melamine to diets fed to growing pigs decreased feed intake and increased blood and urinary melamine concentrations.

Key Words: growth performance, swine, urine

1009 Feed additives reduced diarrhea occurrence in a medication-free postweaning pig diet. Z. Yang*[1], X. Wang[1], F. Chi[2], and S. Ching[2], *[1]College of Animal Science, Shandong Agricultural University, Tai-an, China, [2]Amlan International, Chicago, IL.*

Because of concerns about the use of antibiotics in animal diets and zinc oxide pollution in China in recent years, we conducted a trial to evaluate 2 feed additives (FA1, FA2) in an antibiotic and ZnO free diet in post-weaning pigs. One hundred-sixty newly weaned nursery pigs (30-d-old, 8.67" ± 0.35 kg body weight) were randomly allotted to 4 TRTs with 10 pigs per pen and 4 replications. The 4 TRTs were: Control (CON); CON+FA1 (0.25%); CON+FA2 (0.15%); and CON+FA1 (0.25%)+FA2 (0.15%). A mineral-based product, FA1 (MD-09™) has been shown to reduce wet droppings in poultry. The second product, FA2 (NeoPrime™) was designed to enhance gut health. The control feed was a corn-SBM basal diet formulated to meet or exceed NRC recommendations and contained no antibiotic or ZnO at levels higher than needed to meet the Zn requirement. A two-phase-feeding program with phase I from d 0 to 14 and phase II from d 15 to 28 was used in the study. Body weight and feed intake were measured weekly to determine ADG, ADFI, and FCR. Fecal scores were recorded daily using a 0 to 5 scale (0-solid to 5-watery). Fecal

samples were collected at 14 and 28 d post-weaning and fecal microorganisms were analyzed. Data were analyzed using ANOVA procedure of SAS (SAS 9.2) with pen as the experimental unit. Post-weaning pigs supplemented with FA1 and FA2 had numerically higher ADG (0.42 and 0.45 vs. the CON 0.33) and significantly increased ADFI (0.67 and 0.71 vs. the CON 0.56) ($P < 0.05$) during the 4-wk experimental period resulting in better FCR 1.64 and 1.61 vs. the CON 1.68. Feeding FA1 or FA2 significantly reduced ($P < 0.05$) the diarrhea index from a 4.31 score in the CON to 0.84 and 0.93, respectively. Fecal samples of pigs fed the diet with FA1 had higher *Lactobacilli* counts on both d-14 and d-28 ($P < 0.05$), lower *E. coli* on d-14, and lower *Salmonella* on d-28 ($P < 0.05$). Supplementing FA2 to post-weaning pigs significantly reduced *E. coli* and increased*Lactobacilli* on both d-14 and d-28 of tested period ($P < 0.05$). Fecal *Salmonella*counts were numerically lower in the FA2 group on both d-14 and d-28. In conclusion, FA1 or FA2 can be used as feed additives to reduce diarrhea, improve growth performance, and improve microorganism profiles in the intestine of post-weaning pigs.

Key Words: gut health, growth performance, diarrhea, post-weaning pigs

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1010 Optimization of B vitamins for improving the quality of fermented feed with response surface methodology. Z. Yang*[1] and X. M. Wang[2], *[1]College of Animal science, Shandong Agricultural University, Taian, China, [2]College of Animal science, Shandong Agricultural University, Tai-an, Shandong, Taian, China.*

