The Effects of Feed Budgeting, Complete Diet Blending, and Corn Supplement Blending on Finishing Pig Growth Performance in a Commercial Environment[1]

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Summary

A total of 808 pigs (PIC 337 x 1050, initially 78.4 ± 1.4 lb BW) were used to compare different feed-blending strategies for finishing pigs using the FeedPro system (Feedlogic Corp., Willmar, MN). There were 3 experimental treatments: (1) a standard-phase complete feed program, (2) blending a high- and low-lysine complete diet (curve), and (3) blending ground corn and a supplement. FeedPro is an integrated feed dispensing system that can deliver and blend 2 separate diets while dispensing. Treatment diets were fed over 4 phases (78 to 231 lb BW) with a common complete diet containing Paylean fed during the fifth phase. The 5 phases were from 78 to 115, 115 to 157, 157 to 191, 191 to 239, and 239 to 281 lb. Each treatment had 10 replicate pens and 26 to 27 pigs per pen. Overall (d 0 to 78), pigs phase-fed complete diets had greater ($P < 0.01$) ADG than pigs fed blended diets and tended to have greater ($P < 0.07$) ADG than those fed the ground corn-supplement blend. Pigs fed the blended diets had lower ($P < 0.001$) ADFI than pigs phase-fed complete diets or fed the corn-supplement blend. However, pigs fed blended diets had improved ($P < 0.001$) F/G compared to pigs phase-fed a ground corn-supplement blend and tended to have improved ($P < 0.07$) F/G compared to pigs fed standard-phase diets. Pigs fed standard-phase diets had heavier ($P < 0.03$) HCW than pigs fed the corn-supplement blend and tended to have heavier ($P < 0.03$) HCW than pigs fed diets on a lysine curve. However, there were no differences ($P \geq 0.11$) in percentage yield, percentage lean, fat depth, or loin depth among treatments. There were no differences ($P \geq 0.11$) in total revenue or income over feed costs (IOFC) across treatments. However, standard phase-fed pigs held a numerical advantage in total revenue, mainly driven by a heavier HCW over other treatments. Also, pigs fed a ground corn-supplement blend had numerically the lowest IOFC compared to other treatments. In conclusion, feeding using the FeedPro system is competitive with standard phase-fed diets on a net return basis, while feeding a ground corn-supplement blend adversely affected net returns.

Key words: carcass characteristics, feed blending, growth

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[2] Feedlogic Corp., Willmar, MN. Appreciation is expressed to Feedlogic Corp. for financial support of this study.
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Introduction

When pigs are fed diets that accurately match their nutrient requirements, growth and efficiency are maximized while nutrient excretion is minimized. The ideal concentration of nutrients required by growing pigs generally decreases over the growing-finishing period, and to accurately adapt to these requirements, phase feeding is the industry standard. In commercial production, phase feeding frequently involves feeding a sequence of 2 to 5 diets, each differing in energy and amino acid levels to match nutrient requirements of that phase.

Blend feeding incorporates 2 complete diets and has the potential to more accurately match the pigs' nutrient requirements by increasing the number of phases. Recent automatic feeding systems, such as the FeedPro system, have diet-blending capabilities and can effectively deliver different ratios of 2 base diets without added labor. However, studies evaluating the benefits of complete diet blending in multiple phases using an automatic feeding system have been limited.

A recent study was conducted at Kansas State University (K-State) by Sulabo et al (2010[4]) to compare different feeding strategies using the FeedPro system. The focus of the current study was to replicate the study conducted by Sulabo et al (2010) in a commercial environment. More specifically, the objectives were: (1) to compare the effects of feeding finishing pigs with 2 base diets blended according to a set lysine curve using the FeedPro system with a standard phase-feeding program on growth performance, carcass characteristics, and economics, and (2) to further assess the blending abilities of the FeedPro system, phase-feeding of blending complete diets was compared with blending ground corn and a complete supplement that provided the identical diet composition as the standard phase-feeding program.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved all procedures used in this study. The experiment was conducted in a commercial research-finishing barn in southwestern Minnesota.

