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Defining the Optimal Feed Budget System for Terminal-Crossed, Growing-Finishing Barrows

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Summary and Implications

This experiment was conducted to evaluate growth performance and carcass quality measurements in growing-finishing barrows assigned to different feed budget systems. Forty-eight barrows with an initial body weight of 47.3 lb were randomly allotted to one of three different feed budget systems. The experiment was continued until the average body weight was 270 lb, at which time all pigs were slaughtered. Growth performance and real-time ultrasound measurements were taken biweekly, except for the final period, which was 24 days. Carcass tenth-rib backfat and longissimus muscle area measurements were made 24 hours postmortem. Overall, average daily feed intake (ADFI) was affected (P < 0.05) by feed budget with barrows assigned to Budget 2 having the greatest ADFI compared to barrows fed Budget 1 (P < 0.05) and 3 (P < 0.10). There was a trend (P = 0.106) toward an effect of feed budget on average daily gain (ADG). Barrows allotted to Budget 2 had greater overall ADG than barrows allocated to Budget 1 (P < 0.10) and 3 (P < 0.10). Feed efficiency for the overall experimental period was not affected (P > 0.10) by feed budget; however, the comparison of Budget 1 and 2 resulted in a difference in feed efficiency with barrows from Budget 1 having better (P < 0.10) feed efficiency than barrows from Budget 2. Ultrasound and carcass measurements were similar for pigs fed the three feed budget systems. The main effect of feed budget on total body electrical conductivity measurements was only significantly different (P < 0.10) for hot carcass weight. Returns above feed cost and feed cost per pound of gain from 50 lb to market weight were not affected by feed budget. Barrows allotted to Budget 2 had the greatest ADG and hot carcass weight; however, this group also had the greatest ADFI, which resulted in no difference in the return above feed costs or feed cost per pound of live weight gain. In summary, there were no major differences in overall growth performance, carcass characteristics, or return above feed costs in growing-finishing barrows fed different feed budgets.

Introduction

An important question that occurs in the feeding of growing-finishing pigs is when to change diets. A feed budget is a mechanism that can be used to ensure that the correct amount of each diet is delivered to a given group of pigs. Feed budgets are designed to provide pigs the correct amount of feed to gain a predetermined amount of body weight. In traditional systems in which pigs are fed on a time basis instead of a feed budget, pigs with poor feed intake and therefore slow growth may not reach the predetermined weight before being switched to the next diet. In a feed budget system, the manager of the finishing barn does not have to guess the weight of the pigs to determine which diet to order because the diet to be delivered to the group of pigs is automatically determined by the feed budget. The use of feed budgeting will result in more accurate phase feeding by not over- or under-delivering diets for each phase. Because environmental and management factors are major determinants affecting pig performance, the greatest challenge to using a feed budget system is customizing the feed budget for a specific production system. Therefore, the objective of this experiment was to compare three different feed budget systems when fed to terminal-crossed, growing-finishing barrows.

Procedures

Forty-eight crossbred (Danbred; Sire - Line 771×Dam - 75% Line 200 or 400× 25% NE White Line) barrows with an initial body weight of 47.3 lb were used in a growing-finishing experiment. Pigs were allotted to one of 24 pens (5 ft × 7.1 ft) which included four location blocks (six pens/block) in an environmentally control room. The average weight within each location block was similar and each treatment was replicated twice within each location block. Treatments consisted of three different feed budget systems (Table 1). Each feed budget offered the same total pounds of feed throughout the growing-finishing period, but the feed budgets differed in the amounts of each diet fed during the experimental period. Therefore, diets were changed on a pen basis when a pen of pigs had consumed the allotted amount of diet. Diets (Table 2) contained corn and soybean meal and were fortified with vitamins and minerals to meet or exceed the NRC (1998) requirements for 44- to 265-lb pigs. Pigs had ad libitum access to feed and water throughout the experimental period. Pigs remained on the experiment until the average body weight of the pigs reached approximately 270 lb, at which time all pigs were removed from the experiment.

(Continued on next page)

Table 1. Lysine concentration and amount of each diet fed per pig for each feed budget.

	Dietary phases					
	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	
Lysine, %	1.15	0.90	0.75	0.65	0.60	
Pounds of each diet, per pig						**Total**
Budget 1	105	110	152	135	118	620
Budget 2	54	108	135	111	212	620
Budget 3	—	210	—	410	—	620

Table 2. Ingredient and calculated composition of diets, as-fed basis.