To investigate the optimization of vitamin B_1, B_2 and B_{12} that were inoculated to improve the quality of fermented feed. Central composite design of response surface methodology (RSM) was employed to optimize vitamin B_1 content (X_1: 0.6~1.0 mg/kg), vitamin B_2 content (X_2:0.6~1.8 mg/kg) and vitamin B_{12} content (X_3: 9~15 μg/kg). After 72 h solid-state fermented (SSF), samples from three fermented feed/pen and 6 replicate pens/treatment were obtained to evaluate the pH value, dry matter recovery (DMR) and reducing-sugar content. Results indicated that the data of pH value, DMR and reducing-sugar were adequately fitted into 3 s-order polynomial models ($P < 0.05$). The vitamin B_1, B_2 and B_{12} were found to have significant linear, quadratic and interaction effects on the pH value, DMR and reducing-sugar ($P < 0.05$). The optimal extraction conditions were predicted to be vitamin B_1 content of 0.65 mg/kg, vitamin B_2 content of 1.29 mg/kg and vitamin B_{12} content of 12.02μg/kg. The pH value, DMR and reducing sugar were predicted by RSA to be 4.09, 91.57, and 6.46%, respectively. These detection indexes what obtained through the verification experiment were close to the predicted values significantly ($P < 0.01$). The establishment of such a model provides a good experimental basis with employing RSM for optimizing the inoculation amount of vitamin B_1 (0.65 mg/kg), vitamin B_2 (1.29 mg/kg) and vitamin B_{12} (12.02μg/kg) to improve the quality of fermented feed.

Key Words: B vitamins, pH, dry matter recovery, reducing-sugar, fermented feed

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1011 Changes in pH of digestive tract and cecal microflora composition in broilers fed with probiotic and prebiotic supplementation (SynerAll). A. Ipek* and A. Sozcu, *Faculty of Agriculture, Department of Animal Science, Uludag University, Bursa, Turkey.*

This study was conducted to investigate the changes in the pH of the digestive tract and cecal microflora composition in broilers fed a combination of probiotic and prebiotic supplementation (PPS) (SynerAll; Global Nutritech LLC, Richmond, VA). A total of 720 1-d-old Cobb 500 broiler chicks were randomly assigned to four treatment groups: Control (no PPS), Group 1 (0.5 kg PPS/ton), Group 2 (1 kg PPS/ton), and Group 3 (2 kg PPS/ton). The combination of probiotics and prebiotics included live *Saccharomyces cerevisiae* (strain NCYC R618), mannan, and glucan. Each experimental group consisted of six replicates, each containing 30 chicks (15 female and 15 male). At 42 d of age, the pH and dry matter of the digestive tract (crop, proventriculus, gizzard, ileum), the pH of feces, and cecal microflora composition (*Lactobacillus* spp. and total *E. coli* spp.) were determined. Data were analyzed using the GLM Procedure of SAS. The crop and gizzard had the lowest ($P < 0.05$) pH values in Group 2 (4.35 and 2.24, respectively) compared to the Control (5.90 and 3.28, respectively), Group 1 (4.88 and 2.91, respectively), and Group 3 (4.63 and 2.78, respectively). The pH of the ileum was higher ($P < 0.01$) for the Control (6.64) than for Group 1, Group 2, and Group 3 (5.38, 5.18, and 5.42, respectively). Dry matter and pH of feces were similar among the treatment groups ($P > 0.05$). The count of *Lactobacillus* spp. increased more in Group 2 (7.97 log CFU/g wet digesta) and Group 3 (6.90 log CFU/g wet digesta) than the Control (1.30 log CFU/g wet digesta) and Group 1 (1.43 log CFU/g wet digesta; $P < 0.01$). Total *E. coli* spp. count was higher ($P < 0.05$) in the Control and Group 1 (8.90 and 7.67 log CFU/g wet digesta, respectively) compared to Group 2 and Group 3 (3.47 and 4.20 log CFU/g wet digesta, respectively). Increasing the dose of SynerAll resulted in increased counts of *Lactobacillus* spp. and decreased counts of total *E. coli* spp. in the cecal microflora. In conclusion, supplementation of SynerAll to broiler diets had a positive effect on the pH of digestive organs and cecal microflora composition, which may increase the performance of broilers.

