
**NONRUMINANT NUTRITION:
NUTRIENT REQUIREMENTS OF
MONOGASTRICS AND AMINO ACID
DIGESTIBILITY OF FEEDSTUFFS**

0435 Determination of additivity of apparent and standard ileal digestibility of amino acids in different ingredients for mixed diets fed to growing pigs. P. Xue*, D. Ragland, and L. Adeola, *Purdue University, West Lafayette, IN.*

An experiment was conducted in growing pigs to investigate the additivity of apparent (AID) or standardized (SID) ileal digestibility of CP and AA in mixed diets based on multiple protein sources. Additivity refers to values calculated (predicted) from determined AID or SID of individual ingredients vs. measured values in mixed diets. Using the measured AID or SID for CP and AA in corn, soybean meal (SBM), corn distillers' dried grains with solubles (DDGS), or canola meal (CM), the AID or SID for 4 mixed diets based on corn-SBM (CS, 65% corn and 22% SBM), corn-SBM-DDGS (CSD, 57% corn, 17% SBM, and 11% DDGS), corn-SBM-CM (CSCM, 58% corn, 13% SBM, and 13% CM), or corn-SBM-DDGS-CM (CSDCM, 55% corn, 10% SBM, 10% DDGS, and 10% CM) were predicted and compared with measured AID or SID, respectively. *t* test was applied to test the difference between predicted and measured values. Eighteen pigs (initial BW = 61.3 ± 5.5 kg) were surgically fitted with T-cannula and assigned to a duplicated 9 × 4 incomplete Latin square design with 9 diets and 4 periods. The experimental diets consisted of 4 semipurified diets to determine the AID and SID in the 4 ingredients, 4 mixed diets, and a N-free diet. Chromic oxide was added as an indigestible marker. Pigs were fed 1 of the diets during each 7-d period, and the ileal digesta were collected on d 6 and 7, from 0800 to 1800. The results showed the predicted SID were consistent with determined values, except for Leu, Thr, Asp, Cys, Pro, and Ser, in CS diet; Met and Cys in CSD diet. The determined AID for total AA and 5 individual AA (Arg, His, Trp, Gly, and Pro) in CS diet were greater ($P < 0.05$) than predicted. For CSD diet, the determined AID were greater ($P < 0.05$) than predicted for CP, total AA, and all AA except for Arg, Leu, and Pro. In CSCM diet, the determined AID were greater ($P < 0.05$) than predicted for 3 AA (Arg, Cys, and Gly). When compared with determined values, predicted AID in CSDCM diet were lower ($P < 0.05$) for total AA and 4 AA (Arg, Met, Cys, and Pro). In conclusion, the results indicate that SID of AA are more consistent than AID for predicting ileal digestibility of AA in mixed diets containing multiple protein sources.

Key Words: additivity, amino acid, ileal digestibility

0436 Effects of dietary threonine:lysine ratio and sanitary conditions on performance and plasma urea nitrogen of weaned pigs fed antibiotic-free diets.

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A growth trial was conducted to determine the optimum standardized ileal digestible (SID) Thr:Lys ratio for weaned piglets reared in clean or unclean sanitary conditions and fed antibiotic-free diets. Mixed-sex pigs (Duroc × [Yorkshire × Landrace]); average initial BW of 7.0 ± 0.5 kg) weaned at 21 ± 1 d were randomly assigned to 10 dietary treatments in a 2 × 5 factorial arrangement in a 42-d study giving 6 replicates (3 pigs per pen) per treatment. The main factors were sanitary conditions (clean, CL; unclean, UCL) and 5 dietary SID Thr:Lys ratios (55, 59, 63, 67, and 71%) in a completely randomized design. Diets were corn-wheat-soybean meal based with a constant SID Lys of 1.18% that was set to be seconding limiting AA. Pigs had ad libitum access to feed and water. For the first 21 d, CL group (90 piglets) were kept in a room that was disinfected before arrival of piglets and was cleaned weekly. The UCL group (90 piglets) followed immediately for the next 21 d in the same room. The UCL room was not disinfected and left uncleaned after CL group and manure from swine herd was added (5 kg per pen) to the pens on d 0 and d 7 of the experiment. Pigs and pen feed disappearance were recorded weekly to determine ADG, ADFI, and G:F. Blood samples were collected on d 0 and d 14 via jugular venipuncture for determination of plasma urea nitrogen (PUN). There were no significant interactions ($P > 0.05$) between sanitary conditions and dietary levels on any response criteria. Unclean conditions reduced ($P < 0.05$) ADG and ADFI throughout the experimental period, and tended to reduce ($P < 0.10$) G:F. The overall ADG was 494 vs. 404 g and ADFI was 736 vs. 579 g, for CL and UCL, respectively. Unclean group had significantly higher ($P < 0.05$) PUN (4.12 vs. 2.96) on d 14 compared with CL group. Increasing dietary SID Thr:Lys ratio had no effect on ADG and ADFI throughout the study; however, there was a linear trend ($P < 0.10$) in G:F showing that SID Thr:Lys of 71% improved G:F. The highest ADG was achieved at SID Thr:Lys of 71% for CL and 67% for UCL pigs, respectively. In conclusion, unclean conditions reduced ADG and ADFI in piglets, and increasing levels of SID Thr:Lys to 71% could improve G:F after weaning.

