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Performance of Growing-Finishing Pigs Consuming Diets Formulated on an Ideal Protein (First Four Limiting Amino Acids) Basis

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Summary and Implications

An experiment with growing-finishing pigs was conducted to evaluate the effects of a corn-soybean meal diet supplemented with crystalline amino acids in an ideal pattern for the first four limiting amino acids (lysine, tryptophan, threonine, and methionine) on growth performance, plasma urea concentration, and carcass characteristics in barrows and gilts. Barrows were pair-fed to gilts within the same dietary treatment. For the entire growing-finishing period, there was a diet x sex interaction for daily gain and feed efficiency. Barrows and gilts consuming a corn-soybean meal diet performed similarly; however, barrows receiving diets formulated on an ideal protein basis had a 10 percent lower daily gain and a four percent lower daily feed intake than gilts. Barrows and gilts receiving the ideal protein diet gained weight more slowly and consumed less feed during the growing-finishing period than did pigs receiving the intact corn-soybean diet. Diet did not affect the percent lean in the carcass. Plasma urea concentrations showed that nitrogen was conserved in pigs consuming the ideal protein vs intact corn-soybean meal diet. Differences in plasma urea concentration were not observed between barrows and gilts within either treatment. These results indicate there is no advantage in terms of daily gain and feed efficiency of providing growing-finishing pigs an ideal protein diet. However, feeding an ideal protein diet will reduce the amount of nitrogen the pig wastes. Future research will focus on the effects of ideal protein diets on nitrogen excretion and amino acid utilization.

Introduction

The concept of ideal protein is currently being reviewed by swine nutritionists. An ideal protein is one that supplies essential amino acids and nonessential nitrogen in the exact proportions to meet the requirements for maintenance and growth. Therefore, no amino acid deficiencies or excesses exist with ideal protein diets. Because grain-soybean meal diets do not have an ideal amino acid pattern, excess protein must be provided to meet the amino acid requirement for the first limiting amino acid (e.g., lysine). Consequently, many other amino acids are consumed in excess of the requirement for growth and must be broken down and converted to energy or fat. This breakdown of amino acids results in the production of urea and the excretion of nitrogen (urea; (NH_2-CO-NH_2)).

One strategy is to use the ideal protein concept to reduce the amount of nitrogen excreted by growing-finishing pigs consuming grain-soybean meal diets. However, it is important to recognize that growth performance may also be affected.

The primary objective of this experiment was to examine the effects on growth response, carcass characteris-

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tics, and plasma urea concentration of growing-finishing pigs fed corn-soybean-meal-amino acid supplemented diets formulated on an ideal protein basis for the first four limiting amino acids. Secondly, we attempted to compare the responses of barrows and gilts by pair-feeding the barrows to the feed intake of the gilts.

Table 1. Diet composition (%) and calculated chemical analysis (as-fed basis).

Item	Phase 1[a]		Phase 2[a]	
Diet,	INTACT[b]	IDEAL[b]	INTACT	IDEAL
Corn	66.60	78.25	74.40	85.30
Soybean meal, 46.5% CP	28.90	16.35	21.20	9.50
Tallow	2.00	2.00	2.00	2.00
Dicalcium phosphate	.95	1.20	.90	1.10
Limestone	.45	.40	.40	.35
Salt	.30	.30	.30	.30
Vitamin mix	.70	.70	.70	.70
Trace mineral mix	.10	.10	.10	.10
L-lysine•HCl	—	.39	—	.36
L-threonine	—	.15	—	.13
DL-methionine	—	.10	—	.08
L-tryptophan	—	.04	—	.05
Calculated composition				
Crude protein, %	19.1	14.6	16.2	12.0
Lysine, %	1.00	.97	.80	.77
Calcium, %	.65	.66	.60	.60
Phosphorus, %	.55	.55	.55	.55
Metabolizable energy, Mcal/lb	1.53	1.52	1.54	1.53

[a]Phase 1 = 58.6 to 113 lb; phase 2 = 113 to 237 lb.
[b]INTACT = corn-soybean meal diet; IDEAL = corn-soybean meal-amino acid supplemented diet.

