Influence of Standardized Ileal Digestible Tryptophan:Lysine Ratio on Growth Performance of 13- to 21-lb Nursery Pigs

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Summary

A total of 255 nursery pigs (PIC 327 × 1050, initially 13.8 lb and 3 d postweaning) were used in a 28-d growth trial to determine the minimum standardized ileal digestible (SID) tryptophan:lysine ratio for 13- to 21-lb pigs. A 2-phase diet series was used with treatment diets fed from d 0 to 14 and a common diet fed from d 14 to 28. The 6 SID tryptophan:lysine ratios were 14.7, 16.5, 18.4, 20.3, 22.1, and 24.0%. Pigs were allotted on d 3 after weaning with 6 or 7 pigs per pen and 7 replications per treatment. Weight and feed disappearance were determined on d 0, 7, 14, 21, and 28 to calculate ADG, ADFI, and F/G. From d 0 to 14, increasing SID tryptophan:lysine ratio improved ADG (linear, $P = 0.02$) and generated a tendency for improved ADFI and F/G (linear, $P = 0.06$ and quadratic, $P = 0.08$, respectively). Although ADG and ADFI were linear, the greatest response was observed at a SID tryptophan:lysine ratio of 20.3%. From d 14 to 28, when the common diet was fed, ADFI increased (linear, $P = 0.05$) as SID tryptophan:lysine ratio increased in the previous period, but no differences were found in ADG and F/G.

For the overall trial (d 0 to 28), ADG and ADFI increased (linear, $P = 0.02$ and $P = 0.03$, respectively) with increasing SID tryptophan:lysine ratio, with the greatest response observed at 20.3%. Feed/gain was unaffected by SID tryptophan:lysine ratio. Thus, the optimal SID tryptophan:lysine ratio for 13- to 21-lb nursery pigs in this study appears to be at least 20.3%. This ratio is greater than the minimum ratio currently using in many practical diet formulations in the United States, indicating an importance of tryptophan in diet formulation of low-protein amino acid-fortified diets in the swine industry.

Key words: amino acid ratio, lysine, tryptophan, nursery pig

Introduction

In the swine industry, crystalline amino acids (AA) have been widely used to replace soybean meal in low-protein AA-fortified diets. Several trials have demonstrated the successful use of crystalline AA in diets for nursery pigs to replace specialty protein sources, especially in Phase 2 (15- to 25-lb) diets. Tryptophan is the second limiting AA in most diets containing high levels of dried distillers grains with solubles (DDGS) and the fourth limiting amino acid in a typical corn-soybean meal diet. Thus, knowledge of the optimal tryptophan:lysine ratio is critical for practical diet formulation, but the optimal SID tryptophan:lysine ratio remains controversial due to the vari-

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ability among the trials. A range of 14.5 to 23.1% SID tryptophan:lysine ratio requirements across various pig body weights have been reported (Quant, 2008[3]). In nursery pigs, the calculated tryptophan:lysine ratio based on NRC[4] amino acid requirement estimates is 18%. Several studies indicate a SID tryptophan requirement estimate of greater than 20% of lysine (Pluske and Mullen, 2000[5]; Guzik et al., 2005[6]; Jansman and Van Diepen, 2010[7]), whereas the National Swine Nutrition Guide[8] suggests a SID tryptophan:lysine ratio of 16.8%. Differences among these published studies may be related to diet composition, gender, genetics, chemical analysis, or method of statistical analysis; therefore, more studies are needed to establish a tryptophan:lysine ratio and validate the requirement. Thus, this trial was conducted to determine the minimum SID tryptophan:lysine ratio in nursery diets for 13- to 21-lb pigs.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The study was conducted at the K-State Swine Teaching and Research Center in Manhattan, KS.

A total of 255 pigs were weaned at 21 d of age and placed in the nursery facility. At weaning, pigs were fed a common diet for 3 d. At d 3 after weaning, pigs were weighed and allotted to dietary treatments in a randomized complete block. Therefore, d 3 after weaning was d 0 in the trial. Each treatment had 7 replications with 6 or 7 pigs per pen. A 4-hole, dry self-feeder and a nipple waterer were used in each pen (4 ft × 5 ft) to provide ad libitum access to feed and water. Weight and feed disappearance were determined at d 0, 7, 14, 21, and 28 to calculate for ADG, ADFI, F/G, and income over feed cost (IOFC). Income over feed cost is a method to measure an economic value by assuming that other costs, such as utility and labor, are equal and the only variables are ADG and feed usage. Corn was valued at $233/ton, soybean meal at $340/ton, spray-dried whey at $769/ton, L-lysine HCl at $1,600/ton, DL-methionine at $3,000/ton, threonine at $2,300/ton, tryptophan at $24,000/ton, and pig price at $0.55/lb.