	Dietary phases				
Ingredients, %	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Corn	61.48	71.85	78.13	82.95	84.93
Soybean meal (46.5% CP)	32.25	22.40	16.25	12.50	10.75
Tallow	3.00	3.00	3.00	2.00	2.00
Dicalcium phosphate	1.65	1.08	0.93	1.00	0.75
Limestone	0.38	0.40	0.40	0.25	0.28
Salt	0.30	0.30	0.30	0.30	0.30
Vitamin premix[a]	0.70	0.70	0.70	0.70	0.70
Trace mineral premix[b]	0.10	0.10	0.10	0.10	0.10
Antibiotic	0.125	0.125	0.125	0.125	0.125
Lysine•HCl	0.025	0.05	0.075	0.075	0.075
Calculated nutrient content					
Crude protein, %	20.40	16.70	14.30	12.90	12.20
Lysine, %	1.15	0.90	0.75	0.65	0.60
ME[c], Mcal/lb	1.56	1.57	1.57	1.55	1.55
Calcium, %	0.80	0.65	0.60	0.55	0.50
Phosphorus, %	0.70	0.55	0.50	0.50	0.45
Analyzed nutrient content					
Crude protein, %	20.80	16.50	15.20	12.90	12.40
Lysine, %	1.07	0.85	0.74	0.61	0.57
Gross energy, Mcal/lb	1.85	1.85	1.84	1.81	1.83
Calcium, %	0.81	0.69	0.53	0.53	0.51
Phosphorus, %	0.72	0.60	0.43	0.48	0.48
Fat, %	4.90	5.14	4.67	4.81	5.12
Dry matter, %	91.73	92.05	90.27	90.83	91.49
Ash, %	5.75	4.72	3.95	3.70	3.65

[a]Supplied per kilogram of diet: retinyl acetate, 3,088 IU; cholecalciferol, 386 IU; α-tocopherol acetate, 15 IU; menadione sodium bisulfite, 2.3 mg; riboflavin, 3.9 mg; d-pantothenic acid, 15.4 mg; nicacin, 23.2 mg; choline, 77.2 mg; vitamin B_{12}, 15.4 μg.
[b]Supplied per kilogram of diet: Zn (as ZnO), 110 mg; Fe (as $FeSO_4 \cdot H_2O$), 110 mg; Mn (as MnO), 22 mg; Cu (as $CuSO_4 \cdot 5\ H_2O$), 11 mg; I (as $Ca(IO_3) \cdot H_2O$), .22 mg; Se (as Na_2SeO_3), 0.3 mg.
[c]Metabolizable energy.

Pigs and feeders were weighed biweekly (denoted as periods), except for Period VII which was 24 days, to determine average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (ADG/ADFI). Real-time ultrasound measurements (tenth-rib backfat (BF) depth and longissimus muscle area (LMA)) were recorded at the beginning of each period. The experiment period was 108 days. At the termination of the experiment, pigs were shipped to SiouxPreme Packing Co. in Sioux Center, Iowa, where carcass characteristics were measured on individually identified pigs using total body electrical conductivity (TOBEC). At 24 hours postmortem, tenth-rib BF measurements and LMA traces at the tenth rib were recorded for all carcasses.

Data were analyzed as a randomized complete block design using PROC MIXED of SAS. The main effect of the statistical model was feed budget. Pairwise comparisons between feed budgets were conducted only when the main effect of treatment was significant ($P < 0.10$). Ham, loin, shoulder, and total lean weights were analyzed with hot carcass weight as a covariate. In all analyses pen was the experimental unit.

Results and Discussion

Growth Performance

Average daily gain, ADFI, and feed efficiency (ADG/ADFI) for the seven data collection periods and the entire experimental period are shown in Table 3. During Period I, ADG and feed efficiency were affected ($P < 0.01$) by feed budget. Average daily gain and feed efficiency were greater ($P < 0.007$) in barrows fed diets from Budgets 1 and 2 compared to Budget 3. During Period II, barrows fed diets from Budget 1 had greater ADG ($P < 0.06$) and feed efficiency ($P < 0.01$) than barrows consuming diets from Budgets 2 and 3. An effect of feed budget on ADG and ADFI was detected during Period VII, with barrows consuming diets from Budgets 2 and 3 having the greatest body weight gain ($P < 0.02$) and pigs consuming diets from Budget 2 having the greatest ($P < 0.07$) feed intake. Results for the overall experimental period indicated a trend ($P = 0.106$) toward an effect of feed budget on ADG and a significant effect ($P < 0.05$) on ADFI, with barrows consuming diets from Budget 2 having the greatest ADG and ADFI.

