THE OPTIMUM ISOLEUCINE:LYSINE RATIO IN STARTER DIETS TO MAXIMIZE GROWTH PERFORMANCE OF THE EARLY-WEANED PIG[1]

B. W. James, R. D. Goodband, M. D. Tokach, J. L. Nelssen, and J. M. DeRouchey

Summary

A total of 360 weanling pigs (initially 12.3 lb BW and approximately 18 d of age) was used in a 14-d growth assay to determine the optimal isoleucine:lysine ratio to maximize growth performance. The 12 experimental treatments consisted of either 1.00 or 1.26% apparent digestible lysine with isoleucine concentrations of 45, 50, 55, 60, or 65% of lysine. Two positive control diets were used with 1.10 and 1.39% apparent digestible lysine and 45% isoleucine:lysine to ensure that lysine was not the first limiting amino acid in the basal diets. The results of this experiment indicate that the optimal apparent digestible isoleucine:lysine ratio for the SEW pig is between 50 and 55% of apparent digestible lysine.

(Key Words: Isoleucine, Lysine, Weanling Pigs.)

Introduction

Nutrient profiles of ingredients and amino acid requirements vary between the 1988 and 1998 NRC publications. These changes have resulted in an increase in the isoleucine requirement for the early-weaned pig. The current NRC requirements of apparent digestible lysine and isoleucine for a 6 to 11 lb pig are 1.26% and .69% of the diet, respectively, suggesting an apparent digestible isoleucine:lysine ratio of 55%. Recent changes in starter diets have resulted in increased levels of blood meal or blood cells being used as highly digestible protein sources for weanling pigs. However, these products contain a lower concentration of isoleucine than other protein sources. The objective of this experiment was to determine the appropriate apparent digestible isoleucine:lysine ratio necessary to optimize performance of the SEW pig.

Procedures

Three hundred and sixty weanling pigs (initially 12.3 lb BW and approximately 18 d of age, PIC C22 × 327) were used in a 14-d growth assay. Pigs were blocked by initial weight and allotted randomly to each of the 12 dietary treatments. Each treatment had six replications (pens) and five pigs per pen.

Corn, soybean meal, spray-dried plasma, blood meal, fish meal, and spray-dried whey were analyzed for complete amino acid profiles prior to diet formulation based on apparent digestible amino acid composition of those ingredients. The 12 experimental treatments consisted of two basal diets (Table 1) containing 1.00 and 1.26% apparent digestible lysine with .45 and .57% isoleucine, respectively, and all other amino acids except isoleucine (Table 2) formulated to 110 % of the recommended NRC requirements. Crystalline isoleucine then was added to each of the basal diets to meet the desired level of each treatment (50, 55, 60, and 65% of lysine). Lysine was added to two positive controls to provide 1.10 and 1.39% apparent digestible lysine and ensure that lysine was not the first limiting amino acid. All diets were fed in pellet form.

[1]Appreciation is expressed to Nutri-Quest, Chesterfield, MO, for providing the crystalline amino acids used in this experiment.

Pigs were housed in an environmentally controlled nursery. Temperature was maintained at 90° F for the first week and reduced to 85°F for the second week. Each pen (4 × 4 ft) contained a stainless steel self-feeder and one nipple waterer to allow ad libitum consumption of feed and water.

Table 1. Basal Diet Composition (As-Fed Basis)[a]

	Apparent Digestible Lysine, %	
Ingredient	1.00	1.26
Corn	33.90	42.69
Cornstarch[b]	14.00	.25
Lactose	12.66	10.50
Dried whey	12.00	15.00
Soybean meal (46.5% CP)	6.04	7.92
Choice white grease	5.00	5.00
Spray-dried blood plasma	4.40	5.50
Select menhaden fish meal	4.00	5.00
Spray-dried blood cells	3.20	4.00
Monocalcium phosphate	2.59	1.56
Medicationc	1.00	1.00
Zinc oxide	.37	.37
Limestone	—	.33
Vitamin premix	.25	.25
Salt	.20	.20
Trace mineral premix	.15	.15
DL-Methionine	.08	.09
L-threonine	.07	.08
Sow add pack	.05	.05
Cystine	.02	.03
L-Isoleucine	.02	.03

[a]Diets were formualted to 45% isoleucine:lysine with all other amino acids at 110% of NRC requirements.

