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Jenna J. Bromm
Kansas State University, jbromm@k-state.edu

Mike D. Tokach
Kansas State University, mtokach@k-state.edu

Jason C. Woodworth
Kansas State University, jwoodworth@k-state.edu

See next page for additional authors

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Jenna J. Bromm, Mike D. Tokach, Jason C. Woodworth, Robert D. Goodband, Joel M. DeRouchey, and Jordan T. Gebhardt

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Jenna J. Bromm, Mike D. Tokach, Jason C. Woodworth, Robert D. Goodband, Joel M. DeRouchey, and Jordan T. Gebhardt[1]

Summary

A total of 2,160 pigs (PIC 337 × 1050; initially 82.26 lb) were used in two groups to evaluate the effects of increasing added fat levels in diets containing high levels of DDGS on growth performance and carcass characteristics of finishing pigs. Pens of pigs were blocked by initial BW and randomly assigned to 1 of 4 dietary treatments with 27 pigs per pen and 20 pens per treatment. Three of the four dietary treatments included increasing percentages of added fat (choice white grease; 0, 1, or 3%). The final treatment was fed the control diet without added fat until pigs were approximately 220 lb and then pigs were fed a diet containing 3% added fat until market. Overall, increasing fat from 0 to 3% of the diet led to a decrease (linear, $P = 0.006$) in ADFI and improvement (linear, $P = 0.007$) in overall F/G. Pigs fed diets containing 3% added fat had the lowest ADFI and improved F/G compared to pigs fed diets containing 0% fat, with the other treatments intermediate. There was a tendency for a linear increase ($P = 0.055$) in HCW with increasing fat, where pigs fed the 3% fat diet for the entire trial tended to have the heaviest HCW. Increasing fat increased (linear, $P < 0.001$) feed cost per pig and feed cost per lb of gain. This ultimately reduced (linear, $P < 0.001$) income over feed cost (IOFC) for both the low and high cost scenarios. Pigs fed diets containing 3% added fat had the lowest IOFC compared to pigs fed diets containing no added fat, with the other two treatments intermediate. In conclusion, increasing levels of added fat in the diet from 0 to 3% throughout the duration of the study reduced ADFI with no effect on ADG, resulting in an improvement in F/G. When pigs fed the diet without added fat were transitioned to a diet containing 3% added fat on d 69, they had similar F/G compared to pigs fed 3% added fat during the remainder of the trial. Under both low and high cost scenarios tested, the improvement in feed efficiency does not justify the extra diet cost from increasing added fat in the diet for the entire trial or in late finishing.

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

Introduction

Adding fat to growing and finishing diets is known to improve feed efficiency and ADG, reduce ADFI, and increase carcass fatness. However, the ADG benefits are usually only seen when pigs are in an energy dependent state of growth. In commercial systems, the decision to add fat to growing and finishing diets is based on the ingredient prices.[2] A benefit has also been reported in growth performance when fat is added to the diet during late-finishing when there was no fat added in early-finishing diets, which could be a scenario to achieve some benefits without the added cost of feeding fat throughout.[3] Today, the price of fat is substantially higher than historical values. More research is needed to determine if the benefits of adding fat to growing and finishing diets outweigh its high cost. Therefore, the objective of this study was to evaluate the effects of increasing fat levels in diets containing high levels of DDGS on growth performance and carcass characteristics of commercial finishing pigs.

Procedures

General

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in these experiments. This study was conducted at a commercial research facility in southwestern Minnesota. The barns were naturally ventilated and double-curtain-sided with totally slatted floors. Each pen was equipped with a 5-hole stainless steel dry self-feeder and a bowl waterer for *ad libitum* access to feed and water. Daily feed additions to each pen were accomplished using a robotic feeding system (FeedPro; Feedlogic Corp., Wilmar, MN) that was able to record feed deliveries for individual pens.

Animal and treatment structure

A total of 2,160 pigs (PIC 337 × 1050, PIC; initially 82.26 lb) were used in two groups with 27 pigs per pen and 20 pens per treatment (10 pens per group). Pens of pigs were blocked by initial BW and randomly assigned to 1 of 4 dietary treatments in a randomized complete block design. Three of the four dietary treatments included increasing levels of added fat (choice white grease; 0, 1, and 3%). The final dietary treatment contained 0% added fat until pigs were approximately 220 lb and then pigs were fed a diet containing 3% added fat.

