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Effect of total lysine:crude protein ratio on growth performance of nursery pigs from 15 to 25 lb

Abstract

A total of 282 nursery pigs (PIC TR4 Ã— 1050, initially 15.9 Â± 0.15 lb BW and 3 d postweaning) were used in a 28-d growth trial to evaluate the effects of total lysine:CP ratio, using fish meal as a source of non-essential N, on growth performance. Pigs were allotted to 1 of 6 dietary treatments. Each treatment had 5 replications with 7 pigs per pen and 2 replications with 6 pigs per pen. 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. All diets were in meal form. The 6 total lysine:CP ratios were 6.79, 6.92, 7.06, 7.20, 7.35, and 7.51%. From d 0 to 14, there was a trend for increased (quadratic; P < 0.09) ADG with an increasing dietary total lysine:CP ratio up to 7.35%, with poorer performance in pigs fed the greatest lysine:CP diet. Increasing the total lysine:CP ratio tended to improve (quadratic; P < 0.09) F/G for pigs fed 7.35%, with poorer F/G as total lysine:CP ratio increased to 7.51%. When a common diet was fed (d 14 to 28), there was no difference in ADG or F/G. A response (quadratic; P < 0.04) was detected for ADFI due to an increase in ADFI from the pigs fed the intermediate diets (7.06 and 7.20% total lysine:CP) during the previous period. Overall (d 0 to 28), there was a trend (quadratic; P < 0.07) for increased ADG and ADFI caused by the numerically highest values from pigs fed a total lysine:CP ratio of 7.35% and the numerically lowest values from pigs fed a total lysine:CP ratio of 7.51%. Dietary treatment did not influence F/G for the overall trial. These results indicated that feeding total lysine:CP ratio greater than 7.35% may decrease growth performance of nursery pigs.; Swine Day, Manhattan, KS, November 17, 2011

Keywords

Swine Day, 2011; Kansas Agricultural Experiment Station contribution; no. 12-064-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 1056; Swine; Fish meal; Lysine; Nonessential amino acids; Nursery pig

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Effect of Total Lysine:Crude Protein Ratio on Growth Performance of Nursery Pigs from 15 to 25 lb[1]

J. E. Nemechek, M. D. Tokach, S. S. Dritz[2], R. D. Goodband, J. M. DeRouchey, J. L. Nelssen, and J. Usry[3]

Summary
A total of 282 nursery pigs (PIC TR4 × 1050, initially 15.9 ± 0.15 lb BW and 3 d postweaning) were used in a 28-d growth trial to evaluate the effects of total lysine:CP ratio, using fish meal as a source of non-essential N, on growth performance. Pigs were allotted to 1 of 6 dietary treatments. Each treatment had 5 replications with 7 pigs per pen and 2 replications with 6 pigs per pen. 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. All diets were in meal form. The 6 total lysine:CP ratios were 6.79, 6.92, 7.06, 7.20, 7.35, and 7.51%. From d 0 to 14, there was a trend for increased (quadratic; $P < 0.09$) ADG with an increasing dietary total lysine:CP ratio up to 7.35%, with poorer performance in pigs fed the greatest lysine:CP diet. Increasing the total lysine:CP ratio tended to improve (quadratic; $P < 0.09$) F/G for pigs fed 7.35%, with poorer F/G as total lysine:CP ratio increased to 7.51%. When a common diet was fed (d 14 to 28), there was no difference in ADG or F/G. A response (quadratic; $P < 0.04$) was detected for ADFI due to an increase in ADFI from the pigs fed the intermediate diets (7.06 and 7.20% total lysine:CP) during the previous period. Overall (d 0 to 28), there was a trend (quadratic; $P < 0.07$) for increased ADG and ADFI caused by the numerically highest values from pigs fed a total lysine:CP ratio of 7.35% and the numerically lowest values from pigs fed a total lysine:CP ratio of 7.51%. Dietary treatment did not influence F/G for the overall trial. These results indicated that feeding total lysine:CP ratio greater than 7.35% may decrease growth performance of nursery pigs.

