Influence of Dietary Isoleucine:Lysine Ratio on the Optimal Tryptophan:Lysine Ratio for 13- to 24-lb Pigs[1]

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Summary

A total of 475 nursery pigs (initially 13.4 lb and 5 d postweaning) were used to determine the influence of the standardized ileal digestible (SID) isoleucine:lysine ratio on the optimal SID tryptophan:lysine ratio for growth performance of nursery pigs. This experiment was conducted in the all-in, all-out nursery at the Swine Nutrition Farm at Iowa State University. Each treatment had 8 replications with 4 or 5 pigs per pen, with equal numbers of barrows and gilts within block and across treatments. Pens were allotted to 1 of 12 treatments in a randomized complete block design. Treatments were arranged as a 2 × 6 factorial with main effects of 2 SID isoleucine:lysine ratios (52 and 60% of lysine) and 6 SID tryptophan:lysine ratios (14.7, 16.6, 18.5, 20.4, 22.3, and 24.0% of lysine). Treatment diets were fed for 14 d, then a common diet was fed from d 14 to 21. Overall, no interactions ($P > 0.27$) were observed between SID isoleucine:lysine and SID tryptophan:lysine ratios. For the main effect of SID isoleucine:lysine ratio, no differences ($P > 0.21$) were observed in growth performance between pigs fed the 52 or 60% SID isoleucine:lysine ratio. Increasing the SID tryptophan:lysine ratio also had no effect ($P > 0.30$) on growth performance. In conclusion, dietary SID isoleucine:lysine ratio did not influence the response to increasing SID tryptophan:lysine ratios in 13- to 24-lb pigs. Our results also suggested that the SID isoleucine:lysine ratio is not greater than 52% for pigs fed diets that do not contain blood products. Further research is needed to determine the optimal tryptophan:lysine ratio for 13- to 24-lb pigs.

Key words: isoleucine, nursery pig, tryptophan

Introduction

Numerous recent experiments have examined the dietary standardized ileal digestible (SID) tryptophan:lysine ratio for nursery pigs. Optimal ratios estimated from this research range from 15 to 22% of lysine. We have conducted multiple studies to determine the response to tryptophan:lysine ratio in 15- to 25-lb pigs. In a previous experiment[5] conducted at Kansas State University (an amino acid deletion experiment), deleting L-tryptophan from the diet lowered the tryptophan:lysine ratio from 20 to 15% of lysine and reduced ADG and ADFI. In the next experiment, 15 and 21%

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

tryptophan:lysine ratio diets were used except isoleucine was lowered from 60 to 52% of lysine because this ratio was determined to be adequate in the amino acid deletion experiment. Increasing the tryptophan:lysine ratio from 15 to 21% did not influence growth performance. In a third experiment, the SID isoleucine:lysine was set at 60%, the same as in the amino acid deletion experiment, and ADG, ADFI, and F/G improved linearly as SID tryptophan:lysine increased from 15 to 24% with the optimal level at approximately 20% of lysine (see "Influence of Standardized Ileal Digestible Tryptophan:Lysine Ratio on Growth Performance of 13- to 21-lb Nursery Pigs," p. 138).

Interactions between other branch chain amino acids (leucine and valine) and isoleucine have been demonstrated by others. Additionally, the response to dietary tryptophan has been shown to be influenced by the levels of large neutral amino acids in the diet. Thus, we hypothesize that the isoluecine level in the diet may influence the response to dietary tryptophan. A marginal isoleucine level may limit the response to tryptophan, so this experiment was conducted to determine whether the dietary SID isoleucine:lysine ratio influenced the response to increasing SID tryptophan:lysine ratios in 13- to 24-lb pigs.

