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Effect of Phase-Feeding Strategies on Growth Performance and Carcass Characteristics of Growing-Finishing Pigs: Strategies to Reduce Dietary Phases Using a Field Approach on Lysine Levels

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Effect of Phase-Feeding Strategies on Growth Performance and Carcass Characteristics of Growing-Finishing Pigs: Strategies to Reduce Dietary Phases Using a Field Approach on Lysine Levels

Abstract

The objective of this study was to evaluate whether simplification of phase-feeding strategies using a field approach with lysine specifications slightly below the estimated requirement for maximum growth rate is possible without compromising overall performance and carcass characteristics of grow-finish pigs. A total of 1,188 pigs (PIC; 359 × 1050; initially 63.5 lb body weight (BW)) were used in a randomized complete block design with 27 pigs per pen and 11 pens per treatment under commercial research conditions. Treatments consisted of four feeding programs with lysine specifications set at 98.5% of estimated requirements for maximum growth rate and 97.5% of maximum feed efficiency (F/G) for the weight range in each phase, except for the last phase of one of the 2-phase feeding programs which the lysine specifications were set for 100% of estimated requirements of maximum growth rate. Treatments were: a 2-phase feeding program with 0.91 and 0.72% standardized ileal digestible (SID) lysine (Lys) from 60 to 220 and 220 to 280 lb BW, respectively (2-phase Lys 98%); a 2-phase feeding program with 0.91 and 0.77% SID lysine from 60 to 220 and 220 to 280 lb BW, respectively (2-phase Lys 98%/100%); a 3-phase feeding program with 0.99, 0.79, and 0.72% SID lysine from 60 to 160, 160 to 220, and 220 to 280 lb BW, respectively (3-phase Lys 98%); and a 4-phase feeding program with 1.07, 0.91, 0.79, and 0.72% SID lysine from 60 to 110, 110 to 160, 160 to 220, and 220 to 280 lb, respectively (4-phase Lys 98%). The experimental diets were based on corn, distillers dried grains with solubles (DDGS), and soybean meal. Overall, from d 0 to 114, no evidence (*P* > 0.05) for difference was observed in growth performance across feeding programs. There was no evidence for difference (*P* > 0.05) for hot carcass weight and carcass yield, backfat thickness, loin depth, or percentage lean. Consequently, no evidence (*P* > 0.05) for difference was observed in economics, with all phase-feeding programs resulting in similar income over feed cost (IOFC). In conclusion, simplification of phase-feeding strategies to fewer dietary phases in the grow-finish period with lysine set slightly below the requirements seems to be feasible. However, along with findings from our previous study, in feeding programs with fewer dietary phases and lysine set slightly below the requirements, growth performance can be compromised if initial BW and feed intake in the grow-finish period are lower than expected.

Keywords

lysine, phase-feeding pigs

Cover Page Footnote

Appreciation is expressed to New Horizon Farms (Pipestone, MN) for providing research facilities.

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The Effect of Phase-Feeding Strategies on Growth Performance and Carcass Characteristics of Growing-Finishing Pigs: Strategies to Reduce Dietary Phases Using a Field Approach on Lysine Levels[1]

Mariana B. Menegat,[2] Steve S. Dritz,[2] Mike D. Tokach, Jason C. Woodworth, Joel M. DeRouchey, and Robert D. Goodband

Summary

The objective of this study was to evaluate whether simplification of phase-feeding strategies using a field approach with lysine specifications slightly below the estimated requirement for maximum growth rate is possible without compromising overall performance and carcass characteristics of grow-finish pigs. A total of 1,188 pigs (PIC; 359 × 1050; initially 63.5 lb body weight (BW)) were used in a randomized complete block design with 27 pigs per pen and 11 pens per treatment under commercial research conditions. Treatments consisted of four feeding programs with lysine specifications set at 98.5% of estimated requirements for maximum growth rate and 97.5% of maximum feed efficiency (F/G) for the weight range in each phase, except for the last phase of one of the 2-phase feeding programs which the lysine specifications were set for 100% of estimated requirements of maximum growth rate. Treatments were: a 2-phase feeding program with 0.91 and 0.72% standardized ileal digestible (SID) lysine (Lys) from 60 to 220 and 220 to 280 lb BW, respectively (2-phase Lys 98%); a 2-phase feeding program with 0.91 and 0.77% SID lysine from 60 to 220 and 220 to 280 lb BW, respectively (2-phase Lys 98%/100%); a 3-phase feeding program with 0.99, 0.79, and 0.72% SID lysine from 60 to 160, 160 to 220, and 220 to 280 lb BW, respectively (3-phase Lys 98%); and a 4-phase feeding program with 1.07, 0.91, 0.79, and 0.72% SID lysine from 60 to 110, 110 to 160, 160 to 220, and 220 to 280 lb, respectively (4-phase Lys 98%). The experimental diets were based on corn, distillers dried grains with solubles (DDGS), and soybean meal. Overall, from d 0 to 114, no evidence ($P > 0.05$) for difference was observed in growth performance across feeding programs. There was no evidence for difference ($P > 0.05$) for hot carcass weight and carcass yield, backfat thickness, loin depth, or percentage lean. Consequently, no evidence ($P > 0.05$) for difference was observed in economics, with all phase-feeding programs resulting in similar income over feed cost (IOFC). In conclusion, simplifica-