Key Words: threonine, sanitation, piglets

0437 Estimated lysine requirement of 25 to 50 kg growing gilts. J. K. Mathai* and H. H. Stein,

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An experiment was conducted to determine the standardized ileal digestible (SID) Lys requirement of gilts (G-Performer × Fertilis 25) from 25 to 50 kg BW. Seventy gilts (G-Performer × Fertilis 25; initial BW: 24.54 ± 3.28 kg) were used in a growth

assay with 2 pigs per pen and 7 pens per treatment. Diets were formulated using corn and soybean meal as the sole sources of AA. Under the assumption that Lys is the first limiting AA in corn-soybean meal diets, soybean meal concentration was increased at the expense of corn to increase SID Lys in the diets. Five treatments with calculated SID Lys levels of 0.80, 0.93, 1.06, 1.19, and 1.32% were formulated using values from NRC (2012). Accuracy of diet formulations were confirmed by analyzing diets for total Lys. Daily feed allocations were recorded and individual pig weights were recorded at the beginning and at the conclusion of the experiment, 33 d later. Results indicated that ADG increased ($P < 0.05$) quadratically and G:F increased linearly ($P < 0.05$) as SID Lys increased from 0.80 to 1.32% (Table 0437). Broken-line and curvilinear-plateau regression analyses were used to estimate the requirement for SID Lys. Results indicated that 1.08% SID Lys was needed to maximize ADG and 1.10% SID Lys was needed to maximize G:F. Thus, results of this experiment indicate that the SID Lys requirement for 25- to 50-kg growing gilts is slightly greater than the recent estimate of 0.98% reported by NRC (2012). Under the conditions of this experiment, the requirement for SID Lys for 25 to 50 kg gilts is approximately 1.09%.

Key Words: amino acids, lysine requirement, pigs

Table 0437. Performance of pigs fed increasing levels of standardized ileal digestible Lys

	Standardized ileal digestible lysine, %					Contrasts (P -value) ¹	
	0.80	0.93	1.06	1.19	1.32	Linear	Quadratic
ADG, g	782	809	825	846	794	NS	0.03
ADFI, g	1758	1826	1738	1775	1658	NS	NS
G:F, g	432	444	462	465	467	<0.01	NS

¹NS indicates $P > 0.10$.

0438 Homocysteineinemia, growth performance, and immune responses in suckling and weanling piglets.

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Homocysteine, an intermediary sulfur AA, is recognized as a powerful pro-oxidant with deleterious effects on physiological and immune functions. In piglets, there is an acute 10-fold increase of plasma concentrations of homocysteine (PHcy) during the first 2 wk of life. This project aimed to create wide ranges of PHcy by varying folates and vitamin B₁₂ (B₁₂) supplies to sows and piglets. Growth, immune response, and PHcy were studied until 56 d of age. Third-parity sows were randomly assigned to a 2 × 2 split-plot design with 2 dietary treatments (S) during gestation and lactation, S⁻ (1 mg/kg of folates and 20 µg/kg of B₁₂, $n = 15$) or S⁺ (S⁻ × 10, $n = 16$), and 2 treatments to piglets (P) within each half-litter, i.m. injections (150 µg) of B₁₂ (P⁺) at d 1 and 21 (weaning), or sham-injections of saline (P⁻). Within each litter of 12 piglets, 3 P⁺ and 3 P⁻ were studied for growth, and the others for