Procedures

A total of 475 pigs were used to determine the influence of dietary isoleucine:lysine ratio on the optimal tryptophan:lysine ratio for growth performance of nursery pigs. The experiment was conducted under Iowa State University Animal Care and Use Guidelines in the all-in, all-out nursery at the Swine Nutrition Farm, Iowa State University, Ames, IA. The nursery is an environmentally controlled facility with 96 pens. Upon arrival, pigs were tagged, weighed, selected for allocation to the experimental pens, and fed a common phase 1 (starter) diet for 5 d. On d 5 after arrival, pigs were weighed and allotted to the dietary treatments in a randomized complete block design based on ADG from arrival to the start of trial; therefore, d 5 after arrival was d 0 in the trial. Each treatment had 8 replications with 4 to 5 pigs per pen and equal numbers of barrows and gilts within block and across treatments. A 4-hole, dry self-feeder and a nipple waterer were used in each pen to provide ad libitum access to feed and water. Pig weight and feed disappearance were determined on d 0 and 14 to calculate ADG, ADFI, and F/G. After d 14, pigs were fed a common diet for 7 d then weighed. The amount of feed from d 14 to 21 was not recorded; thus, the response variable calculated in this period was only ADG.

Dietary treatments were arranged as a 2 × 6 factorial with main effects of SID isoleucine:lysine ratio (52 and 60%) and 6 SID tryptophan:lysine ratios (14.7, 16.6, 18.5, 20.4, 22.3, and 24.0%). The diets were manufactured by producing 5 basal diets that were used to form the 12 dietary treatments. Blend 1 was included at 50% of all 12 diets with the goal of minimizing variability in diets (Tables 1 and 2). Four more basal diets (blends 2 through 5) were mixed and blended in proportions to create all 12 experimental diets (Table 3). Thus, isoleucine and tryptophan were the only ingredients that varied among the 12 experimental diets. For the different blends, all crystalline amino acids, monocalcium phosphate, limestone, salt, zinc oxide, phytase, vitamin premix, and trace mineral premix were mixed as 1 ingredient to ensure even distribution. The diets contained zinc oxide but no feed medication. The vitamin and trace

mineral premixes and phytase were supplied by Kansas State University to ensure that the same ingredients that were used in our previous trials were included in these diets. All diets contained 10% spray-dried whey and did not contain a specialty protein source such as spray-dried blood meal or menhaden fish meal. All experimental diets were in meal form and were prepared at the Iowa State University Swine Nutrition Feed Mill. The calculated nutrient analysis (Table 4) was developed using ingredient values based on NRC (1998). Diets subsamples were analyzed for amino acid content.

The experimental data were analyzed using the MIXED procedure of SAS (SAS institute, Inc., Cary, NC). Pen was the experimental unit for all data analysis and statistical significance was claimed at $P < 0.05$. Data were analyzed for the main effects of SID isoleucine:lysine ratio, SID tryptophan:lysine ratio, linear and quadratic effect of SID tryptophan:lysine ratio, and any interactions between isoleucine level and tryptophan level.

Results and Discussion

Analyzed amino acid content agreed with calculated values. No linear or quadratic interactions ($P > 0.27$; Table 5) occurred between SID isoleucine:lysine and SID tryptophan:lysine ratios; however, a trend (quadratic, $P = 0.07$) was observed for an interaction in ADG from d 14 to 21 when pigs were fed the common diet. Pigs previously fed 52% SID isoleucine:lysine had greatest ADG at 14.7 and 24.0 % SID tryptophan:lysine ratio, whereas greatest ADG of pigs previously fed 60% SID isoleucine:lysine ratio was found at 18.5% SID tryptophan:lysine ratio.

For the main effect of SID isoleucine:lysine ratio, no differences ($P > 0.21$; Table 6) were found in growth performance between pigs fed 52 and 60% SID isoleucine:lysine ratio. Also, increasing SID tryptophan:lysine ratio did not affect ($P > 0.30$) growth performance (Table 6).

With no differences in growth performance among pigs fed 52 and 60% SID isoluecine:lysine ratio, this study suggests that the optimal SID isoluecine:lysine ratio of nursery pigs fed a diet without spray-dried blood cells was no greater than 52% of lysine, but the National Swine Nutrition Guide[6] suggests a SID isoleucine:lysine ratio of 55% for 15- to 25-lb pigs.