Key Words: broiler, probiotic, prebiotic, pH, cecal microflora

1012 Effects of dietary inclusion of probiotics and prebiotics (SynerAll) on growth performance and serum biochemical parameters in broilers.
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This study was conducted to investigate the effects of the dietary inclusion of probiotics and prebiotics (PPS) (SynerAll; Global Nutritech LLC, Richmond, VA) on broiler growth performance and serum biochemical parameters. A total of 720 1-d-old Cobb 500 broiler chicks were randomly assigned to four treatment groups: Control (no PPS), Group 1 (0.5 kg PPS/ton), Group 2 (1 kg PPS/ton), and Group 3 (2 kg PPS/ton). The combination of probiotics and prebiotics included live *Saccharomyces cerevisiae* (strain NCYC R618), mannan, and glucan. Each experimental group consisted of six replicates, each containing 30 chicks (15 female and 15 male). Growth performance, live weight gain, and feed conversion rate were determined between d 1–21 and d 22–42. At 42 d of age, serum biochemical parameters (heterophil (H), lymphocytes (L), monocytes, eosinophils, basophils) were analyzed and the H:L ratio was calculated. Data were analyzed using the GLM Procedure of SAS. Final live body weight on d 42 was the highest ($P < 0.01$) for Group 2 (3238.6 g) and the lowest ($P < 0.01$) for the Control (2818.5 g). Final body weight was 6.8%, 14.9%, and 5.8% higher ($P < 0.01$) for Group 1, Group 2, and Group 3, respectively, when compared to the Control. Feed consumption was lower ($P < 0.01$) for Group 2 and Control (1683.5 and 1727.2 g/bird, respectively) compared to Group 1 and Group 3 (1926.3 and 1935.4 g/bird, respectively). Dietary inclusion of PPS affected the feed conversion ratio ($P < 0.01$). The feed conversion ratio was the highest for the Control (2.04) and the lowest for Group 2 (1.72). It was intermediate for Group 1 and Group 3 (1.88 and 1.97, respectively). Mortality rate was not statistically significant among treatment groups ($P > 0.05$). Serum biochemical parameters and H:L ratio were similar among treatment groups ($P > 0.05$). These findings demonstrated that SynerAll can be used in broiler diets to improve weight gain and profitability.

Key Words: broiler, probiotic, prebiotic, live weight, blood parameters

1013 Changes in pH of digestive tract and cecal microflora composition in broilers fed with probiotic and prebiotic supplementation, SynerAll.
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This study was conducted to investigate the changes in pH of the digestive tract and cecal microflora composition in broilers fed a combination of probiotic and prebiotic supplementation (PPS) (SynerAll; Global Nutritech LLC, Richmond, VA). A total of 720 1-d-old Cobb 500 broiler chicks were randomly assigned to four treatment groups: Control (no PPS), Group 1 (0.5 kg PPS/ton), Group 2 (1 kg PPS/ton), and Group 3 (2 kg PPS/ton). The combination of probiotics and prebiotics included live *Saccharomyces cerevisiae* (strain NCYC R618), mannan, and glucan. Each experimental group consisted of six replicates, each containing 30 chicks (15 female and 15 male). At 42 d of age, the pH and dry matter of the digestive tract (crop, proventriculus, gizzard, ileum), the pH of feces, and cecal microflora composition (*Lactobacillus* spp. and total *E. coli* spp.) were determined. Data were analyzed using the GLM Procedure of SAS. Crop and gizzard had the lowest ($P < 0.05$) pH values in Group 2 (4.35 and 2.24, respectively) compared to the Control (5.90 and 3.28, respectively), Group 1 (4.88 and 2.91, respectively), and Group 3 (4.63 and 2.78, respectively). The pH of the ileum was higher ($P < 0.01$) for the Control (6.64) than Group 1, Group 2, and Group 3 (5.38, 5.18, and 5.42, respectively). Dry matter and the pH of feces were similar among treatment groups ($P > 0.05$). The *Lactobacillus* spp. count increased more in Group 2 (7.97 log CFU/g wet digesta) and Group 3 (6.90 log CFU/g wet digesta) than the Control (1.30 log cfu/g wet digesta) and Group 1 (1.43 log CFU/g wet digesta; $P < 0.01$). The total *E. coli* spp. count was higher ($P < 0.05$) in the Control and Group 1 (8.90 and 7.67 log CFU/g wet digesta, respectively) compared to Group 2 and Group 3 (3.47 and 4.20 log CFU/g wet digesta; respectively). Increasing the dose of SynerAll resulted in increased counts of *Lactobacillus* spp. and decreased counts of total *E. coli* spp. in the cecal microflora. In conclusion, supplementation of SynerAll to broiler diets had a positive effect on the pH of digestive organs and cecal microflora composition, which may increase the performance of broilers.