Table 2. Total and apparent ileal digestible amino acid compositions of diets (as-fed basis).

Item	Phase 1[a]		Phase 2[a]	
Diet,	INTACT[b]	IDEAL[b]	INTACT	IDEAL
Lysine, %	1.00(.84)[c]	.97(.84)	.80(.66)	.77(.66)
Tryptophan, %	.24(.18)	.22(.16)	.20(.14)	.19(.13)
Threonine, %	.73(.56)	.71(.56)	.63(.47)	.60(.46)
Methionine + cysteine, %	.61(.53)	.61(.53)	.55(.47)	.53(.46)
Isoleucine, %	.81(.68)	.60(.50)	.68(.57)	.49(.40)
Valine, %	.90(.79)	.71(.60)	.78(.68)	.60(.50)

[a]Phase 1 = 58.6 to 113 lb; phase 2 = 113 to 237 lb.
[b]INTACT = corn-soybean meal diet; IDEAL = corn-soybean meal-amino acid supplemented diet.
[c]Values in parentheses represent calculated apparent ileal digestible percentages.

Procedures

Thirty-six crossbred pigs (18 gilts and 18 barrows) with an initial weight of 58.6 lb were used in an experiment with a randomized-complete block arrangement of treatments and animals. All pigs were individually penned in one environmentally controlled room kept at 72°F. Pigs remained on the study for 98 days. Pigs were weighed, feed disappearance was determined, and blood samples were taken weekly. Plasma samples were subsequently analyzed for urea. At the end of the experiment, pigs were shipped to a packer in northwestern Iowa. Carcass characteristics were acquired from relationships derived using Total Body Electrical Conductivity (TOBEC). These included ham weight, loin weight, shoulder weight, and carcass lean percentage (5% fat basis).

The dietary treatments used in the experiment are presented in Table 1. Phase 1 diets were offered until pig weight was approximately 113 lb (4 weeks). Phase 2 diets were provided from 113 to approximately 237 lb. Within each phase, corn-soybean meal (INTACT) or corn-soybean meal-amino acid supplemented (IDEAL) diets were fed. Nine gilts and nine barrows received one of the aforementioned dietary treatments. One gilt allotted to the INTACT diet died and was not included in the statistical analysis. In addition, carcass weights and characteristics of three barrows receiving the IDEAL diets were not included in the statistical analysis. In the IDEAL diets, the protein concentration was reduced approximately four percent from the INTACT diet (19.1 to 14.6%, Phase 1; 16.2 to 12%, Phase 2). Crystalline amino acids (lysine, threonine, methionine, and tryptophan) were added to the IDEAL diet to meet the lysine concentration of the INTACT diet and provide an amino acid pattern (relative to lysine) similar to the ideal pattern developed at the University of Illinois. The lysine percentages between the INTACT and IDEAL diets presented in Table 1 differ slightly to allow for differences in amino acid digestibility. The concentration of lysine and the ratios used for the next three limiting amino acids were based on calculated apparent ileal digestible values (Table 2).

Gilts had *ad libitum* access to the respective Phase 1 and 2 diets and to water during the entire experiment. Barrows were pair-fed according to the mean feed intake of the respective gilt treatment group (three- or four-day average). Average feed intake of the gilt groups was expressed per unit of body weight. This factor was multiplied by individual barrow weight to determine the daily feed allowance for each barrow.

Results and Discussion

The performance of barrows and gilts consuming the INTACT and IDEAL diets for Phase 1, Phase 2, and the overall growing-finishing period is presented in Table 3. Although barrows were heavier at the start of the experiment, initial weight was not used as a covariate.

During Phase 1, gilts consumed

more feed (P < .05) and gained more weight (P < .05) than barrows. Barrows fed the IDEAL diet during Phase 1 had a 14 percent lower average daily gain (ADG) compared to gilts consuming the same diet; however, barrows and gilts fed the INTACT diet gained similarly (diet x sex, P < .05). Compared to gilts, feed efficiency was reduced in barrows consuming the IDEAL diet but not the INTACT diet (diet x sex, P < .05).

