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Determining the Effect of the Ratio of Tryptophan to Large Neutral Amino Acids on the Growth Performance of Finishing Pigs[1]

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Summary

A total of 96 pigs (PIC TR4 × 1050; initially 77.4 lb) were used in 2 14-d studies to determine the effect of standardized ileal digestible (SID) tryptophan to large neutral amino acids (LNAA) ratio on growth performance of finishing pigs. Pens of pigs were balanced by initial weight and randomly allotted to 1 of 4 dietary treatments in a completely randomized design with 4 pigs per pen and 6 replications per treatment. The treatment diets were fed in 2 phases: early finishing phase (77 to 106 lb BW) and late finishing phase (183 to 217 lb BW), with a common diet fed in between. Dietary treatments included: (1) a corn-soybean meal-based diet without DDGS, (2) a corn-soybean meal-based diet with 45% dried distillers grains with solubles (DDGS), (3) a corn-soybean meal-based diet without DDGS but supplemented with similar amounts of LNAA as the diet containing 45% DDGS, and (4) the LNAA-supplemented diet with added crystalline tryptophan to increase the SID tryptophan:LNAA ratio. The diets were formulated in a similar manner for the late finishing phase with the exception that DDGS were lowered to 30% of the diet. In the early finishing period (77 to 106 lb), pigs fed 45% DDGS diet had poorer F/G ($P = 0.01$) compared with pigs fed the other diets; however, no differences were found in other response criteria. During the late finishing period (183 to 217 lb), pig growth performance was not affected by dietary treatment. These results suggest that the high level of LNAA relative to tryptophan in diets containing 30% DDGS or greater may not be responsible for the apparent increase in the tryptophan requirement of finishing pigs seen in previous studies.

Key words: amino acids, large neutral amino acids, lysine, tryptophan, finishing pig

Introduction

Large neutral amino acids (LNAA; isoleucine, leucine, phenylalanine, tyrosine, and valine) compete with the transport of tryptophan through the intestinal cell membrane as well as the blood-brain barrier. Previous research[4] has indicated that high levels of LNAA in the diet may reduce feed intake unless tryptophan concentrations are increased. Thus, the high concentration of LNAA found in diets with DDGS might be responsible for any reduced growth performance and may also increase the tryptophan

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[4] Henry et al.1992. Interactive effects of dietary levels of tryptophan and protein on voluntary feed intake and growth performance in pigs, in relation to plasma free amino acids and hypothalamic serotonin. J. Anim. Sci. 70:1873-1887.

requirement to offset the competitive inhibition by LNAA for cell membrane transporters.

Thus, our objective in this pilot study was to compare a corn-soybean meal diet to diets with 45 or 30% DDGS, and to a diet with similar LNAA ratios supplemented with and without tryptophan. In addition, a second objective was to evaluate if the high concentration of LNAA provided by DDGS reduces growth performance and if adding tryptophan would improve the performance.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved procedures used in these experiments. These experiments were conducted in the growing-finishing research barn at the K-State Swine Teaching and Research Center. The facility is a totally enclosed, environmentally regulated, mechanically ventilated barn containing 40 pens (8 ft × 10 ft). The pens had adjustable gates facing the alleyway that allowed for 10 ft^2/pig. Each pen was equipped with a Farmweld (Teutopolis, IL) single-sided, dry self-feeder with 2 eating spaces located in the fence line and a cup waterer. Pens were located over a completely slatted concrete floor with a 4-ft pit underneath for manure storage. The facility was also equipped with a computerized feeding system (FeedPro; Feedlogic Corp., Willmar, MN) that delivered and recorded diets as specified. The equipment provided pigs with ad libitum access to food and water.