Pens of pigs were weighed, and feed disappearance was recorded on d 0, 14, 28, 40, 54, 68, 83, and 102; or d 0, 14, 27, 42, 56, 70, 82, and 95 for groups one and two, respectively, to determine ADG, ADFI, and F/G. On d 83 and 82 for groups one and two, respectively, three pigs within each pen were marketed. The remaining pigs were then marketed at the conclusion of the experiment for each group.

At the completion of the study for each group, final pen weights were recorded, and each pig was tattooed with a pen identification number and transported to a commercial abattoir (JBS Swift, Worthington, MN) for processing and carcass data collection.

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[2] De la Llata, M., S. S. Dritz, M. D. Tokach, R. D. Goodband, J. L. Nelssen, and T. M. Loughin. 2001. Effects of dietary fat on growth performance and carcass characteristics on growing-finishing pigs reared in a commercial environment. J. Anim. Sci. 79: 2643-2650. doi:10.2527/2001.79102643x.

[3] Baudon, E. C., J.D. Hancock, and N. Llanes. Added fat in diets for pigs in early and late finishing. 2003. Kansas Agricultural Experiment Station Research Reports: 155-158. doi:10.4148/2378-5977.6839.

Carcass measurements included HCW, backfat depth, loin depth, and percentage lean (as per JBS Swift's proprietary calculation). Carcass yields were then calculated by the pen average HCW divided by the pen average final BW.

Diet preparation

Pigs were fed experimental diets from d 0 to 102; or d 0 to 95 for groups one and two, respectively (Table 1 and Table 2). Diets were formulated to maintain constant SID Lys:NE ratios in each phase of 4.50, 3.85, 3.30, and 3.04 g/Mcal for phases 1, 2, 3, and 4, respectively. All other nutrients were formulated to meet or exceed NRC (2012)[4] requirement estimates. All dietary treatments were manufactured at the New Horizon Farms Feed Mill in Pipestone, MN. Experimental diets were corn-soybean meal-based with 40% DDGS. Phase 1 was fed from approximately 80 to 110 lb, phase 2 from 110 to 165 lb, phase 3 from 165 to 220 lb, and phase 4 from 220 lb to market.

Chemical analysis

Diet samples for each treatment were collected from feeders throughout the study. Complete diet samples were sent to the Kansas State University Swine Lab and stored at -4°F until they were homogenized, subsampled, and submitted for analysis. Samples of each dietary treatment were analyzed (Midwest Laboratories; Omaha, NE) for dry matter, crude protein, and fat (acid hydrolysis).

Economics

For the economic analysis, feed cost, cost per pound of gain, value of gain, and income over feed cost (IOFC) were calculated on a per pig placed basis. Economics were calculated using a low and high feed cost scenario. Choice white grease was assumed to cost $0.75/lb. The following ingredient costs were used for the low cost scenario: corn = $3.00/bu ($107/ton), SBM = $300/ton, DDGS = $220/ton, L-Trp = $3.00/lb, DL-Met = $1.70/lb, L-Lys = $0.65/lb. For the high cost scenario, the following ingredient costs were used: corn = $5.99/bu ($214/ton), SBM = $400/ton, DDGS = $300/ton, L-Trp = $5.00/lb, DL-Met = $2.50/lb, L-Lys = $0.80/lb. Feed cost was calculated by multiplying feed cost per lb by feed consumed in each phase. Value of gain was calculated by total pen gain multiplied by pen carcass yield multiplied by carcass price ($0.60/lb and $0.88/lb) for the low and high scenarios, respectively. Income over feed cost was calculated by subtracting the low or high feed cost from the low or high value of gain.

Statistical analysis

Growth performance data were analyzed using the lmer package of R (Version 4.0.0, R Foundation for Statistical Computing, Vienna, Austria) as a randomized complete block design. The statistical model considered fixed effects of dietary treatment, linear and quadratic contrasts of increasing fat dose, and random effects of group and block. The model for backfat, loin depth, and lean percentage considered HCW as a covariate. The model for mortality and removal data specified a binomial distribution using a logit link function. All data were reported as least square means and considered statistically significant at $P \leq 0.05$ and marginally significant at $0.05 < P \leq 0.10$.