[b]L-Isoleucine replaced cornstarch in the 1.00 and 1.26% apparent digestible lysine basal diets to provide .45, .50, .55, .60, and .65% apparent digestible isoleucine and .567, .63, .693, .756, and .819% apparent digestible isoleucine, respectively. This provided apparent digestible isoleucine:lysine ratios of 45, 50, 55, 60, and 65% at both lysine levels.

[c]Provided 50 g/ton carbadox.

Experimental treatment diets were fed from d 0 to 14 postweaning. Pigs were weighed and feed disappearance measured on d 7 and 14 of the experiment to determine ADG, ADFI, and F/G. Blood samples were obtained on d 10 from two randomly selected pigs in each pen. Feeders were removed 3 hours prior to blood collection. Plasma urea nitrogen (PUN) was determined on each sample. Plasma from pigs in the same pen were pooled and analyzed for amino acid profiles.

Data were analyzed in a randomized complete block design using the general linear model (GLM) procedures of SAS with pen as the experimental unit. Linear and quadratic polynomial contrasts were performed to determine the effects of increasing levels of dietary isoleucine.

Results and Discussion

No isoleucine × lysine interactions were observed (P>.47) from d 0 to 7 (Table 3). Increasing the apparent digestible isoleucine:lysine ratio improved ADG, ADFI, and F/G (linear and quadratic, P<.01) from d 0 to 7. The greatest response occurred as the isoleucine:lysine ratio increased from 45 to 50%, and a smaller incremental improvement occurred as the ratio increased from 50 to 55%. Pigs fed the diet containing 1.26% apparent digestible lysine had better ADG than pigs fed 1.00% apparent digestible lysine (P<.03). From d 0 to 7, growth performance of pigs fed the positive control diets was not different (P>.05) than that of pigs fed the negative control diets. This confirms that isoleucine was first limiting during this phase.

From d 7 to 14, lysine × isoleucine interactions were observed for ADG and ADFI. At either dietary lysine level, increasing apparent digestible isoleucine improved (linear and quadratic, P<.01) ADG, ADFI, and F/G. However, ADG appeared to be maximized at 55% isoleucine in diets containing 1.00% apparent digestible lysine, whereas pigs fed 1.26% apparent digestible lysine maximized ADG at approximately 50% isoleucine. Pigs fed the diet containing 1.26% apparent digestible lysine had better (P<.01) ADG and F/G compared to pigs fed 1.00% apparent digestible lysine. Pigs fed the positive control diet containing 1.39% apparent digestible lysine had better growth performance (P<.06) from d 7 to 14 compared to pigs fed 1.26% apparent digestible lysine. This suggests that lysine was becoming colimiting in the diet with isoleucine.

From d 0 to 14, an isoleucine × lysine interaction (P<.06) was observed for ADFI. Pigs fed 1.00% apparent digestible lysine obtained optimal feed intake at 55% isoleucine; however, those fed 1.26% apparent digestible lysine achieved maximum feed intake at 50% isoleucine. The greatest response to increasing levels of isoleucine occurred as the apparent digestible isoleucine:lysine ratio increased from 45 to 50%, and further numeric improvements occurred as the ratio increased from 50 to 55% at the 1.00% apparent digestible level. Feeding 1.26% apparent digestible lysine improved (P<.02) ADG and F/G from d 0 to 14. Overall, the positive control fed 1.39% apparent digestible lysine had better (P<.02) ADG and F/G compared to pigs fed 1.26% apparent digestible lysine. This suggests that lysine was colimiting with isoleucine in the 1.26% apparent digestible lysine diet.

The plasma isoleucine concentration increased (linear, P<.01) with increasing dietary isoleucine (Table 4). The greatest response occurred as the isoleucine:lysine ratio increased from 50 to 55%. The plasma lysine concentration tended to decrease (quadratic, P<.07) as the ratio of isoleucine: lysine approached the pigs' requirement. This suggests that lysine was used more efficiently when the isoleucine:lysine ratio was not deficient or in excess of the level needed to obtain optimal growth. The greatest response with 1.00% apparent digestible lysine occurred as the isoleucine:lysine ratio increased from 50 to 55%; however, the greatest response at 1.26% lysine occurred as the ratio increased from 45 to 50%.

