AMINO ACID SUBSTITUTION FOR WHEY PROTEIN CONCENTRATE IN THE DIETS OF CONVENTIONALLY WEANED PIGS

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Story in Brief

A total of 120 pigs averaging 21 d of age and 13.9 lb were fed one of five dietary treatments to determine the potential for crystalline amino acid substitution for whey protein concentrate in nursery pig diets. Four of the treatments were arranged as a 2 x 2 factorial with the fifth serving as a negative control. The factorially arranged treatments consisted of two digestible lysine levels (1.22% and 1.43) obtained by formulating with either whey protein concentrate or an ideal mixture of cystalline amino acids. Experimental diets were fed during the first two weeks postweaning, followed by common Phase 2 (d 14 to 28) and Phase 3 diets (d 28 to 42). Average daily gain, average daily feed intake, and gain:feed were assessed weekly and blood samples were taken on d 14 for blood urea nitrogen determination. Increasing whey protein concentrate improved average daily gain and gain:feed during Phase 1 (d 0 to 14), while response decreased with crystalline amino acid addition. Blood urea nitrogen concentration increased with increasing level of dietary lysine when whey protein concentrate was used as the amino acid source, but decreased when diets were formulated with crystalline amino acids. Replacement of amino acids in whey protein concentrate with crystalline amino acids resulted in reduced pig performance.

(Key Words: Swine, Protein Source, Amino Acids.)

Introduction

Providing the protein needs of weanling pigs using high quality, natural feed ingredients results in expensive diets with many excesses of amino acids. Substituting crystalline amino acids for expensive protein sources in nursery pig diets offers the potential to reduce feed costs and decrease the amount of amino acid excesses. The question remains whether diets formulated with crystalline amino acids can produce similar pig performance as those containing natural protein sources.

Research conducted at Kansas State University with early weaned pigs determined average daily gain and feed efficiency improved when the dietary lysine level was increased to 1.70% using crystalline amino acids (Owen et al, 1995). However, other studies exposed problems associated with feeding high levels of crystalline amino acids to nursery pigs. Kerr and Easter (1995), in a nitrogen balance study, observed reduced growth rate and feed efficiency in growing pigs fed a 12% crude protein diet supplemented with a mixture of crystalline amino acids compared to those fed a 16% crude protein diet.

Average daily gain and gain:feed increased linearly as dietary lysine level increased from 1.15% to 1.60% using whey protein concentrate as the amino acid source in a previous experiment (Davis et al., 1996). This study was conducted to determine whether similar performance could be obtained when all or a portion of the whey protein concentrate was replaced by a crystalline amino acid mixture. Therefore, the specific objectives of this experiment were to 1) confirm the response of nursery pigs fed elevated dietary lysine levels using whey protein concentrate as the amino acid source, and 2) to determine if similar growth and efficiency can be obtained when crystalline amino acids were substituted for a portion of the amino acids in whey protein concentrate.

Materials and Methods

A total of 120 pigs weaned at approximately 21 d of age and averaging 13.9 lb were sorted by weight and divided into two weight groups of 60 pigs each. Pigs within each weight group were allotted to ten equal subgroups (six pigs per pen). The pens within each weight group were randomly assigned to five dietary treatments (four pens per treatment). Treatments were arranged as a 2 x 2 factorial with a negative control. Diets were formulated on a digestible amino acid basis. The negative control diet (Treatment 1) contained 1.01% digestible lysine and was devoid of whey protein concentrate. The factorially arranged treatments consisted of two dietary lysine levels (1.22% and 1.43% digestible lysine) in diets containing either whey protein concentrate as the amino acid source (Treatments 2 and 3) or with the whey protein concentrate component replaced by an amino acid mixture (Treatments 4 and 5). Lysine levels were obtained by increasing the amount of whey protein concentrate or crystalline amino acids at the expense of cornstarch and sucrose. Amino acids were added as needed to all diets to meet ideal protein ratios suggested by Chung and Baker (1992). Experimental diets (Table 1) were fed during Phase 1, after which common Phase 2 (1.35% total lysine) and Phase 3 (1.15% total lysine) diets were fed, each for two weeks, to monitor any carryover effect of the diets fed during Phase 1.