[4] National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. https://doi.org/10.17226/13298.

Results and Discussion

Data were summarized into an early, mid, and late-finishing period from approximately 80 to 160 lb, 160 to 220 lb, and 220 to 285 lb, respectively. The early period was from d 0 to 40 in group 1 and d 0 to 42 in group 2 of the study. The mid-period was from d 40 to 68 in group 1 and d 42 to 70 in group 2 of the study. The late period was from d 68 to 102 in group 1 and d 70 to 95 in group 2 of the study.

In the early period from approximately 80 to 160 lb, increasing fat decreased (linear, $P = 0.013$) ADFI (Table 3). There were no significant differences in ADG or F/G during this period.

During the mid-period from approximately 160 to 220 lb, increasing dietary fat decreased (linear, $P = 0.043$) ADFI with no effect on ADG. As a result, increasing fat led to an improvement (linear, $P = 0.006$) in feed efficiency.

In the late finisher from approximately 220 to 285 lb, increasing fat decreased (linear, $P = 0.028$) ADFI. Increasing fat also improved (linear, $P = 0.003$) F/G. Pigs fed 3% added fat throughout and pigs fed 0% fat until they were 220 lb and then fed a diet containing 3% added fat during this period had improved F/G compared to pigs fed diets containing 0% fat, with pigs fed diets containing 1% fat intermediate. There were no significant differences observed in ADG between the different dietary treatments or differences between pigs fed 3% fat throughout and those fed 3% fat only during this period.

For overall growth performance, increasing dietary fat decreased ADFI (linear, $P = 0.006$). Pigs fed diets containing 3% added fat for the entire study had the lowest ADFI compared to pigs fed diets containing 0% fat, with pigs fed the other treatments intermediate. Similarly, increasing fat led to an improvement (linear, $P = 0.007$) in feed efficiency. Pigs fed diets containing 3% added fat for the entire study had improved F/G compared to pigs fed diets containing 0% fat, with the other treatments intermediate. There were no significant differences ($P > 0.10$) in overall ADG between the dietary treatments. There were also no observed differences ($P > 0.10$) in total removals and mortalities over the duration of the study.

For carcass characteristics, there was a tendency for an increase (linear, $P = 0.055$) in HCW, where pigs fed the 3% added fat diet tended to have the heaviest HCW. There was a tendency for increasing backfat depth (quadratic, $P = 0.057$) with backfat increasing when added fat was increased from 0 to 1% but decreased when added fat further increased from 1 to 3%. Similarly, increased added fat from 0 to 3% led to a decreased (quadratic, $P = 0.052$) response in lean percentage when added fat increased from 0 to 1% and then increasing when added fat was increased from 1 to 3%. There were no significant differences ($P > 0.10$) in carcass yield or loin depth between the dietary treatments.

For economics, increasing fat increased (linear, $P < 0.001$) the feed cost and feed cost per lb of gain for the low and high feed cost scenarios. Pigs fed diets without added fat had the lowest feed cost and feed cost per lb of gain compared to pigs fed diets containing 3% added fat, with the other treatments intermediate. There were no significant differences in the value of gain for the low and high feed cost scenarios.

Though BW at the end of the trial and HCW were numerically greater when added fat in the diet increased, total removals and mortality were also numerically higher in diets containing increased levels of added fat. This caused value gain to numerically decrease when added fat increased in the diet. Due to this result, increasing fat led to a decrease (linear, $P < 0.001$) in IOFC in both the low and high feed cost scenarios. Pigs fed diets containing 0% added fat had the highest IOFC compared to pigs fed diets containing 3% added fat, with the other treatments intermediate.

In conclusion, increasing added fat from 0 to 3% throughout the duration of the study reduced ADFI with no effect on ADG, resulting in improved F/G. Pigs fed 3% added fat only during the late finishing phase had similar F/G compared to pigs fed 3% added fat for that stage of the trial in late finishing, and intermediate F/G overall. Increasing fat increased feed cost and reduced income over feed cost. With 3% added fat only from 220 lb to market, feed costs and IOFC were intermediate between diets containing 0% added fat and 3% added fat. Under both low and high cost scenarios, the improvement in feed efficiency does not justify the extra diet cost from increasing added fat levels from 0 to 3% in the diet.