Key words: fish meal, lysine, nonessential amino acids, nursery pig

Introduction
Research has shown that increasing diet complexity improves growth performance of early nursery pigs; thus, these diets commonly contain specialty protein sources (fish meal, meat and bone meal, poultry meal, etc.). Although these products have been shown to positively influence growth compared with soybean meal, specialty protein sources are typically more expensive. The current trial was the fourth experiment of a series in which the primary objective was to determine the effect of replacing expensive specialty protein sources with crystalline amino acids (AA) on growth performance of nursery pigs. The first experiment was a lysine titration that established a standardized

[1] The authors wish to thank Ajinomoto Heartland LLC, Chicago, IL, for providing the synthetic amino acids used in diet formulation and partial financial support.

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ileal digestible (SID) lysine requirement of 1.30% for nursery pigs from 15 to 25 lb. The next experiment completely replaced fish meal with high amounts of crystalline AA with no negative effects on growth performance. This established a low-CP, AA-fortified diet that could then be used in subsequent experiments. By removing specific AA from the previously established diet, the third trial demonstrated that valine, tryptophan, and a source of nonessential AA are required in the low-CP, AA-fortified diet. Thus, in addition to essential AA, pigs must also be supplied with a source of nonessential AA to achieve optimal growth. One method of measuring the nonessential AA relative to essential AA in the diet is by calculating the lysine:CP ratio. Research has shown that, in pigs, the total CP in muscle typically contains about 6.5 to 7.5% lysine, providing an approximate range of dietary lysine:CP ratios to be used in the current experiment. Therefore, the objective of this experiment was to evaluate the maximum total lysine:CP ratio required for optimal growth performance.

Procedures

The Kansas State University 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 282 nursery pigs (PIC TR4 × 1050, initially 15.9 ± 0.15 lb BW) were used in a 28-d growth trial to evaluate the effects of the total lysine:CP ratio, using fish meal as a source of non-essential N, on growth performance. Pigs were weaned at 19.5 ± 1.4 d of age and fed a common pelleted starter diet for 3 d. At weaning, pigs were allotted to pens by initial BW to achieve the same average weight for all pens. On d 3 after weaning, pens were allotted randomly to 1 of 6 dietary treatments; thus, d 3 after weaning was d 0 of the experiment. Each treatment had 5 replications with 7 pigs per pen and 2 replications with 6 pigs per pen. All pens (4 × 5 ft) contained a 4-hole, dry self-feeder and a nipple waterer to provide ad libitum access to feed and water.

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. Treatment diets were corn-soybean meal-based and contained 10% dried whey and 1% soy oil. Diets were formulated to a predetermined SID lysine level of 1.30%. The 6 total lysine:CP ratios were 6.79, 6.92, 7.06, 7.20, 7.35, and 7.51% (Table 1). Crystalline L-Lysine, DL-Methionine, L-Threonine, L-Tryptophan, and L-Valine all increased as fish meal decreased to maintain minimum AA ratios of 58% Met & Cys:lysine, 64% threonine:lysine, 20% tryptophan:lysine, 52% isoleucine:lysine, and 70% valine:lysine. Large batches of the 6.79 and 7.51% total lysine:CP ratio diets were manufactured then blended at ratios of 80:20, 60:40, 40:60, and 20:80 to achieve the intermediate diets. The subsequent common diet for all the trials was a corn-soybean meal-based diet with no specialty protein sources, formulated to 1.26% SID lysine. All experimental diets were in meal form and were prepared at the K-State Animal Science Feed Mill. A subsample of all experimental diets was collected and analyzed for dietary AA by Ajinomoto Heartland LLC (Chicago, IL). Pigs and feeders were weighed on d 0, 7, 14, 21, and 28 to calculate ADG, ADFI, and F/G.