A 2-phase diet series was used with treatment diets fed from d 0 to 14 and a common diet fed from d 14 to 28 (Table 1). Experimental diets were corn-soybean meal-based with addition of crystalline tryptophan to achieve 6 levels of SID tryptophan that were 14.7, 16.5, 18.4, 20.3, 22.1, and 24.0% of lysine. Large batches of the 14.7% and 24.0% SID tryptophan:lysine diets were made then blended to achieve the intermediate SID tryptophan:lysine ratios. The lysine level of 1.3% in these experimental diets was selected based on data of Nemecheck et al. (2010[9]) using the same genotype in the same

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[8] National Swine Nutrition Guide. 2010. Table of Nutrient Recommendations, Ingredient Composition, and Use Rates, U.S. Pork Center of Excellence, Ames, IA.
[9] Nemecheck et al., Swine Day 2010, Report of Progress 1038, pp. 22-26.

nursery facility. The 14.7% SID tryptophan:lysine ratio diet was also verified to be deficient in tryptophan from a previous trial (Nemecheck et al., 2010[10]). All diets contained 10% spray-dried whey and did not contain specialty protein sources such as spray-dried blood meal or menhaden fishmeal. All experimental diets were fed in meal form and were prepared at the K-State Animal Science Feed Mill. Diet samples were collected at the beginning of the trial and on d 7 and 14, then a composite sample was made and analyzed for AA analysis by Ajinomoto Heartland LLC, Chicago, IL (Table 2).

At the end of the trial, data were analyzed for linear and quadratic effects of increasing SID tryptophan:lysine ratio using the PROC MIXED procedure of SAS (SAS Institute, Inc., Cary, NC). Pen was the experimental unit for all data analysis. Results were considered significant at $P \leq 0.05$ and were considered a trend at $P \leq 0.10$.

Results and Discussion

From d 0 to 14, increasing SID tryptophan:lysine ratio improved ADG (linear, $P = 0.02$) and a tendency for improved ADFI and F/G (linear, $P = 0.06$ and quadratic, $P = 0.08$, respectively; Table 3). Although the response was linear for ADG and ADFI, similar to F/G, performance was optimal for pigs fed the 20.3% SID tryptophan:lysine ratio. No differences were found in IOFC; however, pigs fed the 20.3% SID tryptophan:lysine ratio again resulted in the greatest IOFC.

From d 14 to 28, when a common diet was fed, ADFI increased (linear, $P = 0.05$) with increasing SID tryptophan:lysine ratio fed from d 0 to 14; however, no evidence of a carryover effect for ADG, F/G, and IOFC was observed. Again, pigs previously fed the 20.3% SID tryptophan:lysine ratio also had the greatest IOFC during this period. For the overall study (d 0 to 28), ADG and ADFI increased (linear, $P = 0.02$ and $P = 0.03$, respectively) with increasing SID tryptophan:lysine ratio, but no differences occurred in F/G or IOFC. Although ADG and ADFI were linear in response, little benefit was gained in performance above the 20.3% SID tryptophan:lysine ratio. Although not significant, pigs fed the 20.3% SID tryptophan:lysine ratio had the greatest IOFC.

In summary, although the ADG increased linearly with increasing SID tryptophan:lysine ratio, a quadratic trend occurred for F/G ($P = 0.08$), with greatest response in ADG and F/G at 20.3%. Also, based on the IOFC analysis, these data suggest an optimal SID tryptophan:lysine ratio for 13- to 21-lb nursery pigs of at least 20.3%; however, this ratio is greater than the minimum ratio currently using in many practical diet formulations in the U.S., indicating the importance of tryptophan in diet formulation of low-protein AA-fortified diets in swine industry. The statistical analysis in this experiment also indicated a significant linear response with a quadratic trend; therefore, more studies are needed to validate the requirement of SID tryptophan:lysine ratio for nursery pigs in this period.

[10] Nemecheck et al., Swine Day 2010, Report of Progress 1038, pp. 10-16.

Table 1. Diet composition (as-fed basis)

Item	Basal diet	Phase 2[2]
Ingredient, %		
Corn	58.10	65.05
Soybean meal (46.5% CP)	25.20	30.73
Spray-dried whey	10.00	---
Soybean oil	1.00	---
Monocalcium P (21% P)	1.10	1.08
Limestone	0.90	0.95
Salt	0.35	0.35
Zinc oxide	0.25	---
Trace mineral premix	0.15	0.15
Vitamin premix	0.25	0.25
L-Lysine HCl	0.533	0.360
DL-Methionine	0.220	0.130
L-Threonine	0.230	0.130
L-Isoleucine	0.100	---
L-Valine	0.160	---
Glutamine	0.630	---
Glycine	0.630	---
Phytase[3]	0.085	0.165
Corn starch	---	---
L-Tryptophan	---	---
Total	100	100

continued

Table 1. Diet composition (as-fed basis)

Item	Basal diet	Phase 2[2]
Calculated analysis		
Standadized ileal digestible (SID) amino acids, %		
Lysine	1.30	1.26
Isoleucine:lysine	60	61
Leucine:lysine	111	129
Methionine:lysine	36	33
Met & Cys:lysine	58	58
Threonine:lysine	64	63
Tryptophan:lysine	14.7	17.0
Valine:lysine	70	68
Total lysine, %	1.42	1.39
ME, kcal/lb	1,517	1,503
SID lysine:ME, g/Mcal	3.89	3.80
CP, %	20.4	20.8
Ca, %	0.72	0.69
P, %	0.64	0.62
Available P, %	0.47	0.42

