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EFFECTS OF AMINO ACID SUBSTITUTIONS FOR WHEY PROTEIN CONCENTRATE ON WEANLING PIG PERFORMANCE

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Story in Brief

A total of 120 weanling pigs were allotted randomly to five dietary treatments to evaluate the efficacy of replacing whey protein concentrate (WPC) with crystalline amino acids (AA) on growth performance and plasma urea N. Diet 1 (control) consisted of corn, soybean meal, dried whey, plasma protein (3.5%), blood meal (1.5%), and WPC (9.6%). In Diet 2, WPC was replaced with Lys, Thr, Met, Ile, Trp, and Val on an ideal basis. Diet 3 was as Diet 2 with Gly, Glu, and Asp (NEAA) added to approximate NEAA:CP ratio in the control diet. Diets 4 and 5 were as Diet 3 with additions of Trp, Phe, and Tyr (TPT) or Pro, His, and Arg (PHA), respectively, to approximate ratios to lysine in the control diet. Experimental diets were fed during Phase 1 (d 0-14), then all pigs were switched to a common Phase 2 (1.35% Lys) and 3 (1.15% Lys) diet. Pigs fed the control diet grew faster and were more efficient than pigs fed Diet 2. Addition of NEAA, TPT, or PHA to Diet 2 did not affect growth performance. Plasma urea nitrogen (PUN) was markedly lower for pigs fed Diet 2 as compared with pigs fed the control diet. Addition of NEAA to Diet 2 increased PUN, but the greatest increase in PUN was observed with addition of either TPT or PHA to Diet 3. Over the entire 42-d period, ADG and G:F did not differ between pigs fed Diet 1 and 2. However, ADG and G:F remained lower for pigs fed NEAA, TPT, and PHA as compared with those fed Diets 1 and 2 during Phase 1. These results suggest that replacement of WPC with an ideal blend of AA reduced pig performance during Phase 1 of the nursery period. Addition of NEAA, TPT, or PHA to an ideal blend of AA did not improve growth performance.

Key Words: Amino Acid, Early-Weaned Pig, Growth Performance

Introduction

The addition of crystalline amino acids to low protein swine diets have been used to overcome potential deficiencies of amino acids in the diet (Tuitoek et al., 1997), enhance the amino acid balance in the diet to optimize swine performance, and decrease nitrogen excretion from swine (Carter et al., 1996). However, replacement of whey protein concentrate with an ideal mixture of crystalline amino acids reduced pig performance (de Rodas et al., 1997; Davis et al., 1997).

A previous study (Chung et al., 1999) conducted to evaluate the use of crystalline amino acids as the source of amino acids in the diets of Phase 1 (from d 0 to 14) nursery pigs resulted in poor average daily gain (ADG) and feed efficiency (G:F). However, addition of specific amino acids to an ideal mixture of crystalline amino acids in the diet tended to improve growth performance in the same study. Fickler et al. (1994) suggested that in order to enhance growth rate and nitrogen retention, the amount of dispensable amino acids in a chemically defined diet should be increased and the pattern of indispensable amino acids should be further improved in order to attain an ideal protein. Furthermore, Roth et al. (1994) suggested that although alanine, aspartic acid, glycine, and serine are fully dispensable for the growing pig, arginine, glutamine, or proline are indispensable and must be provided in the diet in certain amounts. Therefore, the specific objectives of this study were to 1) determine the efficacy of substitution of whey protein concentrate (WPC) with crystalline amino acids in weanling pig diets on growth performance and plasma urea nitrogen (PUN), and 2) estimate if the specific additions of essential and non-essential amino acids to an ideal blend of amino acids in a low protein diet could improve growth performance of weanling pigs.