Key Words: broiler, probiotic and prebiotic, pH, cecal microflora

1014 Supplementation of chestnut tannins in artificially infected weaned piglets. G. Bee*, S. Thanner, G. Marion, and A. Gutzwiller, *Agroscope Institute for Livestock Sciences, Posieux, Switzerland.*

Weaning is a critical stage for piglets that is associated with disturbances in the intestinal microflora and pre-disposes them to gastrointestinal tract infections such as enterotoxic *E. coli* F4 (ETEC) infections and the development of post-weaning diarrhea. The continuous use of large amounts of antibiotics in animal production has led to the increased occurrence of resistances, so alternative solutions become urgent. Hydrolyzable tannins (HT) are known to have antimicrobial properties. The aim of this study was to determine the effect of HT from chestnut added to a standard starter diet on the prevalence of diarrhea in weaned piglets artificially infected with ETEC. The trial was arranged as a 2 × 2 factorial design and was performed with 72 piglets, weaned at 23 to 31 d of age. Piglets were allocated within weaning body weight and litter to the treatments and housed as pairs in pens. From the day of weaning, piglets had ad libitum access to either a control (**C**) or a 1% tannin (T) supplemented diet. Four days after weaning, 18 C and 18 T piglets received a 5-mL ETEC suspension of 10^8 CFU/ml orally, while the other 18 C and 18 T piglets received 5 mL of a PBS solution. For 14 d after infection, fecal score was assessed daily using the following score scheme: 1 = dry, pelleted feces; 2 = molded feces; 3 = moist, cow-dung appearance; 4 = diarrhea; 5 = watery diarrhea. Once per week, the piglets were weighed and the feed disappearance per pen was determined. In the first week after infection, the fecal score and the number of days in diarrhea were reduced ($P < 0.01$) in the T group (2.7 ± 1.24 and 2 ± 1.9 d, respectively) compared with the C group (3.1 ± 1.32 and 3 ± 2.4 d, respectively). However, average daily weight gain and feed disappearance were similar ($P > 0.05$) between the infected groups in the first week after infection (T: 0.4 ± 0.70 kg/piglet/d; C: 0.2 ± 0.27 kg/piglet/d; T: 517 ± 157.5 g/pen/d; C: 488 ± 193.7 g/pen/d) as well as in the second week after infection (T: 0.9 ± 1.25 kg/piglet/d; C: 0.6 ± 0.69 kg/piglet/d; T: 1043 ± 385.4 g/pen/d; C: 946 ± 347.5 g/pen/d). There was no difference in the frequency of antibiotic treatment between the C and T groups (2 out of 36 T piglets and 2 out of 36 C piglets suffering from watery diarrhea for 4 d received antibiotic treatment), and none of the T and C piglets died. In conclusion, the HT extract reduced the severity of diarrhea in the first week after infection but had no effect on growth performance.

Key Words: ETEC infection, post-weaning diarrhea, piglet

1015 Curcumin prevents hepatotoxic effects of Aflatoxin B1 associated with inhibition of cytochrome P450 isozymes genes in chick liver. L. Sun*, N. Zhang, M. Zhu, L. Zhao, and D. Qi, *College of Animal Science and Technology, Huazhong Agricultural University, Wuhan, China.*

