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Effects of increasing crystalline amino acids in sorghum- or corn-based diets on nursery pig growth performance

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Effects of Increasing Crystalline Amino Acids in Sorghum- or Corn-Based Diets on Nursery Pig Growth Performance[1]

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Summary
A total of 300 pigs (PIC 1050; initially 23.3 lb BW) were used in a 21-d study to compare the effects of increasing crystalline amino acids in sorghum- and corn-based diets on nursery pig growth performance. Treatments with 5 pigs per pen and 10 pens per treatment were arranged in a 2 × 3 factorial with main effects of grain source (sorghum vs. corn) and crystalline amino acid supplementation (low, medium, or high). Amino acid ratios to lysine as well as standardized ileal digestibility coefficients used were set by NRC (2012[3]). Because replacing increasing amounts of soybean meal with crystalline amino acids changes the NE of the diet, all diets were formulated to the same Lys:NE ratio. The lysine concentration in the diets was formulated at 95% of the pig's estimated requirement to ensure that the other amino acids, on a ratio to lysine, would not be underestimated. The grain sources and soybean meal were analyzed for amino acid profile and diets formulated from these concentrations. The low amino acid fortification contained L-lysine HCl and DL-methionine. The medium amino acid fortification contained L-lysine HCl, DL-methionine, and L-threonine, and the high amino acid fortification contained L-lysine HCl, DL-methionine, L-threonine, and L-valine.

Overall, no main or interactive effects ($P > 0.05$) of grain source or added amino acids were detected for any response criteria. This suggests that balancing to the third, fourth, or fifth limiting amino acids is possible in both sorghum- and corn-based diets with the use of crystalline amino acids without detrimental effects on growth performance.

Key words: corn, crystalline amino acid, nursery pig, sorghum

Introduction
To lower feed costs, crystalline amino acids are used routinely in swine diets to replace a portion of the soybean meal. The amino acids that are currently economical to add to swine diets include lysine, threonine, methionine, tryptophan, and valine. The increased availability of economical sources of crystalline amino acids has created the opportunity to formulate either sorghum- or corn-based diets to the fifth or sixth limiting amino acids. If this can be accomplished without negatively affecting pig growth performance, it will result in greater economic return; however, in some cases, low-protein, amino

[1] Appreciation is expressed to the United Sorghum Checkoff Program (Lubbock, TX) for partial financial support and Ajinomoto-Heartland Inc. (Chicago, IL) for amino acid analysis and providing the amino acids used in this study.

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[3] NRC. 2012. Nutrient Requirements of Swine. 11th rev. ed. Natl. Acad. Press, Washington, DC.

acid–fortified diets have not provided growth performance similar to grain-soybean meal–based diets.

The objective of this study was to determine the effects of feeding high levels of crystalline amino acids in sorghum- or corn-based diets on growth performance of nursery pigs.

Procedures

The protocol for this experiment was approved by the Kansas State University Institutional Animal Care and Use Committee. The study was conducted at the Kansas State University Segregated Early Weaning Facility in Manhattan, KS. The facility is a totally enclosed, environmentally controlled, mechanically ventilated barn. Each pen was equipped with a 4-hole stainless steel dry self-feeder and a cup waterer for ad libitum access to feed and water. Pens (4 ft × 4 ft) had wire-mesh floors and deep pits for manure storage.

A total of 300 pigs (PIC 1050; initially 23.3 lb BW) were used in a 21-d study. The experimental treatments with 5 pigs per pen and 10 replications per treatment were arranged in a 2 × 3 factorial with main effects of grain source (grain sorghum vs. corn) and crystalline amino acid level (low, medium, or high). Amino acid to lysine ratios, as well as standardized ileal digestibility coefficients used, were set by NRC (2012). The lysine concentration in the diets was formulated at 95% of the pig's estimated requirement to ensure that the other amino acids, in ratio with lysine, would not be underestimated. Furthermore, because replacing soybean meal with crystalline amino acids increases the NE of the diet, all diets were formulated to a constant lysine:NE ratio. The grain sources and soybean meal were analyzed for amino acid profile and diets formulated from these concentrations (Table 1). The low amino acid fortification contained L-lysine HCl and DL-methionine. The medium amino acid fortification contained L-lysine HCl, DL-methionine, and L-threonine, and the high amino acid fortification contained L-lysine HCl, DL-methionine, L-threonine, and L-valine (Table 2). Pig weight and feed disappearance were measured on day 0, 7, 14, and 21 of the trial to determine ADG, ADFI, and F/G. Experimental diets were fed in meal form and were manufactured at the K-State O.H. Kruse Feed Technology Innovation Center.