The trial was conducted in an environmentally controlled nursery with room temperature maintained initially at 86° F, and decreased by 2° F weekly until room temperature reached 78° F. Pigs were housed in elevated pens (4′11" x 5′) with woven wire flooring and had ad libitum access to water and feed. Pig weight and feed intake were recorded weekly and average daily gain, average daily feed intake, and gain:feed were calculated. A blood sample from each pig was taken on d 14 of the trial and analyzed for blood urea nitrogen.

Data were analyzed as a randomized complete block design with pen as the experimental unit. Blocks were based on initial body weight. Analysis of variance was performed using the General Linear Models procedures of SAS (1988). A comparison of the negative control vs. the average of the diets containing whey protein concentrate and the negative control vs. the average of the diets containing crystalline amino acids were made. Additionally, the effects of lysine source, lysine level and lysine source x lysine level interaction were evaluated.

Results and Discussion

Pigs fed the negative control diet grew more slowly and were less efficient (P<.05) from d 0 to 7 than the average of pigs receiving the diets containing increased protein from whey protein concentrate (Table 2). Pigs fed the diets containing increasing levels of whey protein concentrate as the amino acid source from d 0 to 7 had greater gain and improved efficiency when compared to those that received diets containing crystalline amino acids at the same level of digestible lysine (interaction, P<.1 and P<.05, respectively). During d 0 to 14, growth rate and G/F of pigs fed the control diet were lower (P<.01) than the average of pigs fed diets containing whey protein concentrate. Gain and efficiency increased with increasing lysine when whey protein concentrate was the amino acid source but decreased with increasing lysine when crystalline amino acids were fed at the same level of digestible lysine (interaction, $P<.05$). Average daily feed intake was not affected by dietary treatment during the first two weeks of the experiment. From d 14 to 28, average daily gain of pigs previously fed 1.22% digestible lysine was greater ($P<.07$) than those that had previously been fed 1.43% digestible lysine. Again, average daily feed intake was similar among the five treatments. From d 28 to 42 and for the entire 42-d experiment, average daily gain, average daily feed intake, and gain:feed were not affected by dietary treatments.

Blood urea nitrogen concentrations of pigs fed the negative control diet were lower ($P<.05$) than the average of pigs fed diets containing whey protein concentrate and higher ($P<.01$) than the average of pigs fed diets containing crystalline lysine. Blood urea nitrogen increased as dietary nitrogen increased in pigs fed whey protein concentrate as the amino acid source and decreased with increasing lysine in pigs fed crystalline amino acids (interaction, $P < .05$).

Similar results in a previous study (Davis et al., 1996) where performance improved when whey protein concentrate was used as the protein source in weanling pig diets, suggests whey protein concentrate is an excellent protein source for young pigs. Several reports suggest that pigs have a minimum crude protein requirement and will not respond to amino acid additions if nitrogen is limiting (Kerr and Easter, 1995; Roth et al., 1993). This could be an explanation for the poor response observed in pigs fed diets supplemented with crystalline amino acids since no attempt was made to keep the dietary treatments fed during Phase 1 isonitrogenous. However, the lack of response to crystalline amino acid supplementation is not consistent with the excellent performance observed by Owen et al. (1995) who reported increasing performance and efficiency with increasing amino acid supplementation. In conclusion, crystalline amino acid substitution for whey protein concentrate in the diets of nursery pigs with formulation procedures used in this study did not produce acceptable pig performance.