Carcass Characteristics

Real-time ultrasound, carcass, and TOBEC measurements are provided in Table 4. Ultrasound measurements of tenth-rib BF and LMA did not differ ($P > 0.10$) among feed budgets. Also, tenth-rib BF and LMA carcass measurements were similar ($P > 0.10$) among feed budgets. Although a large difference in ultrasound and carcass tenth-rib LMA measurements was detected (ex. Budget 1 ultrasound LMA = 6.34 in^2 versus carcass LMA = 9.58 in^2; see Table 4), there was no effect of feed budget on ultrasound or carcass

Table 3. Effect of feed budget on growth performance.

Item	Feed budget			SEM	P-Value[a]			
	1	2	3		TRT	1 vs 2	1 vs 3	2 vs 3
No. pens	8	8	8					
Initial wt., lb	47.61	47.78	46.68	0.992	NS	NS	NS	NS
Final wt., lb	268.06	280.71	267.60	4.778	0.1135	0.076	NS	0.066
Period I (day 0-14)								
ADG [b], lb	1.65	1.70	1.38	0.062	0.004	NS	0.007	0.002
ADFI [c], lb	2.76	2.83	2.70	0.085	NS	NS	NS	NS
ADG/ADFI, lb/lb	0.60	0.60	0.51	0.006	<0.001	NS	<0.001	<0.001
Period II (day 15-28)								
ADG, lb	2.22	2.11	2.05	0.049	0.056	0.099	0.020	NS
ADFI, lb	4.01	4.10	4.03	0.102	NS	NS	NS	NS
ADG/ADFI, lb/lb	0.56	0.51	0.51	0.010	0.006	0.007	0.003	NS
Period III (day 29-42)								
ADG, lb	2.18	2.26	2.24	0.066	NS	NS	NS	NS
ADFI, lb	4.76	5.05	4.84	0.135	NS	NS	NS	NS
ADG/ADFI, lb/lb	0.46	0.45	0.46	0.012	NS	NS	NS	NS
Period IV (day 43-56)								
ADG, lb	2.28	2.29	2.17	0.079	NS	NS	NS	NS
ADFI, lb	5.63	6.05	5.59	0.197	NS	NS	NS	NS
ADG/ADFI, lb/lb	0.41	0.38	0.39	0.009	NS	0.058	NS	NS
Period V (day 57-70)								
ADG, lb	2.15	2.24	2.25	0.053	NS	NS	NS	NS
ADFI, lb	6.00	6.45	6.24	0.176	NS	0.084	NS	NS
ADG/ADFI, lb/lb	0.36	0.35	0.36	0.008	NS	NS	NS	NS
Period VI (day 71-84)								
ADG, lb	2.06	2.20	2.04	0.093	NS	NS	NS	NS
ADFI, lb	6.44	6.94	6.32	0.233	NS	NS	NS	0.076
ADG/ADFI, lb/lb	0.32	0.32	0.32	0.009	NS	NS	NS	NS
Period VII (day 85-105)								
ADG, lb	1.87	2.25	2.13	0.068	0.003	0.001	0.016	NS
ADFI, lb	6.45	7.56	6.94	0.223	0.008	0.002	NS	0.064
ADG/ADFI, lb/lb	0.29	0.30	0.31	0.007	NS	NS	NS	NS
Overall (day 0-108)								
ADG, lb	2.04	2.16	2.05	0.042	0.106	0.062	NS	0.071
ADFI, lb	5.27	5.75	5.40	0.133	0.047	0.018	NS	0.072
ADG/ADFI, lb/lb	0.39	0.38	0.38	0.005	NS	0.096	NS	NS

[a]TRT = treatment; NS = nonsignificant effect, $P > 0.10$.
[b]ADG = average daily gain.
[c]ADFI = average daily feed intake.

measurements. Total body electrical conductivity measurement of hot carcass weight was greater ($P < 0.10$) for barrows fed diets from Budget 2 than for barrows fed diets from Budgets 1 and 3. Although barrows allocated to Budget 2 had greater hot carcass weights, the increase in ADFI of pigs in this group resulted in a greater ($P < 0.10$) feed cost per pig (Table 5), which resulted in a similar return above feed cost and feed cost per pound of live weight gain (17 cents per pound, from 50 lb to market weight).