Materials and Methods

A total of 120 pigs (20 d of age and 14.6 lb initial BW) were sorted by weight and divided into four groups (blocks). Pigs within each weight group were allotted to six equal subgroups (six pigs/pen) with stratification based on sex and litter. The pens within each of the four weight groups were assigned randomly to five dietary treatments (four pens/treatment, Table1). The control diet was a fortified corn-soybean meal-dried whey diet containing 9.6% whey protein concentrate (WPC, 77%) as a natural amino acid source. Diets 2 to 5 were formulated to evaluate the effects of replacing WPC with crystalline amino acids. Diets 2 to 5 were: 2) in Diet 2, the WPC component in Diet 1 was replaced with an ideal mixture (Chung and Baker, 1992) of essential crystalline amino acids (Lys, Thr, Met, Ile, Trp, and Val), 3) as Diet 2 with crystalline Gly, Glu, and Asp (NEAA) added to approximate NEAA:CP ratio in the control diet, 4) as Diet 3 with crystalline Trp, Phe, and Tyr added to approximate ratios to lysine in the control diet, and 5) as Diet 3 with crystalline Pro, His, and Arg to approximate ratios to lysine in the control diet. Calculated chemical compositions of the five experimental diets during Phase 1 are shown in Table 2.

All experimental diets were formulated to contain 1.65% total lysine (1.44% digestible lysine), 33.08% corn, 20% dried whey, 10% dehulled oats, 6.57% menhaden fish meal, 3.5% spray dried plasma protein (AP 920), 2.81% soy protein concentrate, and 1.50% spray dried blood meal (AP 301G). All experimental diets except the control diet and Diet 2 contained glycine, aspartate, and glutamine as dispensable nitrogen sources. Potassium bicarbonate was added to Diets 3 to 5 to approximate electrolyte balance in control diet. Pigs were fed five experimental diets from d 0 to 14 postweaning (Phase 1). Upon completion of Phase 1, pigs were fed a common Phase 2 diet (1.35% lysine) from d 14 to 28 and a Phase 3 diet (1.15% lysine) from d 28 to 42 postweaning.

Pigs were housed in an environmentally controlled off-site nursery in elevated pens (5′ x 3′ 7") with woven wire flooring. The initial temperature of 88°F was subsequently decreased 2°F per week. Pigs in each pen had ad libitum access to one nipple waterer and a three-hole feeder. Pig body weight and feed intake were determined weekly to evaluate average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (G:F). Blood samples were taken via anterior vena cava at the end of Phase 1 (d 14) of the trial and serum was analyzed for urea N concentration using The Roche® Reagent for PUN.

Performance data and PUN data were analyzed according to a randomized complete block design with pen as the experimental unit and blocks based on initial body weight. Analysis of variance was performed using the GLM procedures of SAS (1988). Pre-planned non-orthogonal contrasts were used to compare treatment means.

Results and Discussion

From day 0 to 7 postweaning, pigs fed the control diet containing 9.6% WPC as a natural intact amino acid source had greater ($P<.01$) ADG and G:F than pigs receiving the crystalline amino acid diets (Table 3). Average daily feed intake was not affected ($P<.10$) by dietary treatment. From d 0 to 14 postweaning, pigs fed the control diet containing 9.6% WPC had greater ($P<.01$) ADG and G:F than pigs consuming Diet 2. Addition of AA to Diet 2 had only small effects on ADG and G:F. Plasma urea nitrogen concentrations were markedly lower ($P<.01$) for pigs fed Diet 2. Addition of AA to Diet 2 increased ($P<.01$)

PUN, with the greatest increase (P<.01) observed for pigs fed Diet 5.

During Phase 2 (d 14-28) and Phase 3 (d 28-42), only small differences existed in pig performance among dietary treatments. Over the entire 42-d experiment, pigs fed the control diet containing 9.6% WPC had greater (P<.01) ADG than pigs fed Diet 3 containing NEAA. Gain:feed of pigs fed the control diet containing 9.6% WPC or Diet 2 containing IAA were greater (P<.01) than that of pigs fed Diet 3 containing NEAA. However, ADFI was not affected (P<.10) by dietary treatment.

In the present study, pigs fed the WPC diet grew faster and were more efficient than pigs fed an ideal blend of crystalline essential amino acids, or pigs fed other supplemental crystalline amino acids during Phase 1 (from d 0 to 14 postweaning). This result is consistent with a previous study (Chung et al., 1999) carried out at our experiment station. Similarly, other researchers have reported that in nursery pigs, the replacement of amino acids in WPC by an ideal blend of crystalline amino acids resulted in reduced growth performance during Phase 1 (Davis et al., 1997; de Rodas et al., 1997). In addition, Fickler et al. (1994) reported that growth rate and nitrogen retention decreased and percentage of nitrogen utilized increased in pigs fed crystalline amino acids and a mixture of non-essential amino acids (including alanine, aspartic acid, glutamic acid, glycine, proline, and serine) as compared with a control diet containing grains, soybean meal, fish meal, and skim milk. However, the addition of NEAA, TPT, or PHA to Diet 2 containing IAA did not affect growth performance. This is contrary to reports obtained from a previous study conducted at our experiment station, which resulted in acceptable performance when specific amino acids were added to an ideal mixture of amino acids. In conclusion, the results of the present study indicate the replacing WPC with an ideal blend of amino acids during Phase 1 (from d 0 to 14) reduced pig performance and the addition of NEAA, TPT, or PHA to an ideal blend of amino acids did not enhance growth performance.