immunological responses. During lactation, the decrease of PHcy after i.m. B₁₂ was more pronounced in S⁻ than S⁺ piglets (S × P, $P < 0.02$), values were 32% lower in S⁻P⁺ (16.7 ± 0.7 µM) than S⁻P⁻ piglets (24.7 ± 0.7 µM) at 21 d of age. At 56 d of age, PHcy were lower ($P < 0.01$) for P⁺ (15.7 ± 0.5 µM) than P⁻ piglets (18.7 ± 0.5 µM). No treatment effect was observed on growth except for a lower postweaning G:F in S⁺P⁻ piglets than in others (S × P, $P = 0.03$). Positive correlations were observed between PHcy and growth ($r > 0.29$, $P < 0.02$). Antibody responses to ovalbumin were not affected by treatments. Proliferation of lymphocytes in response to the mitogen concanavalin A tended to be lower in culture media with sera from S⁻ piglets than S⁺ ($P < 0.08$) and P⁻ piglets than P⁺ ($P < 0.10$), and this response was more marked ($P = 0.04$) with high PHcy (> 21 µM) as compared with medium (17 to 21 µM) or low (< 17 µM). In conclusion, vitamin supplementations to sows and piglets induced large variations of PHcy in piglets. Although apparently not harmful for growth performance, the detrimental effects of S⁻ and P⁻ treatments or high PHcy on some indicators of cell mediated immunity suggest that these young animals are immunologically more fragile.

Key Words: homocysteine, growth and immunity, piglets

439 Leucine supplementation of a restricted protein diet improves lean growth in neonatal pigs.

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Early weaning of neonatal pigs frequently results in a reduction in food intake due to stress, environmental changes, and a shift from liquid to solid diet. In humans, many low birth weight infants also experience growth failure due to feeding intolerance, resulting in reduced nutrient intake. The branched-chain AA, leucine, has been shown to have anabolic effects on skeletal muscle. The objective of the study was to determine if prolonged enteral leucine supplementation improves lean growth in neonatal pigs fed a restricted protein diet. Five-day-old pigs ($N = 46$; 1.8 ± 0.3 kg initial BW) were fed by gastric catheter either a normal protein (NP; 22.5% protein, 2.4% leucine) or restricted protein (RP; 11.2% protein, 1.2% leucine) milk replacement diet or RP supplemented with leucine to the same level as in the NP diet (RPL). Pigs were fed 40 mL/kg BW per meal every 4 h for 21 d. Body composition was determined by dual-energy X-ray absorptiometry on d 0 and 20. Data were analyzed using the PROC MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). Feeding the NP diet resulted in greater total body weight (5.2 vs. 4.5 ± 0.20

kg) after 21 d and change in lean body mass (3.0 vs. 2.5 ± 0.17 kg) compared with RP-fed pigs ($P < 0.05$). Mass of the longissimus dorsi muscle (68 vs. 53 ± 4.2 g), heart (29 vs. 24 ± 1.2 g), and kidney (27 vs. 20 ± 2.1 g) were also greater in the NP- than RP-fed pigs ($P < 0.05$). Body weight (4.8 kg), lean body mass change (2.6 kg), and mass of the longissimus dorsi (61 g), heart (27 g), and kidney (23 g) in pigs fed the RPL diet were intermediate to the RP- and NP-fed pigs. Prolonged leucine supplementation of a restricted protein diet has the potential to improve overall growth in neonatal pigs and infants with restricted protein intake through an increase in lean tissue growth. *This project was supported by NIH HD072891 and USDA NIFA 2013-67015-20438.*

Key Words: protein, neonatal pig, body composition, lean growth, leucine

0440 Optimal sulfur amino acid to lysine ratio for weaned pigs fed antibiotic-free diets and raised under clean and unclean conditions.