The barns were naturally ventilated and double curtain-sided. Pens had completely slatted flooring and deep pits for manure storage. Each pen was equipped with a 5-hole stainless steel dry self-feeder and a cup waterer for ad libitum access to feed and water. Feed was added to each pen daily with a robotic feeding system (FeedPro; Feedlogic Corp., Willmar, MN) capable of providing and measuring feed amounts by individual pen.

A total of 808 pigs (PIC 337 x 1050, initially 78.4 ± 1.4 lb BW) were randomly assigned to 1 of 3 experimental treatments according to average BW within pen. There were 26 to 27 pigs per pen (mixed sex) with 10 replicates per treatment. The 3 experimental treatments were: (1) a standard 4-phase complete feed program, (2) blending a high- and low-lysine complete diet (Curve), and (3) blending ground corn and a supplement. For the standard 4-phase feeding program, 4 finishing diets (Table 1) were formulated to provide 2.83, 2.59, 2.32, and 2.05 g SID Lys/Mcal ME and were fed from

[4] Sulabo, R.C. et al., Swine Day 2010. Report of Progress 1038, pp. 232-241.

78 to 115 (Phase 1), 115 to 157 (Phase 2), 157 to 191 (Phase 3), and 191 to 239 lb (Phase 4), respectively.

A common complete diet containing 4.5 g/ton ractopamine HCl (RAC; Paylean, Elanco Animal Health, Greenfield, IN) was fed across all treatments for 22 days from 239 to 281 lb BW prior to marketing. This diet was formulated to contain RAC at 9g/ton and 2.67g SID Lys per Mcal ME. For the diet blending treatment, a complete high-lysine and low-lysine diet (Table 1) was formulated to provide 2.98 and 1.93 g SID Lys per Mcal ME, respectively. These 2 diets were incorporated in different ratios daily (Figure 1) to meet a lysine requirement curve that was determined using Feedlogic feed intake data. For the ground corn-supplement treatment, four complete supplements were formulated (Table 2) and were stored separately from ground corn. The FeedPro system blended ground corn and the complete supplement in calculated ratios (Table 2) to be identical in dietary nutrient composition to the standard phase-feeding program for each growing phase. Figure 2 illustrates the stair-step reduction of lysine to calorie ratios used for the phase-feeding and corn-supplement treatments and the more gradual reduction in lysine to calorie ratio for the diet-blending treatment. The gradual reduction in lysine to calorie ratio was achieved by changing the ratio of the 2 diets provided on a daily basis. Pigs from each pen were weighed as a group, and feed disappearance was determined approximately every 3 wk to determine ADG, ADFI, and F/G.

On d 88 of the experiment, the 4 heaviest pigs from each pen (determined visually) were weighed and removed in accordance with the farm's normal marketing procedure. On d 109, up to 4 of the heaviest pigs (determined visually) per pen were again weighed, removed, and marketed. At the end of the experiment, pigs were individually tattooed by pen number to allow for carcass data collection at the packing plant and data retrieval by pen. Pigs were transported to JBS Swift and Company (Worthington, MN) for processing. Standard carcass criteria of loin and backfat depth, HCW, percentage lean, and percentage yield were collected. As a result of misidentification of pigs by plant personnel, of the original 10 replicates per treatment, authors were able to utilize 6 pens from the standard phase-fed treatment, 10 pens from the diet-blending group, and 7 pens from the group phase-fed a corn-supplement blend.

Feed cost was calculated as the sum of diet cost and grind, mixing, and delivery (GMD) costs. The individual components of the GMD charges used were (1) grinding = $5 per ton; (2) mixing = $3 per ton; and (3) delivery = $7 per ton. All three charges (grinding, mixing, and delivery) were applied to the complete diets used in phase feeding and diet blending. For the corn-supplement treatment, grinding was charged to the ground corn, mixing was charged to the supplement, and delivery was charged to both components. Feed cost per pig and feed cost per pound of gain were calculated for each phase and overall. Total revenue and income over feed cost (IOFC) were also determined.
Data were analyzed as a completely randomized design using the MIXED procedure of SAS (SAS Institute, Inc., Cary, NC), with pen as the experimental unit. Hot carcass weight was used as a covariate for fat depth, loin depth, and lean percentage. When treatment effect was a significant source of variation, means were separated using CONTRAST statements in SAS. Least square means were calculated for each independent variable. For all statistical tests, significance and tendencies were set at $P < 0.05$ and $P < 0.10$, respectively.

