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Effect of Nursery Phase Feeding Budget and Weaning Body Weight on Nursery Pig Growth Performance, Fecal Dry Matter, and Economics

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Summary

A total of 270 pigs (initially 13.5 ± 0.59 lb) were used to evaluate the effects of phase feeding budget and weaning weight on nursery performance, fecal dry matter, and economics. At weaning, pigs were sorted by body weight (BW) and then randomly assigned to one of the three dietary treatments in a 3 × 3 factorial design with main effects of nursery phase feeding budget (high, medium, or low) and BW (light, medium, or heavy). There were five pigs per pen and six 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 duration, respectively. All pigs were then fed a common phase 3 thereafter. Each BW category (light, medium, and heavy) contained 33% of the pigs. Phase 1 was formulated using spray-dried bovine plasma, processed soy product, and spray-dried whey, and was formulated to 17.5% lactose with 16.3% soybean meal. In phase 2, specialty protein sources and the lactose level were reduced, and diets contained 22.4% soybean meal. Phase 3 was a typical corn-soybean meal-based diet with no specialty protein sources. Through the course of this trial, pigs were of good health with few mortalities. No interactions were observed ($P > 0.10$) between phase feeding budget and BW category for any response criteria. There was no significant effect ($P > 0.10$) of the nursery phase feeding budget on overall performance; however, pigs fed the low feeding budget program had greater ($P = 0.018$) fecal dry matter on d 10 than those fed the medium phase feeding budget. Feed cost and feed cost/lb of gain decreased as phases 1 and 2 feed budgets decreased ($P < 0.001$). No differences ($P = 0.822$) were observed for revenue between phase feeding programs. For income over feed cost (IOFC) no differences ($P = 0.301$) were observed between any phase feeding budget program. The overall d 41 BW, ADG, ADFI, feed cost, revenue, and IOFC increased ($P < 0.001$) as weaning BW category increased. However, no differences ($P > 0.10$) were observed between any BW category for F/G and feed cost/lb of gain. In conclusion, for a high-health group of pigs, the phase feeding budget program did not significantly impact nursery performance, but economics and d 10 fecal dry matter improved for pigs fed the low phase feeding

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program. Pigs that were heavier at weaning had better overall nursery performance and economical return than lighter pigs.

Introduction

After weaning, pigs may struggle to adapt to new diets and environments. To help with the weaning stress, they are typically fed highly palatable, complex diets that include easily digestible protein and lactose sources. However, complex diets are expensive and may not be cost-effective.[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.

Several studies have demonstrated that using simple versus complex diets doesn't impact overall wean-to-finish performance due to the compensatory gain during the late nursery and finishing period.[4] However, it is unclear whether weaning weight can interact with diet complexity and affect overall nursery performance. Therefore, the objective of this study was to evaluate the effect of phase feeding budget and weaning weight on nursery pig performance, fecal dry matter, and economics.

Material 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 independent rooms located within the same barn at the Kansas State University Swine Teaching and Research Center in Manhattan, KS. Each pen (4 × 5 ft) was equipped with a 6-hole dry feeder and nipple waterer to provide ad libitum access to feed and water.

Animals and diets

A total of 270 pigs (Line 241 × 600, DNA, Columbus, NE) initially weighing 13.5 ± 0.59 lb were used in a 41-d study. The pigs were weaned at approximately 19 d of age and divided into three body weight (BW) categories, each containing 33% of the pigs. The pigs were randomly assigned to pens within the BW category and allotted to one of three dietary treatments. Each pen had five pigs, and there was the same number of pens per BW and phase feeding program (18 pens each).

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. 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 programs, respectively. All diets were formu-

[2] C. H. Lee, 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] M.B. Menegat, 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.

[4] J. D Berrocoso, M. P. Serrano, L. Cámara, P. G. Rebollar, G. G. Mateos.2012. Influence of diet complexity on productive performance and nutrient digestibility of weanling pigs. Anim. Feed Sci. Technol, 171(2-4), 214-222. doi:10.1016/j.anifeedsci.2011.10.013

lated to have similar SID Lys (1.35%), amino acid ratios, and STTD P (0.50%) using different ingredients between phases. Diets were manufactured at the Kansas State University O.H. Kruse FeedTechnology Innovation Center, Manhattan, KS, and fed in pellet form (Table 1).

Pigs and feeders were weighed on d 10, 24, and 41 to determine ADG, ADFI, and F/G. Fecal samples were collected from the same three pigs per pen on d 10 and 24 of the study and later dried in a forced air oven for 48 h at 151°F to determine fecal dry matter.