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Unsanitary production conditions can stimulate an immune response leading to increased sulfur amino acids (SAA) maintenance needs and consequently the SAA to Lys ratio, especially under antibiotic-free feeding regimen. Two 14-d experiments were conducted to determine the optimum SAA:Lys ratio in piglets when reared under clean or unclean condition and fed antibiotic-free diets. For each experiment, 90 mixed-sex pigs (Duroc × [Yorkshire × Landrace]; initial average BW of 7.3 ± 0.6 kg) weaned at 21 ± 1 d with 6 replicates of 3 pigs per pen were used. The basal diet was corn-wheat-soybean meal-based (1.18% SID Lys; 51% SID SAA:Lys). Diets 2 to 5 were the basal supplemented with 4 graded levels of DL-Met (55, 60, 64, and 68% SID SAA:Lys). Piglets were allowed free access to feed and water. In Exp. 1, piglets were raised in a clean room that was previously disinfected and washed weekly, whereas in Exp. 2, piglets were introduced into a room previously occupied by other pigs and was not disinfected. In addition, manure slurry from a sow herd was spread (5 kg per pen) on d 0 and 7 of the study and the room was not cleaned throughout the study. Blood was collected on d 0 and 14 for measurement of plasma urea nitrogen (PUN). On d 14, one pig per pen was slaughtered to collect jejunal tissue for measurement of villus height (VH), crypt depth (CD), and VH:CD. In both experiments, quadratic broken-line model was used to estimate optimum SAA:Lys ratio. The highest average daily gain was at SAA:Lys ratio of 60% (279 g) in Exp. 1 and 64% (305 g) in Exp. 2. Increasing SAA:Lys ratio linearly and quadratically increased ($P < 0.05$) VH and VH:CD in Exp. 1 and 2. In Exp. 2, increasing SAA:Lys ratio linearly reduced ($P < 0.05$) by 18% average daily feed intake and linearly and quadratically decreased PUN. Based on performance parameters, the opti-

imum SAA:Lys ratio was 62 and 61% for piglets raised under clean and unclean conditions, respectively. However, VH and VH:CD estimates were 60 and 64% SAA:Lys ratio under clean and unclean conditions, respectively. Hence, SAA:Lys ratio for gut health was higher under unclean conditions.

Key Words: pigs, sanitation, sulfur amino acids

0441 Energy concentration and amino acid digestibility in two sources of canola meal fed to growing pigs.

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Two experiments were conducted to determine DE and ME and standardized ileal digestibility (SID) of CP and AA by growing pigs in a novel canola meal (CM-HP) produced from high protein canola seeds and to compare these values with DE, ME, and SID values determined in conventional canola meal (CM-CV) and soybean meal (SBM). In Exp. 1, 32 growing barrows (initial BW: 47.25 ± 6.23 kg) were individually housed in metabolism cages and randomly assigned to 4 treatments in a randomized complete block design with 8 replicates per treatment. The 4 diets included a corn-based basal diet and 3 diets formulated by mixing corn and each source of canola meal or SBM. Fecal and urine samples were collected for 5 d following a 5-d adaptation period. The DE and ME in CM-HP, CM-CV, and SBM were calculated using the difference procedure. Concentrations of DE and ME in CM-HP and CM-CV were less ($P < 0.05$) than in corn and SBM (DE: 3419 and 3104 vs. 4012 and 4305 kcal/kg DM, respectively; ME: 2842 and 2720 vs. 3854 and 3894 kcal/kg DM, respectively). No differences in concentrations of DE and ME were observed between CM-HP and CM-CV. In Exp. 2, 8 growing barrows (initial BW: 46.4 ± 5.6 kg) had a T-cannula installed in the distal ileum and randomly allotted to a replicated 4 × 4 Latin square design, with 4 diets and four 7-d periods in each square. Three diets that contained CM-HP, CM-CV, or SBM as the sole source of CP and AA were formulated, and a N-free diet was also used. Ileal digesta were collected on d 6 and 7 of each period. The SID of CP and most AA in CM-HP and CM-CV were less ($P < 0.05$) than in SBM. The SID of CP in CM-HP was greater ($P < 0.05$) than in CM-CV. However, no differences were observed in SID of any AA between CM-HP and CM-CV. The concentration of standardized ileal digestible CP and almost all AA was greater ($P < 0.05$) in SBM than in CM-HP and CM-CV, and CM-HP contained more ($P < 0.05$) standardized ileal digestible CP and AA than CM-CV. In conclusion, increased concentration of CP in canola meal does not compromise the DE and ME and the AID or SID of AA. The novel CM-HP supplies more digestible AA than CM-CV.

