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Effect of Formulating Diets to Reduce Excess Amino Acids on Performance of Growing and Finishing Pigs

G.W. Libal
South Dakota State University

D.N. Peters

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G.W. Libal[1] and D.N. Peters
Department of Animal and Range Sciences

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For every stage of growth, pigs have a requirement for essential amino acids provided in a specific ratio and for additional nitrogen provided as amino acids or other nitrogen sources to allow synthesis of nonessential amino acids. The typical manner of balancing swine diets has involved supplying several traditional feed ingredients in a ratio in the diet that meets the required level of the most limiting amino acid leaving excesses of most other amino acids. With this method, considerable nitrogen above that needed for nonessential amino acid synthesis is provided and excess nitrogen is excreted in the urine as urea.

The Ideal Protein concept is based upon the idea that total amino acid levels and nitrogen levels in the diet are reduced by placing all essential amino acids in the proper ratio and at the proper level with just enough additional nitrogen in the diet to allow nonessential amino acid synthesis. Nitrogen excreted as urea is minimized. This is possible because crystalline amino acids are available for all essential amino acids. However, because of the high cost of some crystalline amino acids, formulation on a complete Ideal Protein basis is not practical. Because crystalline lysine and methionine are affordable and crystalline threonine and tryptophan prices have been reduced, it is practical to formulate to the first limiting amino acid beyond those four amino acids. For pigs in growth stages from 22 to 114 kg that fifth limiting amino acid is isoleucine when using corn and soybean meal as the main dietary ingredients. It is possible, therefore, to exactly meet the amino acid ratio and levels of lysine, methionine, tryptophan, threonine, and isoleucine, leaving excesses for only the last five essential amino acids.

The research reported herein was designed to evaluate the effect on pig performance throughout the four growth phases of the growing and finishing periods when nitrogen levels in the diet are reduced by systematically balancing for the first through the fifth limiting amino acids utilizing crystalline amino acids to maintain the Ideal Protein ratios for the most limiting amino acids.

(Key Words: Growing-finishing pigs, Ideal Protein concept, phase feeding, Split sex feeding.)

Experimental Procedure

A total of 512 pigs were utilized in four trials to evaluate the effect of reducing excess nitrogen in the diet by systematically balancing diets for barrows and gilts for the first through the fifth limiting amino acids for grower I (22 to 36 kg), grower II (36 to 59 kg), finisher I (59 to 86 kg), and finisher II (86 to 114 kg) periods. Diets were formulated by altering the ratio of corn and soybean meal to balance for the first (lysine) through fifth (isoleucine) limiting amino acid. Crystalline lysine, methionine, tryptophan, and threonine were added to provided amino acids in an Ideal Protein ratio relative to lysine. For each growth period, diets were separately formulated for barrows and gilts where their requirements differed. Diets were fed in meal form with feed and water provided ad libitum. Pigs were housed in an environment-modified slatted floor, grow-finishing barn and provided more than the minimum recommended pen space. A different set of pigs was utilized for each growth period to eliminate any carryover effect. Pigs were removed from the trial on a pen basis when the pen average weight reached the final target weight for that phase. Each growth period was expected to be approximately 28 days in length with pig weights and feed additions recorded on a weekly basis.

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Grower I Trial: One hundred forty-four barrows and gilts were allotted to three replications of four dietary treatments. Barrows and gilts were penned by gender with six pigs per pen. Four experimental diets were formulated (barrows and gilts were considered to have the same nutritional requirements for this stage of growth) with lysine, threonine, tryptophan, and isoleucine systematically becoming limiting as the corn and soybean meal ratio was altered. Crystalline methionine was supplemented to all diets, as it was marginally deficient for diets formulated to meet the lysine requirement. The composition of the experimental diets for the grower I phase with the Ideal Protein ratio utilized is shown in Table 1. The protein levels of the diets were reduced from 17.7% by formulating for the lysine requirement to 13.9% by formulating for the isoleucine requirement.

