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

Key Words: lysine, NRC, precision nutrition, swine

110 **The tryptophan:lysine requirement of grow-finish pigs.** L. Greiner[1,*], A. Graham[1], K. J. Touchette[2], *[1]Carthage Innovative Swine Solutions, LLC, Carthage, IL, [2]Ajinomoto Heartland, Inc., Chicago, IL.*

Twelve-hundred grow-finish pigs (PIC 337 × 1050) were evaluated to determine the optimum Trp:Lys ratio for gain and feed conversion. The study was conducted in 3 phases: 23 to 41 kg, 55 to 77 kg, and 98 to 114 kg. Pigs were blocked by gender and weight starting at 23 kg and randomly assigned within block to 1 of 6 treatments (14, 16, 18, 20, 22, and 24 standardized ileal digestible [SID] Trp:Lys ratio) with 13 pens per treatment. Blocks either had 24 or 25 pigs per pen. Pigs were returned to a common diet that maintained a Trp:Lys ratio of 18 between each trial phase. The first phase diet consisted of corn/soybean meal/dried distiller's grains with solubles and was formulated to 2549 kcal/kg NE. The other 2 phases consisted of corn/soybean meal and were formulated to 2666 and 2692 kcal/kg NE respectively. In all phases, soybean meal and fat was held constant and feed-grade Trp was added to alter the Trp:Lys ratio. The SID Lys content was formulated 0.05% lower than the expected requirement for the heaviest weight of each phase across the study, and all other nutrients met or exceeded the NRC requirements. Data were analyzed using Proc Mixed with linear (L) and quadratic (Q) contrasts. Data were reported as LSMEANS. Broken line linear (BLL) and broken line quadratic (BLQ) analyses were conducted to determine the SID Trp:Lys requirement for growth parameters. In Phase 1, pig ADG increased (0.76, 0.79, 0.79, 0.82, 0.83, 0.81 kg/d; L $P < 0.01$, Q $P < 0.04$) as the Trp:Lys ratio increased. In addition, there was a linear improvement in feed conversion (0.49, 0.49, 0.50, 0.50, 0.50, 0.50; $P < 0.08$). In Phase 2, pig ADG was not influenced by Trp:Lys ratio (0.96, 0.91, 0.98, 1.01, 0.98, 0.96; $P = 0.31$), while feed conversion was improved linearly (0.38, 0.38, 0.39, 0.39, 0.39; $P < 0.03$). In phase 3, pig ADG increased linearly (0.91, 0.93, 0.99, 1.00, 1.02, 0.97; $P < 0.05$) and feed conversion was improved (0.32, 0.33, 0.34, 0.34, 0.32; $P < 0.05$) quadratically as the Trp:Lys ratio increased. Based on the data, the optimal ratio for ADG in grow-finish pigs is between 18.0 and 21.4. The optimal ratio for feed conversion is less consistent at about 15 for BLL and 19.5 or greater for BLQ.

Table 110.

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

Key Words: grow-finish, pig, tryptophan

NONRUMINANT NUTRITION: MINERALS AND VITAMINS

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

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

Table 111.

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

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

Key Words: survey, swine industry, trace minerals

112 **Quantitative relationships between standardized total tract digestible phosphorus and calcium intake and its retention and excretion in growing pigs fed corn-soybean meal diets.** N. A. Gutierrez[1,*], N. V. L. Serão[1], A. J. Elsbernd[1], S. L. Hansen[1], C. L. Walk[2], M. R. Bedford[2], J. F. Patience[1], [1]*Iowa State University, Ames,* [2]*AB Vista Feed Ingredients, Marlborough, UK.*

An experiment was conducted to determine the quantitative relationships between standardized total tract digestible (STTD) P and Ca intake with their retention and excretion by growing pigs fed corn-soybean meal diets. Forty-eight barrows (BW = 22.7 ± 0.2 kg) were allotted to 1 of 8 diets, housed individually in pens for 3 wk, then moved to metabolism crates and allowed 4 d adaptation and 5 d for collection of urine and fecal samples. Eight corn-soybean meal diets were formulated for similar NE, fat, and AA concentrations, but with increasing STTD P from 0.16 to 0.62% using monocalcium phosphate. The Ca:STTD P ratios were maintained constant among treatments. The STTD P intake increased ($P < 0.001$) from 64 to 242% of the daily requirement (4.59 g/d of STTD P). Basal urinary P excretion of 0.03 g P/d was observed up to 4.96 g of STTD P intake/d, after which the urinary P excretion increased ($P < 0.001$). Excretion of Ca in urine decreased ($P < 0.001$) with intake, reaching a basal urinary excretion of 0.40 g/d at 17.97 g/d of Ca intake. The daily intake of STTD P and Ca moderately explained the variation in urinary excretion of P ($R^2 = 0.41$) and Ca ($R^2 = 0.64$). The absorption and retention of P increased linearly ($P < 0.001$) with dietary P intake, whereas absorption and retention of Ca increased quadratically ($P < 0.001$). Absorption and retention of P and Ca were highly predictable from the STTD P and Ca intake, with R^2 of 0.87 and 0.90, respectively. The femur mineral content (FMC, g) increased by 2.71 g of FMC per g/d of STTD P intake, but reached a plateau (29.54 g) at 8.84 g/d of STTD P intake. The FMC was highly predictable from the STTD P intake ($R^2 = 0.89$). The FMC affected the urinary P excretion ($P < 0.01$), but moderately explained ($R^2 = 0.19$) the variation in urinary P. In conclusion, constant excretion of P in urine was observed, but increased linearly at STTD P intake levels above the requirement for maximum growth. The FMC increased with STTD P intake, but reached a plateau at a greater STTD P intake level than the requirement for maximum growth. Dietary STTD P was therefore absorbed and used for growth, but excess P was accumulated in bones, until a plateau was reached, and excreted in urine. The predictability of P and Ca excretion in urine from the dietary STTD P and Ca intake was moderate.

Key Words: phosphorus, calcium, urine

113 **Digestible calcium requirements and calcium and phosphorus balance for weanling pigs.** J. C. González-Vega[1,*], C. L. Walk[2], H. H. Stein[1], [1]*University of Illinois, Urbana,* [2]*AB Vista Feed Ingredients, Marlborough, UK.*

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