Effect of Feeding a Reduced Crude Protein and Reduced Phosphorus Diet on Growth Performance and Carcass Characteristics in Grow-Finish Swine

R. Hinson, B. Hill, M. Walsh, D. Sholly, D. Kelly, M. Cobb, L. Peddireddi
S. Radcliffe, A. Sutton, A. Schinckel, and B. Richert
Department of Animal Sciences

Introduction

The swine industry has undergone many production changes over the past two decades. Production facilities have become more concentrated, not only in the number of pigs reared at one operation, but also the number of production facilities located in the same geographic area. A negative aspect of this increased animal concentration is the increase in the amount of manure that is produced and the land that is needed for manure application at environmentally sustainable rates. Many practices are currently being explored to increase the amount of manure that can be spread on the same amount of land by reducing the concentration of nutrients excreted in the urine and feces. Three such practices include: feeding diets with a reduced crude protein level and supplementing with crystalline amino-acids, replacing normal corn with high available phosphorus (HAP) corn, and the inclusion of phytase in the diet.

The purpose of this experiment was to combine these three feeding practices into the same low nutrient excretion (LNE) diet and measure its effect on growth performance and carcass characteristics in grow-finish swine.

Materials and Methods

Fifty barrows and forty-eight gilts (Danbred Hampshire X Duroc by Yorkshire X Landrace) were sorted by sex and weight, and randomly assigned to one of two dietary treatments, control and LNE. Average initial body weight was 70.4 lbs. Pigs were housed in one of two identical environmentally controlled rooms with separate ventilation and manure storage pits at the Purdue Swine Research Center with five pigs/pen and five pens/sex/treatment during the grower phase and three pigs/pen during the finisher phase. Feed was split-sex, phase-fed and feed and water were provided at ad libitum. Pigs were fed two grower rations (Table 1) and two finisher rations (Table 2) for a total of a 16 week feeding trial. Individual pig weights and pen feed consumption were measured in two week intervals to determine body weight changes, ADG, ADFI, and G:F.

Prior to the start of the trial, ten pigs (5 barrows and 5 gilts) were slaughtered to determine initial carcass characteristics and composition. At the end of the grower phase (week 8) nineteen pigs per dietary treatment (10 barrows and 9 gilts) were slaughtered to determine final grower phase carcass characteristics and composition. At the end of the finisher phase (week 16), twenty pigs per treatment (10 barrows and 10 gilts) were slaughtered to determine final carcass characteristics and composition. Blood and flushed visceral organs were collected and weighed at the time of slaughter for all pigs and then frozen for later grinding and chemical analyses. All hot carcass weights include the head weight. All the various time point carcasses were allowed to hang overnight in a chill cooler before being ribbed at the 10^{th} rib to determine LEA, 10^{th} rib backfat (off midline), last rib midline backfat, and last lumbar midline backfat. Data presented for these measurements are the average of both sides of the carcass.

Initial slaughter pigs were ultrasonically scanned prior to harvest for 10th rib backfat depth and LEA. The pigs on test were ultrasonically scanned for last rib and 10th rib backfat depths and 10th rib LEA at week 2 of the trial, at the end of the grower phase (week 8), and at the end of the finisher phase (week16) in order to develop protein and lipid accretion prediction curves. Scan data was utilized to show backfat depth, LEA, and predicted percent fat free lean at different periods and overall backfat and LEA changes during the 16-week grow-finish study. Scan data are also presented for the subset of pigs that were represented at each slaughter.

Data were analyzed as a randomized complete block design with 2 X 2 factorial arrangement of dietary treatments and sex using the GLM procedure of SAS (2000). Pen was the experimental unit for the growth performance data and individual pig was the experimental unit for the carcass data.

Results

Growth performance. There were no sex by diet interactions for any of the growth performance data, therefore, only the main effects of diet and sex will be presented (Table 3). Initial grower phase body weight did not differ (P>0.05) between treatment or sex. There was an increase in ADG (P<0.01) for pigs fed the control diet compared to the LNE during the grower phase (1.92 vs. 1.82 lbs/day). However, there were no differences in ADFI between treatments (P>0.10) resulting in a trend for pigs fed the control diets to have a 4% improvement in feed efficiency (P<0.06) compared to pigs fed the LNE diets during the grower period. There was no difference (P>0.05) in ADG between sexes during the grower phase, however, gilts did tend to have lower feed intake (P<0.10) and were more efficient (P<0.05) than the barrows. Grower phase final body weights did not differ (P>0.10) between treatments or sexes.