Experimental data were analyzed for linear and quadratic effects of increasing total lysine:CP ratio using the PROC MIXED procedure of SAS (SAS Institute Inc., Cary, NC). Pen was the experimental unit for all data analysis. Significant differences were declared at $P < 0.05$ and trends declared at $P < 0.10$.

Results and Discussion

From d 0 to 14, there was a trend for increased (quadratic; $P < 0.09$) ADG with increasing the total lysine:CP ratio up to 7.35%, with a 13% reduction in ADG when the ratio increased from 7.35 to 7.51% (Table 2). Increasing the total lysine:CP ratio tended to decrease (quadratic; $P < 0.09$) F/G for pigs fed 7.35%, with 7% poorer F/G as total lysine:CP ratio increased to 7.51%.

From d 14 to 28, there was no difference in ADG or F/G. A response (quadratic; $P < 0.04$) was observed for ADFI, which was the result of an increase in ADFI from the pigs fed the intermediate diets (7.06 and 7.20% total lysine:CP ratio) during the previous period (Table 2).

Overall (d 0 to 28), there was a trend (quadratic; $P < 0.07$) for increased ADG and ADFI caused by the numerically highest values from pigs fed a total lysine:CP ratio of 7.35% and the numerically lowest values from pigs fed a total lysine:CP ratio of 7.51% (Table 2). Dietary treatment did not influence F/G for the overall trial. These results indicated that feeding total lysine:CP ratio greater than 7.35% may decrease growth performance of nursery pigs. These data are consistent with reports of muscle composition of pigs which consist of approximately 6.5 to 7.5% lysine:CP.

Table 1. Diet composition (as-fed basis)

Item	Total lysine:CP ratio, %[2]						Common Phase 2[1]
	6.79	6.92	7.06	7.20	7.35	7.51	
Ingredient, %							
Corn	56.58	57.19	57.79	58.40	59.01	59.62	65.05
Soybean meal (46.5% CP)	25.21	25.18	25.16	25.14	25.11	25.09	30.73
Spray-dried whey	10.00	10.00	10.00	10.00	10.00	10.00	---
Select menhaden fish meal	4.50	3.60	2.70	1.80	0.90	---	---
Soybean oil	1.00	1.00	1.00	1.00	1.00	1.00	---
Monocalcium phosphate (21% P)	0.51	0.63	0.75	0.86	0.98	1.10	1.08
Limestone	0.55	0.62	0.69	0.76	0.83	0.90	0.95
Salt	0.30	0.31	0.32	0.33	0.34	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	0.275	0.327	0.378	0.430	0.481	0.533	0.360
DL-Methionine	0.124	0.143	0.162	0.182	0.201	0.220	0.130
L-Threonine	0.136	0.155	0.174	0.192	0.211	0.230	0.130
L-Tryptophan	0.046	0.051	0.056	0.060	0.065	0.070	---
L-Valine	0.037	0.062	0.086	0.111	0.135	0.160	---
Phytase[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 (SID) amino acids, %							
Lysine	1.30	1.30	1.30	1.30	1.30	1.30	1.26
Isoleucine:lysine	60	59	57	55	54	52	61
Leucine:lysine	125	122	120	117	114	112	129
Methionine:lysine	35	35	35	36	36	37	33
Met & Cys:lysine	58	58	58	58	58	58	58
Threonine:lysine	64	64	64	64	64	64	63
Tryptophan:lysine	20	20	20	20	20	20	17.4
Valine:lysine	70	70	70	70	70	70	68
Total lysine, %	1.43	1.43	1.43	1.43	1.42	1.42	1.39
ME, kcal/lb	1,528	1,526	1,524	1,522	1,520	1,518	1,503
SID Lys:ME, g/Mcal	3.86	3.86	3.87	3.87	3.88	3.89	3.80
CP, %	21.1	20.6	20.2	19.8	19.4	18.9	20.8
Ca, %	0.72	0.72	0.72	0.72	0.72	0.72	0.69
P, %	0.65	0.65	0.65	0.65	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 5,231 FTU/lb, with a release of 0.10% available P.