Furthermore, the SID tryptophan:lysine ratio demonstrated in this study was no greater than 14.7% of lysine, but other studies have shown higher tryptophan requirement estimates. Pluske and Mullen (2000[7]), Guzik et al. (2005[8]), and Jansman et al. (2010[9]) demonstrated requirement estimates greater than 20% of lysine. A recent trial at Kansas State University (see "Influence of Standardized Ileal Digestible Tryptophan:Lysine

[6] National Swine Nutrition Guide. 2010. Table of Nutrient Recommendations, Ingredient Composition, and Use Rates, U.S. Pork Center of Excellence, Ames, IA.
[7] Pluske, J., and B. P. Mullan. 2000. Determining the optimum Tryptophan:Lysine ratio in diets for weaner pigs. Cited in: L–Tryptophan supplementation to enhance piglet growth. Ajinomoto Eurolysine Information. 23:1-11.
[8] Guzik, A. C., M. J. Pettit, E. Beltranena, L. L. Southern, and B. J. Kerr. 2005b. Threonine and tryptophan ratios fed to nursery pigs. J. Anim. Physiol. Anim. Nutr. 89:297-302.
[9] Jansman, A. J. M., J. T. M. Van Diepen, D. Melchior. 2010. The effect of diet composition on tryptophan requirement of young piglets. J. Anim. Sci. 88:1017-1027.

Ratio on Growth Performance of 13- to 21-lb Nursery Pigs," p. 138) also suggested an optimal SID tryptophan:lysine ratio for 13- to 21-lb pigs of at least 20.3% lysine. Variation among trials is apparent, and the SID tryptophan:lysine requirement in nursery pigs is not conclusive.

In summary, this trial indicated that dietary SID isoleucine:lysine ratio did not influence the response to increasing dietary SID tryptophan:lysine ratios for 13- to 24-lb pigs; therefore, the variability in response to SID tryptophan:lysine ratio on growth performance in nursery pigs among several studies cannot be explained by the interaction of isoleucine on tryptophan. This leaves the question of why response to tryptophan varied; the causative factors of the variation need to be further investigated.

Table 1. Composition of 5 blends (as-fed basis)

	Basal diet blend[1]				
Ingredient, %	1	2	3	4	5
Corn	58.22	57.97	57.97	57.97	57.97
Soybean meal (46.5% CP)	25.26	25.14	25.14	25.14	25.14
Spray-dried whey	10.02	9.98	9.98	9.98	9.98
Corn starch	---	0.39	0.20	0.24	---
Soybean oil	1.00	1.00	1.00	1.00	1.00
Monocalcium P (21% P)	1.10	1.10	1.10	1.10	1.10
Limestone	0.90	0.90	0.90	0.90	0.90
Salt	0.35	0.34	0.34	0.34	0.34
Zinc oxide	0.25	0.25	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15	0.15	0.15
Vitamin premix	0.25	0.25	0.25	0.25	0.25
L-Lysine HCl	0.53	0.53	0.53	0.53	0.53
DL-Methionine	0.22	0.22	0.22	0.22	0.22
L-Threonine	0.23	0.23	0.23	0.23	0.23
L-Tryptophan	---	0.05	0.24	---	0.24
L-Isoleucine	---	---	---	0.20	0.20
L-Valine	0.16	0.16	0.16	0.16	0.16
Glutamine	0.63	0.63	0.63	0.63	0.63
Glycine	0.63	0.63	0.63	0.63	0.63
Phytase[2]	0.09	0.08	0.08	0.08	0.08
Total	100	100	100	100	100

[1] Five basal diet blends were manufactured to create the 12 experimental diets with the goal of minimizing variability in experimental diets so the test amino acid was the only difference between diets.
[2] Phytase 600 (Danisco Animal Nutrition, St.Louis, MO) provided 231 FTU/lb, with a release of 0.10% available P.