Dietary treatment had no effect on ADG, ADFI, or G:F during the finisher period (week 8-16; P>0.10) or for the overall study (week 0-16; P>0.10). Average daily gains were not different (P>0.10) between sexes, however, gilts did have lower feed intakes (P<0.03) and greater G:F (P<0.02) than barrows during the finishing phase (week 8 to 16) and for the overall experiment (week 0 to 16). Final body weights at week 16 did not differ (P>0.10) between treatments or sexes.

Carcass characteristics. There were no differences between the sexes in initial (d 0) carcass composition (P>0.10; Table 4). No differences were observed between treatments or sexes for live weights at slaughter, the hot carcass weights, or subsequent dressing percentages (P>0.10; Table 5) at the end of the grower period. There was no difference between treatments for 10th rib, last rib, or last lumbar backfat depths (P>0.10). There was also no difference (P>0.10) in the LEA of the two treatments, but control pigs had a numerically larger LEA than that of the LNE-fed pigs (5.43 vs. 5.32 in^2). There was no difference (P>0.10) between treatments for predicted fat free lean % based on carcass measurements. The LNE treatment reduced blood weight (6.96 vs. 6.44 lbs.), and visceral weight (17.69 vs. 16.72 lbs.), compared to the control pigs (P<0.05) at the end of the grower period.

No difference was observed in LEA (P>0.05) between the sexes, however, fat depth at the 10th and last rib were less (P<0.05) for gilts than for the barrows. Gilts also had a greater predicted fat free lean % (P<0.05) compared to barrows (59.62 vs. 57.43 %). There was one interaction in the grower carcass data, with gilts having less 10th rib backfat compared to barrows in the control treatment compared to gilts and barrows having similar 10th rib backfats when fed the LNE diet (P<0.05). No differences were observed between treatments for the ultrasound scan data (P>0.10) at the end of the grower period. However, gilts tended to have less ultrasound 10th rib backfat thickness than barrows (P<0.08)

Final body weight at slaughter, hot carcass weights or dressing % did not differ (P>0.10) between treatments or sexes (Table 6). However, LNE fed pigs tended to have numerically greater fat depths at the 10^{th} rib (0.90 vs. 0.85 in.), last rib (1.15 vs. 1.11 in.), and last lumbar regions (0.88 vs. 0.78 in.; P<0.08) compared to the control pigs. Control pigs tended to have larger LEA (8.12 vs. 7.63 in^2; P<0.10) when compared to the LNE-fed pigs. There was no difference between treatments for predicted fat free lean % based on carcass measurements (P>0.10). Unlike the pigs at the grower slaughter point, there was no difference between blood or visceral weights (P>0.10) at the finisher slaughter point between dietary treatments. There were no differences between treatments for either backfat measurements using the ultrasound scan information (P>0.10). Ultrasound LEA was higher in the control pigs compare to the LNE pigs (7.93 vs 7.00 in^2; P<0.05).

At the end of the study, gilts continued to have less backfat depths at the 10^{th} rib, last rib, and last lumbar regions, compared to barrows (P<0.05). There was also a difference between the sexes in LEA, with gilts having greater LEA than the barrows (8.32 vs. 7.43 in^2; P<0.01). Gilts continued to have greater predicted fat free lean % (39.03 vs. 37.43 %; P<0.001) compared to barrows. There was a difference between sexes for ultrasound 10^{th} rib backfat (0.79 vs. 0.68 in.) and last rib backfat thickness (0.74 vs. 0.63 in.), with barrows having great backfats than gilts (P<0.05).

Mass scan data. Based on the ultrsound mass scan data (all pigs on test), 10^{th} rib backfat was observed to be higher in the LNE fed pigs (0.31 vs. 0.34 in.; P<0.01) compared to the control-fed pigs, but the last rib backfat was higher in the control-fed pigs (.33 vs.315 in; P<.06) than the LNE–fed pigs at the week two scan. Week eight and sixteen scans revealed no difference (P>0.10) in 10^{th} rib or last rib backfat depths between dietary treatments and the overall change in 10^{th} rib or last rib backfat thickness was not different (P>0.10) between the LNE and Control diets. No difference was observed in the initial ultrasound scan LEA (P>0.10) between dietary treaments. Over the remainder of the experimental period, control pigs exhibited larger LEA (P<0.05) compared to the LNE pigs at week 8 (5.34 vs. 5.05 $in.^2$) and week 16 (7.98 vs. 7.12 $in.^2$). This resulted in an overall increase in ultrasound scan based LEA changes over time (P<0.001) measurements for the control-fed pigs compared to the LNE-fed pigs (5.23 vs. 4.29 $in.^2$).