Grower II Trial: One hundred twenty barrows and gilts were allotted to four replications of three dietary treatments for each gender. Barrows and gilts were penned by gender with five pigs per pen. Six experimental diets were formulated (three for barrows and three for gilts as they were considered to have different nutritional requirements for this stage of growth) with lysine, tryptophan, and isoleucine systematically becoming limiting for barrows and lysine, threonine, and isoleucine becoming limiting for gilts as the corn and soybean meal ratio was altered to reduce protein content. Threonine for barrows and tryptophan and methionine for gilts became limiting when balancing the diet for the isoleucine requirement with natural ingredients. The composition of the experimental diets with the Ideal Protein ratio utilized for the grower II phase is shown in Table 2. Protein content of the diet was reduced from 16.1 to 12.3% for barrows and from 16.6 to 12.7% for gilts by balancing for isoleucine rather than for lysine

Finisher I Trial: One hundred twenty barrows and gilts were allotted to four replications of three dietary treatments for each gender. Barrows and gilts were penned separately with five pigs per pen. Six experimental diets were formulated (three for barrows and three for gilts). Lysine was first limiting, tryptophan and threonine became co-limiting, and isoleucine was fifth limiting for barrows and gilts as the corn and soybean meal ratio was altered to reduce protein content. Methionine became limiting for gilts when formulating diets for the tryptophan and threonine requirement with natural ingredients. The composition of the experimental diets for the finisher I phase with the Ideal Protein ratio utilized is shown in Table 3. Protein content of the diet was reduced from 14.3 to 10.3% for barrows and from 16.1 to 11.8% for gilts by balancing for isoleucine rather than for lysine.

Finisher II Trial: One hundred twenty-eight barrows and gilts were allotted to four replications of four dietary treatments for each gender. Barrows and gilts were penned separately with four pigs per pen. Eight experimental diets were formulated with lysine, tryptophan, threonine, and isoleucine systematically becoming limiting as the corn and soybean meal ratio was altered. The composition of the experimental diets for the finisher II phase with the Ideal Protein ratio utilized is shown in Table 4. No soybean meal was included in the diet balanced for isoleucine for barrows. The protein levels of the diets were reduced from 12.6 and 13.6% obtained by formulating for the lysine requirement to 8.8 and 9.8% by formulating for the isoleucine requirement for barrows and gilts, respectively.

TABLE 1. COMPOSITION OF EXPERIMENTAL DIETS FOR GROWER I (22 TO 36 KG) TRIAL, %

	Experimental diets, barrows and gilts				
	Diet balanced for[a]				
Ingredient	LYS	THR	TRP	ILE	Ideal ratio
Ground corn	69.55	74.74	80.68	81.79	
Soybean meal, 44%	26.55	21.28	15.25	14.12	
Dicalcium phosphate	1.25	1.36	1.48	1.50	
Limestone	.85	.82	.79	.79	
White salt	.30	.30	.30	.30	
Vitamin-trace mineral premix[b]	1.50	1.50	1.50	1.50	
Added amino acids, g/ton					
L-lysine HCl		1630	3516	3865	
D-L methionine	153	508	915	989	
L-threonine			731	878	
L-tryptophan				55	
Calculated nutrient composition, %					
Lysine	.95	.95	.95	.95	100
Methionine	.59	.59	.59	.59	62
Threonine	.71	.64	.64	.64	67
Tryptophan	.23	.20	.17	.17	18
Isoleucine	.78	.69	.59	.57	60
Valine	.87	.79	.70	.68	68
Histidine	.49	.44	.39	.38	32
Arginine	1.15	1.01	.84	.81	36
Phenylalinine	.88	.79	.70	.68	48
Leucine	1.73	1.61	1.48	1.46	100
Protein	17.7	16.0	14.2	13.9	

[a]Balanced with natural ingredients for the first-, second-, third-, and fourth-limiting amino acids with crystalline amino acids utilized to correct amino acid deficiencies created.

[b]Provided per kg of complete diet: 100 mg Zn, 75 mg Fe, 7.5 mg Cu, 25 mg Mn, 175 :g I, 300 :g Se, 16.5 IU vitamin E, 3.3 mg riboflavin, 17.6 mg niacin, 13.2 :g vitamin B_{12}, 2.2 mg vitamin K_3, 13.2 mg pantothenic acid, 3960 IU vitamin A, and 396 IU vitamin D_3.