Key Words: amino acid digestibility, canola meal, energy concentration

0442 Amino acid digestibility in processed soybean products and rapeseed products fed to weanling pigs. D. M. D. L. Navarro*¹, Y. Liu¹, T. S. Bruun², and H. H. Stein¹, ¹University of Illinois at Urbana-Champaign, Urbana, ²Danish Pig Research Centre, Copenhagen, Denmark.

An experiment was conducted to determine the standardized ileal digestibility (SID) of CP and AA in 4 sources of processed soybean meal, in conventional soybean meal (SBM-CV), in rapeseed expellers (RSE), and in a fermented co-product mixture (FCM) that contained rapeseed meal, wheat, soy molasses, and potato peel. The 4 processed soybean products included 2 sources of enzyme-treated soybean meal (ESBM-1 and ESBM-2), extruded soybean meal (SBM-EX), and soy protein concentrate (SPC). A N-free diet and 7 corn-starch-based diets that contained each of the 7 protein sources as the sole source of CP and AA were prepared. Twenty-seven ileal-cannulated weanling barrows (initial BW: 9.29 ± 0.58 kg) were allotted to three 9 × 5 Youden squares with 9 pigs and 5 periods in each square. In each square, 7 pigs were each fed 1 of the 7 AA-containing diets and 2 pigs were fed the N-free diet. Results indicated that the SID of CP was greater ($P < 0.05$) in ESBM-1 than in SPC, RSE, and FCM. The SID of Arg, His, Ile, Leu, Met, and Phe were greater ($P < 0.05$) in ESBM-1 than in SPC, and the SID of Lys was greater ($P < 0.05$) in SBM-CV than in ESBM-2. The SID of Thr, Trp, Val and total indispensable AA were not different among the soybean products. The SID of most AA in RSE and the SID of all AA in FCM were less ($P < 0.05$) than in all soybean products, but the SID of all AA in RSE was greater ($P < 0.05$) than in FCM. Results of this experiment indicate that, although processing of soybean meal results in increased concentration of CP, processing may also reduce the digestibility of some AA, which is likely due to heat damage during processing. There are, however, differences among processed soy products, with some products having greater SID of AA than others. Results also indicate that fermentation of a mixture of rapeseed meal, wheat, and relatively low quality co-products does not result in SID values that are similar to those of unfermented rapeseed expellers or soybean products.

Key Words: amino acid digestibility, soybean products, rapeseed products

0443 Standardized ileal crude protein and amino acid digestibility of eight wheat genotypes fed to growing pigs. P. Rosenfelder*¹, H. K. Spindler¹, K. E. B. Knudsen², H. Jørgensen², N. Sauer^{1,3}, J. K. Htoo⁴, M. Eklund¹, and R. Mosenthin¹, ¹University of Hohenheim, Institute of Animal Nutrition, Stuttgart, Germany, ²Aarhus University, Department of Animal Science, Tjele, Denmark, ³Landwirtschaftliche Untersuchungs- und Forschungsanstalt Speyer, Speyer, Germany, ⁴Evonik Industries AG, Hanau-Wolfgang, Germany.