The involvement of cytochrome P450 (CYP450) isozymes in curcumin-mediated protection against aflatoxin B_1 (AFB_1)-induced adverse effects in broilers remains unclear. This study was designed to establish if curcumin could alleviate AFB_1-induced hepatotoxic effects and then to determine if these effects were due to changes in the CYP450 isozymes expression in the livers of chicks. 120 1-d-old male Avian broilers were assigned to 4 groups with 5 replicates of 6 birds to be included in a 2 by 2 factorial trial, in which the main factors included supplementation of AFB_1 (<5 vs. 100 μg/kg) and curcumin (0 vs. 150 mg/kg) in a corn/soybean-based diet for 4 wk. The liver histology, antioxidant enzymes, and mRNA of CYP450 isozymes in liver were analyzed. Administration of AFB_1 induced liver injury, which was indicated by induced hepatic necrosis and bile duct hyperplasia at wk 2. AFB_1 also decreased ($P < 0.05$) hepatic activities of catalase and glutathione peroxidase, while increasing ($P < 0.05$) exo-AFB_1–8,9-epoxide (AFBO)-DNA concentration. Curcumin supplementation was found to prevent the changes induced by AFB_1 in broilers. Moreover, the mRNA of the enzymes responsible for the bioactivation of AFB_1 into AFBO, which included CYP1A1, CYP1A2, CYP2A6, and CYP3A4, were induced ($P < 0.05$) in liver microsomes after 2 wk exposure to AFB_1. These alterations induced by AFB_1 were prevented by curcumin supplementation. In summary, dietary curcumin supplementation protected chicks from the AFB_1-induced liver injury, potentially through the synergistic actions of increased antioxidant capacities, and inhibition of the pivotal CYP450 isozyme-mediated activation of AFB_1 to toxic AFBO.

Key Words: curcumin, aflatoxin B_1, CYP450, AFBO-DNA, chicks

1016 Effects of humic acid supplementation on pig growth performance, Nitrogen digestibility, odor, and ammonia emission. C. H. Ponce[*1], C. Arteaga[2], and A. Flores[2], [1]*Escuela de Medicina Veterinaria, Colegio de Ciencias de la Salud, Universidad San Francisco de Quito USFQ, Quito, Ecuador,* [2]*Departamento de Ciencias de la Vida y Agricultura, Universidad de las Fuerzas Armadas ESPE, Sangolqui, Ecuador.*

An experiment was conducted to evaluate the effects of the level of supplementation of humic acid salts (HF) on pig performance, nitrogen digestibility, odor, and ammonia emissions from manure. A total of 150 piglets were used in a completely randomized block design (10 pens/treatment and 5 piglets/

pen) and assigned into 3 experimental treatments: 1) control, without HF supplementation (0HF), 2) supplementation of 2 g/pig/day of HF (Huminfeed; 2HF), and 3) supplementation of 4 g/pig/day of HF (Huminfeed; 4HF). Commercial diets were fed ad libitum in a pellet form in 2 phases, from weaning (21 d) to d 49 (pre-starter) and from d 49 to 70 (starter). Growth parameters were measured weekly. Total fecal and urine samples were collected form 3 pens/treatment on d 14 of the experiment for 5 consecutive days to measure nitrogen digestibility. On d 20 of the experiment, fecal samples mixed with urine samples (1:2) were placed into plastic containers to measure ammonia emissions over 48 h. Additionally, fecal samples were collected to measure odor characteristics. Overall, body weight, ADFI, ADG, and the G:F ratio were not altered by HF supplementation ($P > 0.59$). Nitrogen intake and N fecal excretion were linearly decreased as HF increased ($P < 0.01$). Apparent total nitrogen digestibility increased linearly as HF increased ($P = 0.02$). However, N retention was not different across treatments ($P > 0.37$). There was a tendency toward decreased NH_3 emission from manure from the 4HF treatment over 48 h ($P = 0.09$). Odor hedonic tone and odor intensity from manure were significantly reduced by HF supplementation ($P < 0.01$). Results from this experiment suggest that there are benefits of HF supplementation on odor parameters, NH_3 emissions, and N digestibility without altering pig growth performance.

Key Words: ammonia emissions, growth performance, humic acids

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1017 A standardized blend of capsicum and turmeric oleoresins given during late gestation improves the performance of sows vaccinated against *E. coli*.