For the initial scan data, gilts exhibited less 10^{th} rib backfat (P<0.01) than the barrows (0.31 vs. 0.34 in.), this difference was carried throughout the remaining scans, with gilts having less 10^{th} rib and last rib backfat depths (P<0.05), and less overall change at of 10^{th} rib and last rib backfat thickness (P<0.05) for the remained of the study. Gilts exhibited larger (P<0.05) LEA measurements at all three scan periods. Yet, there was no difference (P>0.10) in the overall LEA change between barrows and gilts (4.71 vs. 4.80 $in.^2$).

Discussion

As our data shows, feeding diets that incorporate reduced CP, amino acid supplementation, HAP corn, and phytase can maintain growth performance in grow-finish swine, providing similar performance to typical commercial control diets. Pigs fed the LNE diets grew slower (P<0.05) and had slightly decreased feed efficiency during the grower phase. This slower growth rate and lower feed efficiency deficit was erased during the finisher phase, with the LNE pigs having very comparable growth performance data with that of the control pigs for the overall grower/finisher phase.

Carcass and ultrasound mass scan measurements for the ending grower phase and final slaughter yielded no differences (P>0.05) between the two treatments in backfat thickness, although, LNE pigs tended to have numerically greater backfat depths at the 10^{th} rib, last rib, and last lumbar regions. Also, LNE fed pigs had LEAs that tended to be numerically smaller. Consequently, over the coarse of the scan period, predicted fat free lean % for the control pigs became greater ($P<0.05$) than that of the LNE pigs.

It has been presented by Kendall et al. (1999) that the increase in backfat depths could be attributed an increase in the net energy of the LNE diets. The increase in net energy is due to the substitution of soybean meal with HAP corn in the LNE diets, which will lead to a more energy dense diet. Shelton et al.(2003) reported that the edition of phytase also had a tendency to increase backfat depths, potentially due to liberation of some energy previously bound by the phytate molecule.

Application

From this study, it appears that diets formulated with reduced crude protein, crystalline amino-acid supplementation, high available phosphorus corn, and phytase, are able to meet the nutrient requirements of the pigs and maintain sufficient growth performance. Carcass quality was slightly negatively impacted with the LNE diet for reasons that are not fully understood at this time. Further research in this area is needed to determine the exact cause of the numerical decreases in carcass qualities when the LNE diet is fed. Possibilities are that the NE level of the LNE diet is eleveated due to the increase in corn and decrease in soybean meal, and/or possibly the need to further evaluation of the amino-acid requirements and ratios suggested by the NRC (1998) for the genetic lines of pigs used in this study.

Acknowledgement

Partial support for this research is from a multi-state consortium EPA grant which is greatly appreciated.

References

Kendall, D.C., B.T. Richert, A.L. Sutton, J.W. Frank, S.A. Decamp, K.A. Bowers, D. Kelly, M. Cobb, and D. Bundy. 1999. Effects of Fiber Addition (10% Soybean Hulls) to a Reduced Crude Protein Diet Supplemented With Synthetic Amino Acids Versus a Standard Commercial Diet on Pig Performance, Pit Composition, Odor and Ammonia Levels in Swine Buildings. Purdue Swine Day Reports. pp. 46-52

Kerr, B.J., F.K. McKeith, and R.A. Easter. 1995. Effect on Performance and Carcass Characteristics of Nursery to Finisher Pigs Fed Reduced Crude Protein, Amino Acid-Supplemented Diets. J. Anim. Sci. 73:433-440

NRC. 1998. Nutrient Requirements of Swine. 10th rev. ed. Natl. Acad. Press, Washington, DC.

Shelton, J.L., L.L. Southern, T.D. Bidner, M.A. Persica, J. Braun, B. Cousins, and F. McKnight. Effect of Microbial Phytase on Energy Availability, and Lipid and Protein Deposition in Growing Swine. J. Anim. Sci. 81:2053-2062.