Barrows and gilts receiving the IDEAL diet consumed less feed (P < .05) and had lower ADG (P < .05) than barrows and gilts consuming the INTACT diet during Phase 2. Likewise, averaged for the entire experimental period, pigs consuming the INTACT diet gained weight 10 percent faster (P < .05) and consumed six percent more feed than pigs in the IDEAL group. The diet x sex interaction (P < .05) for ADG and feed efficiency was a result of the reduced ADG observed for barrows consuming the IDEAL diet.

Performance criteria suggest that the pair-feeding of barrows to gilts resulted in similar feed intakes for barrows and gilts consuming the INTACT diets. However, for the entire growing-finishing period, barrows had a 10 percent lower ADG and a four percent lower average daily feed intake (ADFI) than gilts receiving the IDEAL diet. Therefore, for the entire experimental period, gilts seemed to utilize the IDEAL diet more efficiently than barrows.

The reduction in feed efficiency and(or) the efficiency of amino acid utilization in barrows vs gilts consuming the IDEAL diets not only reduced ADG, but also reduced the pair-feeding allotment (barrows feed allotment was calculated according to body weight). This observation in part could be a result of barrows receiving their feed allotment once daily rather than in two to three allotments during a 24-hour period. The efficiency of lysine utilization from amino-acid supplemented diets can be reduced if the feed is consumed over a short time period. However, this is not supported by the response of plasma urea concentrations observed in this study (Figure 1). Barrows and gilts consuming the IDEAL diets had reduced plasma urea concentrations compared to barrows and gilts receiving the INTACT diets. Within both the INTACT and IDEAL treatments, plasma urea was similar for barrows and gilts. These latter observations are consistent with reduced crude protein (nitrogen) content of the IDEAL diets.

Carcass characteristics are presented in Table 4. The diet x sex inter-

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Table 3. Performance criteria of barrows and gilts consuming intact corn-soybean meal and ideal protein diets.

Item[a]	Diet,	INTACT[b]		IDEAL[b]		
	Sex,	Gilts	Barrows	Gilts	Barrows	SEM[c]
No. of pigs		8	9	9	9	
Phase 1						
Initial wt., lb[e]		57.4	59.4	58.0	59.4	.80
Final wt., lb[f]		112.3	113.3	116.2	109.4	1.83
ADG, lbe,f		1.96	1.92	2.08	1.78	.05
ADFI, lb[e]		4.95	4.75	5.13	4.67	.12
Gain/feed[f]		.40	.41	.41	.38	.01
Phase 2						
Final wt., lb[d,f]		241.1	245.8	239.2	222.8	4.83
ADG, lb[d]		1.84	1.89	1.76	1.62	.06
ADFI, lb[d]		5.54	5.63	5.17	5.09	.14
Gain/feed		.33	.34	.34	.32	.01
Overall						
ADG, lb[d,f]		1.87	1.90	1.85	1.67	.05
ADFI, lb[d]		5.37	5.38	5.16	4.97	.12
Gain/feed[f]		.35	.35	.36	.34	.01

[a]ADG = average daily gain, ADFI = average daily feed intake, and gain/feed = feed efficiency.
[b]INTACT = corn-soybean meal diet; IDEAL = corn-soybean meal-amino acid supplemented diet.
[c]Standard error of the mean.
[d]Diet effect, P < .05.
[e]Sex effect, P < .05.
[f]Diet x sex interaction, P < .05.

Table 4. Carcass weight and characteristics of barrows and gilts consuming intact corn-soybean meal and ideal protein diets[a].