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Previous research projects have demonstrated that a standardized protected blend of capsicum and turmeric oleoresins (XT, Xtract® Nature, Pancosma, Switzerland) had an immunemodulating effect and could potentiate and complement the effects of vaccines in poultry. However, similar data were not available in swine. The objective of this trial was to evaluate if the supplementation of XT in late gestation could improve the performance of sows vaccinated against *E. coli* during farrowing and lactation. A total of 1531 sows vaccinated against *E. coli* at 80 d of gestation and regrouped in 3 successive bands were involved. Sows in phases 1 and 3 were fed an unsupplemented basal diet (CT, $N = 529$ and 329, respectively), whereas animals in the second phase were provided the same basal diet supplemented with 200 g/t XT ($N = 673$) from 80 until 110 d of gestation. In terms of sow performance, the proportion of piglets born/litter was recorded at farrowing as well as piglets' mortality during lactation. Colostrum was also collected at birth ($N = 14$ and 16, respectively, for the XT and CT groups) for analysis of total protein, albumin, and globulins. Data were analyzed by analysis of variance, considering the effect of the treatment for colostrum quality, and the effects of the treatment, parity, and their interaction for performance outcomes. Results showed that XT increased the levels of total proteins by +5.0% in colostrum ($P = 0.04$), and this was mainly driven by a greater concentration in globulins (+5.0%, $P = 0.08$). XT enhanced the proportion of piglets born alive per litter (92.6% vs. 90.7%, respectively, for XT and CT; $P < 0.01$). This effect was more pronounced in sows of parity 1 or 2 (+2.2%, $P = 0.02$) than in sows of parity 3 or more (+1.9%, $P = 0.06$). The treatment did not affect the piglets' mortality during suckling, but there was a treatment*parity effect on this outcome: litters in primiparous and parity 2 sows had reduced mortality when fed XT compared to CT (10.1 vs. 12.5%, $P = 0.01$). These results suggest that XT supplementation to vaccinated sows during late gestation has the potential to improve nutrient supply to the progeny, litter performance at farrowing, and litter size at weaning.

Key Words: performance, vaccinated sows, Xtract

1018 Evaluation of biodegraded and undegraded plantain peels as replacement to wheat offal in broiler production.

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This study evaluated the replacement of wheat offal with biodegraded and undegraded plantain peels in raising broilers. Plantain peels were biodegraded using fungus, and three diets were formulated. Diet I with 12% wheat offal was the control, and in diets II and III, wheat offal was replaced with undegraded and biodegraded plantain peels. Ninety day old broilers were randomly assigned to these diets, which were replicated thrice and lasted for 8 wk. During this feeding trial, data on the performance characteristics of the birds were collected. Blood samples were also taken at the eighth week for analysis, and all data generated were subjected to analysis. Results revealed that body weight gain was similar ($P = 0.05$) across the diets at both starter and finisher phases, implying that the energy and protein content of the diets were not below the maintenance requirements. The broilers fed control diets had a similar feed intake to those on the degraded plantain peel diet, but it was significantly ($P < 0.05$) higher than those on the undegraded plantain peel diet at the starter phase, while at the finisher phase the intake was similar across the diets possibly due to age. Feed conversion ratio had a similar pattern to intake at both phases. Among the serum metabolites observed, the glucose, total protein, cholesterol, urea, creatinine, and the enzymes were all significantly affected by the diets and were mostly within normal range. Morphological analysis of the birds revealed significant effects of treatments on the

heart, proventriculus, gizzard, lung, spleen, liver, and intestine. The carcass analysis revealed that the shank, wing, back, and the head of the control and those fed diet II were similar and higher than those fed diet III, but the breasts of broilers on diet III were better than those on diets I and II. The mortality that occurred could not be traced to diets. Biodegraded or undegraded plantain peels could be used as a replacement for wheat offal weight for weight in broiler production without adversely affecting performance characteristics, morphology, blood parameters, and carcass analysis.

Key Words: plantain peels, broilers, performance characteristics

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1019 Effect of lysophospholipids supplementation in different energy diets on growth performance, nutrient digestibility, milk composition, litter performance, and fecal score in lactating sows.

