THE OPTIMAL THREONINE:LYSINE RATIO TO MAXIMIZE GROWTH PERFORMANCE OF NURSERY PIGS

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Summary

A total of 210 pigs (initially 18.2 lb and 25 d of age) were used in a 21-d growth assay. The seven treatments consisted of a basal diet (14.1% CP) with increasing levels of threonine (45, 50, 55, 60, 65, and 70% of 1.07% apparent digestible lysine) and a negative control containing 0.97% lysine. Increasing dietary threonine improved feed efficiency; however, there was no improvement in growth performance between pigs fed 0.97 and 1.07% apparent digestible lysine. Therefore, these results suggest the requirement for apparent digestible threonine is approximately 60% of lysine for 18- to 40-lb pigs.

(Key Words: Threonine, Lysine, Nursery Pigs.)

Introduction

The current NRC (1998) requirements for a 22- to 44-lb pig suggest an apparent digestible threonine:lysine ratio of 60%. Because many practical diets used in the swine industry contain less than 60% apparent digestible threonine:lysine, supplementation of threonine to nursery diets has increased in recent years. The objective of this experiment was to determine the optimal ratio of threonine to lysine in diets to maximize growth performance of nursery pigs.

Procedures

Pigs were weaned at an average age of 21 d and fed a common diet for 7 d prior to the experimental diets. Pigs were housed in an environmentally controlled nursery. Temperature was maintained at 90°F for the 1st week and reduced by 5°F each week to maintain pig comfort. Each pen (4 ft^2 with slatted metal flooring) contained a stainless steel self-feeder and one nipple waterer to allow ad libitum consumption of feed and water.

Experimental diets were fed for 21 d. Pigs were weighed and feed disappearance measured every 7 d to determine ADG, ADFI, and F/G. Blood samples were obtained by venipuncture on d 14 from two randomly selected pigs in each pen following a 3-h period of feed deprivation. Plasma urea N (PUN) concentration was determined on each sample. Plasma from pigs in the same pen was pooled for amino acid analysis.

Corn, soybean meal, and spray-dried whey were analyzed for amino acids before diet formulation. The analyzed total amino acid levels and the apparent amino acid digestibility percentages from NRC (1998) were used to calculate the apparent digestible amino acid levels in each ingredient for diet formulation. Diets were corn-soybean meal-based and contained 8% spray-dried whey and 1.78% L-lactose (Table 1). Crystalline L-threonine was added to the basal diet (1.07% apparent digestible lysine; 14.1% CP) to provide 0.45, 0.50, 0.55, 0.60, 0.65, and 0.70 apparent digestible threonine:lysine. The negative control diet contained less L-lysine·HCl to provide 0.97% apparent digestible lysine and 0.77

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apparent digestible threonine:lysine to ensure that lysine was not above the pigs' requirement in the experimental diets. All other amino acids were formulated to 110% of the NRC (1998) requirements (Table 2). Diets were fed in meal form.

Data were analyzed in a randomized complete block design using the GLM procedures of SAS with pen as the experimental unit. Linear and quadratic polynomial contrasts were performed to determine the effects of increasing dietary threonine. Contrasts were performed to compare the negative control to the diet containing the same level of apparent digestible threonine (1.07% vs. 0.97% apparent digestible lysine). One-slope and two-slope, broken-line regression models were used to estimate the requirement of threonine to lysine. These ratios were estimated from the response curves of the least squares means.

Table 1. Basal Diet Composition (as-fed basis)[a]

Ingredient	%
Corn	66.41
Cornstarch[b]	0.27
L-lactose	1.78
Dried whey	8.00
Soybean meal (46.5% CP)	15.00
Choice white grease	3.00
Monocalcium phosphate (21% P)	1.05
Medication[c]	1.00
Zinc oxide	0.25
Limestone	1.00
Vitamin premix	0.30
Salt	0.30
Trace mineral premix	0.15
L-lysine·HCl	0.65
L-valine	0.23
DL-methionine	0.17
L-threonine	0.08
L-isoleucine	0.17
L-phenylalanine	0.09
L-tryptophan	0.06
L-histidine·HCl	0.04

[a]Diet was formulated to 45% apparent digestible threonine:lysine with all other amino acids meeting or exceeding 1998 NRC requirements.

[b]L-Threonine replaced cornstarch to provide 0.48, 0.54, 0.59, 0.64, 0.70, 0.75, and 0.75% apparent digestible threonine. This provided apparent digestible threonine:lysine ratios of 45, 50, 55, 60, 65, 70, and 77%.

[c]Provided 55 mg/kg carbadox.

Table 2. Calculated Composition of Basal Diet[a,b]

Item	%
CP (N × 6.25)	14.13
Calcium	0.69
Phosphorus	0.57
Total	
Arginine	0.81
Histidine	0.40
Isoleucine	0.71
Leucine	1.29
Lysine	1.21
Methionine	0.43
Phenylalanine	0.74
Threonine	0.61
Tryptophan	0.22
Valine	0.77
Apparent digestible	
Arginine	0.71
Histidine	0.34
Isoleucine	0.61
Leucine	1.12
Lysine	1.07
Methionine	0.40
Phenylalanine	0.64
Threonine	0.48
Tryptophan	0.18
Valine	0.73
True digestible[c]	
Arginine	0.73
Histidine	0.36
Isoleucine	0.63
Leucine	1.16
Lysine	1.12
Methionine	0.40
Phenylalanine	0.67
Threonine	0.51
Tryptophan	0.19
Valine	0.68

[a]Values were calculated from analyzed composition of corn, soybean meal, and spray-dried whey.