We then used break-point analysis to determine the isoleucine requirement. The broken-line method, which predicts requirements for the average animal in the population, predicted requirements of approximately 55% isoleucine:lysine at 1.00% apparent digestible lysine and approximately 50% isoleucine:lysine at 1.26% apparent digestible lysine to achieve optimal growth performance (Table 5). Calculation of the daily isoleucine intake requirement, using NRC 1998 equations based on actual BW and performance of all pigs in this experiment, estimated average requirements of 1.2 g/d isoleucine from d 0 to 7 and 2.3 g/d from d 7 to 14. The calculated isoleucine intake requirements that correlated with 55% isoleucine:lysine at 1.00% apparent digestible lysine were 1.2 g/d for d 0 to 7 and 2.5 g/d for d 7 to 14. The calculated requirements with 50% isoleucine:lysine at 1.26% apparent digestible lysine were 1.4 g/d for d 0 to 7 and 2.5 g/d for d 7 to 14.

Based on the results of this experiment, the optimal apparent digestible isoleucine: lysine ratio for the 15 lb SEW pig is between 50 to 55% of apparent digestible lysine.

Table 2. Calculated Composition of Control Diets[a,b], %

	Apparent Digestible Lysine, %			
	1.00		1.26	
Item, %	Total	Digestible	Total	Digestible
CP (N × 6.25)	16.12	—	20.35	—
Threonine	.81	.66	1.02	.83
Valine	.93	.79	1.17	.99
Methionine	.34	.30	.42	.37
Isoleucine	.53	.45	.67	.57
Leucine	1.61	1.40	2.02	1.77
Tyrosine	—	—	—	—
Phenylalanine	.83	.71	1.04	.90
Histidine	.56	.50	.71	.63
Lysine	1.17	1.00	1.47	1.26
Arginine	.85	.75	1.07	.95
Tryptophan	.25	.21	.32	.27
Ca, %	.90	—	.90	—
P, %	.88	—	.80	—

[a]Values were calculated from analyzed composition of corn, soybean meal, spray-dried plasma, blood meal, menhaden fish meal, and spray-dried whey.
[b]All amino acids in the positive control diets were the same with the exception of increased levels of lysine.

Table 3. Effects of Isoleucine:Lysine Ratio on Growth Performance of the Early-Weaned Pig

	Apparent Digestible Lysine, %																	
	1.00					1.26					1.10	1.39		Probability (P<)				
	Isoleucine, % of Lysine																	
Item	45	50	55	60	65	45	50	55	60	65	45	45	SEM	Iso*Lys	Lys	Iso	Linear	Quad
Day 0 to 7																		
ADG, lb	0.17	0.26	0.32	0.33	0.30	0.19	0.35	0.35	0.34	0.37	0.16	0.23	0.02	0.62	0.03	0.01	0.01	0.01
ADFI, lb	0.26	0.31	0.35	0.39	0.35	0.27	0.39	0.38	0.35	0.37	0.27	0.27	0.02	0.47	0.27	0.01	0.01	0.01
F/G	1.67	1.32	1.10	1.20	1.17	1.49	1.13	1.08	1.07	1.07	1.51	1.22	0.10	0.97	0.15	0.01	0.01	0.01
Day 7 to 14																		
ADG, lb	0.38	0.50	0.64	0.63	0.58	0.40	0.71	0.64	0.75	0.65	0.34	0.55[a]	0.02	0.04	0.01	0.01	0.01	0.01
ADFI, lb	0.52	0.64	0.79	0.78	0.78	0.49	0.79	0.73	0.81	0.70	0.52	0.58[b]	0.02	0.01	0.87	0.01	0.01	0.01
F/G	1.39	1.27	1.23	1.23	1.34	1.27	1.12	1.14	1.08	1.08	1.46	1.06[a]	0.03	0.29	0.01	0.01	0.01	0.01
Day 0 to 14																		
ADG, lb	0.27	0.38	0.48	0.48	0.44	0.29	0.53	0.50	0.54	0.51	0.25	0.39[a]	0.02	0.12	0.02	0.01	0.01	0.01
ADFI, lb	0.39	0.48	0.57	0.58	0.56	0.38	0.59	0.56	0.58	0.54	0.39	0.43	0.02	0.06	0.47	0.01	0.01	0.01
F/G	1.45	1.27	1.17	1.21	1.28	1.33	1.12	1.12	1.08	1.06	1.44	1.10[a]	0.03	0.48	0.01	0.01	0.01	0.01
Day 10																		
PUN, mg/dL	3.74	2.82	3.44	2.49	2.19	5.19	4.32	5.76	4.88	3.31	2.87	6.61[a]	0.51	0.64	0.01	0.01	0.01	0.14

Initial BW, 12.3 lb.

