2000 Animal Science Research Report

Pages 147-153

Effects of Providing Amino Acids from Whey Protein Concentrate or Crystalline Amino Acids on The Performance of Conventionally Weaned Pigs

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Story in Brief

Two experiments were conducted to evaluate the potential for crystalline amino acid (CAA) substitutions for whey protein concentrate in weanling pig diets. Pigs were allotted in each study to one of five dietary treatments. Experimental diets were fed for the first 2 wk postweaning, followed by a common Phase 2 (d 14 to 28) and Phase 3 (d 28 to 42) diet. In Exp. 1, pigs were allotted randomly to five dietary treatments arranged in a 2 x 2 factorial with a negative control. The five dietary treatments consisted of a negative control (1.01% digestible lysine) with two additional dietary lysine concentrations (1.22 and 1.43% digestible lysine) provided by whey protein concentrate or CAA. In general, increasing dietary lysine with either whey protein concentrate or crystalline amino acids improved growth performance. However, the magnitude of improvement in growth performance was smaller for pigs fed CAA as compared with pigs fed whey protein concentrate. In Exp. 2, 108 pigs were allotted randomly to five dietary treatments. Dietary treatments consisted of a negative control diet, the negative control diet with CAA additions to provide 1.15, 1.30, and 1.45% digestible lysine, and a positive control diet containing whey protein concentrate (1.45% digestible lysine). Growth performance was improved for pigs fed the positive control diet compared with pigs fed the negative control diet. Increasing lysine with CAA improved growth performance, but this increase was not of the same magnitude as observed for pigs fed the positive control diet. Plasma urea nitrogen concentrations were reduced markedly with crystalline amino acid addition.

Key Word: Crystalline Amino Acids, Whey Protein Concentrate, Pigs

Introduction

Substituting crystalline amino acids for natural protein sources offers the potential to reduce cost and avoid amino acid excesses. Also, supplementation of crystalline amino acids may be used to increase intakes of specific amino acids. Studies have shown that adding crystalline amino acids to low protein, Phase 1 nursery diets decreased average daily gain and feed:gain (Davis et al., 1997). These results may have been due to an amino acid imbalance or limited nitrogen for synthesis of disposable amino acids (Chung et al, 1999). Chung et al. (1999) also concluded that the addition of crystalline amino acids decreased ADG and feed efficiency. However, the addition of specific amino acids to an ideal mixture of crystalline amino acids in the diet tended to improve growth performance. Owen et al. (1995) reported that the addition of crystalline amino acids to the diet would result in acceptable performance when the diet contained wheat gluten. An explanation for the inconsistent performance in previous experiments is that the protein source used may affect the response to crystalline amino acid supplementation. The objectives of these studies were to evaluate the efficacy of replacing whey protein concentrate (WPC, 77% CP) with crystalline amino acids in the diets of weanling pigs on growth performance and blood metabolites.

Materials and Methods

In Exp. 1, 110 pigs were blocked by weight and sex and randomly allotted to one of five dietary treatments. Treatments were arranged in a 2 x 2 factorial array with a negative control. The negative control diet (NC; Diet 1) was a corn-soybean meal-dried whey based diet containing spray-dried plasma and blood meal and it was formulated to contain 1.01% digestible lysine (Table 1). Diets 2 through 5 were formulated by adding either whey protein concentrate (WPC) or crystalline amino acids (CAA) to the negative control diet to provide two dietary digestible lysine levels (1.22 and 1.43%). All diets were formulated on a digestible lysine basis. Crystalline amino acids were added to each diet as needed to provide a minimum ratio of essential amino acids to lysine. Experimental diets were fed during Phase 1 (d 0 to 14). There were four pens per treatment of 4 to 5 pigs per pen.

