

Nonruminant Nutrition: Amino acids and minerals

302 Long-term leucine and branched-chain amino acid supplementation in a protein and energy deficient diet increases muscle mTORC1 activation in neonatal pigs. Rodrigo Manjarín*, Daniel A. Columbus, Agus Suryawan, Hanh V. Nguyen, Adriana Hernández-García, Rosemarie D. Parada, Marta L. Forotto, and Teresa Davis, *USDA-ARS, Children's Nutrition Research Center, Houston, TX.*

Suboptimal nutrient intake represents a limiting factor for growth and long-term survival of low-birth weight infants and runt pigs. The objective of this study was to determine if enteral leucine or branched chain amino acid (BCAA) supplementation will upregulate the mammalian target of rapamycin complex 1 (mTORC1) pathway in skeletal muscle and lead to an increase in protein synthesis in neonates who consume only 70% of their protein and energy requirements. Twenty-two 4-d-old piglets were fed by gastric tube 1 of 4 diets, containing (kg body weight⁻¹·d⁻¹) 15 g protein and 215 kcal (CON; n = 5), 10.5 g protein and 156 kcal (R; n = 5), 10.5 g protein + 1.19 g leucine and 156 kcal (RL; n = 6), or 10.5 g protein + 1.67 g BCAA (n = 6) at 4-h intervals for 21 d. On d 21, plasma AA and insulin levels were measured during 6 post-feeding intervals, whereas muscle protein synthesis rate and mTORC1 activation were determined at 120 min post-feeding. Data were analyzed by ANOVA using a linear mixed model with repeated measures. *P*-values for pre-planned pairwise comparisons were calculated using Student's *t*-tests. Compared with CON, the RL and BCAA diets increased plasma leucine levels (*P* ≤ 0.01), whereas RL decreased isoleucine and valine (*P* ≤ 0.01) between 0 and 120 min post-feeding. At 120 min insulin was higher in CON compared with R (*P* ≤ 0.01). Compared with CON, BCAA, RL and R decreased (*P* < 0.01) body weight gain (3.5, 2.9, 3.0 and 2.9 ± 0.01 kg, respectively), protein synthesis (19.3, 14.2, 15.2 and 14.6 ± 1.3%·d⁻¹), phosphorylation of S6 kinase (p-S6K1; 0.6, 0.4, 0.4 and 0.2 ± 0.01 AU) and 4E-binding protein (p-4EBP1; 0.4, 0.2, 0.2 and 0.1 ± 0.03 AU), and activation of eukaryotic initiation factor 4 complex (eIF4E·eIF4G; 1.5, 1.1, 1.1, and 0.4 ± 0.02 AU). BCAA and RL increased (*P* ≤ 0.01) p-S6K1, p-4EBP1 and eIF4E·eIF4G compared with R. In conclusion, when protein and energy intakes are restricted, leucine or BCAA supplementation increases muscle mTORC1 activation but does not improve body weight gain or skeletal muscle protein synthesis in neonatal pigs.

Key Words: leucine, neonate, muscle

303 Effect of fermentation on ileal digestibility of nutrients and amino acids in soybean meal with low solubility in growing pigs. S. D. Upadhyaya¹, J. H. Ryu², K. I. Kang², S. J. Cho², and I. H. Kim¹, ¹*Department of Animal Resource & Science, Dankook University, Cheonan, Chungnam, South Korea,* ²*CJ Food Ingredients R&D Center, Seoul, South Korea.*

Fermentation of soybean meal with microbes has been reported to increase digestibility of nutrients. The objective of this study was to evaluate the effects of fermentation on digestibility of soybean meal with protein solubility below optimal range. Apparent ileal digestibility (AID) and standardized ileal digestibility (SID) of GE, DM, N and amino acids were evaluated in 5 cannulated [(Landrace × Yorkshire) × Duroc] barrows with an average initial BW of 27.05 kg. The pigs were used in a 5 × 5 Latin square design with treatments of soybean meal (SBM) with protein solubility of 84% and fermented soybean meal (FSM) with protein solubility of 52%, 62% and 72% and designated as