Results and Discussion

There were no differences ($P \geq 0.37$) in pig weights across all treatments in phases 1 to 3 (Table 3). However, in Phase 4, pigs given standard phase-fed diets tended to be heavier ($P < 0.10$) than those fed the corn-supplement blended diets. In Phase 5 (239 to 281 lb), pigs fed standard phase diets tended to be heavier ($P < 0.10$) than pigs fed a ground corn-supplement blend. In Phase 1 (78 to 115 lb), there were no differences ($P \geq 0.29$) in performance across all treatments. In Phase 2 (115 to 157 lb), ADG and F/G were similar across all treatments; however there was a tendency for increased ($P < 0.10$) ADFI for pigs fed the ground corn-supplement blend as compared to pigs fed blended diets. For Phase 3 (157 to 191 lb), ADG was similar ($P \geq 0.19$) across all treatments. For ADFI, pigs fed diets blended on a set lysine curve had lower ($P < 0.001$) ADFI than pigs fed either standard phase diets or those fed a corn-supplement blend. However, pigs fed blended diets tended to have improved ($P < 0.08$) F/G compared to pigs fed a corn-supplement blend. In Phase 4 (191 to 239 lb), pigs fed using the corn-supplement blend had poorer ($P < 0.01$) ADG than pigs fed using either standard phase feeding or blended diets on a lysine curve. Additionally, pigs phase-fed using complete diets had improved ($P < 0.01$) ADFI as compared to pigs fed blended diets in Phase 4. Finally, pigs fed diets blended on a lysine curve had improved ($P < 0.02$) F/G compared to pigs fed using phase-feeding of either complete diets or the ground corn-supplement blend. In Phase 5 (239 to 281 lb), pigs previously fed the corn-supplement blended diets had higher ($P < 0.05$) ADG and ADFI than those previously fed using diet blending.

Overall (78 to 281 lb), pigs fed blended diets on a lysine curve had poorer ($P < .01$) ADG and ADFI than pigs using phase feeding of complete diets. Additionally, pigs fed blended diets had lower ($P < .001$) ADFI and improved ($P < .001$) F/G than pigs fed a ground corn-supplement blend. Finally, pigs consuming the standard phase-feeding diet tended ($P < .07$) to have higher ADG but also poorer F/G ($P < .07$) than those fed a corn-supplement blend. These results are consistent with the results of Sulabo et al (2008[5]).

For carcass characteristics, there were no differences ($P \geq 0.11$) in percentage yield, percentage lean, backfat depth or loin depth across all treatments (Table 4). However, pigs phase-fed complete diets had heavier ($P < 0.03$) HCW than pigs fed blended diets on a lysine curve and tended to have heavier ($P < 0.07$) HCW than those fed a ground corn-supplement blend. These results were similar to Sulabo et al (2008), where pigs were fed based on similar treatments to the current study showed no differences in percentage yield or loin depth but did show a numerical advantage in HCW for the standard phase-fed treatment. The improvement in HCW for the standard phase-fed diet corresponds to the increased ADG seen in the overall growth data.

Feed costs on a per-pig basis were similar ($P \geq 0.27$) across all treatments within phases 1 and 2 (Table 5). However, in phases 3 and 4, feed costs per pig were lower ($P < 0.01$) for diets blended on a set lysine curve as compared to phase-feeding of either complete diets or a ground corn-supplement blend. In Phase 5, where a common Paylean diet was fed across all treatments, pigs that had been fed blended diets had decreased ADFI and improved F/G which translated into a lower ($P < 0.01$) feed cost per pig than those that had been fed a ground corn-supplement blend in the first four phases. Overall, feed

[5] Sulabo, R.C. et al. Swine Day 2008. Report of Progress 1001, pp. 231-235.

cost on a per-pig basis was lower ($P < 0.01$) for pigs fed blended diets than pigs fed the standard diets or a ground corn-supplement blend.

Feed cost per lb gain was lower ($P < 0.05$) in Phase 3 for diets blended on a lysine curve as compared to those fed a ground corn-supplement blend. During Phase 4, feed cost per lb gain was lower ($P < 0.02$) for pigs fed blended diets than those phase-fed complete diets or a ground corn-supplement blend. Overall, pigs fed blended diets tended to have lower ($P < 0.07$) feed cost per lb gain than pigs phase-fed a corn-supplement blend.