[b]All amino acids in the negative control diet were the same with the exception of decreased lysine (1.07 vs. 0.97% apparent digestible lysine).

Results

Pigs fed the negative control diet (0.97% apparent digestible lysine) had similar (P>0.10) growth performance as those fed

0.70 apparent digestible threonine:lysine and 1.07% lysine (Table 3). Although there was not a significant (P<0.12) main effect response to threonine, we observed a linear increase (P<0.02) in ADG as dietary threonine increased. This response occurred because ADG was relatively similar for pigs fed threonine from 45 to 60% of lysine, but greatest for pigs fed threonine at 65% of lysine. Feed intake tended to decrease and then increase (quadratic, P<0.09) with increasing levels of apparent digestible threonine. Feed efficiency improved (linear, P<0.01) as the ratio of apparent digestible threonine:lysine increased and appeared to plateau between 55% and 60% of lysine.

Plasma urea N, measured on d 14, tended to decrease (linear, P<0.08) with increasing apparent digestible threonine (Table 4). The greatest response occurred as the apparent digestible threonine to lysine ratio increased from 45% to 50%.

Plasma threonine concentration increased (linear, P<0.01) with increasing dietary threonine. Plasma lysine concentration was not different (P>0.10) for pigs fed varying levels of apparent digestible threonine; however, pigs fed the negative control had a lower (P<0.01) plasma lysine concentration than pigs fed the higher lysine diet. Plasma leucine, tyrosine, phenylalanine, histidine, and arginine concentrations decreased (linear, P<0.04) with increasing levels of dietary threonine.

The one-slope broken-line method (Table 5) predicted an apparent digestible threonine requirement of 52% of apparent digestible lysine for F/G. The two-slope broken-line method also predicted an apparent digestible threonine requirement 52% of apparent digestible lysine for F/G.

Discussion

Because there was no response to our negative control diet, the apparent digestible lysine requirement of pigs in this experiment may have been closer to 0.97%. This would indicate that the actual threonine:lysine requirement should be calculated by the level of apparent digestible threonine needed to obtain maximum growth performance on a ratio to the level of lysine in the negative control (0.97% apparent digestible lysine) rather than 1.07% apparent digestible lysine. Feed efficiency and PUN appeared to be optimized close to 0.55 threonine:lysine. If we assume that the negative control (0.97% apparent digestible lysine) was closer to the actual lysine requirement, these results suggest an apparent digestible threonine requirement of 57% of lysine for F/G.

The results of our experiments suggest that the apparent digestible threonine:lysine ratio for 18- to 40-lb pigs is not more than approximately 60%. This ratio is similar to the requirement suggested by the NRC (1998).

Table 3. Effect of Apparent Digestible Threonine:Lysine Ratio on Growth Performance of the Nursery Pig[a,b]

	Apparent Digestible Lysine, %											
	1.07						0.97					
	Threonine, % of Lysine								Probability (P<)			
Item	45	50	55	60	65	70	77	SEM	Lys	Thr	Linear	Quad
ADG, lb	0.97	0.98	1.01	0.99	1.07	0.98	1.06	0.03	0.94	0.12	0.02	0.76
ADFI, lb	1.77	1.68	1.67	1.61	1.80	1.73	1.83	0.05	0.22	0.23	0.82	0.09
F/G	1.82	1.71	1.65	1.63	1.68	1.77	1.73	0.04	0.14	0.06	0.01	0.06

[a]Initial BW, 18.2 lb.

[b]Values are means of six replications (pens) and five pigs per pen for the 21-d experiment.

Table 4. Effect of Apparent Digestible Threonine:Lysine Ratio on Plasma Amino Acid Profile and PUN of the Nursery Pig[a]

	Apparent Digestible Lysine, %											
	1.07						0.97					
	Threonine, % of Lysine								Probability (P<)			
Item	45	50	55	60	65	70	77	SEM	Lys	Thr	Linear	Quad
Amino acid, µm/L												
Threonine	77	173	256	591	674	959	1038	107.81	0.61	0.01	0.01	0.34
Arginine	128	96	104	82	92	92	95	8.40	0.78	0.02	0.01	0.06
Histidine	38	35	33	32	28	31	38	3.65	0.16	0.37	0.04	0.46
Isoleucine	139	145	148	135	142	131	158	7.61	0.02	5	0.35	0.35
Leucine	184	155	174	136	154	144	168	8.48	0.05	0.01	0.01	0.22
Lysine	213	238	206	232	217	226	138	23.90	0.01	0.10	0.90	0.96
Methionine	51	57	52	46	53	52	63	4.05	0.05	0.13	0.66	0.72
Phenylalanine	70	66	66	55	59	60	64	3.68	0.41	0.12	0.01	0.20
Tryptophan	49	46	48	44	45	45	49	2.70	0.31	0.69	0.22	0.54
Tyrosine	81	66	76	59	64	64	78	3.99	0.02	0.01	0.01	0.12
Valine	324	321	364	331	388	342	398	19.51	0.05	0.04	0.10	0.34
PUN, mg/dL	1.70	1.20	1.38	1.36	1.19	1.23	1.11	0.16	0.47	0.14	0.08	0.40

[a]Values are means of six replications (pens) of individual samples from two pigs per pen for PUN concentration and pooled samples from two pigs per pen for plasma amino acid concentrations.

Table 5. Predicted Apparent Digestible Threonine:Lysine Requirement from Break-Point Analysis

Item	One-Slope[a]	Two-Slope[b]
ADG	55.7	65.0
ADFI	48.3	57.8
F/G	52.1	52.4
PUN, mg/dL	64.4	65.2

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