FSMA, FSMB and FSMC, respectively. A purified diet without protein was used to determine basal endogenous losses of CP and amino acids. Data were analyzed using the Mixed procedure of SAS with pig as the experimental unit for all analyses. Tukey's test was used to determine significant differences among treatments. The AID of DM and N was greater (*P* < 0.05) in FMSC (75.9% and 73.7%) and tended to improve in FSMA (74.4% and 71.3%) and FSMB (73.7% and 71.8%) compared with SBM (71.1% and 69.1%). The AID of Ile, Phe and Val was greater in all fermented soybean meal whereas that of Lys was greater (*P* < 0.05) in FSMC (76.19%) compared with SBM (69.05%). Likewise, the AID of Asp and Pro was greater (*P* < 0.05) in FSMA and FSMC than SBM. The SID of CP and Lys was higher (*P* < 0.05) in FSMC (85.03% and 83.86%) and tended to improve in FSMA (82.4% and 81.08%) and FSMB (83.11% and 82.23%) compared with SBM (80.68% and 77.72%) whereas the SID of Ile was higher (*P* < 0.05) in FSMA (87.47%), FSMB (84.86%) and FSMC (86.75%) compared with SBM (80.29%). In conclusion, fermentation of soybean meal showed better digestibility compared with SBM regardless of its protein solubility values.

Key Words: amino acid, ileal digestibility, fermented soybean meal

304 Requirement of valine and optimal valine:lysine ratio in diets for 8- to 18-kg pigs. John K. Htoo^{*1} and Georg Dusel², ¹*Evonik Industries AG, Hanau-Wolfgang, Germany,* ²*University of Applied Sciences Bingen, Bingen am Rhein, Germany.*

A 28-d experiment was conducted to estimate the optimal SID Val:Lys in diets for starter pigs. A total of 192 weaned pigs (Topigs; initial BW of 8.5 ± 0.12 kg) were randomly assigned to 8 dietary treatments with 6 pen replicates (2 barrows and 2 gilts/pen) per treatment. A corn-wheat-soybean meal-based basal diet was formulated using analyzed ingredient AA contents and published SID coefficients to meet requirements of AA other than Val and Lys. Valine was first limiting (0.69% SID Val) and Lys was second limiting (1.15% SID Lys). Graded levels of L-Val were added to the basal diet to obtain 5 SID Val:Lys ratios (60, 64, 68, 72 and 76%). In addition, diets 6, 7 and 8 were produced to be adequate in SID Lys (1.34%) but varied in SID Val (0.86, 0.91 and 0.97%). All diets contained 2,474 kcal/kg NE. Based on analyzed AA contents, the corrected SID Val:Lys ratios in diets 1 to 5 were 63, 66, 72, 76 and 78%, and corrected SID Val contents in diets 6 to 8 were 0.86, 0.94 and 1.01%, respectively. Data were analyzed by ANOVA using the GLM procedure of SAS. Orthogonal-polynomial contrasts were used to determine linear and quadratic effects of SID Val:Lys ratios (diets 1–5) on response criteria. Increasing dietary SID Val:Lys from 63 to 78% (Diet 1 to 5) increased (*P* = 0.046) the final BW quadratically, and tended to increase (*P* = 0.075) the ADG (d 0–28) quadratically. The greatest final BW (16.47 vs. 15.55 kg) and ADG (284 vs. 258 g/d) in comparison to the basal diet were achieved at a SID Val:Lys ratio of 66%. The FCR (d 0–28) tended to improve (*P* = 0.078; quadratic) and the best FCR (1.377 vs. 1.545) in comparison to the basal diet was achieved at a SID Val:Lys ratio of 72%. Feed intake was not affected by dietary treatments. A 2-slope broken-line regression estimated the SID Val:Lys ratio of 67% to optimize both the ADG and FCR. When containing adequate Lys (diets 6 to 8), increasing the SID Val from 0.86 to 0.94% (SID Val:Lys from 66 to 71%) improved FCR (*P* = 0.011) but did not affect ADG (*P* = 0.148). Based on these results an optimal SID Val:Lys ratio of at least 67% is recommended in diets for 8 to 18 kg pigs.

