Evaluation of Feed Budgeting, Complete Diet Blending, and Corn-Supplement Blending on Finishing-Pig Performance

R. C. Sulabo, G. A. Papadopoulos, J. R. Bergstrom, J. M. DeRouchey, D. Ryder[1], M. D. Tokach, S. S. Dritz[2], R. D. Goodband, and J. L. Nelssen

Summary

A total of 283 pigs (PIC TR4 × 1050, initially 77.2 ± 1.4 lb BW) were used to compare phase feeding with blending finishing diets by using the FeedPro system (Feedlogic Corporation, Willmar, MN). There were 3 experimental treatments: (1) a standard 4-phase complete feed program, (2) blending high- and low-lysine complete diets over the entire experiment, and (3) blending ground corn and a separate complete supplement within each phase. FeedPro is an integrated feed dispensing system that can deliver and blend 2 separate diets while dispensing. The 4 phases were 77 to 120, 120 to 175, 175 to 221, and 221 to 278 lb. Each treatment had 12 replicate pens and 8 pigs per pen. Overall (77 to 278 lb), ADG and ADFI were similar ($P > 0.24$) across treatments. However, pigs fed the ground corn-supplement blend had poorer ($P < 0.01$) F/G than pigs fed diets blended in multiple phases and tended to have poorer ($P < 0.09$) F/G than pigs fed the standard phase diets. There were no differences ($P > 0.70$) in HCW, percentage yield, and loin depth across treatments. Pigs fed using phase feeding of the ground corn-supplement blend had greater ($P < 0.02$) percentage lean and lower ($P < 0.04$) fat depth than pigs fed using phase feeding of complete diets or diet blending. There were no ($P > 0.28$) statistical differences in total revenue and income over feed costs (IOFC) across treatments. However, the highest IOFC was obtained from diet blending, which had a numeric advantage of $1.44 to $2.32/pig over other treatments. In conclusion, the FeedPro system blended separate complete diets and a ground corn-supplement combination without adversely affecting growth performance and carcass characteristics.

Key words: carcass characteristics, feed blending, growth

Introduction

Pig growth and efficiency are maximized and nutrient excretion is reduced when pigs are fed diets that match their nutrient requirements. The optimal concentration of nutrients required by growing pigs generally decreases over the growing-finishing period, and phase feeding is practiced to accurately adjust to these requirements. In commercial production, phase feeding commonly involves feeding a series of 2 to 5 diets, each differing in energy or amino acid balance to match nutrient requirements at each phase. Increasing the number of feeding phases has economic and environmental

[1] Feedlogic Corporation, Willmar, MN. Appreciation is expressed to Feedlogic Corporation for financial support for this study.

[2] Department of Diagnostic Medicine/Pathobiology, College of Veterinary Medicine, Kansas State University.

benefits (Van der Peet-Schwering et al, 1999[3]); however, it may concomitantly increase costs of feed storage and management.

Blend feeding, which involves mixing 2 base diets in proportionate ratios, can potentially increase the number of phases to more accurately meet pigs' nutrient requirements. Recent automatic feeding systems, such as the FeedPro system, have diet-blending capabilities that provide a practical means of feeding diets in multiple phases. However, few studies have been conducted to evaluate the benefits of complete diet blending in multiple phases by using an automatic feeding system.

The objective of this study was to compare the effects (i.e., growth performance, carcass characteristics, and economics) of feeding finishing pigs blended diets made from 2 base diets fed to a set lysine curve using the FeedPro system with the effects of feeding pigs a standard 4-phase feeding program. To further test the blending capabilities of the FeedPro system, we compared phase-feeding of blended complete diets with phase-feeding of a blended ground corn-supplement diet that provided a diet composition identical to that in the standard 4-phase feeding program.

Procedures

Procedures used in this study were approved by the Kansas State University (K-State) Institutional Animal Care and Use Committee. The experiment was conducted at the K-State Swine Teaching and Research Center growing-finishing facility.

A total of 283 pigs (PIC TR4 × 1050, initially 77.2 ± 1.4 lb BW) were allotted to 1 of 4 experimental treatments in a completely randomized design. Barrows and gilts were equally distributed among the treatments. Each treatment had 12 replicate pens and 8 pigs per pen (4 barrows and 4 gilts). Each pen was 8 × 10 ft and equipped with a Farmweld (Teutopolis, IL) dry, single-sided self-feeder with 2 feeding spaces. The facility also had the FeedPro system (Feedlogic Corp., Willmar, MN), an integrated feed dispensing system, and 12 feed storage bins.

