Evaluation of Deleting Crystalline Amino Acids from Low-CP, Amino Acid-Fortified Diets on Growth Performance of Nursery Pigs from 15 to 25 lb[1]

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Summary

A total of 294 nursery pigs (PIC TR4 × 1050, initially 15.2 lb, 3 d postweaning) were used in a 28-d trial to evaluate the effects on growth performance of eliminating specific crystalline amino acids from a low-CP, amino acid-fortified diet. On d 3 after weaning, pigs were allotted to 1 of 6 dietary treatments. 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. All diets were in meal form. The formulation was based on data from previous trials in which fish meal was replaced with crystalline amino acids in the diet for 15- to 25-lb pigs. The objective of this trial was to determine which amino acids are required in this low-CP, amino acid-fortified diet. The positive control diet contained L-lysine HCl, DL-methionine, L-threonine, L-isoleucine, L-tryptophan, L-valine, L-glutamine, and L-glycine. The 6 treatments were (1) positive control, (2) positive control with L-isoleucine deleted from the diet, (3) positive control with L-tryptophan deleted, (4) positive control L-valine deleted, (5) positive control with L-glutamine and L-glycine deleted, and (6) positive control with L-isoleucine, L-tryptophan, L-valine, L-glutamine, and L-glycine deleted from diet (negative control). There were 7 pigs per pen and 7 pens per treatment. Pigs and feeders were weighed on d 0, 7, 14, 21, and 28 to calculate ADG, ADFI, and F/G. From d 0 to 14, pigs fed the positive control diet had improved ($P < 0.03$) ADG and ADFI compared with pigs fed the negative control or diets with L-tryptophan or L-valine deleted, with pigs fed the diet without crystalline glutamine and glycine being intermediate. The pigs fed the diet containing no crystalline isoleucine had similar ($P > 0.40$) ADG, ADFI, and F/G to pigs fed the positive control, but had improved ($P < 0.03$) ADG compared to the pigs fed the other 4 diets. For unknown reasons, when the common diet was fed from d 14 to 28, the deletion of crystalline isoleucine in the previous period caused a decrease ($P < 0.01$) in ADG compared to the positive control. Pigs from the other treatment groups had similar ($P > 0.12$) ADG to the positive control. There were no differences ($P > 0.10$) in ADFI from d 14 to 28. Because of the decrease in ADG from d 0 to 14, pigs fed the negative control or diets without L-tryptophan or L-valine had decreased ($P < 0.04$) ADG for the overall trial (d 0 to 28) compared to pigs fed the positive control. ADFI from all treatment diets decreased compared to the positive control, although only the negative control group tested significantly ($P < 0.04$). There was no difference ($P > 0.24$) in F/G for the overall data. In conclusion, L-tryptophan and L-valine were needed in the low-CP, high amino acid-fortified

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nursery diet to achieve maximum growth performance from 15 to 25 lb. This suggests that the tryptophan:lysine and valine:lysine requirements are greater than 15 and 57% of lysine, respectively. The numerical decrease in performance when L-glutamine and L-glycine were removed from the diet during the first period suggests a need for nonessential nitrogen in the low-CP, amino acid-fortified diet or a benefit to one of these amino acids separate from its role as a nitrogen source.

Key words: amino acid requirement, glutamine, glycine, isoleucine, tryptophan, valine

Introduction

Several experiments have been conducted to replace expensive specialty protein sources (fish meal, blood products, poultry meal, etc.) with crystalline amino acids in the diet for 15- to 25-lb pigs. The experiments have yielded mixed results. A series of experiments have been conducted to determine the reason for inconsistency. Defining the minimum ratio for the key amino acids relative to lysine is essential to allow diet formulations with higher levels of crystalline amino acids and removal of the specialty protein sources. This will ensure that amino acid requirements relative to lysine are not responsible for the inconsistent responses.