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Table 1. Phases 1 and 2 diet composition (as-fed basis)[1]

	Phase 1			Phase 2		
	Added fat, %			Added fat, %		
Ingredient, %	**0**	**1**	**3**	**0**	**1**	**3**
Corn	47.47	45.65	42.03	52.86	51.18	47.70
Soybean meal (46.5% CP)	9.45	10.29	11.91	4.43	5.11	6.57
Choice white grease	---	1.00	3.00	---	1.00	3.00
Corn DDGS	40.00	40.00	40.00	40.00	40.00	40.00
Limestone, ground	1.50	1.50	1.50	1.40	1.40	1.40
Monocalcium P (21% P)	0.20	0.17	0.15	---	---	---
Salt	0.40	0.40	0.40	0.40	0.40	0.40
L-Lys-HCl	0.62	0.62	0.62	0.60	0.60	0.60
DL-Met	0.04	0.04	0.05	---	---	0.02
L-Trp	0.06	0.06	0.06	0.06	0.06	0.06
Thr[2]	0.13	0.13	0.14	0.13	0.13	0.13
Vitamin trace mineral premix	0.10	0.10	0.10	0.09	0.09	0.09
Tribasic copper chloride	0.03	0.03	0.03	0.03	0.03	0.03
Phytase[3]	0.02	0.02	0.02	0.01	0.01	0.01
Total	100	100	100	100	100	100

continued

Table 1. Phases 1 and 2 diet composition (as-fed basis)[1]

	Phase 1			Phase 2		
	Added fat, %			Added fat, %		
Ingredient, %	**0**	**1**	**3**	**0**	**1**	**3**
Calculated analysis						
SID Amino acids, %						
Lys	1.06	1.08	1.12	0.92	0.94	0.97
Ile:Lys	56	56	57	56	56	56
Leu:Lys	166	164	160	178	176	172
Met: Lys	33	33	33	32	31	32
Met and Cys:Lys	60	60	60	61	60	61
Thr:Lys	62	62	62	63	63	63
Trp:Lys	19	19	19	19	19	19
Val:Lys	70	70	70	72	72	71
His:Lys	42	42	41	43	43	42
Total Lys, %	1.27	1.29	1.33	1.12	1.14	1.17
NE NRC,[4] kcal/lb	1,070	1,089	1,125	1,087	1,105	1,142
SID Lys:NE, g/Mcal	4.50	4.50	4.50	3.85	3.85	3.85
CP, %	20.4	20.7	21.2	18.4	18.6	19.0
Ca, %	0.65	0.64	0.65	0.56	0.56	0.57
P, %	0.59	0.58	0.58	0.53	0.53	0.53
STTD P, %	0.34	0.34	0.34	0.29	0.30	0.30
Ca:P	1.10	1.10	1.11	1.07	1.07	1.07
Chemical analysis, %[5]						
DM	86.2	86.0	86.4	85.4	85.8	86.3
CP	19.8	20.5	19.9	20.2	19.6	19.0
Acid hydrolyzed fat	5.7	6.6	8.6	4.9	6.0	8.0

[1]Phase 1 was fed from approximately 82 to 110 lb, and phase 2 was fed from approximately 110 to 165 lb.
[2]Thr Pro, CJ America Bio, Downers Grove, IL.
[3]For phase 1, Optiphos Plus (Huveoharma, Sofia, Bulgaria) was included at 227 FTU/lb providing an estimated release of 0.11% for STTD P. For phase 2, Optiphos Plus 2500 G was included at 113 FTU/lb providing an estimated release of 0.08% for STTD P.
[4] National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. https://doi.org/10.17226/13298.
[5]A composite sample of each treatment diet was collected and submitted to Midwest Laboratories (Omaha, NE) for analysis of dry matter, crude protein, and fat (acid hydrolysis).

