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Evaluation of Phase Feeding and Complete Diet Blending on Growing-Finishing Pigs' Growth Performance and Diet Economics

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Summary

A total of 962 pigs [Fast LW × PIC L02 × PIC 800; initially 58.4 ± 0.81 lb] were used in a 116-d study to compare feeding strategies (phase feeding vs. diet blending) on growing-finishing pig growth performance and diet economics. Pens of pigs were randomly assigned to one of two treatments following a randomized complete block design with barn and initial BW as blocking factors. The treatments included two feeding programs, a phase feeding strategy or complete diet blending with pre-defined mixing proportions of two diets to meet 100% of the SID Lys curve requirement estimates for 50- to 250-lb pigs. The experimental period spanned from 50 to 250 lb BW, and a common feeding period from 250 to 300 lb BW. Diets in phase feeding strategies were provided from 50 to 100, 100 to 175, and 175 to 250 lb. Pigs were fed on a feed budget set at 97, 181, and 230 lb of feed per pig for phases 1 to 3, respectively. During the common period, all pigs received the same DDGS-free diet. Feeding strategy did not influence BW or ADG at any time during the study, except for BW at d 56 and ADG on d 28 to 56, where pigs in the phase feeding group had greater ($P \leq 0.013$) BW and ADG compared to the diet blending group. For ADFI, pigs fed the diet blending strategy had lower ($P \leq 0.017$) ADFI than those fed by phase feeding both during experimental and overall periods, but not during the common period. Pigs fed by diet blending had improved ($P = 0.012$) feed efficiency compared to pigs fed the phase-feeding strategy during the experimental period but not overall. During the common feeding period (d 84 to 102), F/G of pigs previously phase fed was improved ($P = 0.029$) compared to pigs previously fed the diet-blending strategy. Consistently, caloric efficiency was improved ($P = 0.007$) with the diet-blending strategy compared to the phase-feeding strategy during the experimental period. For diet economics, pigs fed the diet-blending strategy tended to have lower feed cost per pig and per lb of gain ($P = 0.078$ and 0.083, respectively) than those fed the phase-feeding strategy during the experimental period, but not during the overall period. Feeding strategy had no effect on total revenue or IOFC in either period. In conclusion, diet blending improved F/G

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by reducing ADFI without affecting ADG during the blending strategy feeding period. However, the inclusion of a common diet diminished the F/G advantage, resulting in similar overall IOFC between the two feeding strategies.

Introduction

Modern pig production aims to maximize animal performance while minimizing nutrient excretion. One effective approach to reducing excess nutrient loss is to tailor nutrient supply to the growing pigs' changing requirements as their body weight increases. Traditionally, pigs are fed using two to five dietary phases with varying SID Lys to calorie ratios. These ratios are typically calculated based on the midpoint of the weight range for each phase, which often leads to underfeeding pigs during the first half of the phase and overfeeding them in the latter half. Although increasing the number of dietary phases can offer both economic and environmental benefits, it also introduces complexity in feed management and may require additional investment in feed manufacturing infrastructure.

Curve- or blend-feeding strategies present a practical solution by allowing daily nutrient adjustments through the blending of two or more basal diets in precise proportions. This approach has become more feasible with the adoption of automated feeding systems. A recent study by Navales et al. (2023)[4] demonstrated that blending two diets at different proportions over the entire finishing period improved F/G by reducing ADFI without negatively affecting ADG. However, IOFC remained unchanged, likely due to the costs associated with the diets used for blending in that experiment.

Therefore, the objective of the present study was to compare phase feeding and complete diet-blending strategies in terms of growth performance and diet economics in growing-finishing pigs. Unlike the previous research, this experiment utilized three diets for blending to provide a more refined nutrient supply.

Materials and Methods

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The study was conducted at a commercial research-finishing site owned and operated by New Fashion Pork (Jackson, MN). The barns were mechanically ventilated, solid sided, and tunnel ventilated. Each pen was equipped with a three-hole stainless steel dry self-feeder and a single pan waterer for *ad libitum* access to feed and water. Daily feed additions to each pen were accomplished using a robotic feeding system (FeedPro, FeedLogic by ComDel Innovation, Wahpeton, ND) able to record feed amounts for individual pens.