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Table 1. Composition of experimental diets (Phase 1).	
	Diet

	1	2	3	4	5
	Amino acid source[a]				
	WPC	IAA	IAA+ NEAA	As 3+ TPT	As 3+ PHA
Fixed ingredients[b]	77.45	77.45	77.45	77.45	77.45
Lactose	3.29	4.65	4.65	4.65	4.65
WPC, 77%	9.60	-	-	-	-
$Ca_2H_2(PO_4)_2$	1.04	1.40	1.40	1.40	1.40
Limestone	.04	.06	.06	.06	.06
L-Lysine HCl	-	.54	.54	.54	.54
DL-Methionine	.08	.34	.34	.34	.34
L-Threonine	-	.29	.29	.29	.29
L-Tryptophan	-	.10	.10	.10	.10
L-Valine	-	.14	.14	.14	.14
L-Isoleucine	-	.30	.30	.30	.30
Glycine	-	-	1.08	1.33	1.17
Aspartic acid	-	-	1.08	1.33	1.17
Glutamic acid	-	-	1.08	1.33	1.17
L-Phenylalanine	-	-	-	.135	-
L-Tyrosine	-	-	-	.135	-
L-Tryptophan	-	-	-	.040	-
L-Proline	-	-	-	-	.30
L-Histidine	-	-	-	-	.15
L-Arginine	-	-	-	-	.13
Other[c]	4.38	3.53	4.08	4.38	4.28
Sucrose	2.06	5.60	3.612	2.58	2.88
Corn starch	2.06	5.60	3.611	3.27	3.30
$KHCO_3$[d]	-	-	.19	.19	.19

[a]WPC, Basal + whey protein concentrate; IAA, Basal + synthetic essential AAs; IAA+NEAA, as Diet 2 + Gly, Glu, Asp; As 3+TPT, as Diet 3 + Trp, Phe, Tyr; As 3+PHA, as Diet 3 + Pro, His, Arg.

[b]Contained 33.08% corn, 20% dried whey, 10% dehulled oats, 6.57%

menhaden fish meal, 3.5% spray dried plasma protein (AP 920), 2.81% soy protein concentrate, and 1.50% spray dried blood meal (AP 301G).

[c]Contained .10% flavor, .03% ethoxyquin, 2.15-3.00% soybean oil, .20% salt, .30% trace minerals and vitamins, .30% zinc oxide, 1.00 neo-terramycin.

[d]Added to approximate (Na+K)-Cl balance in control diet.

Table 2. Chemical composition of diet (Phase 1).					
	Diet				
	1	2	3	4	5
	Amino acid source[a]				
			IAA +	As 3 +	As 3 +
Ingredient	WPC	IAA	NEAA	TPT	PHA
ME, Kcal/lb	1500	1500	1500	1501	1501
CP, %	24.5	18.4	21.2	21.8	21.4
Total AA, %					
Lysine	1.65	1.62	1.62	1.62	1.62
Threonine	1.20	1.10	1.10	1.10	1.10
Methionine	.51	.65	.65	.65	.65
Cystine	.51	.33	.33	.33	.33
Met. + Cys.	1.01	.98	.98	.98	.98
Tryptophan	.35	.29	.29	.33	.29
Digestible AA, %					
Lysine	1.44	1.44	1.44	1.44	1.44
Threonine	.96	.93	.93	.93	.93
Methionine	.44	.60	.60	.60	.60
Tryptophan	.30	.26	.26	.30	.26
AA ratios (% of digestible lysine)					
Lysine	100	100	100	100	100
Threonine	66	65	65	65	65
Methionine	31	42	42	42	42
Met. + Cys.	60	60	60	60	60
Tryptophan	21	18	18	21	18
Isoleucine	62	60	60	60	60
Leucine	145	104	104	104	104
Valine	81	68	68	68	68
Histidine	43	33	33	33	43
Arginine	68	58	58	58	68
Phe. + Tyr.	112	93	93	112	93
Ca, %	.91	.91	.91	.91	.91
P, %	.80	.80	.80	.80	.80