Multiple samples of each diet were collected from feeders, blended and subsampled, and submitted to Ward Laboratories, Inc. (Kearney, NE) for analysis of DM, CP, Ca, and P. Amino acid analysis was conducted by Ajinomoto Heartland, Inc. (Chicago IL; Table 3).

Data were analyzed as a randomized complete block design using PROC MIXED in SAS (SAS Institute, Inc., Cary, NC) with pen as the experimental unit and barn as a random effect. Results from the experiment were considered significant $P \leq 0.05$ and a tendency between $P > 0.05$ and ≤ 0.10.

Results and Discussion

The amino acid profiles of the ingredients varied somewhat from values published by the NRC (2012). As a result, the order of limiting amino acids was different than expected. Based on the amino acid analysis, in both sorghum and corn, the limiting

amino acids were lysine, methionine and cysteine, threonine, and valine. The diets were then co-limiting on tryptophan and isoleucine. The variation of these amino acid profiles for these grain sources confirms the need to evaluate sources routinely and update amino acid profiles when formulating and manufacturing diets. As expected, the analyzed CP content of the experimental diets decreased as soybean meal was replaced by the crystalline amino acids (Table 3).

Overall, no main or interactive effects ($P > 0.05$) of grain source or added crystalline amino acid level were detected for any response criteria measured (Tables 4 and 5). Pigs fed sorghum-based diets had similar growth performance and feed efficiency to those fed corn-based diets. Sorghum is typically thought to have approximately 96% the energy value of corn, resulting in slightly poorer feed efficiency than pigs fed corn-based diets, but this was not the case in our study. Furthermore, we saw no negative responses to increasing crystalline amino acid concentrations in place of soybean meal in the diets. This suggests that balancing to the third, fourth, or fifth limiting amino acid is possible in both sorghum- or corn-based diets with the use of crystalline amino acids without detrimental effects on growth performance.

Table 1. Analyzed amino acid concentration of sorghum, corn, and soybean meal (%, as-fed basis)[1]

Item	Sorghum	Corn	Soybean meal
Arginine	0.29	0.36	3.33
Histidine	0.16	0.23	1.19
Isoleucine	0.26	0.28	2.12
Leucine	0.82	0.98	3.47
Lysine	0.17	0.23	2.86
Methionine	0.13	0.17	0.65
Phenylalanine	0.34	0.37	2.33
Threonine	0.23	0.28	1.82
Tryptophan	0.08	0.06	0.68
Valine	0.33	0.36	2.13

[1] Values represent the mean of 3 samples analyzed in duplicate by Ajinomoto Heartland, Inc., Chicago, IL.

Table 2. Diet composition (as-fed basis)[1]

	Sorghum			Corn		
Ingredient, %	Low	Medium	High	Low	Medium	High
Corn	--	--	--	61.59	67.37	70.73
Milo	61.11	67.10	72.68	--	--	--
Soybean meal (46.5% CP)	35.86	29.41	23.24	35.33	29.07	25.36
Monocalcium phosphate	1.10	1.15	1.23	1.18	1.25	1.3
Limestone	1.03	1.05	1.08	1.00	1.04	1.05
Salt	0.35	0.35	0.35	0.35	0.35	0.35
L-lysine HCl	0.16	0.37	0.59	0.18	0.39	0.52
DL-methionine	0.08	0.15	0.22	0.05	0.12	0.16
L-threonine	--	0.10	0.20	--	0.10	0.15
L-valine	--	--	0.11	--	--	0.07
Trace mineral premix	0.15	0.15	0.15	0.15	0.15	0.15
Vitamin premix	0.15	0.15	0.15	0.15	0.15	0.15
Phytase[2]	0.02	0.02	0.02	0.02	0.02	0.02
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis						
Standardized ileal digestible (SID) lysine:NE, g/Mcal	5.04	5.04	5.04	5.04	5.04	5.04
SID amino acids, %						
Lysine	1.11	1.13	1.14	1.15	1.16	1.17
Isoleucine:lysine	72	61	51.2	71	60	55
Leucine:lysine	136	120	105	140	126	117
Methionine:lysine	31.7	34.8	37.7	30.4	33.2	34.8
Met & Cys:lysine	55.3	55.3	55.3	55.3	55.3	55.3
Threonine:lysine	59.4	59.4	59.4	59.4	59.4	59.4
Tryptophan:lysine	23.2	19.7	16.3	21.7	18.2	16.3
Valine:lysine	73.7	63.4	63.4	73.1	63.4	63.4
Total lysine, %	1.25	1.25	1.25	1.29	1.29	1.30
NE NRC, kcal/lb	1,054	1,069	1,084	1,085	1,101	1,112
CP, %	22.3	19.9	17.7	22.7	20.4	19.1
Ca, %	0.70	0.70	0.70	0.7	0.7	0.7
P, %	0.63	0.61	0.60	0.64	0.63	0.62
Available P, %	0.43	0.43	0.44	0.43	0.44	0.45

[1] Experimental diets were fed for 21 d beginning approximately 18 d after weaning.
[2] Ronozyme HiPhos (GT) 2700 (DSM Nutritional Products, Parsippany, NJ) provided 216.0 phytase units (FTU)/lb with a release of 0.10% available P.