The objective of this study was to determine in growing pigs the standardized ileal digestibility (SID) of CP and AA of 8 currently available wheat genotypes grown in Southern Germany under standardized field test conditions. The assay diets were formulated to contain 1 of the 8 wheat genotypes each, with wheat as the sole dietary source of CP and AA. All diets were supplemented with 0.7% titanium oxide as an indigestible marker. Nine ileal cannulated barrows (32 ± 2 kg BW) were fed 8 diets in 8 periods of 6 d each at a daily intake level of 40 g/kg of their average BW, corresponding to about 3 times the animals' energy requirement for maintenance (106 kcal of ME/kg of BW^{0.75}). The SID of the 8 wheat genotypes was calculated using literature data for correction of basal ileal endogenous losses of CP and AA. Data were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC) with genotype and pig as fixed effects, and periods and pigs as random effects. Effects of chemical composition of the wheat genotypes on SID of CP and AA in the wheat genotypes were analyzed by linear regression analyses. Among proximate nutrients, only small differences in DM, crude ash, and ether extract content were observed between the 8 different wheat genotypes. On as-fed basis, concentrations of CP and starch ranged from 10.9 to 13.3 and 61.5 to 64.4% in the 8 wheat genotypes, respectively. The greatest concentrations of NDF and ADF were 11.6 and 3.3% (as-fed), respectively, whereas ADL concentration did not exceed 0.7% (as-fed) in the 8 wheat genotypes. Among the 8 wheat genotypes, SID of CP, Lys, Met, Thr, and Trp ranged from 83 to 87% ($P = 0.010$), 69 to 74 ($P = 0.037$), 84 to 88 ($P = 0.010$), 78 to 82 ($P = 0.053$), and 80 to 85% ($P = 0.005$), respectively. Fiber fractions and CP contents in the 8 wheat genotypes had minor effects on SID of CP, Lys, Met, Thr, and Trp. Moreover, SID of CP, Lys, Met, Thr, and Trp of this study were up to 5, 15, 6, 8, and 8% lower when compared with current feed tables. Due to the observed variations in SID of CP and AA between wheat genotypes in the present study, differences in SID between different batches of wheat should be taken into account for pig diet formulations.

Key Words: digestibility, pig, wheat

0444 Standardized ileal amino acid digestibility in eight genotypes of rye fed to growing pigs.

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A study was conducted to determine in growing pigs the standardized ileal digestibility (SID) of CP and AA in 8 currently available genotypes of rye. The rye genotypes were grown under the same standardized field conditions at the University of Hohenheim, Germany. The experiment was conducted with 8 barrows with an initial BW of 24 ± 2 kg, and 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 rye genotypes each, with rye as the sole source of CP and AA. An N-free diet was fed to determine basal ileal endogenous losses of CP and AA in an additional period at the conclusion of the experiment. Diets were supplemented with titanium dioxide as digestible marker and fed at a daily intake level of 40 g/kg 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 4 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 (SAS Inst. Inc., Cary, NC) with genotype and pig as fixed effects, and pigs and periods as random effects. The CP and nonstarch polysaccharides (NSP) concentrations (as-fed) in the 8 rye genotypes ranged from 9.5 to 11.2%, and 10.7 to 12.9%, respectively. The greatest concentrations of NDF, ADF, and ADL were 15.1, 3.0, and 0.9% (as-fed) in the 8 rye genotypes. Among the 8 rye genotypes, SID of CP, Lys, Met, Thr, and Trp ranged from 70 to 74, 60 to 65, 74 to 78, 62 to 66, and 63 to 67%, respectively. The SID of CP and AA did not differ between the 8 rye genotypes, except for SID of Cys ($P = 0.044$). The SID of CP and AA were not affected by NSP and NDF content. Overall, SID of CP, Lys, Met, Thr, and Trp in rye derived from the present study were up to 13, 14, 7, 12, and 13%-units lower than the values reported in current feed tables. Using these SID values will aid for accurate AA balancing when these new rye genotypes are used in pig diet formulations.

