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Effect of Phase Feeding Budget and Weaning Weight on Nursery Pig Growth Performance and Economics: A Follow-Up Study

Julian Arroyave, Mike D. Tokach, Jason C. Woodworth, Joel M. DeRouchey, Robert D. Goodband, Katelyn N. Gaffield, and Jordan T. Gebhardt[1]

Summary

This experiment was conducted to validate the results of a previous study that observed no difference in overall growth performance, but better economic outcomes when a simple phase feeding program was used compared to a more traditional complex program. At weaning, a total of 360 pigs (initially 13.3 ± 0.36 lb) were sorted by body weight (BW) and then randomly assigned to one of three dietary treatments arranged in a 3 × 3 factorial. Main effects included nursery phase feeding budget (high, medium, or low) and BW category (light, medium, or heavy). There were five pigs per pen and 12 pens per treatment. The feed budgets for phases 1 and 2 were 4, 2, 0, and 12, 8, 4 lb/pig for high, medium, and low nursery feeding budget programs, respectively. All pigs were then fed a common phase 3 diet thereafter. Phase 1 was formulated with specialty animal protein and lactose products and was formulated to contain 18.0% lactose with 16.3% soybean meal. In phase 2, specialty protein sources and the lactose level were reduced, with diets containing 7.2% lactose and 22.5% soybean meal. Phase 3 was a common corn-soybean meal-based diet with no specialty protein or lactose sources. Through the course of this trial, pigs were in good health with no mortality or removals. No interactions were observed between phase feeding budget and BW category for any response criteria. Overall (d 0 to 43), pigs fed with the low-budget program had greater ($P < 0.05$) ADG than those fed the high-budget program, with pigs fed the medium budget program intermediate. No differences in ADFI were observed among feed budget programs. Pigs fed the low-budget program tended ($P = 0.054$) to have improved F/G compared with those fed the high-budget program, while pigs fed the medium-budget program were intermediate. Feed cost and feed cost/lb of gain decreased as the phase 1 and 2 feed budgets were reduced ($P < 0.001$). There was a tendency ($P = 0.077$) for increased revenue with decreasing feed budget; however, no pairwise differences between treatments were observed. Income over feed cost improved ($P < 0.001$) as the phase feeding budgets decreased. For BW category, d 42 BW, ADG, and ADFI increased ($P < 0.001$) as the initial BW increased. However, no differences in F/G were observed between any BW category. Also, economic criteria improved ($P < 0.001$) as weaning BW category increased. In conclusion, in healthy pigs, the use

[1] Department of Diagnostic Medicine/Pathology, College of Veterinary Medicine, Kansas State University.

of low phase 1 and 2 feed budget programs resulted in an overall improvement of ADG and F/G. Economics improved as simpler feed budgets were used. Finally, pigs that were heavier at weaning had better overall nursery performance and economic returns than lighter-weight weaned pigs.

Introduction

The use of complex diets after weaning is a common nutritional strategy to maximize growth performance, but complex starter diets containing specialty animal protein and lactose sources are expensive and may not lead to the best return on investment.[2] During the nursery period, a three-phase diet program is often used. Each diet's feed budget is assigned according to the group's average weight.[3] However, this feeding strategy may not be the most cost-effective approach for feeding weaned pigs, as it is well established that pigs can have compensatory growth during the late nursery or early finishing period if they are initially fed diets that may not achieve maximum growth immediately post-weaning.

A previous experiment conducted at Kansas State University indicated that reducing phase 1 and 2 feed budgets immediately after weaning did not affect overall growth performance but decreased feed cost/lb of gain by 10%.[4] However, more data are needed to validate these results. Therefore, the objective of this study was to evaluate the effect of phase feeding budget and weaning weight on nursery pig performance and economics.

Materials and Methods

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The experiment was conducted in two barns located at the Kansas State University Segregated Early Weaning (SEW) facility in Manhattan, KS. Each pen (4 × 4 ft) was equipped with a 6-hole dry feeder and a cup drinker to provide *ad libitum* access to feed and water.

Animals and diets

A total of 360 pigs (Line 200 × 400, DNA, Columbus, NE) initially weighing 13.3 ± 0.36 lb were used in a 42-d study. The pigs were weaned at approximately 21 d of age and divided into three body weight (BW) categories. The pigs were then randomly assigned to pens within the BW categories, and pens were allotted to one of three dietary treatments. Each pen had five pigs and there were 12 pens per dietary treatment

[2] Lee, C. H., D. Y. Jung, M. J. Park, C. Y Lee. 2014. Effects of varying nursery phase-feeding programs on growth performance of pigs during the nursery and subsequent grow-finish phases. J. Anim. Sci. Technol. 56:1-6. doi:10.1186/2055-0391-56-24.