There were 3 experimental treatments: (1) a standard 4-phase complete feed program (phase feeding), (2) blending high- and low-lysine complete diets over the entire experiment (diet blending), and (3) blending ground corn and a separate complete supplement within each phase (corn-supplement). All diets were dispensed using the FeedPro system, which provided ad libitum access to feed. For the standard 4-phase feeding program, 4 finishing diets (Table 1) were formulated to provide 2.72, 2.30, 2.00, and 1.81 g standardized ileal digestible (SID) lysine/Mcal ME and were fed from 77 to 120 (Phase 1), 120 to 175 (Phase 2), 175 to 221 (Phase 3), and 221 to 278 lb (Phase 4), respectively. For the diet-blending treatment, complete high-lysine and low-lysine diets (Table 1) were formulated to provide 3.15 and 1.63 g SID lysine/Mcal ME, respectively. The 2 diets were blended in varying ratios on a daily basis (Figure 1) to meet a lysine requirement curve that was set using Feedlogic feed intake data. For the corn-supplement treatment, 4 complete supplements were formulated (Table 2) and were stored separately from ground corn in feed storage bins. The FeedPro system

[3] Van der Peet-Schwering, C. M. C., A. W. Jongbloed, and A. J. A. Aarnink. 1999. Nitrogen and phosphorus consumption, utilization, and losses in pig production : The Netherlands. Livest. Prod. Sci. 58:213-224.

blended ground corn and the complete supplement in calculated ratios (Table 2) to be identical in dietary nutrient composition to those fed the standard phase-feeding program for each growing phase. The SID lysine:ME ratios (g/Mcal) provided by the 3 feeding programs to pigs throughout the finishing period are shown in Figure 2. The figure illustrates the stair-step reduction of lysine:calorie ratios used for the phase feeding and corn-supplement treatments and the more gradual reduction in lysine:calorie ratio used in the diet-blending treatment. The gradual reduction in lysine:calorie ratio was achieved by changing the ratio of the 2 diets provided on a daily basis. All complete diets, ground corn, and supplements were manufactured at the K-State Animal Science Feed Mill.

Pigs were weighed and feed disappearance was determined at the end of each phase to calculate ADG, ADFI, and F/G. At the end of the study, pigs were tattooed and sent to Triumph Foods, LLC (St. Joseph, MO), where standard carcass criteria of hot carcass weight (HCW), carcass yield, percentage lean, and loin and backfat depth were measured. Feed cost was calculated as the sum of diet cost and grinding, mixing, and delivery (GMD) costs. The individual components of the GMD charges used were (1) grinding = $5/ton, (2) mixing = $3/ton, and (3) delivery = $7/ton. The complete diets used in phase feeding and diet blending received all 3 charges (grinding, mixing, and delivery). 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 for the overall period of the experiment. Total revenue and income over feed cost (IOFC) were also determined under 2 scenarios (carcass base prices of $51.99 and $67.95 for Scenario 1 and 2, respectively).

Data were analyzed as a completely randomized design using the GLM procedure of SAS (SAS Institute, Inc., Cary, NC) with pen as the experimental unit. Hot carcass weight was used as a covariate for yield, fat depth, loin depth, and percentage lean. When treatment effect was a significant source of variation, means were separated using the PDIFF option of SAS. Least square means were calculated for each independent variable. Statistical significance and tendencies were set at $P < 0.05$ and $P < 0.10$, respectively, for all statistical tests.

Results and Discussion

Average daily gain and pig weights were similar ($P > 0.13$) across treatments in each of the individual 4 phases (Table 3). In phases 1 to 3, ADFI was also similar ($P > 0.30$) across treatments; however, pigs fed using diet blending had lower ($P < 0.03$) ADFI during Phase 4 than pigs fed using phase feeding of complete diets or the corn-supplement blend. For Phase 1 (77 to 120 lb), pigs fed the corn-supplement blend had lower ($P < 0.03$) F/G than pigs fed using phase feeding of complete diets and diet blending. However, for Phase 3 (175 to 221 lb), F/G was higher ($P < 0.05$) for pigs fed the corn-supplement blend than for pigs fed with phase feeding of complete diets or with diet blending. In Phase 4 (221 to 278 lb), pigs fed using diet blending had lower ($P < 0.05$) F/G than pigs fed using phase feeding of complete diets or the corn-supplement blend.