In Exp. 2, 108 pigs were blocked by weight and sex and randomly allotted to one of five dietary treatments with four pens per treatment of four to five pigs per pen. The negative control diet (Diet 1) was similar to that used in Exp. 1 and contained 1.00% digestible lysine (Table 2). Diets 2 through 4 consisted of three levels of digestible lysine (1.15, 1.30 and 1.45%) provided by L-lysine HCl. Other crystalline amino acids were added similar to that explained in Exp. 1. Diet 5 served as the positive control diet (WPC; 1.45% dig. lysine) and was similar to Diet 4 used in Exp. 1.

Both experiments were conducted in an environmentally controlled nursery with room temperature maintained at 86oF, and decreased by 2oF weekly until the room temperature reached 78oF. Pigs were housed in elevated pens with wire flooring and had ad libitum access to feed and water. Pig weight and feed intake were measured weekly and average daily gain (ADG), average daily feed intake (ADFI), and feed:gain (F:G) were calculated. In Exp. 2, blood samples were taken from each pig on d 14 of the experiment and analyzed for plasma urea nitrogen (PUN), albumin, total protein, and ammonia.

In Exp. 1, data were analyzed as a 2 x 2 factorial with a negative control in a randomized complete block design. Pen was used as the experimental unit. Blocks were based on initial body weight. The effects of lysine level (1.01, 1.22, 1.43%), lysine source (WPC vs CAA), and the lysine level x lysine source interaction were tested using orthogonal contrasts. The design of Exp. 2 was similar to Exp. 1 (randomized complete block). The linear and curvilinear effects of increasing lysine from CAA were partitioned using orthogonal polynomial contrasts. The remaining degree of freedom contrast tested the effect of the negative control diet (Diet 1) vs the positive control diet (Diet 5).

Results and Discussion

In Exp. 1, increasing digestible lysine resulted in an improvement ($P<.01$) in ADG from d 0 to 7 (Table 3). There also was a trend ($P<.15$) for pigs fed CAA to grow slower than pigs fed WPC. Feed intake was not affected ($P>.10$) by either AA source or level of lysine. Feed:gain decreased ($P<.10$) as digestible lysine increased and pigs fed WPC had improved ($P<.10$) feed:gain ratios compared with pigs fed CAA.

From d 7 to 14, ADG and ADF increased ($P<.10$) and F:G decreased ($P<.10$) in a linear fashion with increasing dietary lysine. However, the decrease in F:G was more pronounced in pigs fed WPC compared with pigs fed CAA (lysine level x lysine source, $P<.10$).

For d 0 to 14, ADG and feed efficiency improved ($P<.10$) with increasing levels of lysine. Furthermore, pigs fed WPC had better ($P<.10$) ADG and F:G compared with pigs fed CAA. The improvement in F:G associated with increasing lysine was more pronounced in pigs fed WPC compared with pigs fed CAA (lysine level x lysine source, $P<.10$).

In Exp. 2, ADG and F:G of pigs fed the positive control diet (Diet 5) were improved ($P<.01$) over those the fed negative control diet from d 0 to 7 (Table 5). Increasing lysine level with lysine HCl also improved (P<.10) F:G; however, the increase in F:G with increasing CAA did not produce similar results to that observed for pigs fed the positive control diet. From d 7 to 14, ADG and F:G were better (P<.10) for pigs fed the positive control diet compared with pigs fed the negative control diet. Increasing dietary lysine via CAA addition also improved (P<.10) ADG and F:G. From d 0 to 14, feed intake was not affected, but ADG was greater (P<.01) for the pigs fed the positive control diet. Increasing dietary lysine resulted in linear improvements (P<.10) in ADG and F:G. However, increasing dietary lysine via CAA failed to improve ADG or F:G in the same magnitude as pigs fed the positive control diet.

The effects of diet on plasma variables are shown in Table 4. Increasing dietary lysine via CAA increased (P<.10) plasma albumin and total protein in a linear fashion. Unlike the growth performance response, the increase in albumin and total protein with CAA addition was equivalent to that observed in pigs fed the positive control diet. On the other hand, plasma urea nitrogen (PUN) was markedly reduced in pigs fed the CAA diets, and PUN continued to decrease (linear, P<.10) with increasing CAA additions.