Table 2. Percentages of the 5 basal diet blends included in the 12 experimental diets[1]

SID[2] ile:lys ratio, %	52						60					
SID trp:lys ratio, %	14.7	16.6	18.5	20.4	22.3	24.0	14.7	16.6	18.5	20.4	22.3	24.0
Blend 1	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Blend 2	50%	40%	30%	20%	10%	---	---	---	---	---	---	---
Blend 3	---	10%	20%	30%	40%	50%	---	---	---	---	---	---
Blend 4	---	---	---	---	---	---	50%	40%	30%	20%	10%	---
Blend 5	---	---	---	---	---	---	---	10%	20%	30%	40%	50%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

[1] Five basal diet blends were manufactured to create the 12 experimental diets with the goal of minimizing variability in experimental diets so that the test amino acid was the only difference between diets.
[2] Standardized ileal digestible.

Table 3. Composition of experimental diets (as-fed basis)

	Standardized ileal digestible (SID) isoleucine:lysine ratio, %											
	52						60					
SID trptophan:lysine ratio, %	14.7	16.6	18.5	20.4	22.3	24.0	14.7	16.6	18.5	20.4	22.3	24.0
Ingredient, %												
Corn	58.09	58.09	58.09	58.09	58.09	58.10	58.09	58.09	58.09	58.09	58.09	58.09
Soybean meal (46.5% CP)	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20
Spray-dried whey	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Corn starch	0.22	0.20	0.17	0.15	0.12	0.10	0.12	0.10	0.07	0.05	0.02	---
Soybean oil	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Monocalcium P (21% P)	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Limestone	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Zinc oxide, 72%	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
L-Lysine HCl	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
DL-Methionine	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
L-Threonine	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
L-Tryptophan	---	0.03	0.05	0.08	0.10	0.12	---	0.03	0.05	0.08	0.10	0.12
L-Isoleucine	---	---	---	---	---	---	0.10	0.10	0.10	0.10	0.10	0.10
L-Valine	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
L-Glutamine	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
L-Glycine	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
Phytase [1]	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Total	100	100	100	100	100	100	100	100	100	100	100	100

[1] Phytase 600 (Danisco Animal Nutrition, St. Louis, MO) provided 231 FTU/lb, with a release of 0.10% available P.

Table 4. Calculated nutrient analysis

	Standardized ileal digestible (SID) isoleucine:lysine ratio, %											
	52						60					
SID trp:lys ratio, %	14.7	16.6	18.5	20.4	22.3	24.0	14.7	16.6	18.5	20.4	22.3	24.0
Standadized ileal digestible (SID) amino acids %												
Lysine	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
Isoleucine:lysine	52	52	52	52	52	52	60	60	60	60	60	60
Leucine:lysine	111	111	111	111	111	111	111	111	111	111	111	111
Methionine:lysine	36	36	36	36	36	36	36	36	36	36	36	36
Met & Cys:lysine	58	58	58	58	58	58	58	58	58	58	58	58
Threonine:lysine	64	64	64	64	64	64	64	64	64	64	64	64
Tryptophan:lysine	14.7	16.6	18.5	20.4	22.3	24.0	14.7	16.6	18.5	20.4	22.3	24.0
Valine:lysine	70	70	70	70	70	70	70	70	70	70	70	70
Total lysine, %	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42
ME, kcal/lb	1,516	1,516	1,517	1,517	1,517	1,517	1,517	1,517	1,518	1,518	1,518	1,518
SID lysine:ME, g/Mcal	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.88	3.88
CP, %	20.3	20.3	20.3	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.5	20.5
Ca, %	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
P, %	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
Available P, %	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
Ca:P	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13

Table 5. Effects of standardized ileal digestible (SID) isoleucine:lysine ratio on the trptophan:lysine ratio for 13- to 24-lb pigs (interactive means)[1]