Results from other experiments included in this publication have led to several conclusions about amino acid requirements of nursery pigs from 15 to 25 lb. A lysine titration test was first conducted to determine the standardized ileal digestible (SID) lysine level for optimal growth, which resulted in a value of 1.30% SID lysine. This lysine level was then used to perform an experiment that suggests fish meal can be replaced by crystalline amino acids when balanced for minimum amino acid requirements. Subsequently, the diet without fish meal and including crystalline amino acids was used in this study for further investigation. The object of this study was to determine if L-isoleucine, L-tryptophan, L-valine, and a combination of L-glutamine and L-glycine are required in the low-CP, amino acid-fortified diets for optimal growth performance of nursery pigs from 15 to 25 lb. Once the requirement of individual amino acids is determined, the base diet can be used to determine the ratio of those amino acids relative to lysine.

Procedure

The Kansas State University (K-State) 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 294 weanling pigs (PIC TR4 × 1050, initially 15.2 lb, 3 d postweaning) were used in a 28-d trial to evaluate the effects of eliminating specific crystalline amino acids from a low-CP, amino acid-fortified diet on growth performance. Pigs were weaned at approximately 21 d of age and allotted to pens by initial BW to achieve the same average pen weight for all pens. Pigs were fed a common pelleted, segregated early weaning diet for 3 d. On d 3 postweaning, pens were allotted to 1 of 6 dietary treatments. Thus, d 3 after weaning was d 0 of the experiment. There were 7 pigs per pen and 7 pens per treatment. Each pen contained a 4-hole, dry self-feeder and a nipple waterer to provide ad libitum access to feed and water. Pigs and feeders were weighed on d 0, 7, 14, 21, and 28 to calculate ADG, ADFI, and F/G.

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). The positive control diet contained L-lysine, DL-methionine, L-threonine, L-isoleucine, L-tryptophan, L-valine, L-glutamine, and L-glycine. The 6 treatments were (1) positive control, (2) positive control with L-isoleucine deleted from the diet, (3) positive control with L-tryptophan deleted, (4) positive control with L-valine deleted, (5) positive control with L-glutamine and L-glycine deleted, and (6) positive control with L-isoleucine, L-tryptophan, L-valine, L-glutamine, and L-glycine removed from diet. Treatment 6 served as the negative control diet. Treatment diets were corn-soybean meal-based and contained 10% dried whey. The common Phase-2 diet was a corn-soybean meal-based diet formulated to 1.26% SID lysine. All experimental diets were in meal form and were prepared at the K-State Animal Science Feed Mill.

Although analyzed lysine levels were lower than expected, amino acid analysis verified the removal of each individual crystalline amino acid in the experimental diets (Table 2).

At the conclusion of the experiment, data were analyzed as a completely randomized design with pen as the experimental unit. Analysis of variance was performed using the PROC MIXED procedure of SAS (SAS Institute, Inc., Cary, NC). Differences between treatments were determined using the PDIFF statement in SAS, with differences declared at $P < 0.05$.

Results and Discussion

From d 0 to 14 (treatment diet period), the pigs fed the positive control diet had increased ($P < 0.03$) ADG and ADFI compared with pigs fed the negative control diet or diets with L-tryptophan or L-valine deleted (Table 3). The pigs fed the diet containing no crystalline isoleucine had similar ($P > 0.40$) ADG, ADFI, and F/G as pigs fed the positive control, but had increased ($P < 0.03$) ADG compared to the pigs fed the other 4 diets. Pigs fed the diet without L-glutamine and L-glycine had intermediate performance. There were no differences ($P > 0.10$) in F/G between any of the treatments during the first period.

From d 14 to 28, when the common diet was fed, pigs fed the diet with L-isoleucine deleted during the previous period had decreased ($P < 0.01$) ADG and poorer ($P < 0.02$) F/G compared with the positive control. The reason for this response is unclear. Pigs in the other treatment groups had similar ($P > 0.12$) ADG and F/G to the positive control. There were no differences ($P > 0.10$) in ADFI.

Because of the decrease in ADG from d 0 to 14, pigs fed the negative control diet or diets without L-tryptophan or L-valine had decreased ($P < 0.04$) ADG for the overall trial (d 0 to 28) compared to the pigs fed the positive control. A numerical decrease in ADFI was shown from all treatment diets relative to the positive control, although the only significant ($P < 0.04$) comparison was the negative control group. There was no difference ($P > 0.24$) in F/G for the overall data.