TABLE 2. COMPOSITION OF EXPERIMENTAL DIETS FOR GROWER II (36 TO 59 KG) TRIAL, %

	Experimental diets						
	Barrows			Gilts			
	Diet balanced for[a]						
Ingredient	LYS	TRP	ILE	LYS	THR	ILE	Ideal ratio
Ground corn	74.27	82.06	86.15	72.78	80.21	85.03	
Soybean meal, 44%	22.01	14.10	9.95	23.52	15.98	11.08	
Dicalcium phosphate	1.07	1.23	1.31	1.04	1.19	1.29	
Limestone	.85	.81	.79	.86	.82	.80	
White salt	.30	.30	.30	.30	.30	.30	
Vitamin-TM premix[b]	1.50	1.50	1.50	1.50	1.50	1.50	
Added amino acids, g/ton							
L-lysine	23	2007	3772	16	2367	3882	
D-L methionine						179	
L-threonine			482			616	
L-tryptophan			181			212	
Calculated nutrient composition, %							
Lysine	.83	.83	.83	.87	.87	.87	100
Methionine	.54	.49	.46	.55	.50	.48	55
Threonine	.65	.55	.49	.67	.57	.57	65
Tryptophan	.21	.16	.16	.22	.18	.17	19
Isoleucine	.70	.57	.50	.73	.60	.52	60
Valine	.80	.68	.62	.83	.71	.64	68
Histidine	.45	.38	.35	.46	.40	.36	32
Arginine	1.03	.81	.69	1.07	.86	.73	36
Phenylalinine	.81	.68	.61	.83	.71	.63	48
Leucine	1.63	1.46	1.37	1.67	1.50	1.37	100
Protein	16.1	13.5	12.3	16.6	14.1	12.7	

[a]Balanced with natural ingredients for the first-, second-, and third-limiting amino acids with crystalline amino acids utilized to correct amino acid deficiencies created.

[b]Provided per kg of complete diet: 100 mg Zn, 75 mg Fe, 7.5 mg Cu, 25 mg Mn, 175 :g I, 300 :g Se, 16.5 IU vitamin E, 3.3 mg riboflavin, 17.6 mg niacin, 13.2 :g vitamin B_{12}, 2.2 mg vitamin K_3, 13.2 mg pantothenic acid, 3960 IU vitamin A, and 396 IU vitamin D_3.

TABLE 3. COMPOSITION OF EXPERIMENTAL DIETS FOR FINISHER I (59 TO 86 KG) TRIAL, %

	Experimental diets						
	Barrows			Gilts			
	Diet balanced for[a]						
Ingredient	LYS	TRP-THR	ILE	LYS	TRP-THR	ILE	Ideal ratio
Ground corn	79.55	86.41	91.75	74.54	81.22	86.41	
Soybean meal, 44%	16.90	9.93	4.50	21.99	15.20	9.93	
Dicalcium phosphate	.90	1.04	1.15	.79	.93	1.04	
Limestone	.85	.82	.80	.88	.85	.82	
White salt	.30	.30	.30	.30	.30	.30	
Vitamin-TM premix[b]	1.50	1.50	1.50	1.50	1.50	1.50	
Added amino acids, g/ton							
L-lysine		2157	3595	47	2156	3786	
D-L methionine					93	446	
L-threonine			525			676	
L-tryptophan			274			275	
Calculated nutrient composition, %							
Lysine	.69	.69	.69	.83	.83	.83	100
Methionine	.51	.46	.42	.54	.50	.50	60
Threonine	.59	.49	.47	.65	.56	.56	67.5
Tryptophan	.18	.14	.14	.21	.17	.17	20
Isoleucine	.62	.50	.41	.70	.59	.50	60
Valine	.73	.62	.53	.81	.70	.62	68
Histidine	.41	.38	.30	.45	.39	.35	32
Arginine	.89	.69	.54	1.03	.84	.69	30
Phenylalinine	.72	.61	.52	.81	.70	.61	48
Leucine	1.52	1.37	1.25	1.63	1.49	1.37	100
Protein	14.3	12.0	10.3	16.1	14.4	11.8	

[a]Balanced with natural ingredients for the first-, second-, and third-limiting amino acids with crystalline amino acids utilized to correct amino acid deficiencies created.

[b]Provided per kg of complete diet: 100 mg Zn, 75 mg Fe, 7.5 mg Cu, 25 mg Mn, 175 :g I, 300 :g Se, 16.5 IU vitamin E, 3.3 mg riboflavin, 17.6 mg niacin, 13.2 :g vitamin B_{12}, 2.2 mg vitamin K_3, 13.2 mg pantothenic acid, 3960 IU vitamin A, and 396 IU vitamin D.