A total of 96 pigs (PIC TR4 × 1050) with an initial BW of 77.4 lb were used in 2 14-d studies. A similar number of barrows and gilts were placed in each pen with 4 pigs per pen and 6 pens per treatment. Pens of pigs were allotted at the start of the early finishing phase and re-allotted before the late finishing phase to 1 of 4 dietary treatments in a completely randomized design while balancing for BW. The treatment diets were fed in 2 phases, early finishing phase (77 to 106 lb BW) and late finishing phase (183 to 217 lb BW), with a common diet fed between the 2 phases. Treatments included (1) a corn soybean-meal-based diet without DDGS, (2) a corn-soybean meal-based diet with 45% DDGS, (3) a corn-soybean meal-based diet without DDGS but supplemented with similar amounts of LNAA as the diet containing 45% DDGS, and (4) the LNAA supplemented diet with added L-tryptophan to increase the SID tryptophan:LNAA ratio (Table 1). The 45% DDGS diet was supplemented with L-lysine HCl to provide a minimum SID tryptophan:lysine ratio of 16.5%. Crystalline isoleucine, valine, leucine, phenylalanine, and tyrosine were added to provide the LNAA. Treatment diets contained 16.5% SID tryptophan:lysine ratio except the last diet, to which crystalline tryptophan was added to achieve a ratio of 21.0%. The diets were formulated in a similar manner for the late finishing phase with the exception that the DDGS level was lowered to 30% (Table 2). The DDGS used in the 2 phases were not from the same lot but came from the same source. The SID tryptophan:LNAA ratios were 3.0 and 3.8% in early finishing phase and 3.1 and 4.1% in late finishing phase. Pens of pigs were weighed and feed disappearance was recorded at d 7 and 14 in each phase to determine ADG, ADFI, and F/G.

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 significance and tendencies were set at $P < 0.05$ and $P < 0.10$, respectively.

Results and Discussion

In the early finishing period (77 to 106 lb), pigs fed the 45% DDGS diet had poorer F/G ($P = 0.01$; Table 3) compared with pigs fed the other dietary treatments, which was a result of numerically lower ($P = 0.11$) ADG without a change in feed intake; however, no other differences occurred in other response criteria. During the late finishing period (183 to 217 lb), pig growth performance was not different among treatments (Table 4). These results indicate that late finishing pigs can tolerate 30% DDGS without reducing performance; however, performance was reduced when 45% DDGS was fed to early finishing pigs.

In the early and late finishing period, pigs fed the corn-soybean meal diet had similar growth performance as those fed corn soybean-meal and LNAA, indicating that a high concentration of LNAA in DDGS may not be responsible for the poor growth performance in pigs fed diets containing DDGS. Also, increasing the percentage of tryptophan:LNAA (3.1 to 4.1% and 3.0 to 3.8% in early and late finisher) diets containing high level of supplemented LNAA neither improved growth performance nor appeared to increase the pigs' requirement for tryptophan.

Table 1. Composition of diets (early finishing phase, 77 to 106 lb; as-fed basis)[1]

	Standardized ileal digestible (SID) tryptophan:LNAA, %[2]			
	3.8	3.0	3.0	3.8
SID tryptophan:lysine, %	16.5	16.5	16.5	21.0
Ingredient, %				
Corn	76.06	40.81	76.06	76.06
Soybean meal (46.5% CP)	19.94	11.78	19.94	19.94
DDGS[3]	---	45.00	---	---
Corn starch	1.28	---	0.05	---
Monocalcium P (21% P)	0.65	---	0.65	0.65
Limestone	0.95	1.35	0.95	0.95
Salt	0.35	0.35	0.35	0.35
Trace mineral premix	0.15	0.15	0.15	0.15
Vitamin premix	0.15	0.15	0.15	0.15
Lysine HCl	0.31	0.41	0.31	0.31
DL-Methionine	0.05	---	0.05	0.05
L-Threonine	0.11	---	0.11	0.11
L-Tryptophan	---	---	---	0.05
L-Isoleucine	---	---	0.10	0.10
L-Valine	---	---	0.18	0.18
L-Leucine	---	---	0.61	0.61
L-Phenylalanine	---	---	0.19	0.19
L-Tyrosine	---	---	0.15	0.15
Total	100	100	100	100

continued

Table 1. Composition of diets (early finishing phase, 77 to 106 lb; as-fed basis)[1]