[a]WPC, Basal + whey protein concentrate; IAA, Basal + synthetic essential AAs; IAA+NEAA, as Diet 2 + Gly, Glu, Asp; As 3+TPT, as Diet 3 + Trp, Phe, Tyr; As 3+PHA, as Diet 3 + Pro, His, Arg.

Table 3. The effects of crystalline amino acids additions to low crude protein diets for weanling pigs[a].

	Diet					
	1	2	3	4	5	
	Amino acid source[b]					
Item	WPC	IAA	IAA+NEAA	As 3+ TPT	As 3+ PHA	SE
Day 0 to 7						
ADG, lb	$.737^{c}$	$.617^{d}$	$.568^{d}$	$.620^{d}$	$.621^{d}$	.026
ADFI, lb	$.645^{gh}$	$.665^{g}$	$.618^{gh}$	$.598^{h}$	$.614^{gh}$	.025
Gain:feed	1.131^{c}	$.923^{d}$	$.912^{d}$	1.017^{e}	1.002^{e}	.019
Day 7 to 14						
ADG, lb	$.711^{c}$	$.621^{cd}$	$.574^{d}$	$.547^{d}$	$.551^{d}$	.028
ADFI, lb	$.874^{g}$	$.876^{g}$	$.812^{gh}$	$.757^{h}$	$.756^{h}$	.033
Gain:feed	$.806^{g}$	$.713^{gh}$	$.710^{gh}$	$.704^{h}$	$.729^{gh}$	.072
Day 0 to 14						
ADG, lb	$.724^{c}$	$.619^{d}$	$.571^{d}$	$.583^{d}$	$.586^{d}$	.018
ADFI, lb	$.760^{gh}$	$.771^{g}$	$.715^{ghi}$	$.677^{I}$	$.685^{hi}$	.025
Gain:feed	$.951^{c}$	$.807^{d}$	$.800^{d}$	$.860^{cd}$	$.854^{cd}$	.032
Day 14 to 28						
ADG, lb	1.104^{gh}	1.158^{g}	1.076^{gh}	1.033^{h}	1.085^{gh}	.045
ADFI, lb	1.590^{g}	1538^{gh}	1.512^{h}	1.468^{gh}	1.485^{gh}	.046
Gain:feed	$.691^{g}$	$.752^{h}$	$.710^{gh}$	$.704^{gh}$	$.727^{gh}$	.037
Day 28 to 42						
ADG, lb	1.210	1157	1.095	1.403	1.096	.046
ADFI, lb	2.111	1.975	2.003	2.078	1.959	.070
Gain:feed	$.571^{gh}$	$.586^{g}$	$.545^{h}$	$.547^{h}$	$.560^{gh}$	.037
Day 0 to 42						
ADG, lb	1.012^{c}	$.978^{cd}$	$.914^{d}$	$.920^{cd}$	$.922^{cd}$	.022
ADFI, lb	1.487^{g}	1.428^{gh}	1.410^{gh}	1408^{gh}	1.376^{h}	.036
Gain:feed	$.680^{gh}$	$.685^{h}$	$.648^{i}$	$.652^{gi}$	$.670^{ghi}$	.022
PUN, mg/dL						
Day 14	7.944^{c}	1.183^{d}	4.319^{e}	6.181^{cf}	6.447^{cf}	.409

[a]Least squares means for four pens (six pigs/pen) per treatment. Pigs averaged 14.6 and 54.5 lb at trial initiation and termination, respectively.

[b]WPC, Basal + whey protein concentrate; IAA, Basal + synthetic essential AAs; IAA+NEAA, as Diet 2 + Gly, Glu, Asp; As 3+TPT, as Diet 3 + Trp, Phe, Tyr; As 3+PHA,

as Diet 3 + Pro, His, Arg.

[c,d,e,f]Means within same row with different superscripts differ (P<.01).

[g,h,i]Means within same row with different superscripts differ (P<.10).

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