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Table 1. Composition of experimental dietsa.							
	Phase 1					Phase 2	Phase 3
	Lysine, % (digestible)					Lysine, % (total)	
Ingredient, %	1.01	1.22	1.43	1.22	1.43	1.35	1.15
Corn, ground	35.52	35.52	35.52	35.52	35.52	55.075	68.975
Lactose	4.65	3.97	3.29	4.65	4.65	10.00	-
Whey, dehyd.	20.00	20.00	20.00	20.00	20.00	-	-
SBM, 48% CP	-	-	-	-	-	22.25	27.50
Soy oil	4.00	4.00	4.00	4.00	4.00	2.50	-
St-rolled oats	10.00	10.00	10.00	10.00	10.00	-	-
AP-301[b]	1.50	1.50	1.50	1.50	1.50	2.00	-
Fish meal	6.57	6.57	6.57	6.57	6.57	5.00	-
Soy prot. conc.	2.67	2.67	2.67	2.67	2.67	-	-
AP-920[c]	3.50	3.50	3.50	3.50	3.50	-	-
Micro curb	-	-	-	-	-	.10	-
Lysine, HCl	-	-	-	.27	.54	.15	.15
WPC[d] 77% CP	-	4.80	9.60	-	-	-	-
Ethoxiquin	.03	.03	.03	.03	.03	.03	-
Isoleucine	.03	-	-	.16	.30	-	-
Threonine	.01	-	-	.15	.29	.05	-
Valine	-	-	-	-	.12	-	-

Tryptophan	.02	-	-	.06	.10	-	-
Methionine	.08	.09	.08	.22	.34	.12	-
Neoterramycin	1.00	1.00	1.00	1.00	1.00	-	-
CuSO4	.07	.07	.07	.07	.07	.05	.08
Ca carbonate	-	-	-	-	-	.27	.60
Vit. min. mix[e]	.38	.38	.38	.38	.38	.25	.25
Dicalcium phos.	1.39	1.30	1.19	1.40	1.39	1.43	1.90
Cornstarch	3.99	2.00	-	3.62	3.21	-	-
Sucrose	3.99	2.00	-	3.63	3.22	-	-
Salt	.20	.20	.20	.20	.20	.30	.42
Flavor	.10	.10	.10	.10	.10	-	-
Zinc oxide	.30	.30	.30	.30	.30	.30	-
Tylan40-Sulfa	-	-	-	-	-	.125	.125

a Diets were formulated on an as fed basis and to meet or exceed the NRC (1988) standards for all nutrients.

b Blood meal source, American Protein Corp., Ames, IA.

c Plasma protein source, American Protein Corp., Ames, IA.

[d] Whey protein concentrate, Land O□Lakes, Fort Dodge, IA.

eVitamins and minerals meet or exceed the NRC (1988) requirements.

Table 2. Performance of pigs fed whey protein concentrate vs. crystalline amino acids during Phase 1 of the nursery period.[a]		
	Lysine source[b]	

	Control	WPC	WPC	CRYST	CRYST	
	Lysine level (% digestible)					
Item	1.01	1.22	1.43	1.22	1.43	SEM
d 0 to 7						
ADG, lb[d,f]	.42	.51	.55	.45	.37	.03
ADFI, lb	.55	.59	.57	.54	.54	.04
Gain:feed[e,f]	.77	.87	.98	.84	.70	.05
d 0 to 14						
ADG, lb[e,g]	.60	.66	.69	.62	.50	.03
ADFI, lb	.81	.82	.78	.78	.74	.06
Gain:feed[e,g]	.76	.84	.90	.81	.68	.04
d 14 to 28						
ADG, lb[h]	1.02	1.06	.96	1.05	.96	.05
ADFI. lb	1.60	1.73	1.64	1.57	1.56	.08
Gain:feed	.64	.63	.59	.67	.62	.04
d 28 to 42						
ADG, lb	1.20	1.29	1.25	1.25	1.36	.06
ADFI,lb	2.21	2.40	2.50	2.34	2.40	.16
Gain:feed	.54	.56	.51	.53	.57	.03
d 0 to 42						
ADG, lb	.94	1.00	.96	.97	.94	.03
ADFI, lb	1.54	1.65	1.64	1.57	1.57	.09
Gain:feed	.65	.68	.67	.67	.62	.03

BUN, mg/dl[c,e,f,i]	4.95	4.80	6.99	2.62	2.46	.34

[a] Data are means of 4 pens/treatment with 6 pigs/pen.

[b] WPC, whey protein concentrate (77% CP); CRYST, crystalline lysine.

[c] Blood urea nitrogen.

[d] Lysine source x lysine level interaction (P<.09).

[e] Lysine source x lysine level interaction (P<.05).

[f] Control vs. WPC (P< .05).

[g] Control vs. WPC (P<.1).

[h] Lysine level effect (P<.07).

[i] Control vs. CRYST (P<.01).