[1] Appreciation is expressed to New Horizon Farms (Pipestone, MN) for providing research facilities.

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tion of phase-feeding strategies to fewer dietary phases in the grow-finish period with lysine set slightly below the requirements seems to be feasible. However, along with findings from our previous study,[3] in feeding programs with fewer dietary phases and lysine set slightly below the requirements, growth performance can be compromised if initial BW and feed intake in the grow-finish period are lower than expected.

Introduction

Previous studies suggest simplification of feeding strategies to fewer dietary phases can lead to similar growth performance, carcass characteristics, and economics similar to feeding strategies with multiple dietary phases in the grow-finish period. However, this has been particularly observed when using lysine specifications set at 100% of the estimated requirement of maximum growth rate. When simplification of feeding programs from 4 to 3 or 2 dietary phases was applied using a field approach with lysine levels at approximately 98% of the estimated requirement of maximum growth rate, there were negative implications on overall F/G. It may be speculated that the lysine levels in phase-feeding strategies with fewer dietary phases were severely reduced in the early grower period or were not sufficiently increased in the late finisher period to allow for compensatory growth to occur.

Therefore, the objective of this study was to evaluate whether simplification of phase-feeding strategies using a field approach with lysine specifications slightly below the estimated requirements is possible without compromising overall performance and carcass characteristics of grow-finish pigs. Our hypothesis is that increasing lysine levels from 98 to 100% of estimated requirements in late finishing in a 2-phase feeding strategy or decreasing lysine levels earlier instead of later in a 3-phase feeding strategy with lysine at 98% of estimated requirements could lead to similar performance to a 4-phase feeding strategy with lysine at 98% of estimated requirements for maximum growth rate.

Procedures

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 facility in southwestern Minnesota. The barn was naturally ventilated and double-curtain-sided. Each pen was equipped with a 4-hole stainless steel dry self-feeder and a cup waterer for *ad libitum* access to feed and water. Feed additions to each individual pen were made and recorded by a robotic feeding system (FeedPro, Feedlogic Corp., Wilmar, MN).

A total of 1,188 pigs (PIC; 359 × 1050; initially 63.5 lb BW) were used in a 114-d growth trial with 27 pigs per pen and 11 pens per treatment. Pigs were allotted to treatments based on initial BW in a randomized complete block design.
Treatments consisted of four phase-feeding programs arranged in a 1-way treatment structure. Lysine specifications were set at 98.5% of the maximum growth rate and 97.5% of the maximum F/G for the weight range in each phase, except for the last phase of one of the 2-phase feeding programs which the lysine specifications were set

[3] Menegat, M. B., Dritz, S. S., Tokach, M. D., Woodworth, J. C., DeRouchey, J. M., and Goodband, R. D. 2018. The effect of phase- feeding strategies on growth performance and carcass characteristics of growing-finishing pigs: II. Field approach on lysine levels. Kansas Agricultural Experiment Station Research Reports: Vol. 4: Iss. 9.

for 100% of maximum growth rate. The equation used for lysine requirement estimates for finishing gilts in g/Mcal NE was: $0.000056 \times BW^2$, lb - $0.02844 \times BW$, lb + 6.6391, provided by the genetic supplier.[4]

Treatments were: a 2-phase feeding program with 0.91 and 0.72% SID lysine from 60 to 220 and 220 to 280 lb BW, respectively (2-phase Lys 98%); a 2-phase feeding program with 0.91 and 0.77% SID lysine from 60 to 220 and 220 to 280 lb BW, respectively (2-phase Lys 98%/100%); a 3-phase feeding program with 0.99, 0.79, and 0.72% SID lysine from 60 to 160, 160 to 220, and 220 to 280 lb BW, respectively (3-phase Lys 98%); and a 4-phase feeding program with 1.07, 0.91, 0.79, and 0.72% SID lysine from 60 to 110, 110 to 160, 160 to 220, and 220 to 280 lb, respectively (4-phase Lys 98%) (Table 1).