TABLE 4. COMPOSITION OF EXPERIMENTAL DIETS FOR FINISHER II (86 TO 114 KG) TRIAL, %

	Experimental diets								
	Barrows				Gilts				
	Diets balanced for[a]								
Ingredient	LYS	TRP	THR	ILE	LYS	TRP	THR	ILE	Ideal ratio
Ground corn	85.30	92.26	94.94	96.93	82.33	88.63	91.61	94.33	
Soybean meal, 44%	11.82	4.75	2.02	.00	14.83	8.43	5.41	2.64	
Dicalcium Phosphate	.72	.86	.92	.96	.66	.79	.85	.91	
Limestone	.86	.83	.82	.81	.88	.85	.83	.82	
White salt	.30	.30	.30	.30	.30	.30	.30	.30	
Vitamin-TM premix[b]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Added amino acids, g/ton									
L-lysine HCl	99	2263	2865	3595	104	2074	2995	3601	
D-L methionine									
L-threonine			30	285			75	420	
L-tryptophan			125	231			140	280	
Calculated nutrient composition, %									
Lysine	.56	.56	.56	.56	.64	.64	.64	.64	100
Methionine	.47	.42	.40	.39	.49	.45	.43	.41	60
Threonine	.52	.42	.38	.38	.56	.47	.43	.43	67.5
Tryptophan	.15	.11	.11	.11	.17	.13	.13	.13	20
Isoleucine	.54	.42	.37	.34	.59	.48	.43	.38	60
Valine	.65	.54	.50	.47	.70	.60	.62	.51	68
Histidine	.36	.30	.28	.26	.39	.34	.31	.29	32
Arginine	.75	.55	.48	.42	.83	.65	.57	.49	30
Phenylalinine	.64	.53	.48	.45	.69	.59	.54	.49	48
Leucine	1.42	1.26	1.20	1.16	1.48	1.34	1.28	1.22	100
Protein	12.6	10.3	9.3	8.8	13.6	11.5	10.7	9.8	

[a]Balanced with natural ingredients for the first-, second-, third-, and fourth-limiting amino acids with crystalline amino acids utilized to correct amino acid deficiencies created.

[b]Provided per kg of complete diet: 100 mg Zn, 75 mg Fe, 7.5 mg Cu, 25 mg Mn, 175 :g I, 300 :g Se, 16.5 IU vitamin E, 3.3 mg riboflavin, 17.6 mg niacin, 13.2 :g vitamin B_{12}, 2.2 mg vitamin K_3, 13.2 mg pantothenic acid, 3960 IU vitamin A, and 396 IU vitamin D_3.

Results

The results of pig performance for individual growth phases are summarized in Tables 5 through 8. In most cases gender by dietary treatment interactions (P>.10) were not found. However, main effect means for dietary treatments as well as gender x dietary treatment interaction means are presented in the tables. Average days on test were 21, 25, 29, and 31 for grower I, grower II, finisher I, and finisher II trials, respectively.

Grower I Trial (22 to 36 kg). Average daily gain and daily feed intake were unaffected (P>.10) by dietary treatment (Table 5). However, gain/feed was affected (P<.10). When diets were formulated to meet the tryptophan or isoleucine requirement, gain/feed was reduced. No gender effects on gain, feed intake, or feed efficiency (P>.10) were observed. However, there was a gender by dietary treatment interaction (P<.05) for gain/feed. Formulating the diet for the isoleucine requirement with natural ingredients produced a negative response in gain/feed for gilts but not barrows. It had been assumed that the nutrient requirements for barrows and gilts were the same at this early grower period. However, the fact that barrows maintained gain/feed and gilts exhibited reduced gain/feed as protein was reduced from 17.7 to 13.9% and replaced with amino acids might suggest that the requirements of gilts for amino acids were not being met.

Grower II Trial (36 to 59 kg). Daily gain, daily feed intake, and gain/feed were unaffected (P>.10) by dietary treatment in the grower II trial (Table 6). By supplementing the diet with amino acids in this growth phase, diets were reduced in protein from 16.1 to 12.3% for barrows and from 16.6 to 12.7% for gilts without adverse effects on pig performance. Gender effects were found for daily gain (P<.05) and daily feed intake (P<.10). Barrows consumed more feed and gained faster than gilts. However, gain/feed was similar (P>.10) between genders. No dietary treatment by gender interactions (P>.10) were observed.