Overall (77 to 278 lb), ADG, ADFI, and final weights were similar ($P > 0.51$) across treatments. However, pigs fed the corn-supplement blend had poorer ($P < 0.01$) F/G

than pigs fed diets blended in multiple phases and tended to have poorer ($P < 0.09$) F/G than pigs fed using the standard phase-feeding program. These results agree with similar studies in which growth performance of finishing pigs fed using standard phase-feeding programs or multiphase programs was compared. Pomar et al. (2007[4]) compared, for pigs weighing 55 to 230 lb, a 3-phase feeding program with a daily multiphase system in which diets were blended using an automatic feeding system. In that study, pigs fed in multiple phases tended to have greater ADG than pigs fed using the standard phases; however, ADFI and F/G were similar for both groups of pigs. Moore and Mullan (2009[5]) also compared, for pigs weighing 50 to 195 lb, a conventional 3-phase feeding program with a 2-diet blend fed in weekly phases using a similar Feedlogic system and found no differences in growth performance.

In terms of carcass characteristics, there were no differences ($P > 0.70$) in HCW, percentage yield, and loin depth across treatments (Table 4). Pigs fed using phase feeding of the corn-supplement blend had greater ($P < 0.02$) percentage lean and lower ($P < 0.04$) fat depth than pigs fed using phase feeding of complete diets or diet blending in multiple phases. These results are similar to those of Moore and Mullan (2009), who showed that pigs fed in 3 phases or fed blended diets in weekly phases had similar HCW, yield, and fat depth. However, the greater lean percentage and lower fat depth observed in pigs fed the corn-supplement blend was not expected because the blend was formulated and mixed to contain the same nutrient levels and followed the same program as the standard phase feeding. Though not significant, HCW and carcass yield of pigs fed the corn-supplement blend were 2.4 to 3.5 lb lower than those of pigs fed using standard phase feeding and diet blending; this result suggests that pigs fed the corn-supplement blend were lighter at slaughter and also may have contributed to the differences observed in percentage lean and fat depth.

Feed cost per pig was $1.92 and $1.20 less for diet blending in multiple phases and phase feeding using the corn-supplement blend, respectively, than the standard phase-feeding program, but this difference was not significant (Table 5). The majority of the difference in cost for diet blending and phase feeding was due to the lower ADFI and better F/G observed in Phase 4, which resulted in a $0.98 decrease ($P < 0.05$) in feed cost per pig. For the corn-supplement blend, the cost of mixing ($3/ton) was not assessed for ground corn, which contributed to the lower GMD cost and feed cost per pig. Feed cost per pound of gain was lower ($P < 0.05$) for pigs fed the corn-supplement blend in Phase 1 and pigs fed with diet blending in phases 3 and 4, but overall, no differences were observed across the treatments. We evaluated total revenue and IOFC by using 2 carcass base prices: Scenario 1 = $51.99, October 2009 price; and Scenario 2 = $67.95, October 2008 price. In both scenarios, there were no ($P > 0.28$) statistical differences in total revenue and IOFC across treatments. However, the highest IOFC was obtained from diet blending in multiple phases; the numeric advantage over other treatments ranged from $1.44 to $2.32/pig depending on the scenario. This conforms

[4] Pomar, C., J. Pomar, D. Babot, and F. Dubeau. 2007. The impact of daily multiphase feeding on animal performance, body composition, and nitrogen and phosphorous excretion in growing-finishing pigs. Journées de la Recherche Porcine en France, 39:23-30.

[5] Moore, K., and B. Mullan. 2009. Evaluation of feeding strategies and measurement of feed consumption using the Feedlogic system: Final report. Cooperative Research Centre for an Internationally Competitive Pork Industry, Department of Agriculture and Food, Australia. http://www.porkcrc.com.au/2A-104_Final_Report_0902.pdf. Accessed November 25, 2009.

with results of Moore and Mullan (2009), who showed that feeding pigs in weekly phases improved net return (about $3.00/pig, Australian dollars) compared with feeding pigs a standard 3-phase feeding program.

In conclusion, blending 2 complete diets in multiple phases or a blending ground corn and a complete supplement with the FeedPro system did not affect growth performance and carcass characteristics. Diet blending may provide higher net returns than standard phase feeding by effecting small improvements in feed efficiency. Although blending the ground corn and supplement resulted in poorer F/G during the last phase of the trial, the practical advantage of this feeding approach suggests that it should be investigated further.