The diets were based on corn, DDGS, and soybean meal (Table 2). Lysine levels in experimental diets were achieved by altering the ratio of corn to soybean meal while keeping the amount of L-lysine HCl constant within phases. Diet samples from each phase were taken from 6 feeders per dietary treatment 3 d after the beginning and 3 d before the end of each phase and stored at -4°F. Composite samples were homogenized, subsampled, and analyzed for dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), ether extract, Ca, and P (Ward Laboratories Inc., Kearney, NE). Composite samples were also analyzed for total amino acid by Ajinomoto Heartland, Inc. (Chicago, IL).

Pens of pigs were weighed and feed disappearance measured on d 0, 14, 28, 42, 52, 63, 77, 100, and 114 to determine average daily gain (ADG), average daily feed intake (ADFI), and F/G. On d 114, final pen weights were taken and pigs were tattooed with a pen identification number and transported to a U.S. Department of Agriculture-inspected packing plant (JBS Swift and Co., Worthington, MN) for processing and carcass data collection. Carcass measurements included hot carcass weight (HCW), backfat, loin depth, and percentage lean. Percentage lean was calculated from a plant proprietary equation. Carcass yield was calculated by dividing the pen average HCW by the pen average final live weight obtained at the farm.

For the economic analysis, feed cost per pig, feed cost per lb of gain, revenue per pig, and IOFC were calculated on a pen basis. Corn was valued at $3.53/bu ($126/ton), soybean meal at $350/ton, DDGS at $176/ton, L-lysine at $0.75/lb, DL-methionine at $1.40/lb, L-threonine at $1.05/lb, and L-tryptophan at $8/lb. Feed cost per pig was calculated by multiplying the feed cost per lb by ADFI and by the number of days in each phase, then adding up the values of each phase. Feed cost per lb of gain was calculated by dividing the feed cost per pig by the overall weight gain. Revenue was obtained by multiplying carcass gain by an assumed value of $70 per cwt of carcass. The IOFC was calculated by subtracting the feed cost per pig from revenue per pig.
Data were analyzed using a linear mixed model with treatment as fixed effect, block as random effect, and pen as the experimental unit. Hot carcass weight was used as a covariate for analyses of backfat, loin depth, and lean percentage. Statistical models were

[4] PIC. 2016. Nutrient Specifications Manual. Available at: *http://na.pic.com/tech_support/nutrition/nutrient_specifications_manual_download.aspx*

fitted using the GLIMMIX procedure of SAS version 9.4 (SAS Institute Inc., Cary, NC). Results were considered significant at $P \leq 0.05$.

Results and Discussion

In phase 1 (d 0 to 28), pigs fed the 2-phase programs had lower ($P = 0.001$) ADG and poorer F/G compared to those fed the 3- and 4-phase feeding programs (Table 3). Consequently, pigs fed the 2-phase programs had lower ($P = 0.001$) BW than other feeding programs at the end of phase 1 (d 28).

In phase 2 (d 28 to 52), no evidence ($P > 0.05$) for difference was observed in growth performance across feeding programs. However, pigs fed the 2-phase programs remained with lower ($P = 0.001$) BW than other feeding programs at the end of phase 2 (d 52).

In phase 3 (d 52 to 77), pigs fed the 2-phase programs had improved ($P = 0.01$) ADG compared to those fed the 4-phase program, and pigs fed the 3-phase program had intermediate ADG. The improvement in ADG was mainly driven by F/G, as pigs fed the 2-phase programs had improved F/G compared to those fed the 3- and 4-phase feeding programs. Pigs fed the 3-phase program had greater ADFI than those fed the 2-phase program with Lys at 98.5% of maximum growth rate, and pigs fed the other feeding programs had intermediate ADFI.

In phase 4 (d 77 to 114), no evidence ($P > 0.05$) for difference was observed in growth performance across feeding programs.