Table 3. Chemical analysis of experimental diets (as-fed basis)[1]

	Grain source					
	Sorghum			Corn		
Item Crystalline amino acids:	Low	Medium	High	Low	Medium	High
DM, %	89.15	89.34	89.26	89.99	89.72	89.71
CP, %	23.3	20.5	18.1	23.3	21.5	20.0
Ca, %	0.66	0.82	0.70	0.83	0.74	0.76
P, %	0.53	0.68	0.54	0.62	0.71	0.62
Amino acids						
Arginine	1.43	1.26	1.07	1.51	1.39	1.28
Histidine	0.55	0.49	0.43	0.59	0.55	0.52
Isoleucine	0.95	0.87	0.70	0.98	0.91	0.79
Leucine	1.89	1.75	1.50	1.98	1.86	1.74
Lysine	1.30	1.33	1.34	1.40	1.44	1.46
Methionine	0.39	0.42	0.47	0.40	0.42	0.44
Threonine	0.83	0.80	0.85	0.89	0.90	0.88
Tryptophan	0.27	0.25	0.21	0.28	0.23	0.21
Valine	1.01	0.95	0.92	1.06	1.00	0.94

[1] Multiple samples were collected from each diet throughout the study, homogenized, then subsampled for analysis at Ward Laboratories, Inc. (Kearney, NE) and Ajinomoto Heartland, Inc. (Chicago, IL).

Table 4. Interactive effects of grain source and crystalline amino acid level on growth performance of pigs[1]

	Grain source								
	Sorghum			Corn				Probability, $P <$ [3]	
Crystalline amino acids[2]:	Low	Medium	High	Low	Medium	High	SEM	Grain source	Amino acid level
d 0 to 21									
ADG, lb	1.07	1.04	1.03	1.04	1.06	1.05	0.044	0.973	0.721
ADFI, lb	1.64	1.59	1.63	1.61	1.61	1.63	0.074	0.803	0.603
F/G	1.52	1.52	1.57	1.53	1.51	1.54	0.023	0.449	0.954
BW, lb									
d 0	23.29	23.38	23.32	23.35	23.35	23.34	0.793	0.939	0.895
d 21	45.87	45.36	45.09	45.30	45.62	45.51	1.691	0.952	0.804

[1]A total of 300 pigs (PIC 1050) were used in a 21-d study with 5 pigs per pen and 10 pens per treatment.
[2] The low amino acid fortification contained L-lysine HCl and DL-methionine. The medium amino acid fortification contained L-lysine HCl, DL-methionine, and L-threonine, and the high amino acid fortification contained L-lysine HCl, DL-methionine, L-threonine, and L-valine.
[3] No grain source × amino acid level interactions were detected ($P > 0.10$).

Table 5. Main effects of grain source and crystalline amino acid on growth performance of nursery pigs[1]

							Probability, $P <$		
	Grain source		Added crystalline amino acids[2]					Crystalline amino acids	
Item	Milo	Corn	Low	Medium	High	SEM	Grain source	Linear	Quadratic
d 0 to 21									
ADG, lb	1.05	1.05	1.06	1.05	1.04	0.04	0.973	0.633	0.994
ADFI, lb	1.62	1.61	1.62	1.60	1.63	0.07	0.803	0.871	0.410
F/G	1.54	1.53	1.53	1.51	1.55	0.02	0.449	0.116	0.089
BW, lb									
d 0	23.33	23.35	23.32	23.36	23.33	0.77	0.939	0.967	0.870
d 21	45.44	45.48	45.59	45.49	45.30	1.60	0.952	0.706	0.942

[1]A total of 300 pigs (PIC 1050) were used in a 21-d study with 5 pigs per pen and 30 pens for grain source or 20 pens for added crystalline amino acid.
[2] The low amino acid fortification contained L-lysine HCl and DL-methionine. The medium amino acid fortification contained L-lysine HCl, DL-methionine, and L-threonine, and the high amino acid fortification contained L-lysine HCl, DL-methionine, L-threonine, and L-valine.