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Emulsifiers are substances that stabilize mixtures and prevent oil and water from separating, which is good for the digestion of lipids. This study was conducted to evaluate the effect of dietary emulsifier (lysophospholipids, LPL) supplementation with different energy diets in lactating sows. A total of 32 multiparous sows (Landrace × Yorkshire) were used in a 21-d experiment. On d 110 of gestation, sows were weighed and moved into the farrowing facility, randomly assigned in a 2 × 2 factorial arrangement with two levels of Lipidol (0 and 0.1%; Lipidol contains 3% LPL) and two level of metabolizable energy (3265 and 3165 kcal/kg) according to their BW. Individual sows were weighed and scanned for backfat thickness to determine weight and backfat loss. Chromium oxide (0.2%) was added to the diet as an indigestible marker to determine ATTD of DM, N, and GE. Milk crude fat (Method 960.39; AOAC, 2007) was measured according to the Association of Official Analytical Chemists. Lactose was assayed using an enzymatic method. Data were analyzed as a randomized complete block design with a 2 × 2 factorial arrangement using the GLM Procedure of SAS (SAS Inst. Inc., Cary, NC). A probability level of $P < 0.05$ was considered to be significant. Body weight loss (18.6 vs. 15.1 kg) and backfat thickness loss (2.4 vs. 1.9 mm) were decreased ($P < 0.05$) by LPL supplementation. Backfat thickness (17.0 vs. 14.5 mm) at weaning was higher ($P < 0.05$) in sows fed LPL supplementation diets. The ATTD of DM (84.4 vs. 83.2%), N (83.6 vs. 82.5%), GE (82.9 vs. 82.1%), and crude fat (80.1 vs. 79.2%) in sows fed LPL diets was increased ($P < 0.05$) compared with those fed non-LPL diets. Sows fed the high energy diets had higher ($P < 0.05$) milk fat (11.3 vs. 10.0%) on d 10 and milk lactose (4.6 vs. 3.9%) on d 20 than those fed the low energy diets. Milk fat (11.3 vs. 9.9%) and lactose concentrations (4.6 vs. 4.0%) in LPL supplementation treatments were increased ($P < 0.05$) compared with non-LPL treatments on d 10 and d 20, respectively. Interactive effects ($P < 0.05$) between energy and LPL were observed on milk fat concentration on d 10. In conclusion, LPL addition decreased body weight loss and backfat thickness loss and improved nutrient digestibility and milk fat as well as milk lactose concentrations. Additionally, LPL and energy can interactively increase milk fat concentration in lactating sows.

Key Words: growth performance, lysophospholipids, sow

1020 Effect of crystalline silicon dioxide in piglet feed on growth performance with different levels of growth promoters.

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Silicon dioxide is a common mineral that can be found under different forms (crystalline or amorphous) and is also found in many clays and diatomaceous earth. The purpose of this trial was to assess, in a factorial 2×2 arrangement, the growth performance of piglets reared with a feeding program including, or not, a crystalline silica-based feed supplement (SI) with or without antibiotics as growth promoters (AGP; chlortetracycline and high levels of Cu and Zn in Phase 1 and chlortetracycline in Phase 2). All diets were formulated to be iso-caloric and iso-nitrogenous. An ANOVA was performed on zootechnical parameters with the pen as the experimental unit for all analyses. Effects of AGP, SI, block (based on sex and body weight), and interaction between AGP and SI were included in the statistical model. A total of 252 piglets with body weights of 7 kg were reared until 24 kg of body weight and allocated into 36 pens. According to these results, groups fed with AGP showed improved weight gain, feed intake, and feed conversion during Phase 1, while no significant effect was observed during Phase 2. Concerning the effect of SI, feed intake was improved by 4.13% during the overall nursery period, compared to groups without SI (729 versus 700 g/day; $P < 0,05$). In addition, groups fed SI showed an average daily gain of 3.26% higher than animals without SI during the same period (607 versus 588 g/day; $P < 0.05$). This effect leads to an improvement of 2.2% in piglet's weight at the end of the post-weaning phase (24.52 versus 23.99 kg; $P < 0.05$). It was concluded that under our trial conditions, adding crystalline silicon dioxide to piglet feed (0.02%) increase feed intake, growth rate, and piglet weight at the end of the nursery period. This mineral additive could offer potential economic benefits to swine producers.

Key Words: silicon, silica, piglet