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 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 $4.5/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 $0.84/lb was used as pork price for the revenue calculation and an assumed 75% yield was considered in calculations.

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 phase feeding budget program, BW category, and the associated interaction as fixed effects. Room was considered a random effect in the model. For fecal dry matter, sampling day was also included as a fixed effect and the pen was considered a random effect in addition to the previous variables to account for the subsampling associated with multiple fecal samples collected and analyzed from each pen. 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 very healthy with few mortalities. No significant interactions were observed ($P > 0.10$) between the phase feeding program and BW category on growth measurements, fecal dry matter, and economics (Table 2).

For the main effect of phase feeding budget, there was no significant effect ($P > 0.10$) on growth performance in periods 1, 2 and overall (Table 3). However, during period 3, there was a marginal response ($P = 0.052$) for ADG, where the pigs fed the medium phase feeding budget had greater ADG than the other phase feeding budget programs. No differences ($P > 0.10$) were observed for ADFI and as a result, pigs in the medium budget program had improved F/G compared to the high budget program ($P = 0.021$). On d 10, pigs fed with the low program had increased fecal dry matter ($P = 0.018$) compared to those fed the medium program with those fed the high program having an intermediate fecal dry matter. Feed cost was significantly lower ($P < 0.001$) in the low feed budget compared to the other programs. Feed cost/lb of gain decreased as the phase feeding budgets decreased ($P < 0.001$). No differences ($P = 0.822$) were observed

for revenue between phase feeding programs. No differences ($P = 0.301$) were observed for IOFC between any feed budget programs.

For main effect of weaning BW category, as expected, d 0 BW was different ($P < 0.001$) between the three BW categories (Table 4). Similarly, d 41 BW, ADG, and ADFI increased ($P < 0.001$) as the initial BW increased. However, no differences ($P = 0.721$) in F/G were observed between any BW category. A marginal response ($P = 0.079$) was observed for fecal dry matter on d 10 where pigs in the medium BW category had decreased fecal dry matter compared to those in the light category, and intermediate values were observed for heavy pigs. Feed cost, revenue, and IOFC increased ($P < 0.001$) as weaning weight increased. However, no difference ($P = 0.593$) in feed cost/lb gain was observed between any BW category.

In summary, with this high-health group of pigs, the phase feeding budget program did not significantly affect overall nursery performance, but economics and d 10 fecal dry matter improved when the simple phase feeding program was used. For the BW category, overall nursery performance and economic return improved as the weaning BW increased.

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

Item	Phase 1	Phase 2	Phase 3
Ingredient, %			
Corn	45.00	57.58	62.27
Soybean meal	16.34	22.43	32.66
Spray-dried whey	25.00	10.00	---
Spray-dried bovine plasma	2.50	---	---
Specialty soybean meal[2]	5.00	5.00	---
Soybean oil	3.00	1.00	1.00
L-Lys-HCl	0.37	0.49	0.48
DL-Met	0.22	0.21	0.20
L-Thr	0.16	0.23	0.23
L-Trp	0.03	0.04	0.04
L-Val	0.07	0.11	0.11
Limestone	0.65	0.74	0.82
Monocalcium phosphate	0.50	1.00	1.10
Salt	0.30	0.50	0.60
Trace mineral premix	0.15	0.15	0.15

continued

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

Item	Phase 1	Phase 2	Phase 3
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
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, %	20.40	20.87	21.56
Lactose, %	18.00	7.20	---
Ca, %	0.63	0.68	0.69
P, %	0.57	0.62	0.63
STTD P, %[4]	0.50	0.50	0.50

[1] Phases 1, 2, and 3 were fed according to the treatment structure and in pellet form.
[2] AX3 Digest (Proteka, Newport Beach, CA).
[3]Ronozyme Hiphos 2700 (dsm-firmenich, Parsippany, NJ) provided an estimated release of 0.14% STTD P.
[4]Standardized total tract digestible phosphorus.

Table 2. Effect of phase feeding budget and body weight on nursery performance, fecal dry matter, and economics[1]