Key Words: lysine, pig, valine

305 Effects of dietary fiber on the optimum threonine:lysine ratio for 25- to 50-kg gilts. John K. Mathai¹, John K. Htoo², John Thomson³, Kevin J. Touchette⁴, and Hans H. Stein¹, ¹University of Illinois, Urbana, IL, ²Evonik Industries AG, Hanau-Wolfgang, Hesse, Germany, ³Evonik Degussa Corporation, Kennesaw, GA, ⁴Ajinomoto Heartland Inc., Chicago, IL.

Two experiments were conducted to determine the effect of dietary fiber on the ideal Thr:Lys ratio for 25 to 50 kg gilts. In Exp. 1, 192 gilts (26.3 ± 4.64 kg) were used with 2 pigs/pen and 8 pens/trt. A 2 × 6 factorial arrangement was used to determine the effect of dietary fiber (low and high) and standardized ileal digestible (SID) Thr:Lys ratios 45, 54, 63, 72, 81, and 90:100. At both fiber levels, ADG and G:F increased quadratically ($P < 0.05$), as the concentration of Thr increased in the diets. For pigs fed low-fiber diets, broken-line analyses estimated the optimum SID Thr:Lys ratio for ADG and G:F, respectively, as 0.60 and 0.59, quadratic analyses as 0.76 and 0.73, and combined linear-quadratic analyses as 0.66 and 0.63. For pigs fed high fiber diets, broken-line analyses estimated the optimum SID Thr:Lys ratio for ADG and G:F, respectively, as 0.66 and 0.55, quadratic analyses as 0.80 and 0.75, and combined linear-quadratic analyses as 0.71 and 0.63. In Exp. 2, pigs were fed either low-fiber or high-fiber diets that were very deficient (0.45 SID Thr:Lys) or marginally deficient (0.60 SID Thr:Lys) in Thr. Thirty-six gilts (29.0 ± 0.74 kg) were housed in metabolism crates with 9 replicate pigs per diet. Output of N in feces was greater ($P < 0.05$) from pigs fed high-fiber diets, whereas output of N in urine was greater ($P < 0.05$) from pigs fed low-fiber diets. The ATTD of N and retention of N were greater ($P < 0.05$) in pigs fed low-fiber diets. There was a lower ($P < 0.05$) N output in urine and a greater ($P < 0.05$) N retention in pigs fed high-Thr diets with 0.60 SID Thr:Lys compared with pigs fed low-Thr diets containing 0.45 SID Thr:Lys. There was also an interaction ($P < 0.05$) between fiber level and Thr for output of N in feces with N output increasing ($P < 0.05$) as Thr in the high-fiber diet increased. Results of these experiments indicate that increased fiber levels in diets fed to growing gilts increase the requirement for Thr, and diets with higher fiber levels should, therefore, include a greater concentration of Thr.

Key Words: pig, fiber, threonine

306 Evaluation of L-methionine bioavailability in piglet diets. Helvio C. Ferreira Júnior¹, Melissa I. Hannas¹, Luiz F. T. Albino¹, Horácio S. Rostagno¹, Lyssa Otani², and Lília T. Lopes¹, ¹Federal University of Viçosa, Viçosa, Minas Gerais, Brazil, ²CJ of Brazil Ltda, São Paulo, São Paulo, Brazil.

The objective of this trial was to evaluate the bioavailability of L-Met considering DL-Met as the standard source (100% availability) based on average daily gain (ADG) and feed conversion (FC) of piglets. A total of 135 barrows (14.77 ± 1.46 kg) 24 d old were distributed in a completely randomized block design into 5 treatments with 9 replicates and 3 animals per pen. The treatments were a basal diet (BD) formulated to meet or exceed the nutritional recommendations of all nutrients (except for methionine), BD + 0.041% DL-Met; BD + 0.082% DL-Met; BD + 0.041% L-Met and BD + 0.082% L-Met. The calculated content of Met and Met+Cys in basal diet were 0.206% and 0.441% respectively. The experimental period lasted 28 d and individual pig body weight and feed intake were recorded to calculate performance: ADG, average daily feed intake (ADFI) and FC. Multiple regression model was obtained from linear regression analysis using SAS PROC MIXED procedure at probability level of $P < 0.05$ was regarded as statistically significant. The regression coefficient ratios were utilized to determine bioavailability of L-Met considering that both equations had the same intercept. A linear

increase was observed in ADG ($P < 0.05$) with the supplementation of both DL-Met and L-Met. DL-Met supplementation levels increased ADFI linearly ($P < 0.05$). However there was a linear decrease ($P < 0.05$) in ADFI with supplemental sources of L-Met. The L-Met bioavailabilities estimated by ADG and FC were 105.48 and 130.94%, respectively.