In conclusion, L-tryptophan and L-valine were needed in low-CP, amino acid-fortified nursery diets to achieve maximum growth performance from 15 to 25 lb. This suggests that the tryptophan:lysine ratio of 15% in the diet without L-tryptophan was deficient,

which agrees with other data that suggest a tryptophan:lysine ratio requirement of 16.5%. Also, the valine:lysine ratio of 57% in the diet without L-valine was deficient, which is consistent with data from a subsequent experiment included in this publication, and suggests a valine:lysine ratio of approximately 65% is required for maximum growth. There also was a numerical decrease in performance in the pigs fed the diet without L-glutmaine and L-glycine compared to the positive control. This intermediate performance seems to indicate a benefit to glutamine or glycine either as a source of nonessential nitrogen or as an individual amino acid. Based on the results of this trial, further research should be conducted to determine the requirements for L-tryptophan, L-valine, and glutamine/glycine in a low-CP, amino acid-fortified diet for 15- to 25-lb pigs.

Table 1. Diet composition (as-fed basis)[1]

Item	Positive Control	Crystalline AA removed from the diet				Negative Control	Common Phase 2
		-Ile	-Trp	-Val	-Gly/Gln		
Ingredient, %							
Corn	58.15	58.15	58.15	58.15	58.15	58.15	65.05
Soybean meal (46.5% CP)	25.20	25.20	25.20	25.20	25.20	25.20	30.73
Spray-dried whey	10.00	10.00	10.00	10.00	10.00	10.00	---
Corn starch	---	0.10	0.07	0.16	1.26	1.59	---
Soybean oil	1.00	1.00	1.00	1.00	1.00	1.00	---
Monocalcium phosphate (21% P)	1.10	1.10	1.10	1.10	1.10	1.10	1.08
Limestone	0.90	0.90	0.90	0.90	0.90	0.90	0.95
Salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Zinc oxide	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
Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25
L-lysine HCl	0.533	0.533	0.533	0.533	0.533	0.533	0.360
DL-methionine	0.220	0.220	0.220	0.220	0.220	0.220	0.130
L-threonine	0.230	0.230	0.230	0.230	0.230	0.230	0.130
L-tryptophan	0.070	0.070	---	0.070	0.070	---	---
L-isoleucine	0.100	---	0.100	0.100	0.100	---	---
L-valine	0.160	0.160	0.160	---	0.160	---	---
Glutamine	0.630	0.630	0.630	0.630	---	---	---
Glycine	0.630	0.630	0.630	0.630	---	---	---
Phytase 600[2]	0.085	0.085	0.085	0.085	0.085	0.085	0.165
TOTAL	100	100	100	100	100	100	100
Calculated analysis							
Standardized ileal digestible amino acids (SID), %							
Lysine	1.30	1.30	1.30	1.30	1.30	1.30	1.26
Isoleucine:lysine	60	52	60	60	60	52	61
Leucine:lysine	111	111	111	111	111	111	129
Methionine:lysine	36	36	36	36	36	36	33
Met & Cys:lysine	58	58	58	58	58	58	58
Threonine:lysine	64	64	64	64	64	64	63
Tryptophan:lysine	20	20	15	20	20	15	17.4
Valine:lysine	70	70	70	57	70	57	68
Total lysine, %	1.42	1.42	1.42	1.42	1.42	1.42	1.39
ME, kcal/lb	1,516	1,516	1,516	1,516	1,516	1,516	1,503
SID lysine:ME, g/Mcal	5.27	5.28	5.27	5.28	5.23	5.24	3.80
CP, %	20.4	20.4	20.4	20.3	18.9	18.7	20.8
Ca, %	0.72	0.72	0.72	0.72	0.72	0.72	0.69
P, %	0.64	0.64	0.64	0.64	0.64	0.64	0.62
Available P, %	0.47	0.47	0.47	0.47	0.47	0.47	0.42

[1] Treatment diets were fed from d 0 to 14, and a common diet was fed from d 14 to 28.
[2] Phyzyme 600 (Danisco Animal Nutrition, St. Louis, MO) provided 231 FTU/lb, with a release of 0.10% available P.