Total revenue per pig was similar ($P \geq 0.23$) across all treatments, although standard phase-fed pigs had a numeric advantage over other treatments, which can be primarily attributed to tendency for increased ($P < 0.07$) HCW seen in the standard phase-fed pigs. There were no differences ($P \geq 0.17$) in IOFC across treatments, although pigs fed a ground corn-supplement blend had a numerically lower IOFC compared to other treatments. Although pigs fed a blended diet had decreased ($P < 0.01$) ADG, and thus tended to have a lighter ($P < 0.07$) HCW compared to those phase fed a standard complete diet, the fact that they still had a numeric advantage in IOFC is noteworthy. These results agree withthose of Sulabo et al (2010), in which pigs fed blended diets had improved net returns when compared to those phase-fed either complete diets or a ground corn supplement blend.

In conclusion, diets blended on a set lysine curve experienced a decrease in growth but an improvement in feed efficiency without affecting carcass characteristics. These results confirm results by Sulabo et al (2010) that diet blending may provide higher returns due to feed efficiency improvement. Phase-feeding a ground corn-supplement blend may have practical application in commercial production, but the increased F/G and similar feed cost per lb gain in relation to standard phase-fed diets does not support its use with the FeedPro delivery system.

Table 1. Diet composition for the phase-feeding and diet-blending treatments (as-fed basis)

	Phase feeding[1]					Diet blending[2]	
Item	Diet 1	Diet 2	Diet 3	Diet 4	Paylean	High Lysine	Low Lysine
Ingredient, %							
Corn	52.32	54.98	57.92	60.83	61.45	50.74	61.56
Soybean meal (46.5%)	15.43	12.84	10.06	7.18	16.56	17.01	6.50
Dried distillers grains with solubles	30.00	30.00	30.00	30.00	20.00	30.00	30.00
Limestone	1.25	1.20	1.10	1.10	1.03	1.23	1.10
Salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin and trace mineral premix	0.10	0.10	0.09	0.09	0.09	0.10	0.09
L-threonine	---	---	---	---	0.02	---	---
Biolys	0.55	0.52	0.48	0.45	0.45	0.57	0.40
Phytase[3]	0.01	0.01	---	---	0.00	0.01	---
Ractopamine HCl, 9 g/lb[4]	---	---	---	---	0.05	---	---
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated composition							
SID[5] amino acids, %							
Lysine	0.95	0.87	0.78	0.69	0.90	1.00	0.65
Isoleucine:lysine	69	70	72	75	69	68	78
Methionine:lysine	33	34	37	40	32	32	41
Met & cys:lysine	67	70	75	81	65	65	85
Threonine:lysine	63	65	67	71	65	62	73
Tryptophan:lysine	17	17	17	17	18	17	17
Valine:lysine	83	86	90	95	83	82	99
CP , %	20.19	19.20	18.12	17.00	18.71	20.81	16.71
Total lysine, %	1.11	1.03	0.93	0.83	1.04	1.17	0.79
ME, kcal/lb	1,524	1,525	1,527	1,528	1,526	1,524	1,528
SID Lysine:ME, g/Mcal	2.83	2.59	2.32	2.05	2.67	2.98	1.93
Ca, %	0.55	0.53	0.48	0.47	0.47	0.55	0.47
P, %	0.47	0.46	0.45	0.43	0.43	0.47	0.43
Available P, %[6]	0.30	0.27	0.24	0.22	0.21	0.30	0.22

[1] Phases 1, 2, 3, 4, and 5 were fed from approximately 80 to 120, 120 to 160, 160 to 200, and 200 to 240, and 240 to 250 lb BW, respectively.
[2] Feed delivery based on a lysine requirement curve where a complete high- and low-lysine diet was blended for the duration of the experiment.
[3] Optiphos 2000 (Enzyvia LLC, Sheridan, IN)
[4] Paylean (Elanco Animal Health, Greenfield, IN)
[5] Standardized ileal digestible.
[6] Phytase provided 0.10% available P in diets 1, 2 and the high-lysine blending diet .