[a]Contrast vs 45% Iso at 1.26% Lysine (P<.02).

[b]Contrast vs 45% Iso at 1.26% Lysine (P<.06).

Table 4. Effects of Isoleucine:Lysine Ratio on Plasma Amino Acid Profile of the Early-Weaned Pig

	Apparent Digestible Lysine, %																	
	1.00					1.26					1.10	1.39		Probability (P<)				
	Isoleucine, % of Lysine																	
Item	45	50	55	60	65	45	50	55	60	65	45	45	SEM	Iso*Lys	Lys	Iso	Linear	Quad
Threonine	264	270	282	335	273	237	256	291	300	364	253	397[a]	31.3	0.38	0.82	0.18	0.02	0.85
Valine	307	310	290	326	281	297	311	328	316	308	240[b]	329	19.4	0.69	0.48	0.77	0.92	0.31
Methionine	51	52	43	40	43	61	51	55	53	46	37[b]	42[a]	4.5	0.47	0.01	0.13	0.01	0.66
Isoleucine	28	29	53	74	76	42	40	69	77	105	32	30	8.4	0.73	0.01	0.01	0.01	0.41
Leucine	216	204	195	211	182	205	222	218	213	202	158[b]	208	13.6	0.72	0.27	0.62	0.26	0.41
Tyrosine	92	95	81	83	80	100	87	92	80	96	75	121	7.6	0.53	0.36	0.41	0.14	0.28
Phenylalanine	79	85	82	77	75	83	73	87	77	77	64	79	6.0	0.57	0.95	0.65	0.35	0.54
Tryptophan	36	43	34	36	39	39	35	34	32	42	36	50[a]	2.7	0.21	0.46	0.09	0.93	0.05
Lysine	115	129	73	90	74	115	87	90	79	134	194[b]	262[a]	17.0	0.06	0.65	0.17	0.21	0.07
Histidine	101	95	85	83	75	101	86	82	80	74	72[b]	72[a]	6.6	0.97	0.47	0.01	0.01	0.50
Arginine	64	72	67	68	70	77	75	91	92	110	63	89	10.3	0.56	0.01	0.48	0.07	0.78

[a]Contrast vs 45% Iso at 1.26% Lysine (P<.05).
[b]Contrast vs 45% Iso at 1.00% Lysine (P<.05).

Table 5. Predicted Isoleucine:Lysine Ratio from Break-Point Analysis

	Apparent Digestible Lysine, %			
	1.00		1.26	
Item	Two-Slope[a]	One-Slope[b]	Two-Slope[a]	One-Slope[b]
Day 0 to 7				
ADG, lb	53.83	53.15	49.59	50.10
ADFI, lb	60.47	57.04	49.72	49.14
F/G	53.03	52.33	50.66	50.79
Day 7 to 14				
ADG, lb	56.20	54.86	49.56	49.29
ADFI, lb	55.00	55.00	49.89	49.16
F/G	53.24	50.14	48.17	50.67
Day 0 to 14				
ADG, lb	54.87	53.94	49.67	49.75
ADFI, lb	56.36	55.00	49.89	49.37
F/G	53.40	51.39	49.26	50.79
Plasma amino acids				
Isoleucine	42.32	61.76	48.73	—
Lysine	47.42	55.63	53.00	47.84

[a] $Y = L + U(R–X_{LR}) + V(X_{GR}–R)$, where L = the ordinate of the break point in the curve, R = the abscissa of the break point in the curve (the requirement estimate); X_{LR} = a value of X less than R; X_{GR} = a value of X greater than R; U = the slope of the line for X less than R; V = the slope of the line for X greater than R.
[b] $Y = L + U(R–X_{LR})$, where L = the ordinate of the break point in the curve, R = the abscissa of the break point in the curve (the reqirement estimate); X_{LR} = a value of X less than R; U = the slope of the line for X less than R.