Overall (d 0 to 114), no evidence ($P > 0.05$) for difference was observed in growth performance across feeding programs. There was no evidence for difference ($P > 0.05$) for HCW and carcass traits yield, backfat thickness, loin depth, or percentage lean. Consequently, no evidence ($P > 0.05$) for difference was observed in economics, with all phase-feeding programs resulting in similar IOFC.

This study suggests that it is possible to simplify phase-feeding strategies using lysine specifications slightly below the requirement for maximum growth rate without compromising overall performance and carcass characteristics of grow-finish pigs. The present findings show that increasing lysine levels from 98% to 100% of estimated requirements in late finishing in a 2-phase feeding strategy (2-phase Lys 98%/100%) or decreasing lysine levels earlier instead of later in a 3-phase feeding strategy with lysine at 98% of estimated requirements (3-phase Lys 98%) led to similar performance to a 4-phase feeding strategy with lysine at 98% of estimated requirements (4-phase Lys 98%). In contrast to our previous study,[5] the 2-phase feeding strategy with lysine at 98% of estimated requirements also led to similar growth performance and final BW. The discrepancy between studies could be attributed to a difference in initial BW and overall feed intake. In our previous study,[6] initial BW and overall feed intake were approximately 10% and 4% lower, respectively, compared to the present study.

[5] Menegat, M. B., Dritz, S. S., Tokach, M. D., Woodworth, J. C., DeRouchey, J. M., and Goodband, R. D. 2018. The effect of phase- feeding strategies on growth performance and carcass characteristics of growing-finishing pigs: II. Field approach on lysine levels. Kansas Agricultural Experiment Station Research Reports: Vol. 4: Iss. 9.

Thus, initial lysine levels were further below the estimated requirements in the early grow-finish period and lysine intake in the entire grow-finish period was lower in our previous study.

In conclusion, simplification of phase-feeding strategies to fewer dietary phases in the grow-finish period with lysine set slightly below the estimated requirements seems feasible. However, in feeding programs with fewer dietary phases and lysine set slightly below the requirements, growth performance can be compromised if initial BW and feed intake in the grow-finish period are lower than expected.

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Table 1. Description of feeding phases and lysine (Lys) levels of experimental diets[1]

Phase:	1	2	3	4
Duration, d:	0 to 28	28 to 52	52 to 77	77 to 114
Weight range, lb:	60 to 110	110 to 160	160 to 220	220 to 280
Phase-feeding strategy	SID[2] Lys, %			
2-Phase Lys 98%	0.91	0.91	0.91	0.72
2-Phase Lys 98%/100%	0.91	0.91	0.91	0.77
3-Phase Lys 98%	0.99	0.99	0.79	0.72
4-Phase Lys 98%	1.07	0.91	0.79	0.72
	SID Lys:ME, g/Mcal			
2-Phase Lys 98%	2.74	2.74	2.74	2.14
2-Phase Lys 98%/100%	2.74	2.74	2.74	2.29
3-Phase Lys 98%	2.98	2.98	2.36	2.14
4-Phase Lys 98%	3.23	2.73	2.36	2.14
	SID Lys:NE, g/Mcal			
2-Phase Lys 98%	3.61	3.61	3.61	2.81
2-Phase Lys 98%/100%	3.61	3.61	3.61	3.02
3-Phase Lys 98%	3.96	3.96	3.08	2.81
4-Phase Lys 98%	4.31	3.60	3.08	2.81

[1]The equation used for lysine requirements for finishing gilts in g/Mcal NE was: $0.000056 \times BW^2$, lb - $0.02844 \times BW$, lb + 6.6391 (PIC, 2016).
[2]SID = standardized ileal digestible. ME = metabolizable energy. NE = net energy. BW = body weight.

Table 2. Composition of experimental diets (as-fed basis)[1]