BW category[2]:	Light			Medium			Heavy				*P* =		
Item PFB program[3]:	High	Medium	Low	High	Medium	Low	High	Medium	Low	SEM	BW × Budget	BW	Budget
BW, lb													
d 0	11.1	11.2	10.9	13.5	13.6	13.6	15.7	15.9	15.7	0.59	0.784	< 0.001	0.241
d 10	12.5	12.9	12.5	15.4	15.1	15.5	17.9	17.7	17.6	0.25	0.454	< 0.001	0.943
d 24	24.1	24.0	23.5	28.0	27.0	27.6	31.4	30.9	31.3	1.09	0.940	< 0.001	0.671
d 41	45.9	48.0	46.2	53.5	53.4	52.1	57.6	57.9	58.0	1.36	0.719	< 0.001	0.500
Period 1 (d 0 to 10)													
ADG, lb	0.23	0.23	0.20	0.25	0.21	0.24	0.27	0.25	0.24	0.023	0.628	0.277	0.538
ADFI, lb	0.33	0.30	0.31	0.39	0.38	0.38	0.43	0.40	0.34	0.027	0.494	0.001	0.164
F/G	1.59	1.59	1.58	1.62	1.83	1.57	1.68	1.66	1.46	0.112	0.646	0.605	0.252
Period 2 (d 10 to 24)													
ADG, lb	0.78	0.79	0.78	0.90	0.85	0.87	0.97	0.94	0.98	0.070	0.969	< 0.001	0.915
ADFI, lb	0.90	0.98	0.95	1.10	1.04	1.04	1.17	1.14	1.14	0.064	0.745	< 0.001	0.941
F/G	1.17	1.24	1.21	1.22	1.23	1.21	1.22	1.22	1.17	0.042	0.766	0.860	0.548
Period 3 (d 24 to 41)													
ADG, lb	1.28	1.41	1.34	1.50	1.56	1.44	1.54	1.59	1.57	0.041	0.501	< 0.001	0.052
ADFI, lb	1.69	1.79	1.72	1.97	2.00	1.88	2.03	2.11	2.08	0.061	0.775	< 0.001	0.202
F/G	1.32	1.26	1.29	1.31	1.29	1.31	1.32	1.28	1.32	0.019	0.807	0.307	0.021
Overall (d 0 to 41)													
ADG, lb	0.88	0.91	0.87	0.99	0.98	0.95	1.03	1.04	1.05	0.035	0.792	< 0.001	0.601
ADFI, lb	1.07	1.15	1.11	1.29	1.27	1.23	1.35	1.36	1.33	0.048	0.700	< 0.001	0.550
F/G	1.27	1.26	1.28	1.30	1.30	1.29	1.30	1.31	1.28	0.019	0.721	0.100	0.771

continued

Table 2. Effect of phase feeding budget and body weight on nursery performance, fecal dry matter, and economics[1]

BW category[2]:	Light			Medium			Heavy				*P* =		
Item PFB program[3]:	High	Medium	Low	High	Medium	Low	High	Medium	Low	SEM	BW × Budget	BW	Budget
Fecal dry matter, %[4]													
d 10	21.1	20.1	26.7	18.5	18.0	21.6	21.7	22.1	21.2	1.600	0.120	0.079	0.018
d 24	20.3	16	17.9	19.0	16.5	17.6	17.0	17.4	20.5	1.600	0.404	0.646	0.111
Economics, $/pig placed[5]													
Feed cost	7.34	7.15	6.53	8.35	7.67	7.22	8.67	8.35	7.81	0.032	0.862	< 0.001	< 0.001
Feed cost/lb of gain[6]	0.20	0.19	0.18	0.21	0.20	0.18	0.20	0.20	0.18	0.002	0.839	0.485	< 0.001
Revenue[7]	22.62	23.61	22.50	25.56	24.72	24.63	26.72	26.88	27.00	1.029	0.729	< 0.001	0.822
IOFC[8]	15.28	16.45	15.96	17.21	17.05	17.40	18.04	18.52	19.18	0.733	0.666	< 0.001	0.301

[1] A total of 270 pigs (Line 241 × 600, DNA, Columbus, NE. initially 13.5 ± 0.59 lb) were used in a 41-d growth study with five pigs per pen and six pens per treatment.

[2] Each body weight category contained 33% of the pigs.

[3] The phase feeding budget (PFB) consisted of different doses of phases 1 and 2 followed by a common phase 3. 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.

[4] Same three pigs per pen were sampled on d 10 and 24. BW category × budget × day, $P = 0.04$; Day, $P < 0.001$. The *P*-values represented in the data table show the effect of the BW, budget, and their interaction within day.

[5] Total feed cost per ton were calculated: Phase 1= $517.17; Phase 2= $354.37; Phase 3= $280.40.

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

[7] Revenue = (total gain / pig placed × 0.75) × $0.84.