Table 2. Evaluation of total lysine:CP ratio on growth performance in nursery pigs

	Total lysine:CP ratio, %							Probability, P <	
	6.79	6.92	7.06	7.20	7.35	7.51	SEM	Linear	Quadratic
d 0 to 14									
ADG, lb	0.76	0.79	0.79	0.79	0.85	0.74	0.025	0.72	0.09
ADFI, lb	1.06	1.11	1.10	1.08	1.18	1.09	0.033	0.20	0.39
F/G	1.38	1.41	1.39	1.38	1.38	1.48	0.025	0.08	0.08
d 14 to 28									
ADG, lb	1.13	1.13	1.16	1.18	1.13	1.12	0.030	0.90	0.19
ADFI, lb	1.81	1.85	1.86	1.87	1.85	1.75	0.042	0.38	0.04
F/G	1.60	1.65	1.61	1.58	1.64	1.57	0.025	0.31	0.42
d 0 to 28									
ADG, lb	0.95	0.96	0.97	0.98	0.99	0.93	0.024	0.91	0.07
ADFI, lb	1.43	1.48	1.48	1.47	1.51	1.42	0.031	0.92	0.07
F/G	1.51	1.55	1.52	1.50	1.53	1.53	0.020	0.99	0.73
BW, lb									
d 0	15.3	15.3	15.3	15.4	15.3	15.2	3.18	0.97	0.87
d 14	25.5	25.9	25.9	25.9	26.7	25.2	6.32	0.92	0.46
d 28	40.8	41.1	41.5	41.8	41.9	40.3	10.6	0.99	0.44

[1] A total of 282 nursery pigs (PIC TR4 × 1050) were used in a 28-d growth trial to evaluate the effects of total Lys:CP ratio on growth performance. Values represent the means of 7 pens per treatment.
[2] Treatment diets were fed from d 0 to 14 and a common diet fed from d 14 to 28.

Effect of Replacing Commonly Used Specialty Protein Sources with Crystalline Amino Acids on Growth Performance of Nursery Pigs from 15 to 25 lb[1]

J. E. Nemechek, M. D. Tokach, S. S. Dritz[2], R. D. Goodband, J. M. DeRouchey, J. L. Nelssen, and J. Usry[3]

Summary

A total of 282 nursery pigs (PIC TR4 × 1050, initially 14.5 ± 0.13 lb BW and 3 d postweaning) were used in a 28-d growth trial to determine the effects of replacing high amounts of specialty protein sources with crystalline amino acids (AA) on growth performance of nursery pigs from 15 to 25 lb. Pigs were allotted to 1 of 6 dietary treatments arranged as a 2 × 3 factorial treatment structure. Each treatment had 5 replications with 7 pigs per pen and 2 replications with 6 pigs per pen. 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. All diets were in meal form. Pens were assigned 1 of 3 specialty protein sources with either a low or high crystalline AA level. Thus, diets included either select menhaden fish meal (4.50 vs. 1.00%), porcine meat and bone meal (6.00 vs. 1.20%), or pet food-grade poultry meal (6.00 vs. 1.05%).

From d 0 to 14, pigs fed high crystalline AA had improved ($P < 0.04$) ADG compared with pigs fed the low crystalline AA diets. There was no difference in ADG among pigs fed fish meal, meat and bone meal, or poultry meal. Average daily feed intake and F/G were similar between pigs fed different crystalline AA concentrations or different protein sources. From d 14 to 28, there were no differences in ADG and ADFI between pigs previously fed different crystalline AA levels. There was a tendency for improved ($P < 0.04$) F/G for pigs previously fed fish meal during Phase 1 compared with pigs fed diets containing meat and bone meal or poultry meal. There was no difference between pigs previously fed different crystalline AA concentrations during Phase 2. Overall (d 0 to 28), dietary crystalline AA had no impact on ADG, ADFI, or F/G. Pigs fed diets containing fish meal from d 0 to 14 tended to have improved ADG for the overall trial compared with pigs fed diets containing meat and bone meal or poultry meal. There were no differences in ADFI or F/G among pigs fed different protein sources. These data suggest that crystalline AA can be used to replace specialty protein sources in nursery pig diets without negatively influencing growth.