Table 1 (Abstr. 306). Performance and bioavailability (BV) of L-Met for piglets from 15 to 30 kg¹

Item	DL-Met			P-value	L-Met			s
	BD	0.041%	0.082%		0.041%	0.082%	P-value	
ADG, g	581	648	714	0.001	664	715	0.001	0.246
ADFI, g	1121	1275	1368	0.003	1320	1312	0.052	0.487
FC, g/g	2.085	1.975	1.916	0.001	1.990	1.839	0.001	0.427
L-Met BV	Intercept	b ^D	b ^L	Bioavailability				
ADG	0.584	1.581	1.668	105.48				
FC	2.086	-2.196	-2.876	130.94				

¹Linear regression analysis; b^D = DL-methionine regression coefficients; b^L = L-Met regression coefficients

Key Words: L-isomer amino acid, swine, L-methionine

307 Oral tryptophan supplementation to nursing piglets increases serotonin synthesis and improves performance after weaning under social mixing stress. T. J. Pasquetti^{1,2}, I. Park¹, J. Y. Guo¹, P. C. Pozza², and S. W. Kim¹, ¹Department of Animal Science, North Carolina State University, Raleigh, NC, ²Departamento de Zootecnia, Universidade Estadual de Maringá, Bolsista do Ciências sem Fronteiras / CNPQ, Maringá, PR, Brazil.

This study was to evaluate the effect of oral Trp supplementation to nursing piglets on serotonin (5-HT) metabolism, growth performance, and behavior during nursing (from 14 to 21 d of age) and nursery (from 21 to 56 d of age) periods under social mixing stress at weaning (from 21 to 22 d of age). Eighty piglets from 10 sows (4 males and 4 females per litter) at 14 d of age were randomly allotted to 2 treatments based on sex. Treatments (Trp, 0.46 g/kg BW/d; or Ala + glucose, 0.38 + 0.42 g/kg BW/d, respectively) were orally given to piglets during nursing period. At weaning on d 21, 6 piglets from each treatment were euthanized to collect hypothalamus to analyze 5-HT and 5-hydroxyindoleacetic acid (5-HIAA) concentrations. Remaining 68 piglets were weaned and moved to nursery pens. Pigs within a treatment, same sex, but from different litters were paired and housed together (2 pigs/pen, 17 pens/treatment). Normal and aggressive behaviors were recorded from 21 to 22 d of age immediately after weaning and mixing. All pigs were fed the same diet during nursery period. Growth performance was measured during nursing and nursery periods. Data were analyzed using Proc Mixed of SAS with treatment and sex as fixed effects. Oral Trp feeding during nursing period increased ($P \leq 0.05$) hypothalamic concentration of 5-HT and 5-HIAA (2.84 to 5.94 and 59.1 to 104.6 ng/mg of protein, respectively), tended to increase the frequency of visits to the feeders ($P = 0.057, 0.42$ to 0.83%) during mixing period and G:F ratio ($P = 0.094, 0.440$ to 0.514) during the first week of nursery period. Collectively, oral Trp feeding during nursing period increased hypothalamic serotonin affecting eating behavior and potentially enhancing feed efficiency immediately after weaning.

Key Words: mixing stress, pig, tryptophan

308 Concentrations of nitrogen-corrected apparent metabolizable energy and amino acid digestibility in soybean meal from Argentina, Brazil, China, Thailand, and the United States fed to broilers. Kelly M. Sotak-Peper^{*1}, Rommel C. Sulabo², Carl M. Parsons¹, and Hans H. Stein¹, ¹University of Illinois at Urbana-Champaign, Urbana, IL, ²University of the Philippines Los Banos, Los Banos, Luzon, Philippines.