Table 2. Composition of the complete supplements (as-fed basis) and the proportion of ground corn and supplement by phase[1,2]

	Complete supplement			
Ingredient, %	1	2	3	4
Soybean meal (46.5%)	32.35	28.53	23.90	18.34
DDGS	62.92	66.64	71.29	76.59
Limestone	2.62	2.67	2.61	2.81
Salt	0.73	0.78	0.83	0.89
Vitamin and trace mineral premix	0.21	0.22	0.21	0.23
L-lysine HCl	1.15	1.16	1.14	1.14
Phytase[3]	0.02	0.01	0.01	---
Total	100.00	100.00	100.00	100.00
Blend:				
Ground corn, %	52	55	58	61
Complete supplement, %	48	45	42	39

[1] Diets were blended and feed budgeted to be identical in composition and nutrient analyses for each phase to those fed the standard 4-phase feeding program.
[2] Phases 1, 2, 3, 4, and 5 were fed from approximately 80 to 120, 120 to 160, 160 to 200, 200 to 240, and 240 to 250 lb BW, respectively.
[3] Optiphos 2000 (Enzyvia LLC, Sheridan, IN)

Table 3. Effects of diet blending using the FeedPro system on finishing-pig growth performance[1]

	Treatment[2]			
Item	Phase feeding	Diet blending	Corn-supplement	SEM
Pig weights, lb				
Initial	78.5	78.5	78.3	1.4
End of phase 1	115.5	114.8	114.9	1.6
End of phase 2	157.3	155.7	156.6	2.3
End of phase 3	192.3	189.4	190.8	2.3
End of phase 4	242.1^{y}	237.8^{ab}	236.8^{x}	2.2
End of phase 5	284.7^{b}	280.3^{ab}	277.9^{a}	2.2
Phase 1 (78 to 115 lb)				
ADG, lb	1.76	1.72	1.74	0.03
ADFI, lb	3.89	3.80	3.87	0.07
F/G	2.21	2.21	2.23	0.03
Phase 2 (115 to 157 lb)				
ADG, lb	1.99	1.95	1.98	0.03
ADFI, lb	5.14^{xy}	5.00^{y}	5.20^{x}	0.08
F/G	2.59	2.57	2.62	0.04
Phase 3 (157 to 191 lb)				
ADG, lb	1.66	1.59	1.63	0.04
ADFI, lb	5.91^{b}	5.44^{a}	5.92^{b}	0.08
F/G	3.57^{xy}	3.43^{x}	3.63^{y}	0.08
Phase 4 (191 to 239 lb)				
ADG, lb	1.98^{b}	1.93^{b}	1.83^{a}	0.02
ADFI, lb	6.11^{b}	5.78^{a}	5.97^{ab}	0.08
F/G	3.09^{a}	3.00^{a}	3.25^{b}	0.05
Phase 1 to 4 (78 to 239 lb)				
ADG, lb	1.86^{b}	1.80^{a}	1.81^{a}	0.014
ADFI, lb	5.30^{b}	5.27^{b}	5.04^{a}	0.057
F/G	2.86^{b}	2.93^{c}	2.79^{a}	0.029
Phase 5 (239 to 281 lb)				
ADG, lb	2.06^{ab}	1.94^{a}	2.09^{b}	0.05
ADFI, lb	6.28^{ab}	6.16^{a}	6.42^{b}	0.06
F/G	3.05	3.19	3.09	0.08
Overall (0 to 281 lb)				
ADG, lb	1.89^{by}	1.83^{axy}	1.85^{abx}	0.02
ADFI, lb	5.47^{b}	5.23^{a}	5.47^{b}	0.05
F/G	2.90^{abx}	2.86^{axy}	2.95^{by}	0.02

$^{a,b\ x,y}$ Within a row, means without a common superscript differ $P < 0.05$ for statistical significance and $P < 0.10$ for trends.

[1] A total of 808 pigs (initially 78.4 ± 1.4 lb BW) were used with 10 replicate pens per treatment and 27 pigs per pen.

[2] Phase feeding = complete diets in each phase; diet blending = blending of high- and low-lysine diet fed to a set lysine curve; corn-supplement = blending of ground corn and complete supplement.