Table 1. Ingredient composition of grower phase dietary treatments[a]

Phase	Grower 1				Grower 2			
Dietary Treatment	Control		LNE		Control		LNE	
Ingredient, %	Barrows	Gilts	Barrows	Gilts	Barrows	Gilts	Barrows	Gilts
Corn, normal	71.57	68.12	- -	- -	77.02	73.48	- -	- -
Corn, HAP	- -	- -	81.71	77.99	- -	- -	84.99	82.361
SBM, 48% CP	24.50	28.00	14.30	18.00	18.95	22.55	11.50	14.05
Swine grease	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Limestone	0.85	0.85	1.20	1.17	0.82	0.84	1.111	1.11
Dical. Phos.	1.25	1.20	0.26	0.30	1.38	1.30	0.05	0.05
Vitamin premix[b]	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
TM premix[c]	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875
Phytase[d]	- -	- -	0.075	0.075	- -	- -	0.075	0.075
Salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Lysine-HCL	0.10	0.10	0.46	0.456	0.10	0.10	0.362	0.40
DL-Methionine	- -	- -	0.075	0.10	- -	- -	0.03	0.06
L-Threonine	- -	- -	0.145	0.152	- -	- -	0.12	0.136
L-Tryptophan	- -	- -	0.038	0.035	- -	- -	0.03	0.031
CTC - 50	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Se 600[e]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Total	100	100	100	100	100	100	100	100
Calculated composition								
Crude protein, %	17.7	19.0	13.9	15.4	15.5	16.9	12.8	13.8
ME, Kcal/lb	1522	1522	1523	1522	1521	1522	1531	1529
Calcium, %	0.70	0.70	0.59	0.60	0.70	0.70	0.50	0.51
Phosphorus, %	0.60	0.61	0.39	0.41	0.60	0.60	0.34	0.35
Avail. phosphorus, %	0.30	0.30	0.23	0.24	0.32	0.31	0.19	0.19
Lysine, %	1.00	1.10	1.00	1.10	0.85	0.95	0.85	0.95
Threonine, %	0.66	0.72	0.64	0.71	0.57	0.63	0.58	0.63
Meth. + Cyst., %	0.60	0.64	0.57	0.63	0.54	0.58	0.50	0.55
Tryptophan, %	0.20	0.22	0.18	0.20	0.17	0.19	0.16	0.17
Analyzed composition								
Crude protein, %	19.06	19.72	13.95	16.53	15.52	16.06	13.87	14.10
Crude fat, %	4.38	4.30	3.04	2.80	4.35	3.40	3.40	2.99
Lysine, %	1.10	1.15	1.06	1.26	0.84	0.96	0.96	0.97
Threonine, %	0.70	0.72	0.61	0.71	0.55	0.62	0.59	0.62
Meth. + Cyst., %	0.63	0.65	0.54	0.63	0.53	0.59	0.53	0.57
Tryptophan, %	0.26	0.28	0.23	0.25	0.21	0.25	0.20	0.21

[a]Control = Standard grower diet; LNE = High available phosphorus corn + reduced crude protein, amino acid supplementation + phytase.

[b]Provides per pound of diet: 1,650 IU A; 165 IU D3; 12.0 IU E; 0.54 mg Menadione; 9.52 µg B12; 1.93 mg Riboflavin; 6.0 mg Pantothenic acid; 9.0 mg Niacin.

[c]Provides per pound of diet: 38.5 mg Fe; 38.5 mg Zn; 4.78 mg Mn; 3.6 mg Cu; 0.15 mg I.

[d]Provided 204 phytase units/lb of diet.

[e]Provides .135 mg of selenium per lb diet.

Table 2. Ingredient composition of finisher phase dietary treatments [a]