TABLE 5. PERFORMANCE OF PIGS FED DIETS FORMULATED TO REDUCE EXCESS AMINO ACIDS DURING THE GROWER I (22 TO 35 KG) PERIOD

	Barrows and gilts				
	Diet balanced for[a]				
Item	LYS	THR	TRP	ILE	SE
No. of pigs	36	36	36	36	
Initial wt, kg	22.8	22.8	23.2	23.1	.41
Final wt, kg[b]	38.7	38.0	38.6	37.3	.25
Daily gain, kg	.76	.72	.72	.67	.02
Daily feed, kg	1.64	1.57	1.69	1.60	.04
Gain/feed[c]	.46	.46	.42	.42	.01

	Barrows				Gilts				
	Diet balanced for								
	LYS	THR	TRP	ILE	LYS	THR	TRP	ILE	SE
No. of pigs	18	18	18	18	18	18	18	18	
Initial wt, kg	22.6	23.0	22.4	22.5	22.9	22.6	24.0	23.8	.58
Final wt, kg[d]	37.4	37.5	38.1	36.8	40.0	38.5	39.1	37.8	.25
Daily gain, kg	.70	.69	.72	.68	.81	.76	.72	.67	.02
Daily feed, kg	1.57	1.60	1.71	1.50	1.70	1.55	1.68	1.70	.04
Gain/feed[e]	.45	.43	.42	.45	.48	.49	.43	.39	.01

[a]Balanced with natural ingredients for the first-, second-, third-, and fourth-limiting amino acids with crystalline amino acids utilized to correct amino acid deficiencies created.
[b]Diet effect (P<.05).
[c]Diet effect (P<.10).
[e]Gender effect (P<.10).
[e]Diet x gender effect (P<.05).

TABLE 6. PERFORMANCE OF PIGS FED DIETS FORMULATED TO REDUCE EXCESS AMINO ACIDS DURING THE GROWER II (36 TO 59 KG) PERIOD

	Barrows and gilts			
	Diet balanced for[a]			
Item	LYS	TRP-THR	ILE	SE
No. of pigs	40	40	40	
Initial wt, kg	36.0	35.9	36.0	.07
Final wt, kg	60.1	59.3	59.3	.49
Daily gain, kg	.96	.95	.93	.02
Daily feed, kg	2.70	2.96	2.74	.08
Gain/feed	.36	.33	.34	.02

	Barrows			Gilts			
	Diet balanced for						
	LYS	TRP	ILE	LYS	THR	ILE	SE
No. of pigs	20	20	20	20	20	20	
Initial wt, kg[b]	35.8	35.9	35.9	36.2	35.9	36.1	.10
Final wt, kg[b]	61.0	59.4	60.6	59.1	59.2	58.1	.70
Daily gain, kg[b]	1.04	.97	1.02	.88	.93	.85	.04
Daily feed, kg[c]	2.90	2.89	2.82	2.49	2.82	2.66	.12
Gain/feed	.37	.34	.36	.36	.33	.32	.02

[a]Balanced with natural ingredients for the first-, second-, and third-limiting amino acids with crystalline amino acids utilized to correct amino acid deficiencies created.
[b]Gender effect (P<.05).
[c]Gender effect (P<.10).

Finisher I Trial (59 to 86 kg). Pig performance for the finisher I trial was similar (P>.10) across the three dietary treatments for both genders (Table 7). Performance of both barrows and gilts was maintained as protein was reduced and amino acids supplemented. Balancing the diets with natural ingredients and supplementing with crystalline amino acids reduced protein from 14.3 to 10.3% for barrows and from 16.1 to 11.8% for gilts with no adverse effects. Treatment x gender interactions were not observed. During the finisher I period, barrows consumed more feed (P<.10) than gilts, but no difference (P>.10) in gain or gain/feed was observed due to gender.

Finisher II Trial (86 to 114 kg). Average daily gain daily feed, and gain/feed were unaffected (P>.10) by dietary treatment (Table 8). Barrows consumed more feed (P<.01) and exhibited a faster rate of gain (P<.01) than gilts. However, gain/feed was similar (P>.10) between genders of pigs. A dietary treatment x gender interaction (P<.10) was observed for daily gain. Gain was unexplainably high for barrows receiving the diet formulated to meet the tryptophan requirement. Feed intake for that same group was also numerically, not statistically, higher than for other groups of pigs. By supplementing the diet with amino acids and balancing for isoleucine with natural ingredients, protein content was reduced from 12.6 to 8.8% for barrows and from 13.6 to 9.8% for gilts without affecting performance.