Table 4. Effects of diet blending using the FeedPro system on carcass characteristics of finishing pigs[1]

	Treatment[2]			
Item	Phase feeding	Diet blending	Corn-supplement	SEM
HCW, lb	210.2[by]	206.6[abx]	204.2[a]	1.72
Yield, %	75.7	76.0	76.0	0.344
Lean, %[3]	53.0	53.6	53.1	0.02
Fat depth, in.[3]	0.80	0.78	0.81	0.245
Loin depth, in.[3]	2.22	2.30	2.24	0.047

[a,b x,y] Within a row, means without a common superscript differ $P < 0.05$ and $P < 0.10$, respectively.

[1] Carcass data from 483 pigs. Phase feeding (6 pens); diet blending (10 pens); corn-supplement (7 pens).

[2] Phase feeding = complete diets in each phase; diet blending = blending of high- and low-lysine diet fed to a set lysine curve; corn-supplement = blending of ground corn and complete supplement.

[3] Adjusted with HCW as covariate

Table 5. Economics of diet blending using the FeedPro system[1]

	Treatment[2]			
Item	Phase feeding	Diet blending	Corn-supplement	SEM
Feed cost/pig, $				
Phase 1	6.99	6.78	6.81	0.13
Phase 2	9.00	8.78	8.95	0.14
Phase 3	9.86a	9.18[b]	10.03[a]	0.13
Phase 4	12.33[a]	11.42[b]	11.64[b]	0.17
Phase 5[3]	14.19[ab]	13.91[b]	14.50[a]	0.14
Total	52.38[a]	50.06[b]	51.94[a]	0.47
Feed cost/lb gain, $[4]				
Phase 1	0.189	0.188	0.186	0.002
Phase 2	0.216	0.214	0.215	0.003
Phase 3	0.283[ab]	0.275[b]	0.293[a]	0.006
Phase 4	0.297[a]	0.282[b]	0.302[a]	0.004
Phase 5	0.329	0.344	0.333	0.008
Total	0.265[xy]	0.262[y]	0.268[x]	0.002
Total revenue, $/pig[5,6]	147.35	145.94	144.87	1.36
IOFC[7]	94.40	95.88	93.45	1.25

[a,b x,y] Within a row, means without a common superscript differ P < 0.05 for statistical significance and P < 0.10 for trends.

[1] Data collected from 808 pigs (approximately 270 pigs per treatment).

[2] Phase feeding = complete diets in each phase; diet blending = blending of high- and low-lysine diet fed to a set lysine curve; corn-supplement = blending of ground corn and complete supplement.

[3] Paylean diet delivered in same form across all treatments. Differences are due to variation in performance.

[4] Feed cost/lb gain = (direct feed cost + GMD cost/pig) ÷ total live gain; assumed grinding = $5/ton; mixing = $3/ton; delivery and handling = $7/ton.

[5] Carcass base bid = $70.81 (June 2010)

[6] Total revenue = carcass price (including premiums/discounts for lean and yield) × HCW.

[7] IOFC, income over feed cost = total revenue/pig - feed cost/pig.