[3] Menegat, M.B., M. D. Tokach, J. C. Woodworth, J. M. DeRouchey, R. D. Goodband, and S.S Dritz. 2019. Kansas State University Swine Nutrition Guide: Nursery Phase Feeding Program. *Swine Nutrition Guide.*

[4] Arroyave, Julian; Tokach, Mike D.; Woodworth, Jason C.; DeRouchey, Joel M.; Goodband, Robert D.; Gaffield, Katelyn N.; and Gebhardt, Jordan T. (2024) "Effect of Nursery Phase Feeding Budget and Weaning Body Weight on Nursery Pig Growth Performance, Fecal Dry Matter, and Economics, Kansas Agricultural Experiment Station Research Reports: Vol. 10: Iss. 6. *https://doi.org/10.4148/2378-5977.8633*.

and BW category combination. The two identical barns had an equal representation of dietary treatments and BW categories.

Treatments were arranged in a 3 × 3 factorial with main effects of phase feeding budget (high, medium, or low) and BW category (light, medium, and heavy). Each phase feeding program consisted of different budgets for phases 1 and 2 diets followed by a common phase 3 diet. Phases 1 and 2 budgets were 4, 2, and 0, and 12, 8, and 4 lb/pig for the high, medium, and low phase feeding budget programs, respectively. All diets were formulated to have similar SID Lys (1.35%) and amino acid ratios relative to Lys using different ingredients between phases. Diets were manufactured at the Kansas State University O.H. Kruse Feed Technology Innovation Center, Manhattan, KS, and fed in pellet form (Table 1). Pigs and feeders were weighed on d 0, 10, 24, and 42 to determine ADG, ADFI, and F/G.

Economic analysis

Total feed cost per pig, feed cost/lb gained, revenue, and income over feed cost (IOFC) were calculated. Feed cost per pig placed was determined by multiplying total feed intake per pig by diet cost. Feed cost/lb gain was calculated by dividing the total feed cost per pig by the total weight gained. The following ingredient prices were used: corn $4.50/bushel ($161/ton); soybean meal = $350/ton; dried-whey powder = $0.32/lb; spray-dried plasma= $2/lb; specialty soy concentrate = $0.27/ lb; L-Lys HCl = $0.90/lb; DL-Met = $1.40/lb; L-Thr = $1.05/lb; L-Trp = $4.50/lb; L-Val = $2.20/lb; monocalcium phosphate = $0.35/lb. For this experiment, the revenue calculation was based on a pork price of $0.82/lb and an assumed 75% carcass yield.

Statistical analysis

Data were analyzed as a randomized complete block design in a 3 × 3 factorial arrangement. The lmer function was used from the lme4 package in RStudio [Version 4.0.2 (2020-06-22), R Core Team, R Foundation for Statistical Computing, Vienna, Austria] with pen serving as the experimental unit. The model incorporated the phase feeding budget program, BW category, and the associated interaction as fixed effects. Barn was considered a random effect in the model. Differences between treatments were considered significant at $P \leq 0.05$ and marginally significant at $0.05 < P \leq 0.10$.

Results and Discussion

Overall, pigs in this trial were healthy with no mortality or removals. No significant interactions were observed between the phase feeding program and BW category on growth performance and economics (data not presented).

For period 1 (d 0 to 10), no differences were observed between feed budget programs for d 10 BW, ADG, and ADFI. However, pigs fed the low-feed-budget program had better ($P < 0.05$) F/G than those pigs fed with the medium- or high-feed budget (Table 2).

For period 2 (d 10 to 24), pigs fed the low-budget program were heavier ($P < 0.05$) on d 24 than those fed the high-budget program. Body weight of pigs fed the medium-budget programs was intermediate. A marginal response ($P < 0.10$) was observed

for ADG and ADFI in which pigs fed the low feed budget had the greatest response, but no difference between individual treatments was observed. No differences between budget programs were observed for F/G.