TABLE 7. PERFORMANCE OF PIGS FED DIETS FORMULATED TO REDUCE EXCESS AMINO ACIDS DURING THE FINISHER I (59 TO 85 KG) PERIOD.

	Barrows and gilts			
	Diet balanced for[a]			
Item	LYS	TRP-THR	ILE	SE
No. of pigs	40	40	40	
Initial wt, kg	57.7	57.8	57.7	.06
Final wt, kg	79.4	81.2	80.0	1.16
Daily gain, kg	.77	.84	.80	.04
Daily feed, kg	2.74	2.90	2.93	.08
Gain/feed	.28	.29	.27	.01

	Barrows			Gilts			
	Diet balanced for						
	LYS	TRP	ILE	LYS	THR	ILE	SE
No. of pigs	20	20	20	20	20	20	
Initial wt, kg[b]	57.6	57.6	57.4	57.9	57.9	57.9	.08
Final wt, kg	79.9	82.5	81.5	78.9	79.9	78.5	1.65
Daily gain, kg	.80	.89	.86	.75	.78	.74	.06
Daily feed, kg[c]	2.93	3.14	3.05	2.56	2.67	2.82	.11
Gain/feed	.27	.28	.28	.29	.29	.26	.01

[a]Balanced with natural ingredients for the first-, second-, and third-limiting amino acids with crystalline amino acids utilized to correct amino acid deficiencies created.
[b]Gender effect (P<.05).
[c]Gender effect (P<.10).

TABLE 8. PERFORMANCE OF PIGS FED DIETS FORMULATED TO REDUCE EXCESS AMINO ACIDS DURING THE FINISHER II (86 TO 114 KG) PERIOD

	Barrows and gilts				
	Diets balanced for[a]				
Item	LYS	THR	TRP	ILE	SE
No. of pigs	32	32	32	32	
Initial wt, kg	85.9	85.9	86.1	85.9	.08
Final wt, kg[b]	114.3	115.6	114.3	114.1	.43
Daily gain, kg	.98	1.01	.95	.96	.02
Daily feed, kg	4.05	3.88	3.92	3.98	.12
Gain/feed[c]	.24	.26	.24	.24	.01

	Barrows				Gilts				
	Diet balanced for								
	LYS	THR	TRP	ILE	LYS	THR	TRP	ILE	SE
No. of pigs	16	16	16	16	16	16	16	16	
Initial wt, kg	86.3	86.4	86.4	86.4	85.5	85.4	85.7	85.3	.11
Final wt, kg[d]	114.2	115.9	114.0	113.6	114.4	115.2	114.6	114.7	.61
Daily gain, kg	1.02	1.09	1.00	.97	.94	.93	.91	.94	.02
Daily feed, kg	4.12	4.20	4.24	4.07	3.99	3.65	3.61	3.90	.17
Gain/feed[e]	.25	.26	.24	.24	.24	.26	.25	.25	.01

[a]Balanced with natural ingredients for the first-, second-, third-, and fourth-limiting amino acids with crystalline amino acids utilized to correct amino acid deficiencies created.
[b]Gender effect (P<.01).
[c]Diet x gender effect (P<.10).

Summary

Four trials (512 pigs) evaluated the effect of systematically balancing diets for barrows and gilts for the first through the fifth limiting amino acids for grower I (22 to 36 kg), grower II (36 to 59 kg), finisher I (59 to 86 kg), and finisher II (86 to 114 kg) periods. Protein content of the diets was reduced by altering the ratio of corn and soybean meal to balance for the first (lysine) through fifth (isoleucine) limiting amino acid with crystalline lysine, methionine, tryptophan, and threonine added to provided amino acids in an Ideal Protein ratio relative to lysine. For each growth period, diets were separately formulated for barrows and gilts where their requirements differed. Formulating diets for the isoleucine requirement rather than the lysine requirement with natural ingredients supplemented with crystalline amino acids reduced protein content from 17.7 to 13.9% for barrows and gilts in grower I, from 16.1 and 16.6% to 12.3 and 12.7% in grower II, from 14.3 and 16.1% to 10.3 and 11.8% in finisher I and from 12.6 and 13.6% to 8.8 and 9.8% in finisher II for barrows and gilts, respectively.