	SID isoleucine:lysine ratio, %													Probability, $P <$	
	52						60							Trp × ile	
SID trp:lys, %	14.7	16.6	18.5	20.4	22.3	24.0	14.7	16.6	18.5	20.4	22.3	24.0	SEM	Linear	Quadratic
d 0 to 14															
ADG, lb	0.70	0.77	0.74	0.72	0.75	0.77	0.76	0.79	0.72	0.71	0.80	0.74	0.045	0.42	0.67
ADF, lb	0.90	1.00	0.94	0.93	0.97	0.97	1.00	1.00	0.93	0.91	1.02	0.94	0.051	0.27	0.35
F/G	1.29	1.30	1.28	1.30	1.29	1.27	1.32	1.26	1.29	1.29	1.28	1.28	0.024	0.79	0.35
d 14 to 21[2]															
ADG, lb	1.23	1.16	1.14	1.17	1.20	1.24	1.19	1.21	1.32	1.17	1.22	1.23	0.07	0.85	0.07
d 0 to 21															
ADG, lb	0.87	0.90	0.87	0.87	0.90	0.92	0.90	0.93	0.92	0.86	0.94	0.90	0.05	0.42	0.63
Pig weight, lb															
d 0	13.4	13.4	13.4	13.4	13.4	13.5	13.4	13.4	13.4	13.4	13.4	13.4	0.62	0.87	0.76
d 14	23.2	24.2	23.7	23.6	23.9	24.2	24.0	24.6	23.5	23.3	24.6	23.7	1.12	0.44	0.79
d 21	32.2	32.3	31.9	31.9	32.3	32.9	32.3	33.0	32.8	31.8	33.5	32.3	1.47	0.72	0.40

[1] A total of 475 pigs with 4 to 5 pigs per pen and 8 replications per treatment.

[2] Experimental diets were fed from d 0 to 14 and common diet was fed from d 14 to 21. Weight and feed disappearance were determined from d 0 to 14, but only weight was determined after d 14.

Table 6. Effects of standardized ileal digestible (SID) isoleucine:lysine ratio the trptophan:lysine ratio for 13- to 24-lb pigs (main effects)[1]

	SID isoleucine:lysine ratio, %				SID trpophan:lysine ratio, %							Probability, $P <$ Tryptophan	
	52	60	SEM	Probability, $P <$	14.7	16.6	18.5	20.4	22.3	24.0	SEM	Linear	Quadratic
d 0 to 14													
ADG, lb	0.74	0.75	0.03	0.58	0.73	0.78	0.73	0.72	0.78	0.75	0.04	0.72	0.73
ADF, lb	0.95	0.97	0.04	0.54	0.95	1.00	0.94	0.92	0.99	0.95	0.04	0.86	0.60
F/G	1.29	1.29	0.01	0.90	1.31	1.28	1.29	1.29	1.28	1.27	0.02	0.30	0.89
d 14 to 21[2]													
ADG, lb	1.19	1.22	0.05	0.21	1.21	1.18	1.23	1.17	1.21	1.24	0.06	0.51	0.40
d 0 to 21													
ADG, lb	0.89	0.91	0.04	0.29	0.89	0.92	0.89	0.86	0.92	0.91	0.04	0.52	0.48
Pig weight, lb													
d 0	13.4	13.4	0.60	0.94	13.4	13.4	13.4	13.4	13.4	13.4	0.60	0.90	0.90
d 14	23.8	24.0	0.99	0.63	23.6	24.4	23.6	23.5	24.3	24.0	1.04	0.74	0.80
d 21	32.3	32.6	1.34	0.33	32.3	32.7	32.3	31.9	32.9	32.6	1.39	0.59	0.64

[1] A total of 475 pigs with 4 to 5 pigs per pen and 8 replications per treatment.

[2] Experimental diets were fed from d 0 to 14 and common diet was fed from d 14 to 21. Weight and feed disappearance were determined from d 0 to 14; however, only weight was determined after d 14.