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	High Lysine	Low Lysine
Ingredient, %						
Corn	78.42	83.11	86.54	88.45	73.75	90.53
Soybean meal (46.5%)	18.95	14.61	11.40	9.63	23.30	7.70
Monocalcium phosphate (21% P)	0.50	0.30	0.23	0.15	0.70	0.05
Limestone	0.95	0.95	0.90	0.90	0.96	0.89
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin premix	0.15	0.13	0.10	0.08	0.16	0.07
Trace mineral premix	0.15	0.13	0.10	0.08	0.16	0.07
Lysine HCl	0.30	0.26	0.24	0.22	0.34	0.20
DL-Methionine	0.03	0.00	0.00	0.00	0.05	0.00
L-Threonine	0.07	0.04	0.03	0.03	0.10	0.03
Phytase 600	0.13	0.13	0.13	0.13	0.13	0.13
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated composition, %						
SID[3] amino acids						
Lysine	0.91	0.77	0.67	0.61	1.05	0.55
Isoleucine:lysine	61	63	64	66	60	67
Methionine:lysine	29	28	30	32	29	34
Met & Cys:lysine	56	58	62	66	55	70
Threonine:lysine	62	62	63	65	62	66
Tryptophan:lysine	16.5	16.5	16.5	16.5	16.5	16.5
Valine:lysine	71	74	78	81	68	84
CP (N × 6.25)	15.83	14.14	12.90	12.22	17.53	11.48
Total lysine	1.01	0.86	0.75	0.69	1.16	0.63
ME, kcal/lb	1,515	1,519	1,522	1,525	1,511	1,527
SID lysine:ME, g/Mcal	2.72	2.30	2.00	1.81	3.15	1.63
Ca	0.54	0.49	0.45	0.43	0.60	0.40
P	0.46	0.40	0.37	0.35	0.51	0.32
Available P[4]	0.28	0.23	0.21	0.19	0.33	0.17

[1] Standard 4-phase complete diet feeding program; Phase 1 was from 77 to 120 lb BW, Phase 2 was from 120 to 175 lb BW, Phase 3 was from 175 to 221 lb BW, and Phase 4 was from 221 to 278 lb BW.
[2] Feed delivery was based on a lysine requirement curve; complete high- and low-lysine diets were blended throughout the duration of the experiment.
[3] Standardized ileal digestible.
[4] Phytase provided 0.10% available P to the 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%)	87.85	86.51	84.66	83.37
Monocalcium phosphate (21% P)	2.32	1.78	1.67	1.30
Limestone	4.40	5.63	6.69	7.80
Salt	1.62	2.07	2.60	3.03
Vitamin premix	0.70	0.74	0.74	0.65
Trace mineral premix	0.70	0.74	0.74	0.65
Lysine HCl	1.39	1.54	1.75	1.86
DL-Methionine	0.12	---	---	---
L-Threonine	0.34	0.25	0.22	0.26
Phytase 600	0.58	0.74	0.93	1.08
Total	100.00	100.00	100.00	100.00
Blend				
Ground corn, %	78	83	87	88
Complete supplement, %	22	17	13	12

[1] Diets were blended and feed budgeted to be identical in composition and nutrient analyses for each phase to those fed in the standard 4-phase feeding program.
[2] Phase 1 was from 77 to 120 lb BW, Phase 2 was from 120 to 175 lb BW, Phase 3 was from 175 to 221 lb BW, and Phase 4 was from 221 to 278 lb BW.

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	77.2	77.2	77.2	1.4
End of phase 1	120.2	120.2	120.6	1.6
End of phase 2	176.5	173.4	175.6	2.2
End of phase 3	223.2	220.9	219.7	2.6
End of phase 4	280.4	277.6	277.5	3.1
Phase 1 (77 to 120 lb)				
ADG, lb	2.05	2.05	2.07	0.02
ADFI, lb	4.68	4.72	4.59	0.06
F/G	2.29[a]	2.30[a]	2.22[b]	0.02
Phase 2 (120 to 175 lb)				
ADG, lb	2.16	2.05	2.11	0.04
ADFI, lb	5.83	5.69	5.88	0.09
F/G	2.70	2.79	2.79	0.04
Phase 3 (175 to 221 lb)				
ADG, lb	1.96	1.98	1.84	0.05
ADFI, lb	6.10	5.92	6.02	0.11
F/G	3.13[a]	3.02[a]	3.28[b]	0.06
Phase 4 (221 to 278 lb)				
ADG, lb	2.20	2.18	2.22	0.04
ADFI, lb	7.71[a]	7.37[b]	7.78[a]	0.05
F/G	3.51[a]	3.39[b]	3.51[a]	0.04
Overall (77 to 278 lb)				
ADG, lb	2.10	2.07	2.06	0.02
ADFI, lb	6.14	5.99	6.14	0.07
F/G	2.93[ax]	2.90[a]	2.98[by]	0.02