In the grower I phase, daily gain and feed intake were unaffected by dietary treatment. However, gain/feed was affected. When diets were formulated to meet the tryptophan or isoleucine requirement, gain/feed was reduced. There was a gender by dietary treatment interaction for gain/feed. Formulating the diet for the isoleucine requirement with natural ingredients produced a negative response in gain/feed for gilts but not for barrows, suggesting that the requirements for amino acids of gilts were not being met. For the grower II, finisher I and finisher II phases, dietary treatment did not affect average daily gain, daily feed, and gain/feed. In the grower II, finisher I and finisher II phases, barrows consumed more feed than gilts. They also gained faster in the grower II and finisher II phases. However, in no phase was gain/feed different between genders of pigs. Reducing protein content of the diet by altering corn and soybean meal ratio with appropriate supplementation of available amino acids did not negatively affect growing and finishing pig performance.

Implications

The four trials, through the use of the Ideal Protein concept and split sex feeding, demonstrated that performance of barrows and gilts can be maintained while significantly reducing total nitrogen in the diet of growing and finishing pigs. Formulating the diet for isoleucine with natural feed ingredients and supplementing with crystalline lysine, methionine, tryptophan, and threonine, where appropriate, reduced dietary nitrogen content by about 21.5% in the grower I phase and by about 30.0% in the finisher II phase. When crystalline amino acid use is economically viable, or when it is desirable to reduce nitrogen output, a strategy such as demonstrated in this research may be appropriate.

Effects of protein level and gender on estimation of lean gain per day of pigs from a terminal crossbreeding system

G.W. Libal, C.R. Hamilton, and J.N. Tembei
Department of Animal and Range Sciences

SDSU

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Lean growth potential is currently used to typify pigs when designing nutritional programs. The most common method of estimating lean growth type is by measuring gain over the grow-finish period and obtaining carcass information for the pigs evaluated. This information is placed in a model to calculate lean gain/day. Excess protein is fed to ensure that the genetic potential for lean gain per day is not limited by nutrition. The data reported herein are the results of determining the lean growth potential of the SDSU research herd in 1992 with pigs fed two different protein regimens.

(Key Words: Growing swine, Lean gain, Protein level, Sex.)

Experimental Procedure

The effect of protein regimen on lean growth of the SDSU swine research herd was evaluated with a factorial arrangement of sex and protein regimen in a complete block design. Seventy-two pigs averaging 28.7 kg, the result of a terminal cross (Landrace x Large White by Duroc x Hampshire), were allotted to dietary treatments and sex groups from within six sire outcome groups (blocks). Pigs were housed by sex, three per pen, in an environment-modified confinement building with slatted floors. Two dietary protein regimens were fed ad libitum: (1) 16% protein from initial weight to a pen average weight of 50 kg and 14% protein after 50 kg or (2) 18% protein for the entire test. Diets (Table 1) were formulated with corn and soybean meal and fortified with vitamins and minerals. Pigs were removed individually from test on weekly weigh dates when they reached 110 kg, were slaughtered, and carcass data collected. Calculation of lean gain/day (5% fat) was made with the NPPC (1991) formula utilizing hot carcass weight, 10th rib fat, longissimus muscle area, initial weight, and days on test.

TABLE 1. PERCENTAGE COMPOSITION OF GROWER AND FINISHER DIETS

Ingredients	Grower 16%	Finisher 14%	Grower-Finisher 18%
Ground corn	75.14	81.13	68.10
Soybean meal, 44%	21.69	15.99	28.60
Dicalcium phosphate	1.07	.91	1.20
Limestone	.85	.72	.85
White salt	.25	.25	.25
Premix[a]	1.00	1.00	1.00
Calculated analysis, (%)			
Crude protein	16.0	14.0	18.0
Calcium	.65	.65	.65
Phosphorus	.55	.55	.55
Lysine	.82	.65	1.00

[a]Provided per kg of complete diet: 100 mg Zn, 75 mg FE, 7.5 mg Cu, 25 mg Mn, 175 :g I, 1300 :g Se, 16.5 IU vitamin E, 3.3 mg riboflavin, 17.6 mg niacin, 13.2 :g vitamin B_{12}, 2.2 mg vitamin K_3, 13.2 mg pantothenic acid, 3960 IU vitamin A, and 396 IU vitamin D_3.