These results are consistent with reports of Chung et al. (1999) and Davis et al. (1997). Although improvements in pig performance were observed with increasing lysine provided by CAA, these responses were not equivalent to those observed when WPC was used as a source of amino acids. Additionally, the marked reduction in PUN with increasing CAA addition is intriguing. Plasma urea nitrogen concentrations have been shown to decrease as the amino acid profile of the diet comes closer to meeting the demand of the pig (Coma et al., 1995). However, because growth performance was not improved to the same degree in pigs fed CAA as compared with pigs fed WPC, the reduction in PUN may suggest a deficiency in total nitrogen.

Implications

Growth performance of newly-weaned pigs was improved with increasing digestible lysine concentrations. However, the improvement in growth performance was greater in pigs fed whey protein concentrate as compared with pigs fed crystalline amino acids. The mechanism for the reduction in growth performance of pigs fed crystalline amino acids as compared with pigs fed whey protein concentrate a similar digestible lysine concentrations is unclear, but it may be related to the total nitrogen content of low protein, amino acid supplemented diets.

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Table 1. Composition of diets in Exp. 1 (as fed basis).

	Lysine level (% digestible)				
	1.01	1.22	1.43	1.22	1.43
	Lysine source[a]				
Ingredient, %	NC	WPC	CAA	WPC	CAA
Corn, dent grain	35.00	35.00	35.00	34.97	35.00
Whey protein conc		4.80		9.60	
Whey, dried	20.00	20.00	20.00	20.00	20.00
Lactose	4.65	4.65	4.65	4.65	4.65
Plasma, spray dried	4.00	4.00	4.00	4.00	4.00
Blood meal, spray dried	1.50	1.50	1.50	1.50	1.50
Oat groats	10.00	10.00	10.00	10.00	10.00
Fish meal, menhaden	6.00	6.00	6.00	6.00	6.00
Soy protein conc	3.30	3.30	3.30	3.30	3.30
Limestone	.14	.14	.14	.14	.14
Dicalcium phosphate	1.41	1.21	1.41	1.04	1.41
Ethoxyquin	.03	.03	.03	.03	.03
Soy oil	1.90	1.90	1.90	1.90	1.90
Salt	.20	.20	.20	.20	.20
Trace mineral/vitamin mix	.30	.30	.30	.30	.30
Antibiotic	1.00	1.00	1.00	1.00	1.00
Corn starch	5.05	2.96	4.77	.83	4.4
Sucrose	5.05	2.96	4.78	.83	4.4
Zinc Oxide	.30	.30	.30	.30	.30
L-lysine HCL			.27		.53
DL-methionine	.09	.09	.22	.09	.35
L-threonine	.01		.15		.28
L-tryptophan	.02		.06		.10
L-valine					.12
L-isoleucine	.05		.17		.29

[a]NC = negative control; CAA = crystalline amino acids; and WPC = whey protein concentrate.

Table 2. Composition of diets in Exp. 2 (as fed basis).

	Lysine level (% digestible)				
	1.00	1.15	1.30	1.45	1.45
	Lysine source[a]				
Ingredient, %	NC	CAA	CAA	CAA	WPC
Corn, dent grain	35.00	35.00	35.00	35.00	35.00
Whey protein concentrate					10.21
Soy protein concentrate	3.37	3.37	3.37	3.37	3.37
Whey, dried	20.00	20.00	20.00	20.00	20.00
Lactose	4.65	4.65	4.65	4.65	3.20
Plasma, spray dried	4.00	4.00	4.00	4.00	4.00
Blood meal, spray dried	1.50	1.50	1.50	1.50	1.50
Oat groats	10.00	10.00	10.00	10.00	10.00
Fish meal, menhaden	6.00	6.00	6.00	6.00	6.00
Dicalcium phosphate	1.38	1.38	1.38	1.38	1.00
Limestone	.16	.16	.16	.16	.14
Ethoxyquin	.03	.03	.03	.03	.03