Animals and diets

A total of 962 pigs (Fast LW × PIC L02 × PIC 800; initially 58.4 ± 0.81 lb) were used. Pigs were housed in mixed, even-gender pens with 18 to 19 pigs per pen and 26 pens per treatment. Pens of pigs were allotted to one of two feeding strategies in a randomized complete block design, with barn and initial BW as blocking factors. The dietary treatment strategies were 1) phase feeding or 2) diet blending. The experimental period

[4] Navales, R. A. S., M. D. Tokach, D. A. Krogstad, J. M. DeRouchey, J. T. Gebhardt, R. D. Goodband, and J. C. Woodworth. 2023. Evaluation of phase feeding and complete diet blending at different standardized ileal digestible lysine levels on growing-finishing pigs' growth performance, carcass characteristics, and diet economics. Kansas Agricultural Experiment Station Research Reports: Vol. 9: Iss. 7. doi:10.4148/2378-5977.8528.

spanned from ~50 to ~250 lb BW, and the common feeding period from ~250 to ~300 lb BW.

Diets for the phase-feeding strategy were provided in three phases from 50 to 100, 100 to 175, and 175 to 250 lb. Pigs were fed on a feed budget set at 97, 181, and 230 lb of feed per pig for phases 1 to 3, respectively. From 250 to 300 lb, a DDGS-free common diet was provided until the end of the study. Diets were formulated to contain 4.65, 3.75, 3.00, and 2.65 g SID Lys per Mcal NE for phases 1 to 3 and common diet, respectively. Phase changes took place when the allotted feed budgets were consumed on a barn basis.

For the diet-blending strategy, three diets were formulated to contain 5.09 (High), 3.60 (Med), and 2.76 (Low) g SID Lys per Mcal NE, designed to meet the pigs' requirements at 50, 150, and 250 lb BW. Two of these three diets were blended daily at different proportions to meet the targeted SID Lys curve (aligned with 100% of PIC 2021[5] SID Lys recommendation; Figure 1) until pigs reached 250 lb BW (end of experimental phase). Adjustments on feed drops were implemented based on mortality and removals. Thereafter, pigs were then fed a DDGS-free common diet similar to the phase-feeding strategy (2.65 g SID Lys per Mcal NE) from 250 to 300 lb. The blending is only applied up to 250 lb to accommodate slaughter plant's requirement for a DDGS-free diet in the final finishing phase. All diets met or exceeded NRC (2012) requirement estimates for the ratio of other essential SID AA to SID Lys. All diets were manufactured at New Fashion Pork feed mill in Round Lake, MN.

Pen weight, number of pigs per pen, and feed delivery were recorded approximately every 14 d to calculate ADG, ADFI, and F/G. Two weeks before the trial's conclusion, the four to seven heaviest pigs in each pen were selected for marketing (first cut). Remaining pigs, excluding those that were too small or had physical defects, were marketed at the end of the trial (dumping). Additionally, caloric efficiency and SID Lys intake per kilogram gain were calculated as the total calorie or SID Lys intake, respectively, divided by total gain.

Diet costs were calculated by determining the formula cost, grinding, mixing, and delivery charges. Total feed cost during the experimental and overall periods were calculated as the sum-product of the total feed consumed during each respective period and the corresponding diet cost. For the experimental period, feed cost per pig was calculated by dividing the experimental period feed cost by the number of pigs placed at the start of the experiment, and feed cost per pound of gain was calculated by dividing the experimental feed cost by the total gain achieved during the experimental period. Similarly, for the overall period, feed cost per pig and feed cost per pound of gain were calculated using the total feed cost and total gain accumulated over the entire trial period. Total revenue for each period was calculated by multiplying the total gain per pig during that specific period by a live market price of $66 per cwt. Income over feed cost (IOFC) was then determined as the difference between total revenue and total feed cost for each period.

Statistical analysis

Data were analyzed as a randomized complete block design using R (Version 4.3.1, R Core Team, Vienna, Austria), with pen serving as the experimental unit and barn and

[5] Pig Improvement Company. 2021. PIC Nutrition and Feeding Guidelines. Available at: https://www.pic.com/resources/pic-nutrition-and-feeding-guidelines-imperial/.

initial BW as the blocking factors included as random effects. Results were considered significant at $P \leq 0.05$, and marginally significant (tendency) at $P \leq 0.10$.

Results and Discussion

Feeding strategy had no effect on BW at any time during the study, except on d 56, when pigs in the phase feeding group had greater BW ($P = 0.013$). Similarly, top weight, dump weight, and average market weight were not affected by feeding strategy.