Results

Sex differences in pig performance to 110 kg and carcass traits were typical of those expected for barrows and gilts (Table 2). Barrows gained at a faster rate (P<.05) than gilts resulting from greater feed intake (P<.05). Gain/feed (P>.10) was similar between gilts and barrows. At the same slaughter weight, barrow carcasses measured more 10th rib fat (P<.01) and smaller longissumus muscle area (P<.01).

Both barrows and gilts consumed more feed (P<.05) when fed the dietary protein regimen that supplied 18% protein during the entire growth period (Table 2). However, gain/feed, 10th rib fat, and longissumus muscle area, the criteria typically affected by protein level, were unaffected by protein regimen (P>.10).

In spite of the differences observed in average daily gain, 10th rib fat, and longissimus muscle between sexes, lean gain/day was similar (P>.10) between barrows and gilts. The additional energy consumed by barrows was apparently converted to fat and did not contribute to additional muscle deposition. Although protein regimen had affected feed intake and average daily gain, the 16% to 14% protein regimen was adequate for barrows and gilts with no improvement in lean gain/day for pigs fed 18% protein (P>.10). At the time this research was conducted, lean gain/day (5% fat) for the SDSU herd was estimated to be between .29 and .30 kg. This would be considered to be within, but at the high end of, the medium lean growth range.

TABLE 2. LEAST SQUARES MEANS FOR MAIN EFFECTS OF SEX AND PROTEIN REGIMEN

Item	Sex	P	Protein regimen 16% to 14%	Protein regimen 18%
Average daily gain, kg				
	Barrows	.86*	.84	.89
	Gilts	.80	.78	.82
			.81	.86*
Average daily feed, kg				
	Barrows	3.25*	3.09	3.40
	Gilts	3.06	3.03	3.09
			3.06	3.25*
Gain/feed				
	Barrows	.26	.27	.26
	Gilts	.26	.26	.27
			.26	.26
10th rib fat, cm				
	Barrows	2.47**	2.43	2.50
	Gilts	1.86	1.82	1.90
			2.13	2.20
Longissimus area, cm^2				
	Barrows	31.48**	31.9	31.1
	Gilts	35.00	34.3	35.7
			33.1	33.4
Lean gain/day, kg				
	Barrows	**.29**	**.28**	**.29**
	Gilts	**.30**	**.29**	**.31**
			.29	**.30**

Probabilities for main effects (sex or protein regimen), *P<.05, **P<.01.

Although means for the six sire groups evaluated in this study are not reported, differences among sire groups were found for all criteria evaluated. There were also interactions between sire groups and protein regimen as well as between sire groups and sex. Average lean gain/day for sire groups ranged from a low of .25 kg to a high of .34 kg.

Summary

The effect of protein regimen on lean gain/day was determined for the SDSU swine research herd utilizing 72 barrows and gilts from six sire groups. The two protein regimens were either 16% followed by 14% at 50 kg or 18% protein for the entire growth period from 28.7 to 110 kg. Barrows consumed more feed, gained faster, and measured more 10th rib fat and less longissumus muscle area than gilts. Barrows or gilts consuming the higher protein level consumed more feed and gained faster than those provided the lower protein regimen. However, protein regimen did not affect 10th rib fat, longissumus muscle area, or gain/feed. Lean growth was similar for barrows and gilts and unaffected by dietary protein regimen. Lean gain/day for the SDSU swine research herd was estimated to be between .29 and .30 kg.

Implications

Although the 18% protein regimen provided for more feed intake and greater daily gain, the lean gain observed was similar to that obtained with the 16% to 14% protein sequence. Either the 16% to 14% sequence was adequate to allow both barrows and gilts to express their lean gain capabilities or the equations used to calculate lean gain are not sensitive enough to allow detection of lean gain caused by protein regimen. Lean growth for barrows and gilts is similar even though barrows typically have higher feed intake and gain. Additional weight gain of barrows is apparently primarily gain in fat tissue rather than lean tissue. Lean gain/day for this herd was evaluated across six sire groups with documented differences in performance and carcass characteristics among sire groups. While the entire herd was estimated to have a lean gain/day of between .29 to .30 kg, individual sire groups ranged in estimated lean growth from .25 to .34 kg. These data point out that an estimate of average lean gain/day for a herd can be obtained with either barrows or gilts or with both barrows and gilts. Protein levels fed need not be higher than those, which will produce maximum feed intake and gain. However, errors in the estimate of a herd's average lean gain/day are likely if small samples of pigs are tested which do not accurately represent the range of genetic potential for lean growth found in the herd.