The Philippines import soybean meal (SBM) from many different countries, but the quality of the SBM from the different sources is not known. Therefore, 2 experiments were conducted using SBM from Argentina (ARG 1 and ARG 2), Brazil, China, Thailand, and the U.S (US1, US2, and US3) that was collected at feed mills in the Philippines. The objective was to determine concentrations of nitrogen-corrected apparent metabolizable energy (AMEn) and standardized ileal digestibility (SID) of AA in each source of SBM. In both experiments, ANOVA was used with the PROC MIXED function in SAS. In Exp. 1, 72 d-old male broilers were allotted to 1 of 9 treatments using a completely randomized design with 8 broilers per treatment. Treatments included a corn-SBM based basal diet and 8 diets that were formulated by mixing 70% basal diet and 30% of each SBM source. Broilers were placed in individual metabolism crates equipped with an aluminum tray for total collection of excreta. Excreta were collected for 3 d after a 10 d adaptation period. The AMEn (2,762 kcal/kg) of Chinese SBM was greater ($P < 0.05$) than in ARG 1 (2,699 kcal/kg) and ARG2 (2,737 kcal/kg), but not different from the other sources. No differences in BW gain were observed, but there was reduced ($P < 0.05$) feed intake and improved ($P < 0.05$) G:F for birds fed US1 SBM compared with birds fed Argentinian or US2 SBM. In Exp. 2, 48 cecectomized roosters were allotted to 1 of 8 treatments using a completely randomized design with 6 roosters per treatment. The cecectomized roosters were tube fed 30 g of SBM and excreta were collected for 48 h following feeding. There was a tendency for greater ($P < 0.10$) SID of indispensable AA for US3 SBM than for the other sources of SBM. The SBM from US3 had greater ($P < 0.05$) SID of Lys compared with Brazilian SBM. The SBM from US3 also had greater ($P < 0.05$) SID of dispensable AA and total AA than SBM from China, Thailand, US1 and US2. These studies demonstrated that differences in energy and AA digestibility exist among different SBM sources.

Key Words: amino acid, energy, soybean meal

309 Effect of dietary cation-anion difference during late gestation and lactation on blood and urine parameters of sow. J. Y. Guo^{*1}, D. E. Axe², and S. W. Kim¹, ¹Department of Animal Science, North Carolina State University, Raleigh, NC, ²Granco Minerals, Disputanta, VA.

The experiment was conducted to evaluate the effect of dietary cation-anion difference (DCAD) on pH of blood and urine, mineral concentrations in serum, and hypocalcemia for sows during late gestation and lactation. A total of 22 pre-parturient sows (average parity of 4.5 ± 2.9 and BW of 224.1 ± 38.7 kg) were initially allotted to 2 dietary treatments in a completely randomized design: a control diet with positive DCAD (100 mEq/kg) and a diet with negative DCAD (-100 mEq/kg) with supplemental anionic salt (Cad-mate, Granco Minerals, Disputanta, VA) which were fed from d 93 of gestation to d 18 of lactation. Each sow had a daily access to 2 kg feed during gestation and had ad libitum access to feed during lactation. Feed with positive DCAD was provided during the subsequent parity. The pH of blood and urine were determined at d 93, 108 of gestation, d 1, 9 and 18 of lactation. At d 1 and 18 of lactation, Ca concentration in urine and milk and serum concentrations of Na, K, Mg, Ca, P, and Cl were measured. Data were analyzed using Proc Mixed of SAS with treatment as a fixed effect. Feed intake and

BW loss in current lactation, and litter performance in current as well as subsequent lactations were not affected by changing DCAD. At d 1 of lactation, decreasing DCAD reduced ($P < 0.05$) blood pH (7.83 to 7.72). Urinary pH was reduced ($P < 0.05$) by decreasing DCAD at d 108 of gestation, d 1, 9, and 18 of lactation (6.18 to 5.28; 6.38 to 5.47; 6.47 to 5.10; 6.23 to 5.04). Reducing DCAD increased ($P < 0.05$) Ca concentrations in serum (9.23 to 9.71 mg/dL) and colostrum (66.11 to 79.34 mg/dL) at d 1 of lactation and increased ($P < 0.05$) serum Ca concentration (9.74 to 10.14 mg/dL) at d 18 of lactation. Reducing DCAD tended to increase Mg concentration in serum at d 1 of lactation ($P = 0.097$, 18.73 to 19.84 mg/L) and at d 18 of lactation ($P = 0.087$, 22.11 to 23.97 mg/L). At d 1 of lactation, reducing DCAD increased ($P < 0.05$) Cl concentration in serum (101.8 to 104.7 mEq/L). Collectively, negative DCAD increased Ca mobilization and decreased potential risk of urine tract infection without affecting litter performance.