Key words: crystalline amino acids, nonessential amino acid, nursery pig, protein source

[1] The authors wish to thank Ajinomoto Heartland LLC, Chicago, IL, for providing the synthetic amino acids used in diet formulation and partial financial support.

[2] Department of Diagnostic Medicine/Pathobiology, College of Veterinary Medicine, Kansas State University.

[3] Ajinomoto Heartland LLC, Chicago, IL.

Introduction
Several experiments have been conducted to evaluate replacing expensive specialty protein sources with crystalline AA in diets for nursery pigs. Because variable results have been observed among trials, a series of experiments has been conducted at Kansas State University to determine the reason for the inconsistent response. The current trial was the sixth experiment of the series and was conducted to validate the concepts developed in the previous experiments. These concepts included: (1) at least 1.30% standardized ileal digestible (SID) lysine is required for optimal growth, (2) high amounts of crystalline AA can replace select menhaden fish meal with no negative effects on growth performance, (3) supplementation of valine, tryptophan, and nonessential AA is required in low-CP, AA-fortified nursery pig diets, (4) a total lysine:CP ratio no greater than 7.35% should be fed for optimal growth, and (5) at least 65% SID valine:lysine should be fed for maximum growth performance of nursery pigs. In addition to validating the concepts developed from the previous experiments, the objective of this experiment was to determine the effects of replacing high amounts of specialty protein sources with crystalline AA on growth performance of nursery pigs from 15 to 25 lb.

Procedures
The Kansas State University 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 282 nursery pigs (PIC TR4 × 1050, initially 14.5 ± 0.13 lb BW) were used in a 28-d growth trial to evaluate the effects of replacing high amounts of specialty protein sources with crystalline AA on growth performance. Pigs were weaned at approximately 21 d of age and fed a common pelleted starter diet for 3 d. At weaning, pigs were allotted to pens by initial BW to achieve the same average weight for all pens. On d 3 after weaning, pens were allotted randomly to 1 of 6 dietary treatments; thus, d 3 after weaning was d 0 of the experiment. Each treatment had 5 replications with 7 pigs per pen and 2 replications with 6 pigs per pen. All pens (4 × 5 ft) contained a 4-hole, dry self-feeder and a nipple waterer to provide ad libitum access to feed and water.

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. Treatment diets were corn-soybean meal-based and contained 10% dried whey and 1% soy oil. Diets were formulated to a predetermined SID lysine level of 1.30%. Pens were assigned 1 of 3 specialty protein sources with either a low or high crystalline AA level. Thus, diets included either select menhaden fish meal (4.50 vs. 1.00%), porcine meat and bone meal (6.00 vs. 1.20%), or pet food-grade poultry meal (6.00 vs. 1.05%; Table 1). Specialty protein sources were included at low levels in the high crystalline AA diets to ensure a total lysine:CP ratio no greater than 7.36%. Appropriate amounts of crystalline AA were added to treatment diets to maintain SID AA ratios relative to lysine of 52% isoleucine, 58% methionine and cysteine, 62% threonine, 16.4% tryptophan, and 65% valine. The subsequent common diet for all the trials was a corn-soybean meal-based diet with no specialty protein sources, formulated to 1.26% SID lysine. All experimental diets were in meal form and were prepared at the K-State Animal Science Feed Mill. Pigs and feeders were weighed on d 0, 7, 14, 21, and 28 to calculate ADG, ADFI, and F/G.