Feeding program:	2-Phase Lys 98%		2-Phase Lys 98%/100%		3-Phase Lys 98%			4-Phase Lys 98%			
Item	60 to 220 lb BW	220 to 280 lb BW	60 to 220 lb BW	220 to 280 lb BW	60 to 160 lb BW	160 to 220 lb BW	220 to 280 lb BW	60 to 110 lb BW	110 to 160 lb BW	160 to 220 lb BW	220 to 280 lb BW
Corn	64.98	80.21	64.98	78.17	61.76	70.39	80.21	58.48	65.33	70.39	80.21
DDGS[2]	20.00	---	20.00	---	20.00	20.00	---	20.00	20.00	20.00	---
Soybean meal, 47% crude protein	11.35	17.21	11.35	19.25	14.61	6.42	17.21	17.88	11.33	6.42	17.21
Tallow	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Monocalcium phosphate, 21% P	0.50	0.20	0.50	0.20	0.45	0.10	0.20	0.45	0.25	0.10	0.20
Calcium carbonate	1.23	0.95	1.23	0.95	1.23	1.18	0.95	1.20	1.15	1.18	0.95
Sodium chloride	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
L-Lysine HCl	0.50	0.15	0.50	0.15	0.50	0.50	0.15	0.50	0.50	0.50	0.15
DL-Methionine	0.03	---	0.03	---	0.03	---	---	0.06	0.03	---	---
L-Threonine	0.12	0.02	0.12	0.02	0.13	0.11	0.02	0.13	0.12	0.11	0.02
L-Tryptophan	0.05	---	0.05	---	0.04	0.05	---	0.04	0.05	0.05	---
Vitamin-trace mineral premix[3]	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Calculated analysis											
SID amino acids, %											
Lysine	0.91	0.72	0.91	0.77	0.99	0.79	0.72	1.07	0.91	0.79	0.72
Isoleucine:lysine	58	71	58	71	59	56	71	59	58	56	71
Leucine:lysine	159	169	159	164	154	169	169	149	159	169	169
Methionine:lysine	31	31	31	30	30	30	31	32	31	30	31
Methionine and cysteine:lysine	58	62	58	60	56	58	62	58	58	58	62
Threonine:lysine	64	64	64	64	64	64	64	64	64	64	64
Tryptophan:lysine	19.2	19.7	19.2	19.9	19.0	19.3	19.7	19.2	19.2	19.3	19.7
Valine:lysine	69	81	69	80	69	70	81	69	69	70	81
Total lysine, %	1.05	0.83	1.05	0.88	1.14	0.92	0.83	1.23	1.05	0.92	0.83
ME, kcal/lb	1,506	1,524	1,506	1,523	1,506	1.515	1.524	1.505	1,511	1,515	1,524
NE, kcal/kg	1,144	1,161	1,144	1,156	1,135	1,162	1,161	1,127	1,148	1,162	1,161
SID lysine:ME, g/Mcal	2.74	2.14	2.74	2.29	2.98	2.36	2.14	3.23	2.73	2.36	2.14
SID lysine:NE, g/Mcal	3.61	2.81	3.61	3.02	3.96	3.08	2.81	4.31	3.60	3.08	2.81
Crude protein, %	16.2	14.0	16.2	14.8	17.5	14.2	14.0	18.9	16.2	14.2	14.0
Calcium, %	0.60	0.45	0.60	0.45	0.60	0.50	0.45	0.60	0.53	0.50	0.45
STTD phosphorus, %	0.38	0.26	0.38	0.26	0.38	0.29	0.26	0.38	0.33	0.29	0.26

[1]Diets were fed *ad libitum* in meal form from 63.5 to 286.3 lb body weight for 114 days. Lysine levels in experimental diets were achieved by altering the inclusion of soybean meal.

[2]DDGS = distillers dried grains with solubles. SID = standardized ileal digestible. ME = metabolizable energy. NE = net energy. STTD = standardized total tract digestible. Lys = lysine.

[3]Provided per kg of premix: 3,527,360 IU vitamin A; 881,840 IU vitamin D; 17,637 IU vitamin E; 1,764 mg vitamin K; 15.4 mg vitamin B_{12}; 33,069 mg niacin; 11,023 mg pantothenic acid; 3,307 mg riboflavin; 74 g Zn from zinc sulfate; 74 g Fe from iron sulfate; 22 g Mn from manganese oxide; 11 g Cu from copper sulfate; 0.22 g I from calcium iodate; 0.20 g Se from sodium selenite; and 500,000 FTU phytase from OptiPhos® 2000 (Huvepharma Inc., Peachtree City, GA).