Key Words: sow, dietary cation-anion difference, Ca

310 Effects of copper sources and levels on growth performance and carcass traits in wean-finishing pigs. Ferdinando N. Almeida^{*1}, Jeffery Escobar¹, Gary Allee², Junmei Zhao¹, Yulin L. Ma¹, and Mercedes Vazquez-Anon¹, ¹Novus International Inc., St Charles, MO, ²Porktech LLC, Columbia, MO.

A study was conducted under commercial conditions to compare the effects of 2 different Cu sources [tri-basic copper chloride ($\text{Cu}_2[\text{OH}]_3\text{Cl}$) or $\text{Cu}(\text{HMTBa})_2$] on growth performance and carcass traits in pigs and to evaluate a step-down feeding strategy when supplementing pigs with $\text{Cu}(\text{HMTBa})_2$. $\text{Cu}(\text{HMTBa})_2$ is a chelated Cu with 2-hydroxy 4-methylthio butanoic acid (HMTBa) at 1:2 ratio (Novus International Inc., St. Charles MO). A total of 2,300 weaned pigs (initial BW = 6.60 ± 0.34 kg, 21 d of age, mixed sex) were randomly allotted to 1 of 4 feeding programs with 23 replications and 25 pig/pen. Treatments included 1) control (16 mg/kg Cu in the premix); 2) ($\text{Cu}_2[\text{OH}]_3\text{Cl}$) at 150 mg/kg (wean-finishing); 3) $\text{Cu}(\text{HMTBa})_2$ at 150, 80, and 60 mg/kg (Nursery-Phase-I, Nursery-Phases-II-III, and grow-finishing phases, respectively) and 4) $\text{Cu}(\text{HMTBa})_2$ at 150 mg/kg in Nursery-Phase-I and 80 mg/kg from Nursery-Phase-II to finishing phase. Copper levels were chosen based on current industry practices. Data were analyzed using the Mixed Procedure of SAS. The model included treatment as fixed effect and replication as random effect. From d 7 to 21 post-weaning, the ADG and GF was greater ($P = 0.03$) for pigs fed $\text{Cu}(\text{HMTBa})_2$ than that of the control pigs. Pigs fed ($\text{Cu}_2[\text{OH}]_3\text{Cl}$) were intermediate. From d 0-42, ADG tended ($P = 0.11$) to be greater for pigs fed $\text{Cu}(\text{HMTBa})_2$ than control pigs. In the grow-finishing phase (d 42-153), by d 111, the BW of pigs fed $\text{Cu}(\text{HMTBa})_2$ at 80 mg/kg was heavier ($P < 0.05$) than control pigs and pigs fed ($\text{Cu}_2[\text{OH}]_3\text{Cl}$) or $\text{Cu}(\text{HMTBa})_2$ at 60 mg/kg were intermediate. Overall (d 42-153) the GF was greater ($P < 0.05$) for both (60 and 80 mg/kg) $\text{Cu}(\text{HMTBa})_2$ treatments compared with control (0.377 and 0.378 vs. 0.370, respectively). Pigs fed ($\text{Cu}_2[\text{OH}]_3\text{Cl}$) were intermediate. On average, the hot carcass weight (HCW) of pigs fed both levels of $\text{Cu}(\text{HMTBa})_2$ was 101.48 and 101.49 (60 and 80 mg/kg, respectively) vs. 100.44 kg in pigs fed control, whereas the HCW of pigs fed ($\text{Cu}_2[\text{OH}]_3\text{Cl}$) was 101.34 kg. In conclusion, growth performance was improved by $\text{Cu}(\text{HMTBa})_2$ supplementation to a greater extent than ($\text{Cu}_2[\text{OH}]_3\text{Cl}$). Supplementing $\text{Cu}(\text{HMTBa})_2$ either at 60 or 80 mg/kg resulted in similar performance in terms of feed efficiency.

Key Words: chelated trace mineral, copper, pig growth performance