Table 2. Analyzed nutrient composition of experimental diets (as-fed basis)[1]

Nutrient, %	Positive control	Crystalline AA removed from the diet				Negative control
		-Ile	-Trp	-Val	-Gly/Gln	
DM	88.71	88.27	88.85	89.37	88.70	89.31
CP	19.26	20.08	19.51	20.59	18.89	18.33
Indispensable AA						
Arg	1.23	1.32	1.24	1.32	1.34	1.29
His	0.40	0.40	0.40	0.42	0.40	0.39
Ile	0.72	0.68	0.73	0.81	0.76	0.72
Leu	1.39	1.41	1.37	1.45	1.42	1.41
Lys	1.16	1.26	1.20	1.28	1.23	1.30
Met	0.37	0.39	0.38	0.39	0.39	0.38
Phe	0.77	0.79	0.79	0.81	0.79	0.75
Thr	0.77	0.80	0.78	0.84	0.79	0.77
Trp	0.27	0.26	0.23	0.27	0.20	0.24
Val	0.84	0.89	0.88	0.80	0.87	0.78
Total indispensable AA	7.92	8.20	8.00	8.39	8.19	8.03
Dispensable AA						
Ala	0.81	0.82	0.79	0.84	0.82	0.79
Asp	1.54	1.60	1.52	1.68	1.60	1.54
Cys	0.24	0.25	0.24	0.26	0.25	0.25
Glu	3.21	3.42	3.37	3.46	3.08	2.82
Gly	1.09	1.18	1.14	1.17	0.72	0.60
Pro	0.96	1.24	1.26	0.93	0.92	1.25
Ser	0.78	0.80	0.76	0.82	0.79	0.77
Tyr	0.30	0.32	0.32	0.33	0.33	0.33
Total dispensable AA	8.93	9.63	9.40	9.49	8.51	8.35

[1] A representative sample of each diet was collected and analyzed for amino acid composition.

Table 3. Evaluation of deleting crystalline amino acids from low-CP, amino acid-fortified diets on growth performance in nursery pigs[1, 2]

	Positive control[3]	Crystalline AA removed from the diet				Negative control[4]	SEM
		-Ile	-Trp	-Val	-Gly/Gln		
d 0 to 14							
ADG, lb	0.67^{bc}	0.70^{c}	0.56^{a}	0.54^{a}	0.61^{ab}	0.54^{a}	0.030
ADFI, lb	0.93^{b}	0.95^{b}	0.81^{a}	0.76^{a}	0.86^{ab}	0.76^{a}	0.036
F/G	1.39	1.36	1.44	1.42	1.41	1.43	0.035
d 14 to 28							
ADG, lb	1.18^{b}	1.05^{a}	1.11^{ab}	1.15^{b}	1.17^{b}	1.15^{b}	0.031
ADFI, lb	1.88	1.77	1.78	1.83	1.90	1.80	0.056
F/G	1.59^{b}	1.69^{a}	1.60^{b}	1.59^{b}	1.62^{ab}	1.56^{b}	0.030
d 0 to 28							
ADG, lb	0.93^{b}	0.88^{ab}	0.84^{a}	0.85^{a}	0.89^{ab}	0.85^{a}	0.027
ADFI, lb	1.40^{b}	1.36^{ab}	1.29^{ab}	1.30^{ab}	1.38^{ab}	1.28^{a}	0.042
F/G	1.52	1.56	1.54	1.53	1.55	1.52	0.023
wt, lb							
d 0	15.2	15.2	15.1	15.2	15.2	15.1	1.011
d 14	24.6^{bc}	25.0^{c}	23.0^{a}	22.8^{a}	23.7^{ab}	22.7^{a}	3.273
d 28	41.1^{b}	39.7^{ab}	38.6^{a}	38.9^{a}	40.1^{ab}	38.8^{a}	5.472

[1] A total of 294 nursery pigs (initially 15.2 lb and 3 d postweaning) were used in a 28-d growth trial to evaluate the effects on growth performance of deleting crystalline amino acids from the diet.
[2] Treatment diets were fed from d 0 to 14 and a common diet fed from d 14 to 28.
[3] Contained crystalline lysine, methionine, threonine, isoleucine, tryptophan, valine, glutamine, and glycine.
[4] Positive control diet with removal of crystalline isoleucine, tryptophan, valine, glutamine, and glycine
[abc] Within a row, means without a common superscript differ ($P < 0.05$).