Phase:	Finisher 1				Finisher 2			
Dietary Treatment:	**Control**		**LNE**		**Control**		**LNE**	
Ingredient, %	**Barrows**	**Gilts**	**Barrows**	**Gilts**	**Barrows**	**Gilts**	**Barrows**	**Gilts**
Corn, normal	82.83	79.30	- -	- -	86.72	83.18	- -	- -
Corn, HAP	- -	- -	89.96	87.19	- -	- -	92.76	90.03
SBM, 48% CP	13.50	17.1	6.40	9.10	9.85	13.45	3.80	6.50
Swine grease	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Limestone	0.825	0.84	1.56	1.54	0.83	0.85	1.46	1.435
Dical. Phos.	1.22	1.14	- -	- -	1.03	0.942	- -	- -
Vitamin premix [b]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
TM premix [c]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Phytase [d]	- -	- -	0.075	0.075	- -	- -	0.075	0.075
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine-HCL	0.10	0.10	0.35	0.385	0.10	0.10	0.315	0.35
DL-Methionine	- -	- -	0.025	0.06	- -	- -	- -	0.02
L-Threonine	- -	- -	0.08	0.10	- -	- -	0.085	0.08
L-Tryptophan	- -	- -	0.03	0.03	- -	- -	0.034	0.03
CTC-50	0.10	0.10	0.10	0.10	- -	- -	- -	- -
Tylan 40	- -	- -	- -	- -	0.05	0.05	0.05	0.05
Se 600 [e]	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
Total	100	100	100	100	100	100	100	100
Calculated composition								
Crude protein, %	13.37	14.78	10.78	11.86	11.95	13.37	9.75	10.83
ME, Kcal/lb	1528	1528	1530	1528	1532	1532	1533	1532
Calcium, %	0.65	0.65	0.65	0.65	0.60	0.60	0.60	0.60
Phosphorus, %	0.55	0.55	0.31	0.32	0.50	0.50	0.30	0.32
Avail. phosphorus, %	0.28	0.27	0.19	0.18	0.24	0.23	0.19	0.19
Lysine, %	0.70	0.80	0.70	0.80	0.60	0.70	0.60	0.70
Threonine, %	0.49	0.55	0.46	0.52	0.43	0.49	0.42	0.46
Meth. + Cyst., %	0.49	0.53	0.44	0.50	0.45	0.49	0.39	0.44
Tryptophan, %	0.14	0.16	0.12	0.14	0.12	0.14	0.11	0.13
Analyzed composition								
Crude protein, %	12.55	14.58	11.72	13.25	11.74	13.29	10.52	11.67
Crude fat, %	3.19	3.25	3.18	3.15	5.05	4.93	4.75	3.30
Lysine, %	0.68	0.82	0.74	0.87	0.60	0.70	0.63	0.76
Threonine, %	0.45	0.54	0.50	0.55	0.43	0.47	0.44	0.47
Meth. + Cyst., %	0.49	0.54	0.46	0.50	0.45	0.48	0.42	0.47
Tryptophan, %	0.15	0.19	0.17	0.18	0.14	0.17	0.15	0.15

[a]Control = Standard finisher diet; LNE = High available phosphorus corn + reduced crude protein, amino acid supplementation + phytase.

[b]Provides per pound of diet: 1100 IU A; 110 IU D3; 8.0 IU E; 0.36 mg Menadione; 6.35 µg B12; 1.29 mg Riboflavin; 4.0 mg Pantothenic acid; 6.0 mg Niacin.

[c]Provides per pound of diet: 22 mg Fe; 22 mg Zn; 2.7 mg Mn; 2.0 mg Cu, 0.08 mg I.

[d]Provided 204 phytase units/lb feed.

[e]Provides .068 mg of selenium per lb diet.

Table 3. Effect of dietary treatment and sex on pig grow-finish growth performance [a]

	Control		LNE			Probability, (P<)		
	Barrows	**Gilts**	**Barrows**	**Gilts**	**SE[b]**	**Treatment**	**Sex**	**Trt X Sex**
Grower (week 0-8)								
No. pigs/trt	25	24	25	24				
No. pens/trt	5	5	5	5				
d 0 BW, lbs	70.6	70.4	70.6	70.1	2.94	0.971	0.895	0.971
ADG, lbs	1.95	1.89	1.82	1.83	0.033	0.010	0.394	0.3089
ADFI, lbs	4.71	4.33	4.60	4.42	0.163	0.933	0.099	0.541
G:F	0.41	0.44	0.40	0.42	0.010	0.059	0.047	0.911
d 53 BW, lbs	174.0	170.4	167.1	166.9	4.23	0.237	0.656	0.689
Finisher (week 8-16)								
No. pigs/trt	15	15	15	15				
No. pens/trt	5	5	5	5				
d 53 BW, lbs	175.6	172.3	168.3	168.6	4.01	0.186	0.719	0.665
ADG, lbs	1.91	1.85	1.92	1.93	0.062	0.497	0.677	0.610
ADFI, lbs	6.47	5.82	6.44	6.13	0.182	0.461	0.018	0.370
G:F	0.30	0.32	0.30	0.31	0.007	0.965	0.014	0.642
d 109 BW, lbs	282.5	274.1	275.8	276.5	4.96	0.671	0.441	0.373
Overall grow-finish (week 0-16)								
ADG, lbs	1.93	1.87	1.87	1.88	0.037	0.514	0.468	0.380
ADFI, lbs	5.40	4.94	5.31	5.09	0.143	0.826	0.031	0.434
G:F	0.36	0.38	0.35	0.37	0.007	0.376	0.020	0.882