Salt	.20	.20	.20	.20	.20
Trace mineral/vitamin mix	.30	.30	.30	.30	.30
Fat	1.50	1.50	1.40	1.30	2.30
Antibiotic	1.00	1.00	1.00	1.00	1.00
Zinc Oxide	.30	.30	.30	.30	.30
Corn starch	5.27	5.00	4.80	4.54	.68
Sucrose	5.27	5.00	4.80	4.55	.70
L-lysine HCL		.19	.37	.56	
DL-methionine		.16	.25	.34	.07
L-threonine	.07	.10	.20	.30	
L-tryptophan		.03	.06	.09	
L-valine			.02	.12	
L-isoleucine		.13	.21	.30	

aNC = negative control; CAA = crystalline amino acids; and WPC = whey protein concentrate.

Table 3. Performance of pigs fed whey protein concentrate vs

crystalline amino acids in Exp. 1a.

	Lysine level (% digestible)					
	1.01	1.22	1.43	1.22	1.43	
	Lysine sourceb					
Item	NC	WPC	CAA	WPC	CAA	SE
d 0 to 7						
ADG, lbd	.28	.47	.38	.50	.42	.05
ADF, lb	.42	.49	.44	.47	.46	.04
F:Gcde	1.52	1.06	1.17	.95	1.14	.07
d 7 to 14						
ADG, lbd	.45	.57	.61	.69	.62	.04
ADF, lbd	.70	.95	.95	.84	1.03	.07
F:Gdf	1.78	1.69	1.59	1.24	1.70	.12
d 0 to 14						
ADG, lbd	.37	.52	.50	.60	.53	.04
ADF, lbd	.59	.72	.70	.66	.74	.05
F:Gcdf	1.66	1.38	1.42	1.10	1.43	.09

aLeast squares means for four pens/trt of four pigs/pen.

bNC = negative control; CAA = crystalline amino acids; and WPC = whey protein concentrate.

cWPC vs CAA (P<.10).

dLinear effect of lysine (P<.10).

eQuadratic effect of lysine (P<.10).

fLysine source x Lysine level (P<.10).

Table 4. Performance and blood chemistries of pigs in Exp. 2a.

	Lysine, % digestible					
	1.00	1.15	1.30	1.45	1.45	
	Lysine sourceb					
Item	NC	CAA	CAA	CAA	WPC	SE
d 0-7						
ADG, lbc	.40	.36	.38	.31	.50	.29
ADF, lb	.49	.44	.45	.42	.43	.30
F:Gce	1.34	1.22	1.19	1.33	.87	.08
d 7-14						
ADG, lbcd	.62	.73	.75	.77	.85	.04
ADF, lb	.92	.98	.95	.87	.93	.04
F:Gcd	1.48	1.34	1.27	1.23	1.09	.06
d 0-14						
ADG, lbc	.50	.55	.57	.54	.68	.03
ADF, lb	.70	.71	.67	.67	.68	.02
F:Gcd	1.42	1.30	1.24	1.25	1.01	.05
Plasma Analysis						
Ammonia, mg/dL	1.51	.79	1.85	1.32	1.03	.28
Albumin, g/dLcd	2.25	2.34	2.51	2.57	2.69	.05
PUN, mg/dLe	6.54	2.66	1.22	1.17	6.94	.50
Total protein, mg/dLcd	3.84	4.08	4.33	4.38	4.37	.10

aLeast squares means for four pens/trt of four pigs/trt.

bNC = negative control; CAA = crystalline amino acids; and WPC = whey protein concentrate.

cNC vs WPC (P<.10).

dLinear effect of lysine (P<.10).

eQuadratic effect (P<.10).

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