Conclusions

These results indicate that barrows fed under optimal growing conditions (2 pigs/pen and an environmentally controlled room) do not exhibit major differences in growth performance or carcass characteristics when assigned to different feed budgets throughout the growing-finishing period. Although hot carcass weight was greater in barrows allotted to Budget 2, they also had the greatest ADFI, which resulted in a similar feed efficiency and return above feed costs when compared to the other feed budgets. The greatest effect of the different feed budgets on ADG occurred during Periods 1 and 2 of the growing-finishing period. This suggests that the body weight gain of barrows is the most sensitive to dietary lysine concentration during the first 28 days of the growing-finishing period (initial body weight 50 lb). Although no major differences in the feed budget systems were observed in the current experiment, a much different outcome is possible if this experiment was conducted on a commercial swine operation. Therefore, further research is needed to explore the effects of commercial swine production (i.e., stocking rate, disease, management) on feed budget systems.

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Table 4. Effect of feed budget on ultrasound and carcass measurements.

	Feed budget				P-Value[a]			
Item	1	2	3	SEM	TRT	1 vs 2	1 vs 3	2 vs 3
Ultrasound measurements								
Tenth-rib backfat, in	0.83	0.87	0.87	0.031	NS	NS	NS	NS
LMA[b], in^2	6.34	6.19	6.09	0.129	NS	NS	NS	NS
Carcass measurements								
Tenth-rib backfat, in[c,d]	0.96	0.94	0.98	0.046	NS	NS	NS	NS
LMA, in^2	9.58	9.64	9.05	0.304	NS	NS	NS	NS
TOBEC measurements								
Hot carcass wt., lb	200.57	212.69	200.13	4.347	0.091	0.062	NS	0.054
Ham wt., lb[e,i]	23.05	23.13	22.63	0.492	NS	NS	NS	NS
Loin wt., lb[e,i]	27.55	27.06	27.24	0.335	NS	NS	NS	NS
Shoulder wt., lb[e,i]	27.94	28.13	27.67	0.405	NS	NS	NS	NS
Primal percentage[e,f]	38.46	37.78	38.40	0.633	NS	NS	NS	NS
Total lean, lb[e,i]	100.34	99.17	98.80	1.832	NS	NS	NS	NS
Percent lean[d]	46.21	46.21	45.89	0.841	NS	NS	NS	NS
Lean gain, lb/day[d,g]	0.72	0.77	0.71	0.025	NS	NS	NS	NS

[a]TRT = treatment; NS = nonsignificant effect P > 0.10.
[b]Longissimus muscle area.
[c]Backfat measurements were taken at 3/4 the distance along the loin muscle.
[d]Calculated on a fat-free lean basis.
[e]Contains 5% fat.
[f]Primal percentage was calculated by taking the total weight of the primal cuts (ham, loin, and shoulder) divided by the hot carcass weight.
[g]Lean gain calculation: $\frac{\text{Final fat-free lean} - \text{Initial fat-free lean}^{h}}{108 \text{ d}}$
[h]Initial fat-free equation: .95 * [-3.95 + (.418 * live weight, lb)]
[i]Hot carcass weight used as a covariate in the statistical analysis.

Table 5. Effect of feed budget on revenue and feed costs.

	Feed budget[a]				P-Value[b]			
Item	1	2	3	SEM	TRT	1 vs 2	1 vs 3	2 vs 3
Economics, 50 lb to 260 lb[c,d]								
Average feed cost/pig, $	36.06	35.65	36.14	0.294	NS	NS	NS	NS
Feed cost/lb of gain, $	0.17	0.17	0.17	0.002	NS	NS	NS	NS
Economics, 50 lb to market[d,e]								
Gross income, $/pig	130.54	136.70	130.32	2.327	0.114	0.076	NS	0.066
Average feed cost/pig, $	37.68	39.92	37.30	0.501	0.094	0.082	NS	0.045
Return above feed, $/pig	92.87	96.78	93.02	1.634	NS	NS	NS	NS
Feed cost/lb of gain, $	0.17	0.17	0.17	0.001	NS	NS	NS	NS

[a]Diet costs/lb, $: Diet 1 = 0.075; Diet 2 = 0.069; Diet 3 = 0.065; Diet 4 = 0.061; Diet 5 = 0.060; diet costs only included cost of the ingredients.
[b]TRT = treatment; NS = nonsignificant effect *P* > 0.10.
[c]Feed cost per pig and feed cost per pound of live weight gain were calculated from a starting weight of 50 lb to a constant ending weight of 260 lb.
[d]A live weight price of $48.70 per hundred pounds of live weight was used in the economic analysis.
[e]Feed cost per pig and feed cost per pound of live weight gain were calculated from a starting weight of 50 lb to market weight for all pigs.