	Standardized ileal digestible (SID) tryptophan:LNAA, %[2]			
	3.8	3.0	3.0	3.8
SID tryptophan:lysine, %	16.5	16.5	16.5	21.0
Calculated analysis				
SID amino acid, %				
Lysine	0.94	0.94	0.94	0.94
Isoleucine:lysine	60	71	71	71
Leucine:lysine	143	207	207	207
Methionine:lysine	31	36	31	31
Met & Cys:lysine	57	73	57	57
Threonine:lysine	65	66	65	65
Tryptophan:lysine	16.5	16.5	16.5	21.7
Valine:lysine	70	88	88	88
Phenylalanine:lysine	74	94	94	94
Tyrosine:lysine	53	69	69	69
Histidine:lysine	41	50	41	41
Total lysine, %	1.04	1.13	1.04	1.04
ME, kcal/lb	1,518	1,520	1,503	1,503
SID lysine:ME, g/Mcal	2.81	2.81	2.84	2.84
CP, %	16.1	21.6	16.4	16.4
Ca, %	0.57	0.58	0.57	0.57
P, %	0.49	0.52	0.49	0.49
Available P, %	0.29	0.38	0.29	0.29

[1] Treatment diets were fed for 14 d from 77 to 106 lb BW.
[2] Large neutral amino acids (isoleucine, leucine, phenylalanine, tyrosine, and valine).
[3] Dried distillers grains with solubles.

Table 2. Composition of diets (late finishing phase, 183 to 207 lb; as-fed basis)[1]

	Standardized ileal digestible (SID) tryptophan:LNAA, %[2]			
	4.1	3.1	3.1	4.1
SID tryptophan:lysine, %	16.5	16.5	16.5	21.0
Ingredient, %				
Corn	83.32	60.30	83.32	83.32
Soybean meal (46.5% CP)	13.19	7.59	13.19	13.19
DDGS[3]	---	30.00	---	---
Corn starch	0.84	---	0.03	---
Monocalcium P (21% P)	0.65	---	0.65	0.65
Limestone	0.95	1.15	0.95	0.95
Salt	0.35	0.35	0.35	0.35
Trace mineral premix	0.15	0.15	0.15	0.15
Vitamin premix	0.15	0.15	0.15	0.15
Lysine HCl	0.25	0.31	0.25	0.25
DL-Methionine	0.05	---	0.05	0.05
L-Threonine	0.11	---	0.11	0.11
L-Tryptophan	---	---	---	0.03
L-Isoleucine	---	---	0.06	0.06
L-Valine	---	---	0.11	0.11
L-Leucine	---	---	0.41	0.41
L-Phenylalanine	---	---	0.13	0.13
L-Tyrosine	---	---	0.11	0.11
Total	100	100	100	100

continued

Table 2. Composition of diets (late finishing phase, 183 to 207 lb; as-fed basis)[1]

	Standardized ileal digestible (SID) tryptophan:LNAA, %[2]			
	4.1	3.1	3.1	4.1
SID tryptophan:lysine, %	16.5	16.5	16.5	21.0
Calculated analysis				
SID amino acid, %				
Lysine	0.72	0.72	0.72	0.72
Isoleucine:lysine	63	72	72	72
Leucine:lysine	165	221	221	221
Methionine:lysine	36	38	36	36
Met & Cys:lysine	66	78	66	66
Threonine:lysine	72	68	72	72
Tryptophan:lysine	16.5	16.5	16.5	21.0
Valine:lysine	76	91	91	91
Phenylalanine:lysine	80	97	97	97
Tyrosine:lysine	56	70	70	70
Histidine:lysine	44	52	44	44
Total lysine, %	0.81	0.87	0.81	0.81
ME, kcal/lb	1,518	1,523	1,507	1,508
SID lysine:ME, g/Mcal	2.15	2.14	2.17	2.17
CP, %	13.6	17.1	13.7	13.7
Ca, %	0.55	0.49	0.55	0.55
P, %	0.46	0.43	0.46	0.46
Available P, %	0.29	0.30	0.29	0.29