Item	Diet,	INTACT[b]		IDEAL[b]		
	Sex,	Gilts	Barrows	Gilts	Barrows	SEM[c]
No. of pigs		8	9	9	6	
Carcass wt., lb[d,f]		181.0	185.5	180.8	170.4	3.60
Ham wt, lb		17.9	17.7	18.6	16.0	.74
Loin wt, lb		23.5	23.9	23.8	23.4	.55
Shoulder wt, lb[e,f]		23.5	23.3	23.9	21.4	.60
Primal cut wt/carcass wt, %		35.8	35.0	36.6	35.7	1.24
Lean, % of carcass wt[g]		45.8	45.9	46.4	45.8	1.06

[a]All carcass characteristics were determined using Total Body Electrical Conductivity (TOBEC). Individual carcass data were obtained from Sioux-Preme Packing; Sioux Center, IA.
[b]INTACT = corn-soybean meal diet; IDEAL = corn-soybean meal-amino acid supplemented diet.
[c]Standard error of the mean.
[d]Diet effect, P < .05.
[e]Sex effect, P < .05.
[f]Diet x sex interaction, P < .1.
[g]5% fat basis.

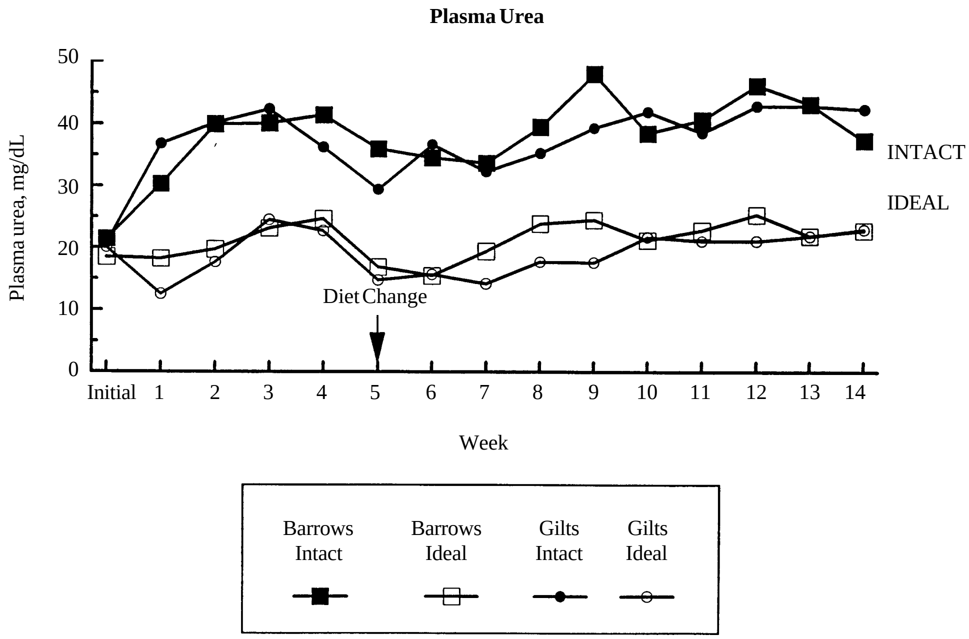

Figure 1. The response of plasma urea in barrows and gilts consuming corn-soybean (INTACT) or corn-soybean meal-amino acid supplemented (IDEAL) diets during a 14-week growing-finishing period.

actions (P < .1) observed for carcass and shoulder weight were due to the low values observed for the barrows receiving the IDEAL diet. For barrows, carcass weight was eight percent lower in the IDEAL vs INTACT diets. Diet did not affect any of the other carcass characteristics evaluated. Although growth rate was reduced in barrows vs gilts consuming the IDEAL diet (see Table 3), there was a numerical decrease in the carcass lean percentage of the barrows (barrows, 45.8%; gilts 46.4%).

Conclusions

Growth performance was not affected in gilts receiving IDEAL vs INTACT diets during the growing-finishing period. Although attempts were made to pair-feed barrow to gilts, the decreased feed efficiency of the barrows consuming the IDEAL diets resulted in reduced ADFI and ADG compared to gilts. However, we recognize that the pair-feeding regimen may have accentuated differences in growth performance between barrows and gilts consuming the IDEAL diets. Plasma urea concentration during the growing-finishing period was reduced in pigs consuming the IDEAL diet. There did not seem to be differences in plasma urea concentration between barrows and gilts receiving either diet.

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[1]Phillip S. Miller is an Assistant Professor, Austin J. Lewis is a Professor, Cynthia K. Wolverton is a Research Technologist, and Christopher A. Borland is an Undergraduate Student.