Key Words: amino acid digestibility, growing pigs, rye

0445 Digestible phosphorus requirement of twenty-kilogram pigs—A cooperative study.

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A 28-d cooperative study involving 10 experiment stations was conducted to determine the standardized total-tract digestible (STTD) P requirement of 20-kg pigs using broken-line regression analysis. Six concentrations of STTD P were fed to 1032 pigs with an average initial BW of 19 kg in 240 pens (120 each of barrows and gilts). Monocalcium phosphate was added to a corn-soybean meal-based diet at the expense of cornstarch to establish the 6 concentrations of STTD P, ranging from 1.54 to 5.15 g/kg of diet, in increments of 0.62 g/kg. Limestone was added to maintain a constant Ca:total P at 1.5:1.0 among all diets. Average daily gain, ADFI, and G:F increased ($P < 0.05$) with increasing STTD P concentration for d 0 to 14, 14 to 28, and 0 to 28. From d 0 to 28, ADG and G:F increased ($P < 0.01$) from 639 to 809 g and 492 to 561 g/kg, respectively, as STTD P increased from 1.54 to 5.15 g/kg of diet. Barrows gained and ate more ($P < 0.05$) than gilts during d 14 to 28 and d 0 to 28. There was no interaction between gender and STTD P concentration for any of the growth performance response criteria. Metacarpal bone ash, Ca, and P increased ($P < 0.01$) from 45.6 to 52.6%, 17.6 to 19.9%, and 8.0 to 9.6%, respectively, with increasing STTD P concentration. Furthermore, Ca and P in metacarpal ash, as well as metacarpal and femur mineral density and content increased ($P < 0.01$) with increasing STTD P concentration. The STTD P requirement determined by broken-line regression using ADG as a response variable was estimated to be 4.21, 3.45, and 3.87 g/kg of diet for pigs from d 0 to 14 (19 to 28 kg BW), d 14 to 28 (28 to 40 kg BW), and d 0 to 28 (19 to 40 kg BW), respectively. Using G:F, the corresponding estimates of STTD P requirement were 4.34, 3.71, and 4.06 g/kg of diet. The STTD P requirement (g/kg of diet) using mineralization response for metacarpus and femur ranged from 3.50 for P in metacarpal ash to 4.28 for femur mineral density. Using an average of the estimates derived from ADG and G:F,

the mean STTD P requirement of pigs from 20 to 40 kg was determined to be 3.97 g/kg of diet.

Key Words: phosphorus, pigs, standardized total tract digestible, requirement

0446 The flow of inositol phosphate esters and phytate phosphorus in the proximal and distal parts of the digestive tract of broilers receiving diets adequate in available phosphorus and supplemented with high levels of phytase. L. A. Beeson*¹, C. L. Walk², and O. Olukosi¹, ¹SRUC, Ayr, UK, ²AB Vista Feed Ingredients, Marlborough, UK.

The aim of this study was to characterize the flow of inositol phosphate (iP) esters and disappearance of phytate phosphorus (PP) in the gizzard and ileum of broilers receiving diets adequate in available phosphorus (aP) and supplemented with high levels of phytase. One-hundred-and-sixty-eight Ross 308 broilers at 1 d of age were allocated to 3 treatments (0, 1500, and 3000 FTU/kg phytase) in a randomized complete block design, where the pen was the experimental unit (6 birds per pen). Feed and water were provided ad libitum, and digesta from the gizzard and ileum were collected on d 21 and analysed for iPs and PP relative to TiO₂, the indigestible marker used. In the gizzard, iP6 and iP5 levels were lower ($P < 0.01$) and inositol higher ($P < 0.01$) in the diet supplemented with 1500 or 3000 FTU/kg phytase com-

pared with the control. In the ileum, supplementation with 1500 or 3000 FTU/kg reduced levels of iP6 (3115, 3552, nmol, for 1500, 3000 FTU/kg respectively, $P < 0.01$) and increased that of iP4 and inositol (3115, 3552, nmol for 1500, 3000 FTU/kg, respectively, $P < 0.05$) compared with broilers fed the control diet (482 iP6, 1650 inositol), except for iP5 which was greater ($P < 0.01$) in control and with 1500 FTU/kg phytase compared with 3000 FTU/kg. There were no phytase effects on IP3 flow. In the gizzard, PP disappearance was greater ($P < 0.01$) in diets supplemented with 1500 or 3000 FTU/kg compared with control diet. No differences were seen in ileal PP disappearance between the control and diet supplemented with 1500 FTU/kg, or between supplementation of 1500 and 3000 FTU/kg; however, PP disappearance was greater in ($P < 0.01$) diets with 3000 FTU/kg than control. Total tract PP disappearance was greater ($P < 0.05$) in diets supplemented with 1500 or 3000 FTU/kg (74.5, 85.5%, respectively) than in the control diet (60.3%). The results show that the phytase rapidly hydrolysed iP6 and iP5 in the gizzard, leading to an accumulation of inositol, and the hydrolysis continued in the distal gut. It is concluded that the phytase was effective in rapidly hydrolysing phytate, releasing free inositol even in the gizzard and that higher phytase doses may lead to further phytate phosphorus hydrolysis in the ileum.

Key Words: phytase, inositol phosphate esters, phytate phosphorus