From d 0 to 28, ADG, ADFI and F/G were not affected by the feeding strategy. However, from d 28 to 56, pigs fed using the phase-feeding strategy had greater ($P \leq 0.014$) ADG, ADFI, and F/G. From d 56 to 84, ADG and ADFI were not influenced by the feeding strategy, but pigs fed the diet-blending strategy had improved F/G ($P = 0.017$). Over the entire experimental period (d 0 to 84), ADG was unaffected by feeding strategy, while F/G was improved ($P = 0.012$) in the diet-blending group, primarily due to a reduction in ADFI ($P = 0.002$).

During the common periods (d 84 to 102 and d 102 to 116), feeding strategy did not influence ADG or ADFI. Feed-to-gain ratios of pigs in the phase feeding group were improved ($P = 0.029$) compared to those in diet blending immediately after the experimental period (d 84 to 102), but not from d 102 to 116.

For the overall period (d 0 to 116), diet blending resulted in lower ADFI ($P = 0.017$), but ADG and F/G were not affected. The improvement in F/G for diet blending during the experimental period aligns with previous findings. However, the current study included a common diet feeding phase, which might have diminished the F/G advantage previously found during the experimental period.

Consistent with the F/G results, caloric efficiency was improved ($P = 0.007$) for pigs fed the diet-blending strategy compared to the phase-feeding strategy during the experimental period. In contrast, during the common feeding period, from d 84 to 102, caloric efficiency tended to be improved ($P = 0.107$) in the phase feeding group. Standardized ileal digestible Lys intake per kilogram of gain was not affected by feeding strategy during the experimental period but was lower ($P = 0.004$) in the phase feeding group from d 84 to 102.

During the experimental period, pigs fed using the diet-blending strategy tended to have lower feed cost per pig and feed cost per pound of gain ($P = 0.078$ and $P = 0.083$, respectively) compared to those fed the phase-feeding strategy. However, total revenue and IOFC were not affected by the feeding strategy. Over the entire period, feeding strategy had no effect on feed cost per pig, feed cost per pound of gain, total revenue, or IOFC.

In conclusion, diet blending improved F/G by reducing ADFI without affecting ADG compared to phase-fed pigs when measured during the feeding period when those strategies were directly compared. However, the inclusion of a common diet phase after the feed strategy evaluation diminished this F/G advantage, resulting in similar IOFC between the two feeding strategies.

Acknowledgments

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

	Diets for phase feeding[1]				Diets for blending[2]		
Item	Phase 1	Phase 2	Phase 3	Common	High-50	Med-150	Low-250
Ingredient, %							
Corn	61.56	69.24	75.68	87.77	58.27	70.62	77.75
Soybean meal[3]	20.21	13.05	6.96	10.16	23.19	11.73	4.98
DDGS, 6.4% oil	15.00	15.00	15.00	---	15.00	15.00	15.00
Limestone	1.19	1.17	1.19	0.90	1.20	1.18	1.15
Dicalcium phosphate	0.54	0.20	---	0.05	0.70	0.15	---
Salt	0.44	0.45	0.46	0.55	0.43	0.45	0.46
L-Lys HCl	0.53	0.49	0.45	0.33	0.57	0.48	0.43
DL-Met	0.13	0.07	0.03	0.02	0.17	0.07	---
L-Thr	0.19	0.15	0.12	0.10	0.22	0.15	0.10
L-Trp	0.05	0.05	0.05	0.04	0.06	0.05	0.05
L-Val	0.07	0.05	0.02	0.02	0.10	0.04	---
Vitamins and trace mineral[4]	0.10	0.10	0.08	0.08	0.10	0.10	0.08
Total	100	100	100	100	100	100	100
Calculated analysis							
SID amino acids, %							
Lys	1.15	0.94	0.76	0.69	1.25	0.90	0.70
Ile:Lys	56	56	56	57	56	56	56
Met:Lys	35	33	31	30	36	33	29
Met and Cys:Lys	58	58	58	58	58	58	58
Thr:Lys	65	65	65	65	65	65	65
Trp:Lys	20	20	19	20	20	20	20
Val:Lys	70	70	70	70	70	70	70
Leu:Lys	135	147	164	153	129	150	171
His:Lys	39	41	43	42	38	41	44
Total Lys, %	1.31	1.08	0.89	0.78	1.42	1.04	0.82
NE, kcal/lb	1,122	1,138	1,151	1,176	1,115	1,141	1,155
SID Lys:NE, g/Mcal	4.65	3.75	3.00	2.65	5.09	3.60	2.76
CP, %[5]	18.48	15.45	12.86	10.54	19.79	14.89	12.01
Ca, %	0.68	0.56	0.50	0.41	0.73	0.55	0.48
P, %	0.55	0.45	0.39	0.31	0.59	0.44	0.38
STTD P, %	0.40	0.33	0.30	0.27	0.43	0.32	0.30
Diet cost/ton, US $[6]	243.54	224.31	207.00	207.21	253.95	220.86	201.47