Table 2. Phases 3 and 4 diet composition (as-fed basis)[1]

	Phase 3			Phase 4		
	Added fat, %			Added fat, %		
Ingredient, %	**0**	**1**	**3**	**0**	**1**	**3**
Corn	56.46	54.81	51.60	57.47	55.82	52.64
Soybean meal (46.5% CP)	0.94	1.58	2.79	0.02	0.67	1.84
Choice white grease	---	1.00	3.00	---	1.00	3.00
Corn DDGS	40.00	40.00	40.00	40.00	40.00	40.00
Limestone, ground	1.40	1.40	1.40	1.40	1.40	1.40
Salt	0.40	0.40	0.40	0.40	0.40	0.40
L-Lys-HCl	0.55	0.55	0.55	0.50	0.50	0.50
L-Trp	0.06	0.06	0.06	0.05	0.05	0.05
Thr[2]	0.10	0.10	0.11	0.08	0.08	0.08
Vitamin trace mineral premix	0.08	0.08	0.08	0.07	0.07	0.07
Tribasic copper chloride	0.03	0.03	0.03	0.03	0.03	0.03
Total	100	100	100	100	100	100

continued

Table 2. Phases 3 and 4 diet composition (as-fed basis)[1]

	Phase 3			Phase 4		
	Added fat, %			Added fat, %		
Ingredient, %	**0**	**1**	**3**	**0**	**1**	**3**
Calculated analysis						
SID Amino acids, %						
Lys	0.80	0.81	0.84	0.74	0.75	0.78
Ile:Lys	57	57	57	60	60	60
Leu:Lys	195	193	188	209	206	201
Met: Lys	35	34	34	37	37	36
Met and Cys:Lys	67	66	64	71	70	69
Thr:Lys	65	65	64	66	66	65
Trp:Lys	19	19	19	19	19	19
Val:Lys	76	76	75	81	80	79
His:Lys	46	45	45	48	48	47
Total Lys, %	0.99	1.00	1.03	0.92	0.94	0.97
NE NRC,[3] kcal/lb	1,096	1,115	1,152	1,099	1,117	1,155
SID Lys:NE, g/Mcal	3.30	3.30	3.30	3.04	3.04	3.04
CP, %	17.00	17.20	17.50	16.60	16.70	17.00
Ca, %	0.55	0.55	0.55	0.54	0.54	0.55
P, %	051	0.51	0.51	0.51	0.51	0.51
STTD P, %	0.29	0.29	0.29	0.28	0.28	0.28
Ca:P	1.07	1.07	1.08	1.07	1.07	1.08
Chemical analysis, %[4]						
DM	85.3	85.4	85.0	85.0	85.1	85.4
CP	17.0	17.5	17.0	15.3	17.3	17.7
Acid hydrolyzed fat	5.4	6.3	7.8	4.8	5.8	7.6

[1]Phase 3 was fed from approximately 165 to 220 lb, and phase 4 was fed from 220 lb to market.
[2]Thr Pro, CJ America Bio, Downers Grove, IL.
[3]National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. https://doi.org/10.17226/13298.
[4]A composite sample of each treatment diet was collected from the feeder and later submitted to Midwest Laboratories (Omaha, NE) for analysis of dry matter, crude protein, and fat (acid hydrolysis).

Table 3. Effects of increasing added fat on growth performance and carcass characteristics of finishing pigs[1]

	Added fat, %[2]					P =[3]	
Item	0	1	3	0 to 3[4]	SEM	Linear	Quadratic
BW, lb							
Initial	82.3	82.1	82.3	82.3	2.05	0.857	0.632
Early-finishing	162.9	161.6	161.8	161.7	4.69	0.470	0.436
Mid-finishing	225.3	226.8	227.2	226.7	7.46	0.291	0.540
Final	282.6	285.0	285.7	287.2	3.00	0.166	0.473
Early-finishing[5]							
ADG, lb	1.94	1.91	1.90	1.91	0.029	0.257	0.674
ADFI, lb	4.70	4.60	4.50	4.67	0.129	0.013	0.622
F/G	2.43	2.41	2.37	2.45	0.011	0.176	0.910
Mid-finishing[6]							
ADG, lb	2.20	2.22	2.23	2.23	0.114	0.383	0.593
ADFI, lb	6.68	6.51	6.40	6.58	0.454	0.043	0.547
F/G	3.04[a]	2.93[ab]	2.87[b]	2.96[ab]	0.007	0.006	0.439
Late-finishing[7]							
ADG, lb	2.10	2.13	2.13	2.16	0.071	0.429	0.495
ADFI, lb	7.37	7.24	7.06	7.21	0.222	0.028	0.853
F/G	3.51[a]	3.41[ab]	3.32[b]	3.35[b]	0.004	0.003	0.599
Overall (d 0 to 99)							
ADG, lb	2.05	2.06	2.05	2.07	0.048	0.904	0.777
ADFI, lb	6.02[a]	5.89[ab]	5.74[b]	5.93[ab]	0.174	0.006	0.622
F/G	2.93[a]	2.86[ab]	2.80[b]	2.87[ab]	0.004	0.007	0.664
Total removals and mortalities, %	4.44	6.48	8.51	8.15	0.624	0.607	0.888
Carcass characteristics							
HCW, lb	206.6	208.4	210.1	209.1	2.14	0.055	0.700
Carcass yield, %	71.9	71.9	72.2	72.0	0.510	0.388	0.720
Backfat, in.[8]	0.62	0.65	0.62	0.64	0.017	0.881	0.057
Loin depth, in.[8]	2.48	2.48	2.49	2.50	0.082	0.874	0.894
Lean, %[8]	56.8	56.4	56.8	56.6	0.17	0.861	0.052