[1] A total of 288 pigs (initially 77.2 ± 1.4 lb BW) were used with 12 replicate pens per treatment and 8 pigs per pen.
[2] Phase feeding = complete diets in each phase; diet blending = blending of high- and low-lysine diets fed to a set lysine curve; corn-supplement = blending of ground corn and complete supplement.
[a,b] $P < 0.05$, [x,y] $P < 0.09$.

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	207.3	206.6	204.2	2.65
Yield[3], %	73.92	74.44	73.61	0.44
Lean[3], %	52.13[a]	52.25[a]	52.90[b]	0.19
Fat depth[3], in.	0.85[a]	0.81[a]	0.76[b]	0.02
Loin depth[3], in.	2.41	2.40	2.38	0.03

[1] Carcass data from 283 pigs (6 to 8 pigs per treatment).
[2] Phase feeding = complete diets in each phase; Diet blending = blending of high- and low-lysine diets fed to a set lysine curve; Corn-supplement = blending of ground corn and complete supplement.
[3] Adjusted with HCW as covariate.
[a,b] $P < 0.05$.

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	9.53	9.62	9.25	0.14
Phase 2	13.53	13.02	13.38	0.20
Phase 3	12.30	11.77	11.70	0.23
Phase 4	16.20[a]	15.22[b]	16.03[a]	0.22
Total	51.56	49.64	50.36	0.62
Feed cost/lb gain[3], $				
Phase 1	0.221[a]	0.221[a]	0.213[b]	0.002
Phase 2	0.239	0.246	0.244	0.004
Phase 3	0.260[a]	0.250[b]	0.265[a]	0.005
Phase 4	0.281[a]	0.269[b]	0.278[a]	0.003
Overall	0.250	0.246	0.250	0.002
Scenario 1[4]				
Total revenue, $/pig[5]	106.85	106.49	105.28	1.37
IOFC[6]	55.29	56.86	54.91	1.03
Scenario 2[4]				
Total revenue, $/pig[5]	140.84	140.37	138.77	1.80
IOFC[6]	89.29	90.73	88.41	1.44

[1] Data collected from 283 pigs (6 to 8 pigs per treatment).
[2] Phase feeding = complete diets in each phase; diet blending = blending of high- and low-lysine diets fed to a set lysine curve; corn-supplement = blending of ground corn and complete supplement.
[3] Feed cost/lb gain = (Direct feed cost + GMD cost/pig) / total live gain. Assumed grinding (G) = $5/ton; mixing (M) = $3/ton; delivery and handling (D) = $7/ton.
[4] Scenario 1: carcass base price = $51.55 (October 2009 price); Scenario 2: carcass base price = $67.95 (October 2008 price).
[5] Total revenue = carcass base price × HCW.
[6] IOFC, income over feed cost = total revenue/pig - feed cost/pig.
[a,b] $P < 0.05$.