[1] Diets in phase-feeding strategies were provided from 50 to 100, 100 to 175, and 175 to 250 lb. Pigs were fed on a feed budget set at 97, 181, and 230 lb of feed per pig for phases 1 to 3, respectively. From 250 to 300 lb, a common diet was fed until the end of the study.
[2] For the diet-blending strategy, two of the three diets were blended at different proportions daily to meet the targeted SID Lys curve, aligned with 100% of PIC 2021 SID Lys recommendation.
[3] Net energy of soybean meal is 85% of the NE of corn.
[4] Phytase is included in the premix and provided 690 FTU/kg diet, providing 0.12% STTD P.
[5] CP = crude protein.
[6] Ingredient prices ($/lb): corn: 0.08, SBM: 0.18, DDGS: 0.09, limestone: 0.04, dicalcium phosphate: 0.30, salt: 0.07, L-Lys HCl: 0.90, DL-methionine: 1.40, L-Thr: 1.05, L-Trp: 4.50, L-Val: 2.20. Grinding, mixing and deliver (GMD) = $15/ton.

Table 2. Effects of phase feeding vs. complete diet blending on growing-finishing pig growth performance

	Feeding strategy			
Item	**Phase[1]**	**Blend[2]**	**SEM**	***P* =**
Body weight, lb				
d 0	58.4	58.4	0.81	0.721
d 28	115.0	114.8	1.26	0.764
d 56	181.1	179.0	1.32	0.013
d 84	249.4	248.0	1.49	0.189
d 102	290.4	288.7	1.53	0.153
d 116	307.6	306.2	1.86	0.456
Top weight (d 102)[3]	318.9	316.9	2.14	0.261
Dump weight (d 116)[4]	309.5	309.9	1.68	0.819
Average market weight[5]	312.5	312.2	1.57	0.827
d 0 to 28				
ADG, lb	2.00	2.00	0.019	0.975
ADFI, lb	3.85	3.84	0.048	0.813
F/G	1.93	1.92	0.020	0.836
d 28 to 56				
ADG, lb	2.34	2.28	0.014	0.004
ADFI, lb	5.69	5.42	0.050	<0.001
F/G	2.43	2.38	0.018	0.014
d 56 to 84				
ADG, lb	2.42	2.45	0.020	0.247
ADFI, lb	7.15	7.06	0.069	0.146
F/G	2.96	2.89	0.026	0.017

continued

Table 2. Effects of phase feeding vs. complete diet blending on growing-finishing pig growth performance

	Feeding strategy			
Item	Phase[1]	Blend[2]	SEM	*P* =
Experimental period (d 0 to 84)				
ADG, lb	2.25	2.24	0.011	0.115
ADFI, lb	5.55	5.42	0.047	0.002
F/G	2.46	2.42	0.019	0.012
Common period (d 84 to 102)				
ADG, lb	2.28	2.24	0.023	0.260
ADFI, lb	7.50	7.60	0.043	0.102
F/G	3.30	3.40	0.032	0.029
Common period (d 102 to 116)				
ADG, lb	2.18	2.19	0.026	0.814
ADFI, lb	7.46	7.53	0.053	0.332
F/G	3.42	3.44	0.035	0.748
Overall period (d 0 to 116)				
ADG, lb	2.25	2.23	0.009	0.107
ADFI, lb	6.02	5.95	0.039	0.017
F/G	2.68	2.66	0.017	0.354