[a]Control = Standard diet; LNE = HAP corn + reduced crude protein, amino acid supplementation + phytase.
[b]Pooled standard error of treatment X sex means.

Table 4. Effect of sex on initial carcass characteristics

	Sex			
	Barrows	**Gilts**	**SE**	**Significance, (P<)**
No. of Pigs	5	5		
Live weight, lbs	75.1	74.0	3.25	0.817
Carcass weight, lbs [a]	57.6	57.9	2.77	0.933
Dressing %	76.5	78.3	0.84	0.172
Average 10th rib backfat, in [b]	0.35	0.32	0.031	0.584
Average loin eye area, in^2 [b]	2.41	2.53	0.195	0.661
Predicted fat free lean, % [c]	79.7	80.8	2.18	0.717
Blood weight	3.77	3.52	0.172	0.327
Visceral weight	10.3	9.5	0.36	0.130
Scan data				
10th rib backfat, in	0.33	0.35	0.020	0.584
Loin eye area, in^2	1.95	1.92	0.106	0.841

[a]Carcass weights include head weight.
[b]Average of left and right side.
[c]Predicted fat free lean = 25.2 + 0.367*CW, lbs + 2.759*LEA, in^2 + -21.17*10th rib backfat, in; $R^2 = 0.84$.

Table 5. Effect of dietary treatment and sex on grower phase carcass characteristics and live ultrasound measures[a]

	Control		LNE			Significance, (P<)		
	Barrows	**Gilts**	**Barrows**	**Gilts**	**SE [b]**	**Treatment**	**Sex**	**Trt X Sex**
No. of pigs	10	9	10	9				
Live weight, lbs	170.3	165.0	164.6	160.8	3.98	0.224	0.258	0.859
Carcass weight, lbs [c]	135.0	131.6	131.2	128.8	3.34	0.328	0.402	0.886
Dressing %	79.2	79.8	79.6	80.1	0.43	0.398	0.253	0.950
10th rib backfat, in [d]	0.61	0.46	0.56	0.54	0.031	0.593	0.012	0.048
Last rib backfat, in [d]	1.03	0.86	1.03	0.96	0.051	0.323	0.036	0.352
Last lumbar backfat, in [d]	0.48	0.44	0.45	0.48	0.037	0.948	0.931	0.330
Loin eye area, in^2 [d]	5.42	5.44	5.13	5.50	0.228	0.616	0.392	0.458
Predicted fat free lean, %[e]	57.1	59.9	57.8	59.3	0.84	0.945	0.013	0.425
Blood weight, lbs	6.98	6.94	6.63	6.25	0.210	0.019	0.334	0.429
Visceral weight, lbs	18.0	17.34	17.01	16.4	0.39	0.019	0.104	0.871
Scan data								
10th rib backfat, in	0.46	0.39	0.44	0.43	0.023	0.671	0.076	0.195
Last rib backfat, in	0.46	0.40	0.43	0.42	0.020	0.876	0.131	0.299
Loin eye area, in^2	5.36	5.11	5.08	5.04	0.195	0.375	0.459	0.601

[a] Control = Standard diet; LNE = HAP corn + reduced crude protein, amino acid supplementation + phytase.
[b]Pooled standard error of treatment X sex interaction means.
[c]Hot carcass weight includes head weight.
[d] Average of left and right carcass sides.
[e]Predicted fat free lean = 25.2 + 0.367*HCW, lbs + 2.759*LEA, in^2 + -21.17*10th rib BF, in; R^2= 0.84.