Experimental data were analyzed using analysis of variance as a 2 × 3 factorial with 2 crystalline AA levels and 3 specialty protein sources. Differences between treatments were determined using the PDIFF statement in SAS (SAS Institute, Inc., Cary, NC). Significant differences were declared at $P < 0.05$ and trends declared at $P < 0.10$. Pen was the experimental unit for all data analysis.

Results and Discussion

From d 0 to 14 (experimental treatment period), pigs fed high crystalline AA had improved ($P < 0.04$) ADG compared with pigs fed the low crystalline AA diets (Table 2). There was no difference in ADG among pigs fed fish meal, meat and bone meal, or poultry meal. Average daily feed intake and F/G were similar among pigs fed different crystalline AA concentrations or different protein sources during the first period.

From d 14 to 28, when the common diet was fed, there were no differences in ADG or ADFI between pigs previously fed different crystalline AA concentrations in place of specialty protein sources. Average daily gain tended ($P < 0.09$) to decrease for pigs previously fed meat and bone meal and ADFI tended ($P < 0.09$) to increase for pigs previously fed poultry meal. These tendencies resulted in improved ($P < 0.04$) F/G for pigs previously fed fish meal during Phase 1 compared with pigs fed diets containing meat and bone meal or poultry meal. There were no differences among pigs fed different crystalline AA levels during the second period.

Overall (d 0 to 28), dietary crystalline AA had no impact on ADG, ADFI, or F/G. Pigs fed diets containing fish meal from d 0 to 14 tended to have improved ADG for the overall trial compared with pigs fed diets containing meat and bone meal or poultry meal. There was no difference in ADFI or F/G among pigs fed different protein sources. There were no interactions between dietary treatments during any phases. These data suggest that crystalline AA can be used to replace specialty protein sources in nursery pig diets without negatively influencing growth.

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

	Crystalline amino acid (AA) level (Phase 1)[2]						
	Low			High			
Item	Fish meal	Meat and bone meal	Poultry meal	Fish meal	Meat and bone meal	Poultry meal	Common (Phase 2)[3]
Ingredient, %							
Corn	56.72	56.03	54.54	59.01	59.07	58.98	65.05
Soybean meal (46.5% CP)	25.20	25.20	25.20	25.27	25.20	25.20	30.73
Spray-dried whey	10.00	10.00	10.00	10.00	10.00	10.00	---
Select menhaden fish meal	4.50	---	---	1.00	---	---	---
Meat and bone meal	---	6.00	---	---	1.20	---	---
Poultry meal	---	---	6.00	---	---	1.00	---
Soybean oil	1.00	1.00	1.00	1.00	1.00	1.00	---
Monocalcium phosphate (21% P)	0.50	---	0.40	1.00	0.85	1.00	1.08
Limestone	0.55	---	0.40	0.75	0.65	0.75	0.95
Salt	0.30	0.30	0.30	0.30	0.30	0.30	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	0.275	0.385	0.310	0.470	0.500	0.495	0.360
DL-Methionine	0.125	0.180	0.140	0.200	0.205	0.200	0.130
L-Threonine	0.100	0.140	0.100	0.175	0.195	0.190	0.130
L-Tryptophan	---	0.010	---	0.018	0.020	0.020	---
L-Valine	---	0.015	---	0.070	0.080	0.075	---
Phytase[4]	0.085	0.085	0.085	0.085	0.085	0.085	0.165
Total	100	100	100	100	100	100	100