[1] Diets in phase-feeding strategies were provided from 50 to 100, 100 to 175, and 175 to 250 lb. Pigs were fed on a feed budget set at 97, 181, and 230 lb of feed per pig for phases 1 to 3, respectively. From 250 to 300 lb, a common diet was fed until the end of the study. Diets were formulated to contain 4.65, 3.75, 3.00, and 2.65 g SID Lys per Mcal NE for phases 1 to 3 and the common diet, respectively.
[2] For the diet blending strategy, three diets were formulated to contain 5.09, 3.60, and 2.76 g SID Lys per Mcal NE. Two of these three diets were blended at different proportions daily to meet the targeted SID Lys curve (aligned with 100% of PIC 2021 SID Lys recommendation) until pigs reached 250 lb BW. Thereafter, pigs were then fed a common diet (2.65 g SID Lys per Mcal NE) from 250 to 300 lb.
[3] On d 102 of the trial, the four to seven heaviest pigs in each pen were selected for marketing.
[4] Pigs marketed on d 116 of the trial. Pigs with defects or too small for marketing were left and excluded from marketing.
[5] Weighted average of marketed pigs (topped and dumped pigs).

Table 3. Effects of phase feeding vs. complete diet blending on caloric efficiency and SID Lys intake per kilogram gain of finishing pigs

	Feeding strategy			
Item	**Phase**[1]	**Blend**[2]	**SEM**	***P* =**
Experimental period (d 0 to 84)				
Diet NE, kcal/lb[3]	1141	1139	---	---
Diet SID Lys, %[3]	0.91	0.92	---	---
Caloric efficiency, Mcal/lb[4]	2.86	2.81	0.021	0.007
SID Lys intake per kg gain, g/kg[5]	22.8	22.7	0.174	0.365
Common period (d 84 to 102)				
Diet NE, kcal/lb[3]	1176	1171	---	---
Diet SID Lys, %[3]	0.69	0.70	---	---
Caloric efficiency, Mcal/lb[4]	3.86	3.96	0.041	0.107
SID Lys intake per kg gain, g/kg[5]	22.7	23.7	0.226	0.004
Common period (d 102 to 116)				
Diet NE, kcal/lb[3]	1176	1176	---	---
Diet SID Lys, %[3]	0.69	0.69	---	---
Caloric efficiency, Mcal/lb[4]	3.37	3.41	0.034	0.422
SID Lys intake per kg gain, g/kg[5]	19.77	20.00	0.197	0.422

[1] Diets in phase feeding strategies were provided from 50 to 100, 100 to 175, and 175 to 250 lb. Pigs were fed on a feed budget set at 97, 181, and 230 lb of feed per pig for phases 1 to 3, respectively. From 250 to 300 lb, a common diet was fed until the end of the study. Diets were formulated to contain 4.65, 3.75, 3.00, and 2.65 g SID Lys per Mcal NE for phases 1 to 3 and the common diet, respectively.
[2] For the diet blending strategy, three diets were formulated to contain 5.09, 3.60, and 2.76 g SID Lys per Mcal NE. Two of these three diets were blended at different proportions daily to meet the targeted SID Lys curve (aligned with 100% of PIC 2021 SID Lys recommendation) until pigs reached 250 lb BW. Thereafter, pigs were then fed the common diet (2.65 g SID Lys per Mcal NE) from 250 to 300 lb.
[3] Diet NE and SID represent the weighted values calculated as the sum-product of diets used in each period and their corresponding NE or SID Lys, respectively.
[4] Caloric efficiency = total calorie intake ÷ total weight gain.
[5] SID Lys intake per kg gain = SID Lys intake total weight gain.

Table 4. Diet economics of growing-finishing pigs fed using different feeding strategies

	Feeding strategy			
Item	**Phase[1]**	**Blend[2]**	**SEM**	***P* =**
Experimental period[3]				
Feed cost per pig, $/pig[4]	51.43	50.45	0.567	0.078
Feed cost per lb gain, $/lb[5]	0.278	0.275	0.0020	0.083
Total revenue, $/pig[6]	122.23	121.28	1.013	0.433
IOFC, $/pig[7]	70.80	70.82	0.706	0.981
Overall period[3]				
Feed cost per pig, $/pig[8]	70.70	69.83	0.655	0.167
Feed cost per lb gain, $/lb[9]	0.289	0.288	0.0019	0.626
Total revenue, $/pig[10]	161.35	159.82	1.207	0.329
IOFC, $/pig[11]	90.65	89.99	0.863	0.561