[1] Treatment diets were fed from d 0 to 14.
[2] Common diet was fed from d 14 to 28.
[3] Phytase 600 (Danisco Animal Nutrition, St. Louis, MO) provided 231 FTU/lb, with a release of 0.10% available P.
[4] L-Tryptophan was added at the expense of corn starch at 0, 0.024, 0.049, 0.074, 0.098, and 0.123% of the diet to provide tryptophan:lysine ratios of 47, 16.5, 18.4, 20.3, 22.1, and 24.0% of lysine.

Table 2. Total amino acid (AA) analysis

	Standardized ileal digestible tryptophan:lysine ratio, %					
Item	14.7	16.5	18.4	20.3	22.1	24.0
Calculated analysis						
Total AA, %						
Lysine	1.421	1.421	1.421	1.421	1.421	1.421
Isoleucine	0.868	0.868	0.868	0.868	0.868	0.868
Leucine	1.605	1.605	1.605	1.605	1.605	1.605
Methionine	0.502	0.502	0.502	0.502	0.502	0.502
Cystine	0.322	0.322	0.322	0.322	0.322	0.322
Threonine	0.934	0.934	0.934	0.934	0.934	0.934
Tryptophan	0.217	0.241	0.265	0.289	0.313	0.337
Valine	1.017	1.017	1.017	1.017	1.017	1.017
Laboratory analysis[1]						
Total AA, %						
Lysine	1.430	1.432	1.424	1.379	1.371	1.419
Isoleucine	0.896	0.949	0.927	0.938	0.913	0.933
Leucine	1.610	1.626	1.600	1.595	1.534	1.595
Methionine	0.495	0.457	0.486	0.470	0.486	0.492
Cystine	0.324	0.324	0.320	0.313	0.311	0.318
Threonine	0.947	0.973	0.952	0.937	0.935	0.945
Tryptophan	0.222	0.226	0.237	0.269	0.295	0.296
Valine	1.069	1.053	1.038	1.048	1.027	1.048

[1] Feed samples were collected at the beginning of the trial and d 7 and 14. Values represent the mean of 3 samples. At the end of trial, subsamples of each diet were sent to Ajinomoto Heartland LLC, Chicago, IL, for the total AA analysis.

Table 3. Influence of standardized ileal digestible (SID) tryptophan:lysine ratio on growth performance of nursery pigs[1]

	SID tryptophan:lysine ratio, %							Probability, P <	
Item	14.7	16.5	18.4	20.3	22.1	24.0	SEM	Linear	Quadratic
d 0 to 14									
ADG, lb	0.50	0.54	0.54	0.59	0.57	0.57	0.026	0.02	0.33
ADFI, lb	0.72	0.75	0.75	0.77	0.75	0.80	0.026	0.06	0.94
F/G	1.46	1.41	1.41	1.32	1.33	1.40	0.039	0.06	0.08
d 14 to 28									
ADG, lb	1.07	1.03	1.08	1.11	1.06	1.10	0.026	0.18	0.88
ADFI, lb	1.56	1.53	1.62	1.62	1.57	1.66	0.036	0.05	0.78
F/G	1.46	1.50	1.50	1.46	1.48	1.51	0.033	0.65	0.92
d 0 to 28									
ADG, lb	0.78	0.78	0.80	0.85	0.81	0.84	0.020	0.02	0.60
ADFI, lb	1.14	1.14	1.18	1.19	1.16	1.23	0.027	0.03	0.86
F/G	1.45	1.46	1.47	1.41	1.42	1.47	0.025	0.64	0.35
wt, lb									
d 0	13.8	13.8	13.7	13.8	13.8	13.8	0.129	0.75	0.87
d 14	20.8	21.4	21.4	22.0	21.7	21.8	0.386	0.03	0.29
d 28	35.8	35.8	36.4	37.5	36.6	37.2	0.559	0.03	0.53
IOFC[2], $/pig									
d 0 to 14	1.48	1.62	1.58	1.88	1.78	1.62	0.135	0.20	0.16
d 14 to 28	5.97	5.70	5.94	6.19	5.89	6.08	0.174	0.36	0.94
d 0 to 28	7.45	7.32	7.49	8.07	7.67	7.68	0.216	0.13	0.42

[1] A total of 255 nursery pigs (initial 13.8 lb, 3 d postweaning) were used in a 28-d trial with 6 to 7 pigs per pen and 7 pens per treatment. Experimental diets were fed from d 0 to 14, and common diet was fed from d 14 to 28.

[2] Income over feed cost: Corn was valued at $233/ton, soybean meal at $340/ton, spray-dried whey at $769/ton, L-lysine HCl at $1,600/ton, DL-methionine at $3,000/ton, threonine at $2,300/ton, tryptophan at $24,000/ton, and pig price at $0.55/lb.