continued

Table 3. Effects of increasing added fat on growth performance and carcass characteristics of finishing pigs[1]

	Added fat, %[2]					P =[3]	
Item	0	1	3	0 to 3[4]	SEM	Linear	Quadratic
Economics, $/pig placed							
Low ingredient prices							
Value of gain[9]	83.71	83.33	82.60	82.92	1.893	0.408	0.996
Feed cost[10]	49.30[c]	52.13[b]	58.50[a]	51.96[bc]	0.909	< 0.001	0.803
Feed cost/lb gain[11]	0.25[c]	0.27[b]	0.31[a]	0.27[b]	0.003	< 0.001	0.644
IOFC[12]	34.42[a]	31.20[b]	24.10[c]	30.96[b]	1.246	< 0.001	0.814
High ingredient prices							
Value of gain[13]	122.78	122.22	121.14	121.62	2.776	0.408	0.996
Feed cost[14]	76.87[b]	78.62[b]	83.49[a]	78.30[b]	1.321	< 0.001	0.741
Feed cost/lb gain[15]	0.40[b]	0.41[b]	0.44[a]	0.41[b]	0.005	< 0.001	0.592
IOFC[16]	45.91[a]	43.60[a]	37.65[b]	43.31[a]	1.900	< 0.001	0.755

[1]A total of 2,160 pigs (PIC 337 × 1050; initially 82.26 lb) were used in two groups with 27 pigs per pen and 20 replicates per treatment.
[2]Choice white grease.
[3]Linear and quadratic contrasts were evaluated based on increasing fat in the diet.
[4]Pigs were fed a diet containing 0% fat until 220 lb and were then fed a diet containing 3% added fat.
[5]The early period was from d 0 to 40 in group 1 and d 0 to 42 in group 2 of the study.
[6]The mid-period was from d 40 to 68 in group 1 and d 42 to 70 in group 2 of the study.
[7]The late period was from d 68 to 102 in group 1 and d 70 to 95 in group 2 of the study.
[8]Adjusted using HCW as a covariate.
[9]Value of gain (low) = total gain per pen × carcass yield × 0.60.
[10]Feed cost (low): corn was valued at $3.00/bu ($107/ton), SBM at $300/ton, DDGS at $220/ton, L-Trp at $3.00/lb, DL-Met at $1.70/lb, L-Lys at $0.65/lb, and CWG at $0.75/lb.
[11]Feed cost per lb of gain (low) = total feed cost (low) per pen divided by total gain per pen.
[12]Income over feed cost (low) = revenue (low) – feed cost (low).
[13]Value of gain (high) = total gain per pen × carcass yield × 0.88.
[14]Feed cost (high): corn was valued at $5.99/bu ($214/ton), SBM at $400/ton, DDGS at $300/ton, L-Trp at $5.00/lb, DL-Met at $2.50/lb, L-Lys at $0.80/lb, and CWG at $0.75/lb.
[15]Feed cost per lb of gain (high) = total feed cost (high) per pen ÷ total gain per pen.
[16]Income over feed cost (high) = revenue (high) – feed cost (high).
[abc]Means within a row with different superscripts differ ($P < 0.05$).