[1] Diets in phase-feeding strategies were provided from 50 to 100, 100 to 175, and 175 to 250 lb. Pigs were fed on a feed budget set at 97, 181, and 230 lb of feed per pig for phases 1 to 3, respectively. From 250 to 300 lb, a common diet was fed until the end of the study. Diets were formulated to contain 4.65, 3.75, 3.00, and 2.65 g SID Lys per Mcal NE for phases 1 to 3 and the common diet, respectively.
[2] For the diet-blending strategy, three diets were formulated to contain 5.09, 3.60, and 2.76 g SID Lys per Mcal NE. Two of these three diets were blended at different proportions daily to meet the targeted SID Lys curve (aligned with 100% of PIC 2021 SID Lys recommendation) until pigs reached 250 lb BW. Thereafter, pigs were then fed the common diet (2.65 g SID Lys per Mcal NE) from 250 to 300 lb.
[3] Ingredient prices ($/lb): corn: 0.08, SBM: 0.18, DDGS: 0.09, limestone: 0.04, dicalcium phosphate: 0.30, salt: 0.07, L-Lys HCl: 0.90, DL-methionine: 1.40, L-Thr: 1.05, L-Trp: 4.50, L-Val: 2.20. Grinding, mixing and deliver (GMD) = $15/ton. Liveweight price: 66 $/cwt.
[4] Feed cost per pig = total feed cost divided by number of pigs at placement. Total feed cost was determined as the sum-product of the total feed consumed from the beginning until the end of the experimental period for each diet and its corresponding cost.
[5] Feed cost per lb of gain = total feed cost divided by the total gain during experimental period.
[6] Total revenue = total gain during experimental period per pig × liveweight price ($/cwt) divided by 100.
[7] Income over feed cost (IOFC) = total revenue during experimental period – total cost during experimental period.
[8] Feed cost per pig = total feed cost divided by number of pigs at placement. Total feed cost was determined as the sum-product of the total feed consumed from the beginning until the end of the trial for each diet and its corresponding cost.
[9] Feed cost per lb of gain = total feed cost divided by the total gain.
[10] Total revenue = total gain per pig × liveweight price ($/cwt) divided by 100. Total gain includes the weight of marketed pigs (topped and dumped).
[11] Income over feed cost (IOFC) = total revenue – total cost.

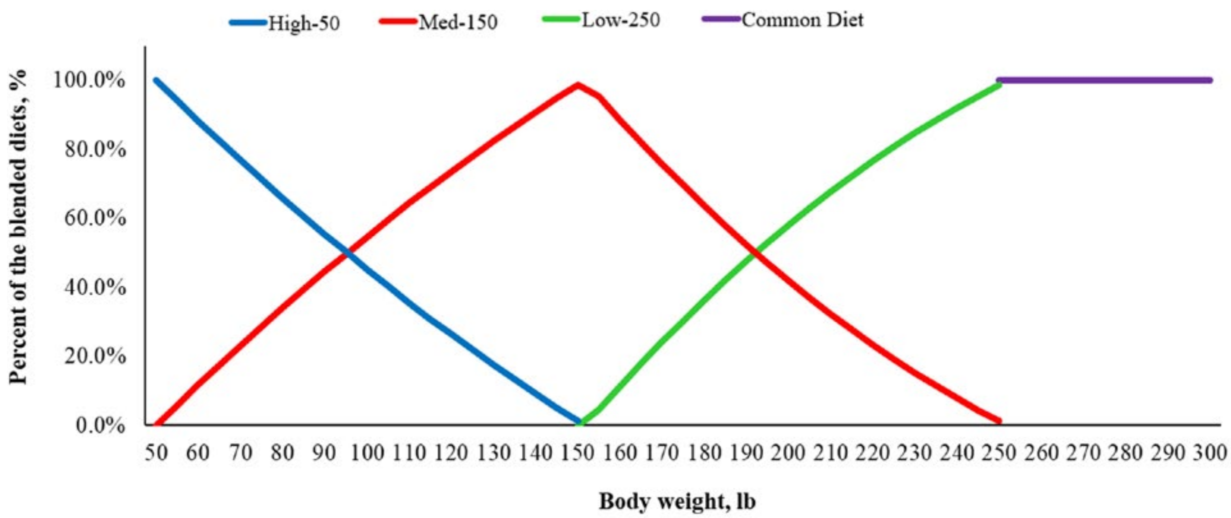

Figure 1. Blending of two of the three diets (High-50, Med-150, and Low-250) to meet the targeted SID Lys curve aligned with 100% of PIC 2021 SID Lys recommendations. Daily feed additions to each pen were accomplished using a robotic feeding system (FeedPro, FeedLogic by ComDel Innovation, Wahpeton, ND).