When the common diet was fed (d 24 to 42) and overall (d 0 to 42), pigs fed the low-feed-budget program had greater ($P < 0.05$) ADG and BW on d 42 than those fed the high-feed-budget program. Body weight at d 42 and ADG of pigs fed the medium-budget program were intermediate. No differences in ADFI were observed among feed-budget programs. There was a tendency ($P = 0.084$) for improved F/G in favor of pigs fed the low-feed-budget program during period 3, although no means separation was detected. Over the entire nursery period, pigs fed the low-budget program also tended ($P = 0.054$) to have improved F/G compared with those fed the high-budget program, while pigs fed the medium-budget program were intermediate.

Feed cost and feed cost/lb of gain decreased ($P < 0.001$) as the phase feeding budgets were reduced. There was a tendency ($P = 0.077$) for increased revenue with decreasing phase 1 and 2 feed budgets; however, no means separation was observed. Income over feed cost improved ($P < 0.001$) as the phase feeding budgets decreased.

For the main effect of weaning BW category, as expected, d 0 BW was different ($P < 0.001$) between the three BW categories (Table 3). Similarly, d 42 BW, ADG, and ADFI increased ($P < 0.001$) as the initial BW increased. However, no differences in F/G were observed between any BW category. Feed cost, revenue, and IOFC increased ($P < 0.001$) as weaning weight increased. Pigs in the heavy BW category had lower ($P < 0.05$) feed cost/lb of gain than those in the light BW category, whereas pigs in the medium BW category were intermediate.

In summary, in the healthy pigs used in this study, the use of low phases 1 and 2 feed-budget programs resulted in an overall improvement of ADG, F/G, and economic criteria. For the BW category, overall nursery performance and economic returns improved as the BW at weaning increased. These results support our previous findings where diet complexity and feed budget did not affect growth performance. Our next step is to take these findings and apply them in a commercial research environment to see if results are repeated.

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Table 1. Diet composition (as-fed basis)[1]

Item	Phase 1	Phase 2	Phase 3
Ingredient, %			
Corn	44.12	56.42	62.27
Soybean meal	16.29	22.49	32.66
Spray-dried whey	25.00	10.00	---
Spray-dried bovine plasma	2.50	---	---
Enzymatically treated soybean meal[2]	6.00	6.00	---
Soybean oil	3.00	1.00	1.00
L-Lys-HCl	0.38	0.49	0.48
DL-Met	0.22	0.21	0.20
L-Thr	0.17	0.23	0.23
L-Trp	0.03	0.04	0.04
L-Val	0.08	0.12	0.11
Limestone	0.65	0.74	0.82
Monocalcium phosphate	0.48	0.98	1.10
Salt	0.23	0.56	0.60
Trace mineral premix	0.15	0.15	0.15
Vitamin premix	0.25	0.25	0.25
Phytase[3]	0.03	0.03	0.03
Choline chloride 60%	0.05	---	---
Zinc oxide	0.39	0.25	---
Copper sulfate	---	---	0.07
Total	100.00	100.00	100.00

continued

Table 1. Diet composition (as-fed basis)[1]

Item	Phase 1	Phase 2	Phase 3
Calculated analysis			
SID AA, %			
Lys	1.35	1.35	1.35
Ile:Lys	57	57	57
Leu:Lys	117	115	116
Met:Lys	36	36	36
Met & Cys:Lys	59	57	57
Thr:Lys	65	65	65
Trp:Lys	20	20	20
Val:Lys	69	69	69
His:Lys	34	35	37
Total Lys, %	1.49	1.49	1.50
ME, kcal/lb	1,587	1,524	1,506
NE, kcal/lb	1,199	1,135	1,113
SID Lys:NE, g/Mcal	5.11	5.39	5.50
CP, %	20.30	20.80	21.60
Lactose, %	18.00	7.20	---
Ca, %	0.67	0.72	0.72
P, %	0.58	0.63	0.63
STTD P, %[4]	0.51	0.51	0.48

[1] Phase 1, 2, and 3 diets were fed in pellet form.
[2] HP 300; Hamlet Protein; Findlay, OH.
[3] HiPhorius 2400 (DSM-Firmenich, Parsippany, NJ) provided an estimated release of 0.11% STTD P.
[4]Standardized total tract digestible phosphorus.