[1] Treatment diets were fed for 14 d from 183 to 217 lb of pig BW.
[2] Large neutral amino acids (isoleucine, leucine, phenylalanine, tyrosine, and valine).
[3] Dried distillers grains with solubles.

Table 3. Effect of tryptophan (trp) to large neutral amino acid (LNAA) ratio on the growth performance of early finishing pigs (77 to 106 lb BW)[1]

Treatments[2]	Corn-SBM	45% DDGS	Corn-SBM +LNAA	Corn-SBM +LNAA+trp		
SID[3] trp:LNAA, %	3.8	3.0	3.0	3.8		
SID trp:lysine, %	16.5	16.5	16.5	21.0	SEM	Probability, $P <$
d 0 to 14						
ADG, lb	2.16	1.89	2.12	2.09	0.08	0.11
ADFI, lb	4.70	4.65	4.54	4.64	0.17	0.93
F/G	2.18[a]	2.48[b]	2.15[a]	2.22[a]	0.07	0.01
Pig wt, lb						
d 0	77.2	77.3	77.6	77.5	3.03	1.00
d 14	107.5	103.8	107.3	106.7	3.88	0.90

[a,b] Within a row, means without a common superscripts differ at $P < 0.05$.
[1] A total of 96 pigs (PIC TR4 × 1050, initially 77.4 lb) were used in a 14-d growing-finishing trial with 4 pigs per pen and 6 pens per treatment. Treatment diets were fed from 77.4 to 106 lb BW.
[2] Treatments included (1) a corn-soybean meal-based diet without DDGS, (2) a corn soybean-meal-based diet with 45% DDGS, (3) a corn-soybean meal-based diet without DDGS but supplemented with amounts of LNAA similar to a diet containing 45% DDGS, and (4) the LNAA-supplemented diet with added crystalline tryptophan to increase the SID tryptophan:LNAA ratio.
[3] Standardized ileal digestible.

Table 4. Effect of tryptophan to large neutral amino acid (LNAA) ratio on the growth performance of late finishing pigs (183 to 217 lb BW)[1]

Treatments[2]	Corn-SBM	30 % DDGS	Corn-SBM +LNAA	Corn-SBM +LNAA+trp		
SID[3] trp:LNAA, %	4.1	3.1	3.1	4.1		
SID trp:lys, %	16.5	16.5	16.5	21.0	SEM	Probability, $P <$
d 0 to 14						
ADG, lb	2.37	2.35	2.49	2.60	0.14	0.56
ADFI, lb	6.86	6.59	6.86	6.98	0.20	0.58
F/G	2.93	2.83	2.79	2.70	0.10	0.43
Pig weight, lb						
d 0	182.7	183.0	182.7	182.6	5.17	1.00
d 14	215.8	215.9	217.5	219.0	5.41	0.97

[1] A total of 96 pigs (PIC TR4 × 1050, initially 77.4 lb) were used in a 14-d growing-finishing trial with 4 pigs per pen and 6 pens per treatment. Treatment diets were fed from 183 to 217 lb BW.
[2] Treatments included (1) a corn-soybean meal-based diet without DDGS, (2) a corn soybean-meal-based diet with 30% DDGS, (3) a corn-soybean meal-based diet without DDGS but supplemented with amounts of LNAA similar to a diet containing 45% DDGS, and (4) the LNAA-supplemented diet with added crystalline tryptophan to increase the SID tryptophan:LNAA ratio.
[3] Standardized ileal digestible.