Table 3. Effect of phase-feeding strategy on growth performance, carcass characteristics, and economics of grow-finish pigs[1,2,3]

Item[4]	2-Phase Lys 98%	2-Phase Lys 98%/100%	3-Phase Lys 98%	4-Phase Lys 98%	SEM	Probability, *P* =
BW, lb						
d 0	63.4	63.6	63.6	63.6	1.036	0.593
d 28	112.1[b]	111.4[b]	114.2[a]	115.2[a]	1.514	0.001
d 52	161.1[b]	160.7[b]	166.0[a]	167.0[a]	1.932	0.001
d 77	214.7	215.4	217.5	215.9	2.054	0.435
d 114	283.9	287.2	288.5	285.7	2.320	0.317
Phase 1 (d 0 to 28)						
ADG, lb	1.74[b]	1.70[b]	1.80[a]	1.84[a]	0.022	0.001
ADFI, lb	3.60	3.54	3.65	3.61	0.060	0.234
F/G	2.07[a]	2.08[a]	2.02[ab]	1.97[b]	0.019	0.001
Phase 2 (d 28 to 52)						
ADG, lb	2.04	2.05	2.16	2.15	0.034	0.029
ADFI, lb	4.90	4.81	4.99	5.03	0.079	0.128
F/G	2.40	2.35	2.32	2.34	0.029	0.108
Phase 3 (d 52 to 77)						
ADG, lb	2.10[ab]	2.19[a]	2.06[bc]	1.96[c]	0.030	0.001
ADFI, lb	5.79[b]	6.02[ab]	6.09[a]	5.87[ab]	0.072	0.021
F/G	2.76[b]	2.75[b]	2.96[a]	3.00[a]	0.037	0.001
Phase 4 (d 77 to 114)						
ADG, lb	2.03	2.07	2.04	2.00	0.036	0.611
ADFI, lb	6.38	6.58	6.44	6.39	0.078	0.257
F/G	3.15	3.18	3.17	3.19	0.043	0.842
Overall (d 0 to 114)						
ADG, lb	1.97	2.00	2.01	1.98	0.013	0.209
ADFI, lb	5.21	5.29	5.34	5.27	0.056	0.305
F/G	2.64	2.65	2.66	2.66	0.019	0.763

continued

Table 3. Effect of phase-feeding strategy on growth performance, carcass characteristics, and economics of grow-finish pigs[1,2,3]

Item[4]	2-Phase Lys 98%	2-Phase Lys 98%/100%	3-Phase Lys 98%	4-Phase Lys 98%	SEM	Probability, $P =$
Carcass characteristics						
HCW, lb	210.2	211.6	213.6	212.0	1.459	0.231
Yield, %	74.1	73.7	74.1	74.2	0.321	0.652
Backfat, in[5]	0.65	0.67	0.66	0.65	0.011	0.582
Loin depth, in[5]	2.71	2.70	2.71	2.75	0.020	0.323
Lean, %	57.0	56.7	56.8	57.1	0.205	0.485
Economics, $ per pig[6]						
Feed cost	54.30	55.72	55.28	54.58	0.570	0.153
Feed cost per lb gain[7]	0.24	0.24	0.24	0.24	0.002	0.195
Revenue[8]	113.85	114.69	116.14	115.02	0.795	0.249
IOFC[9]	59.55	58.97	60.86	60.45	0.693	0.224

[1]A total of 1,188 pigs (PIC; 337 × 1050) with initial body weight (BW) of 63.5 lb were used with 27 pigs per pen and 11 pens per treatment.

[2]Dietary treatments were: a 2-phase feeding program with 0.91 and 0.72% SID lysine (Lys) from 60 to 220 and 220 to 280 lb BW, respectively (2-phase Lys 98%); a 2-phase feeding program with 0.91 and 0.77% SID lysine from 60 to 220 and 220 to 280 lb BW, respectively (2-phase Lys 98%/100%); a 3-phase feeding program with 0.99, 0.79, and 0.72% SID lysine from 60 to 160, 160 to 220, and 220 to 280 lb BW, respectively (3-phase Lys 98%); and a 4-phase feeding program with 1.07, 0.91, 0.79, and 0.72% SID lysine from 60 to 110, 110 to 160, 160 to 220, and 220 to 280 lb, respectively (4-phase Lys 98%).

[3]Means with different superscripts are significantly different ($P < 0.05$) in the row.

[4]ADG = average daily gain. ADFI = average daily feed intake. F/G = feed efficiency.

[5]Adjusted for hot carcass weight (HCW).

[6]Corn was valued at $3.53/bu ($126/ton), soybean meal at $350/ton, DDGS at $176/ton, and L-lysine at $0.75/lb.

[7]Feed cost per lb gain = feed cost per pig ÷ overall gain per pig.

[8]Revenue = (HCW × $0.70) - (d 0 BW × 0.75 × $0.70).

[9]Income over feed cost = revenue - feed cost.