continued

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

	Crystalline amino acid (AA) level (Phase 1)[2]						
	Low			High			
Item	Fish meal	Meat and bone meal	Poultry meal	Fish meal	Meat and bone meal	Poultry meal	Common (Phase 2)[3]
Calculated analysis							
Standardized ileal digestible (SID) AA, %							
Lysine	1.30	1.30	1.30	1.30	1.30	1.30	1.26
Isoleucine:lysine	60	57	60	54	53	54	61
Leucine:lysine	125	121	125	115	114	114	129
Methionine:lysine	35	36	34	36	36	36	33
Met & Cys:lysine	58	58	58	58	58	58	58
Threonine:lysine	62	62	62	62	62	62	63
Tryptophan:lysine	16.7	16.4	16.5	16.5	16.4	16.5	17.4
Valine:lysine	67	65	66	65	65	65	68
Total lysine, %	1.43	1.45	1.46	1.42	1.43	1.43	1.39
ME, kcal/lb	1,528	1,514	1,516	1,520	1,518	1,518	1,503
SID lysine:ME, g/Mcal	3.86	3.89	3.89	3.88	3.88	3.88	3.80
CP, %	21.0	21.4	22.4	19.4	19.4	19.4	20.8
Total lysine:CP, %	6.82	6.78	6.53	7.35	7.36	7.36	6.68
Ca, %	0.71	0.78	0.71	0.70	0.70	0.70	0.69
P, %	0.65	0.70	0.65	0.65	0.65	0.65	0.62
Available P, %	0.47	0.50	0.47	0.48	0.47	0.47	0.42

[1] A total of 282 nursery pigs (PIC TR4 × 1050) were used in a 28-d trial to evaluate the effects of replacing high amounts of fish meal, meat and bone meal, and poultry meal with crystalline AA on growth performance.
[2] Treatment diets were fed from d 0 to 14.
[3] Common diet was fed from d 14 to 28.
[4] Phyzyme 600 (Danisco Animal Nutrition, St. Louis, MO) provided 509 FTU/kg, with a release of 0.10% available P.

Table 2. Comparison of replacing different specialty protein sources with crystalline amino acids (AA) on growth performance in nursery pigs[1,2]

	Crystalline AA level[3,4]								
	Low			High				Probability[5], P <	
	Fish meal	Meat and bone meal	Poultry meal	Fish meal	Meat and bone meal	Poultry meal	SEM	Protein source	Low AA vs. high AA
d 0 to 14									
ADG, lb	0.54	0.49	0.52	0.57	0.54	0.57	0.026	0.19	0.04
ADFI, lb	0.81	0.77	0.81	0.84	0.82	0.84	0.032	0.29	0.14
F/G	1.51	1.56	1.56	1.48	1.51	1.47	0.033	0.45	0.15
d 14 to 28									
ADG, lb	1.15	1.12	1.13	1.14	1.06	1.14	0.031	0.09	0.42
ADFI, lb	1.83	1.82	1.89	1.82	1.77	1.86	0.046	0.09	0.38
F/G	1.60	1.63	1.67	1.60	1.68	1.64	0.025	0.04	0.89
d 0 to 28									
ADG, lb	0.84	0.81	0.83	0.86	0.80	0.85	0.024	0.08	0.57
ADFI, lb	1.32	1.30	1.35	1.33	1.29	1.35	0.036	0.13	0.96
F/G	1.57	1.61	1.63	1.56	1.62	1.58	0.027	0.16	0.40
Weight, lb									
d 0	14.5	14.5	14.5	14.6	14.5	14.5	0.059	0.99	1.00
d 14	22.1	21.5	21.8	22.5	22.1	22.2	0.176	0.59	0.46
d 28	38.1	37.1	37.7	38.5	36.9	37.8	0.328	0.39	0.94

[1] A total of 282 nursery pigs (PIC TR4 × 1050) were used in a 28-d growth trial to evaluate the effects of replacing high amounts of specialty protein sources with crystalline AA on growth performance of nursery pigs. Values represent the means of 7 pens per treatment.
[2] Treatment diets were fed from d 0 to 14 and a common diet fed from d 14 to 28.
[3] Pigs were fed either a low or a high crystalline AA level.
[4] Pigs were fed fish meal, meat and bone meal, or poultry meal.
[5] There were no dietary interactions between treatments.