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

Table 3. Main effect of phase feeding budget on nursery performance, fecal dry matter and economics[1]

		Feed budget				
		High	Medium	Low		
	Phase 1, lb/pig:	4	2	0		
	Phase 2, lb/pig:	12	8	4		
Item	Phase 3, lb/pig:	35	42	46	SEM	*P* =
BW, lb						
d 0		13.4	13.6	13.4	0.58	0.241
d 10		15.2	15.2	15.2	0.14	0.943
d 24		27.8	27.3	27.5	0.91	0.671
d 41		52.3	53.1	52.1	1.04	0.500
Period 1 (d 0 to 10)						
ADG, lb		0.25	0.23	0.23	0.014	0.538
ADFI, lb		0.39	0.36	0.35	0.017	0.164
F/G		1.63	1.69	1.54	0.067	0.252
Period 2 (d 10 to 24)						
ADG, lb		0.88	0.86	0.88	0.057	0.915
ADFI, lb		1.06	1.05	1.04	0.049	0.941
F/G		1.21	1.23	1.20	0.029	0.548
Period 3 (d 24 to 41)						
ADG, lb		1.44	1.52	1.45	0.024	0.052
ADFI, lb		1.90	1.97	1.89	0.041	0.202
F/G		1.32[a]	1.28[b]	1.30[ab]	0.015	0.021
Overall (d 0 to 41)						
ADG, lb		0.97	0.98	0.96	0.027	0.601
ADFI, lb		1.23	1.26	1.23	0.035	0.550
F/G		1.29	1.29	1.28	0.010	0.771
Fecal dry matter, %[2]						
d 10		20.4[ab]	20.1[a]	23.1[b]	0.905	0.018
d 24		18.8	16.6	18.7	0.905	0.111
Economics, $/pig placed[3]						
Feed cost		8.12[a]	7.73[a]	7.19[b]	0.240	< 0.001
Feed cost/lb of gain[4]		0.20[a]	0.19[b]	0.18[c]	0.001	< 0.001
Revenue[5]		24.97	25.07	24.71	0.780	0.822
IOFC[6]		16.85	17.34	17.51	0.547	0.301

[1] A total of 270 pigs (Line 241 × 600, DNA, Columbus, NE. initially 13.5 ± 0.59 lb) were used in a 41-d growth study with five pigs per pen and 18 pens per treatment.

[2]Same three pigs per pen were sampled on d 10 and 24. Budget × day, $P = 0.211$; Day, $P < 0.001$. The *P*-values represented in the data table show the effect of the budget within day.

[3]Total feed cost per ton were calculated: Phase 1= $517.17; Phase 2= $354.37; Phase 3= $280.40.

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

[5] Revenue = (total gain / pig placed × 0.75) × $0.84.

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

[a,b,c] Means with different superscripts differ ($P < 0.05$).

Table 4. Main effect of the body weight category on overall nursery performance, fecal dry matter, and economics[1]

	Body weight category[2]				
Item[3]	Light	Medium	Heavy	SEM	*P* =
BW, lb					
d 0	11.1[a]	13.6[b]	15.7[c]	0.58	< 0.001
d 41	46.7[a]	53.0[b]	57.8[c]	1.04	< 0.001
ADG, lb	0.89[a]	0.97[b]	1.04[c]	0.027	< 0.001
ADFI, lb	1.11[a]	1.26[b]	1.35[c]	0.035	< 0.001
F/G	1.27	1.30	1.30	0.010	0.721
Fecal dry matter, %[4]					
d 10	22.6[b]	19.4[a]	21.7[ab]	0.905	0.079
d 24	18.1	17.7	18.3	0.905	0.646
Economics, $/pig placed[5]					
Feed cost	7.01[a]	7.75[b]	8.28[c]	0.237	< 0.001
Feed cost/lb of gain[6]	0.19	0.19	0.19	0.001	0.485
Revenue[7]	22.91[a]	24.97[b]	26.86[c]	0.780	< 0.001
IOFC[8]	15.90[a]	17.22[b]	18.58[c]	0.5472	< 0.001

[1] A total of 270 pigs (Line 241 × 600, DNA, Columbus, NE. initially 13.5 ± 0.59 lb) were used in a 41-d growth study with five pigs per pen and 18 pens per body weight category.
[2] Each body weight category contained 33% of the pigs.
[3] The values reported for ADG, ADFI and F/G correspond to the overall period (d 0 to 41).
[4] Same three pigs per pen were sampled on d 10 and 24. Budget × Day, $P = 0.211$; Day, $P < 0.001$. The *P*-values represented in the data table show the effect of the BW category within day.
[5] Total feed cost per ton were calculated: Phase 1= $517.17; Phase 2= $354.37; Phase 3= $280.40.
[6] Feed cost/lb of gain = total feed cost ÷ total gain per pen.
[7] Revenue = (total gain / pig placed × 0.75) × $0.84.
[8] Income over feed cost = revenue – feed cost.
[a,b,c] Means with different superscripts differ ($P < 0.05$).