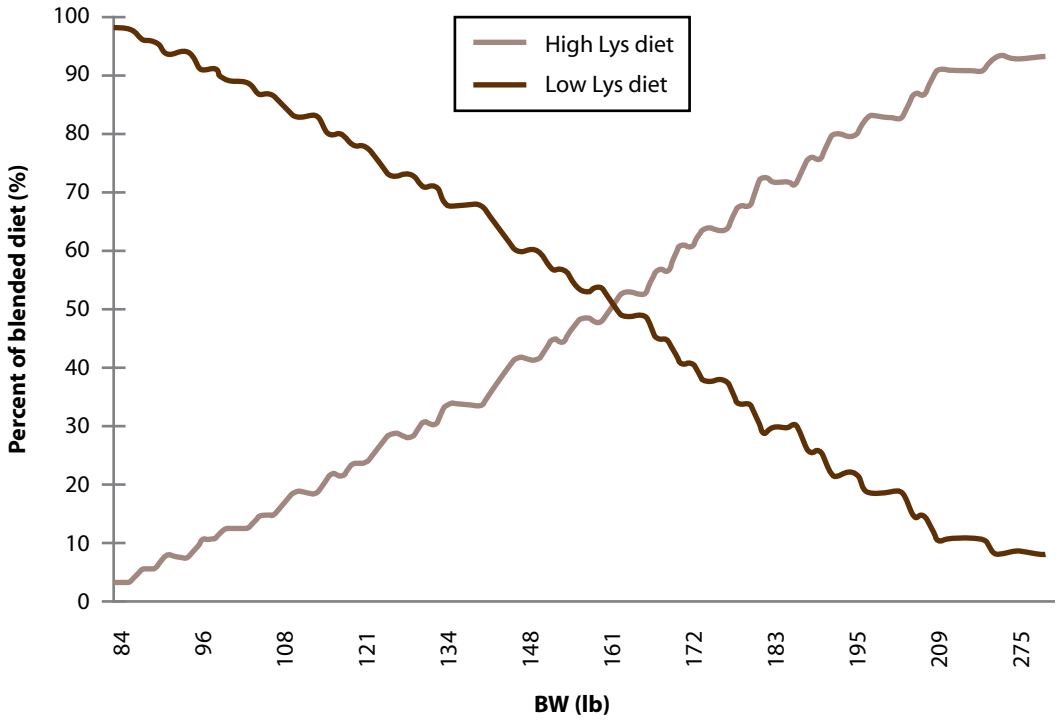

Figure 1. Percentage of the high- and low-lysine diets blended to a set lysine requirement curve using the FeedPro system.

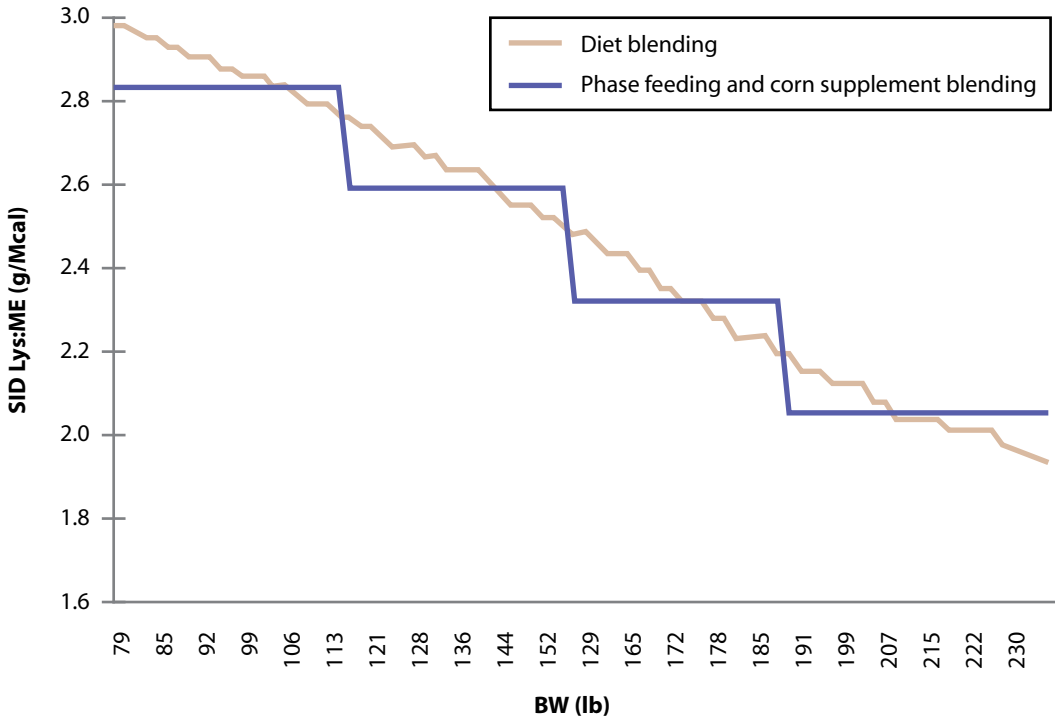

Figure 2. Standardized ileal digestible Lys:ME ratio (g/Mcal) delivered to pigs (78 to 239 lb BW) based on a 4-phase feeding program utilizing either complete finishing diets or a ground corn-supplement blend compared to blending of high- and low-lysine diets based on a predetermined lysine curve using the FeedPro system.