Table 2. Main effect of phase feeding budget on nursery performance and economics[1]

	Phase feeding budget[2]				
Item	**High**	**Medium**	**Low**	**SEM**	***P* =**
BW, lb					
d 0	13.2	13.4	13.3	0.36	0.454
d 10	17.0	17.1	17.3	0.35	0.287
d 24	31.9[a]	32.5[ab]	32.7[b]	0.47	0.034
d 42	60.3[a]	61.8[ab]	62.5[b]	1.03	0.005
Period 1 (d 0 to 10)					
ADG, lb	0.38	0.38	0.40	0.011	0.412
ADFI, lb	0.39	0.40	0.38	0.010	0.720
F/G	1.05[a]	1.05[a]	0.97[b]	0.024	0.020
Period 2 (d 10 to 24)					
ADG, lb	1.06	1.09	1.11	0.016	0.099
ADFI, lb	1.32	1.35	1.38	0.019	0.080
F/G	1.24	1.24	1.24	0.018	0.862
Period 3 (d 24 to 43)					
ADG, lb	1.58[a]	1.63[ab]	1.64[b]	0.021	0.023
ADFI, lb	2.17	2.21	2.22	0.022	0.226
F/G	1.38	1.36	1.35	0.020	0.084
Overall (d 0 to 43)					
ADG, lb	1.12[a]	1.15[ab]	1.17[b]	0.012	0.015
ADFI, lb	1.46	1.49	1.50	0.015	0.219
F/G	1.31[a]	1.30[ab]	1.28[b]	0.015	0.054
Economics, $/pig placed[3]					
Feed cost	10.76[a]	10.29[b]	9.77[c]	0.108	< 0.001
Feed cost/lb of gain[4]	0.30[a]	0.21[b]	0.20[c]	0.002	< 0.001
Revenue[5]	28.95	29.53	30.04	0.333	0.077
IOFC[6]	18.20[a]	19.24[b]	20.27[c]	0.301	< 0.001

[1]A total of 360 pigs (Line 200 × 400, DNA, Columbus, NE; initially 13.3 ± 0.36 lb) were used in a 42-d growth study with five pigs per pen and 24 pens per treatment. No significant interactions between BW category and feed-budget programs were observed for any of the response criteria.

[2]The phase feeding budget treatments consisted of different quantities of phase 1 and 2 diets followed by a common phase 3 diet. High = 4 and 12 lb/pig of phases 1 and 2, respectively. Medium = 2 and 8 lb/pig of phases 1 and 2, respectively. Low = 0 and 4 lb/pig of phases 1 and 2, respectively.

[3]Total feed costs per ton were calculated: Phase 1 = $667.83; Phase 2 = $415.23; and Phase 3 = $304.90.

[4]Feed cost/lb of gain = total feed cost ÷ total gain per pen.

[5]Revenue = (total gain / pig placed × 0.75) × $0.82.

[6]Income over feed cost = revenue – feed cost.

Table 3. Main effect of initial body weight on nursery performance and economics[1]

	BW category[2]				
Item	**Light**	**Medium**	**Heavy**	**SEM**	***P* =**
BW, lb					
d 0	11.3[a]	13.2[b]	15.4[c]	0.36	< 0.001
d 42	56.5[a]	61.7[b]	66.4[c]	0.79	< 0.001
Overall (d 0 to 42)					
ADG, lb	1.07[a]	1.16[b]	1.21[c]	0.012	< 0.001
ADFI, lb	1.40[a]	1.50[b]	1.56[c]	0.015	< 0.001
F/G	1.31	1.30	1.28	0.015	0.547
Economics, $/pig placed[3]					
Feed cost	9.68[a]	10.38[b]	10.76[c]	0.108	< 0.001
Feed cost/lb of gain[4]	0.22[a]	0.21[ab]	0.21[b]	0.002	0.032
Revenue[5]	27.55[a]	29.83[b]	31.14[c]	0.333	< 0.001
IOFC[6]	17.87[a]	19.45[b]	20.38[c]	0.301	< 0.001

[1]A total of 360 pigs (Line 200 × 400, DNA, Columbus, NE; initially 13.3 ± 0.36 lb) were used in a 42-d growth study with five pigs per pen and 24 pens per treatment. No significant interactions between BW category and feed-budget programs were observed for any of the response criteria.
[2]Each body weight category contained 33.33% of the pigs.
[3]Total feed costs per ton were calculated: Phase 1 = $667.83; Phase 2 = $415.23; and Phase 3 = $304.90.
[4]Feed cost/lb of gain = total feed cost ÷ total gain per pen.
[5]Revenue = (total gain / pig placed × 0.75) × $0.82.
[6]Income over feed cost = revenue – feed cost.