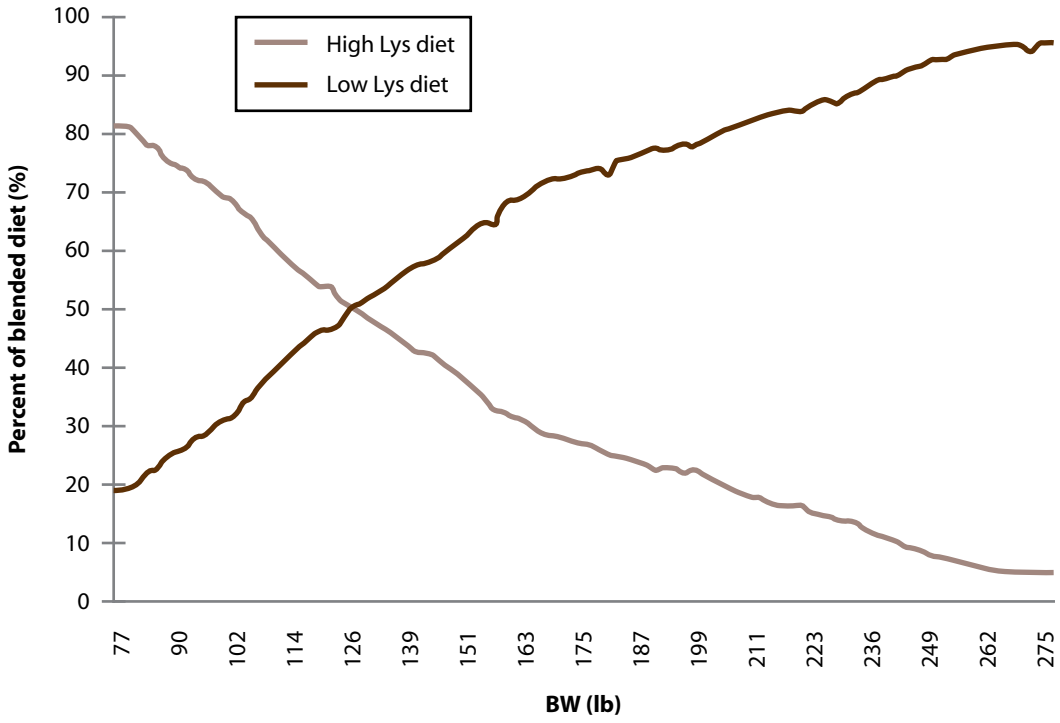

Figure 1. Percentage of the high- and low-lysine diets blended to a set lysine requirement curve with the FeedPro system.

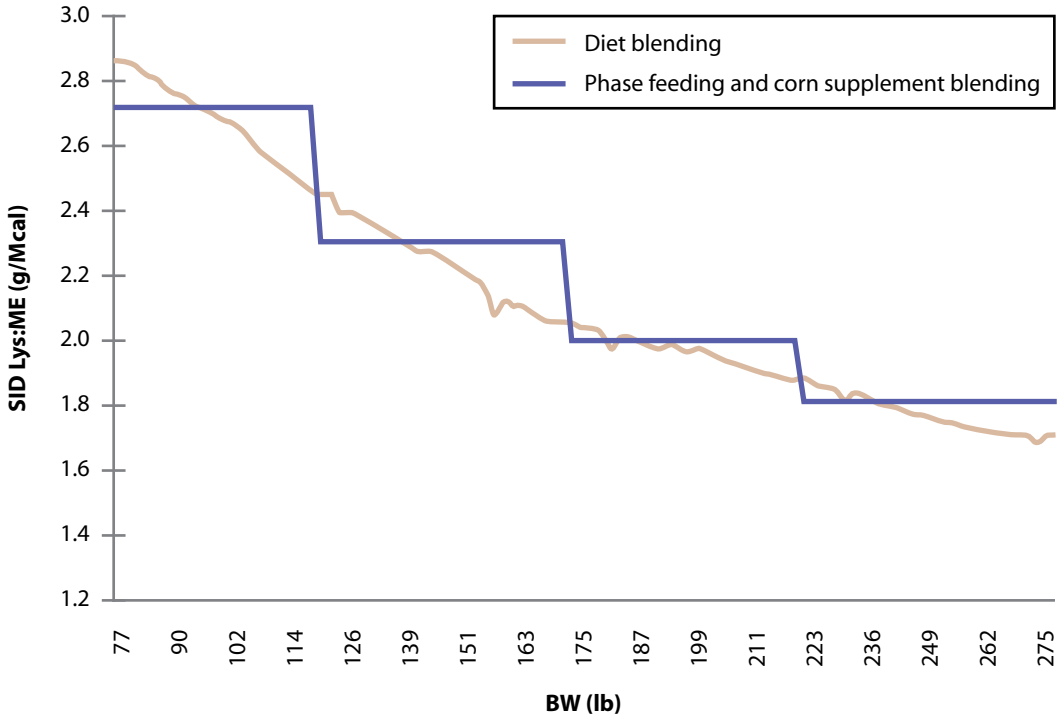

Figure 2. Standardized ileal digestible (SID) lysine:ME ratio (g/Mcal) provided to pigs in a 4-phase feeding program using complete finishing diets or a blend of ground corn and supplement and a diet made by blending complete high- and low-lysine diets to a set lysine curve with the FeedPro system.