Table 6. Effect of dietary treatment and sex on finishing carcass characteristics and live ultrasound measures [a]

	Control		LNE			Probability, (P<)		
	Barrows	**Gilts**	**Barrows**	**Gilts**	**SE[b]**	**Treatment**	**Sex**	**Trt X Sex**
No. of pigs	10	10	10	10				
Live weight, lbs	283.9	274.3	275.1	277.3	5.52	0.603	0.507	0.293
Hot carcass wt., lbs [c]	233.6	225.2	226.9	227.1	4.24	0.580	0.343	0.313
Dressing %	82.3	82.1	82.5	82.0	0.41	0.978	0.371	0.733
10^{th} rib backfat, in [d]	0.97	0.72	0.98	0.81	0.055	0.392	0.001	0.465
Last rib backfat, in [d]	1.17	1.05	1.22	1.08	0.060	0.512	0.048	0.861
Last lumbar backfat, in [d]	0.90	0.65	0.91	0.85	0.054	0.075	0.007	0.090
Loin eye area, in^2 [d]	7.60	8.64	7.27	7.99	0.291	0.099	0.004	0.585
Predicted fat free lean, % [e]	46.7	50.5	46.6	48.7	0.82	0.268	0.001	0.304
Blood weight, lbs	10.79	10.49	11.10	10.40	0.511	0.831	0.331	0.701
Visceral weight, lbs	25.0	23.4	24.1	23.8	0.68	0.752	0.176	0.341
Scan data								
10^{th} rib backfat, in	0.82	0.66	0.77	0.70	0.054	0.890	0.046	0.414
Last rib backfat, in	0.77	0.62	0.72	0.64	0.037	0.560	0.004	0.369
10^{th} rib loin eye area, in^2	7.90	7.97	6.75	7.24	0.232	0.0003	0.236	0.372

[a]Control = Standard diet; LNE = HAP corn + reduced crude protein, amino acid supplementation + phytase.
[b]Pooled standard error of treatment X sex interaction means.
[c]Hot carcass weight includes head weight.
[d]Average of left and right carcass sides.
[e]Predicted fat free lean = 25.2 + 0.367*HCW, lbs + 2.759*LEA, in^2 + -21.17*10^{th} rib BF, in; R^2= 0.84.

Table 7. Effect of dietary treatment and sex on ultrasound mass scan (all pigs on test) data of grow-finish pigs [a]

	Control		LNE			Significance, (P<)		
	Barrows	Gilts	Barrows	Gilts	SE[b]	Treatment	Sex	Trt X Sex
Week 2								
No. of pigs	25	24	25	24				
Live weight, lbs	93.2	90.7	92.1	90.2	1.51	0.592	0.155	0.859
10^{th} rib backfat, in.	0.34	0.29	0.35	0.33	0.010	0.010	0.004	0.279
Last rib backfat, in.	0.34	0.32	0.31	0.32	0.007	0.059	0.435	0.151
10^{th} rib loin eye area, in^2	2.58	2.93	2.66	2.93	0.081	0.596	0.0002	0.618
Week 8								
No. of pigs	25	24	25	24				
Live weight, lbs	174.0	169.9	167.1	166.2	2.16	0.016	0.246	0.447
10^{th} rib backfat, in.	0.47	0.41	0.47	0.46	0.016	0.172	0.015	0.076
Last rib backfat, in.	0.45	0.40	0.45	0.44	0.014	0.225	0.025	0.149
10^{th} rib loin eye area, in^2	5.37	5.30	5.00	5.10	0.124	0.021	0.895	0.499
Week 16								
No. of pigs	15	14	15	15				
Live weight, lbs	282.5	273.8	275.8	276.5	4.40	0.650	0.355	0.286
10^{th} rib backfat, in.	0.79	0.63	0.79	0.71	0.043	0.316	0.007	0.294
Last rib backfat, in.	0.74	0.60	0.71	0.65	0.032	0.657	0.003	0.270
10^{th} rib loin eye area, in^2	7.92	8.03	6.91	7.33	0.173	0.0001	0.132	0.386
Overall Change								
10^{th} rib backfat, in.	0.46	0.30	0.48	0.40	0.039	0.179	0.003	0.391
Last rib backfat, in.	0.39	0.31	0.36	0.31	0.029	0.688	0.022	0.520
10^{th} rib loin eye area, in^2	5.41	5.04	4.20	4.37	0.164	0.0001	0.555	0.108

[a]Control = Standard diet; LNE = HAP corn + reduced crude protein, amino acid supplementation + phytase.
[b]Pooled standard error of treatment X sex interaction means.