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Effects of Fat Source and Level on Growth Performance, Carcass Characteristics, Carcass Iodine Value and Economics of Finishing Pigs in a Commercial Environment

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Effects of Fat Source and Level on Growth Performance, Carcass Characteristics, Carcass Iodine Value and Economics of Finishing Pigs in a Commercial Environment

Jenna J. Bromm, Joel M. DeRouchey, Mike D. Tokach, Kiah M. Berg,[1] Jon A. De Jong,[1] Courtney L. Pohlen,[1] Jason C. Woodworth, Robert D. Goodband, and Jordan T. Gebhardt[2]

Summary

A total of 2,011 pigs (PIC 1050 × DNA 600; initially 62.4 ± 4.6 lb) were used in a 113-d finishing trial to evaluate the effects of two different fat sources fed at two different levels on growth performance, carcass characteristics, carcass iodine value, and economics of finishing pigs raised in a commercial environment. Pigs were randomly allotted to 1 of 5 dietary treatments with 21 to 27 pigs per pen and 16 pens per treatment. Dietary treatments were arranged in a 2 × 2 + 1 factorial with main effects of fat source and fat inclusion level. Dietary treatments included a control diet containing no added fat. The other 4 dietary treatments included two different fat sources, choice white grease or corn oil, included at either 1 or 3% of the diet. Experimental diets were fed based on a feed budget from d 0 to 113 in 6 phases. For overall growth performance, pigs fed increasing dietary fat from 0 to 3% had increased (linear, $P < 0.001$) ADG and decreased (linear, $P = 0.013$) ADFI, which led to an improvement (linear, $P < 0.001$) in F/G. There was no difference in growth performance between pigs fed choice white grease or corn oil. For carcass characteristics, increasing fat increased (linear, $P \leq 0.017$) HCW, carcass yield, and backfat. For carcass fat iodine value, there was a fat source × level interaction ($P < 0.001$) where iodine value increased linearly as corn oil increased in the diet with only a small increase in iodine value when diets with choice white grease were fed. For economics, increasing fat, regardless of fat source, increased feed cost (linear, $P < 0.001$) and revenue (linear, $P = 0.003$). Increasing fat reduced (linear, $P < 0.001$) IOFC in the high feed cost, low revenue scenario, and tended to increase ($P = 0.060$) IOFC in the low feed cost, high revenue scenario. In conclusion, increasing fat from 0 to 3% of the diet, regardless of fat source, increased overall ADG, reduced ADFI, and improved F/G. Increasing fat also increased HCW, carcass yield, and backfat, while pigs fed diets containing corn oil had higher carcass fat iodine values. When feed costs are high and revenue is low, the improvement in growth performance does not

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justify the extra diet cost from increasing added fat from 0 to 3% in the diet. However, adding fat in the diet is justifiable when feed costs are low and revenue is high, regardless of fat source used.

Introduction

Supplementing finishing diets with added fat has been known to reduce ADFI, increase ADG, and improve feed efficiency. There are various fat sources that can be used in swine diets, all that contain different digestibility and energy values. Animal fats contain more saturated fatty acids with lower digestibility and energy concentrations compared to vegetable oils, which are higher in unsaturated fatty acids. Also, the different fatty acid compositions from alternative fat sources can impact carcass characteristics and carcass iodine value differently. Feeding diets containing vegetable oils increases the amount of polyunsaturated fatty acids in the fat, which therefore, increase iodine values compared to pigs fed diets containing animal fats.[3] Additional research is needed to understand the impact of different fat sources and inclusion levels on growth performance and economic return of modern swine genetics, especially with the increased cost of fat that is realized today. Therefore, the objective of this study was to evaluate the effects of two different fat sources, choice white grease or corn oil, fed at two different levels on growth performance, carcass characteristics, carcass iodine value, and economics of finishing pigs reared in a commercial environment.

Procedures

General

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in these experiments. This experiment was conducted at a commercial research facility located in southwest Minnesota (Pipestone Nutrition; Edgerton, MN). Pigs were placed and housed in a temperature-controlled wean-to-finish facility. Each pen (22.4 × 8.3 ft) contained 1 nipple waterer and a 4-hole dry self-feeder to allow for *ad libitum* access to feed and water. Pigs were allowed approximately 6.9 ft^2/pig.

Animal treatment and structure

A total of 2,011 pigs (PIC 1050 × DNA 600; initially 62.4 ± 4.6 lb) were used in a 113-d finishing trial. There were 21 to 27 pigs per pen and 16 pens per treatment. On d 0, pens were blocked by location in the barn and randomly allotted to 1 of 5 dietary treatments. A similar number of barrows and gilts were placed in each pen. Dietary treatments were arranged in a 2 × 2 + 1 factorial with main effects of fat source and fat level. Dietary treatments included a control diet containing no added fat. The other 4 dietary treatments included two different fat sources, choice white grease or corn oil, added at 1 or 3% of the diet. Pens of pigs and feed disappearance was measured on d 0, 13, 31, 50, 65, 78, 93, 105, and 113 to determine ADG, ADFI, and F/G. On d 92 and 104, eight of the heaviest pigs per pen were weighed individually and transported to a commercial packing plant (WholeStone Farms, Fremont, NE) for processing and determination of carcass characteristics. The remaining pigs were marketed at the conclusion of this trial on d 113 and transported to WholeStone Farms for collection of carcass characteristics. A fat sample that included all three layers of fat was taken from the belly

[3] Yanhong, L., D. Y. Kil, V. G. Perez-Mendoza, M. Song, and J. E. Pettigrew. 2018. Supplementation of different fat sources affects growth performance and carcass composition of finishing pigs. Journal of Animal Science and Biotechnology: 9:56. doi: 10.1186/s40104-018-0274-9.

from one barrow per pen per marketing event. Iodine value analysis was conducted using near-infrared spectroscopy at WholeStone Farms.

Diet preparation

Experimental diets were fed in 6 different phases. Pigs were fed on a feed budget with phases 1, 2, 3, 4, and 5 provided at 38, 91, 102, 107, and 90 lb per pig, respectively. Phase 6 was provided for the remainder of the study. All nutrients were formulated to meet or exceed NRC[4] requirement estimates. All diets were a corn-soybean meal-based and were fed in meal form. Diets were manufactured at the Spronk Brothers Feed Mill (Edgerton, MN).

Chemical analysis

Diet samples for each treatment were collected at the end of each phase. Samples from each room for each treatment were then combined to create a composite sample and analyzed for crude protein and acid hydrolysis fat analysis (Midwest Laboratories; Omaha, NE).

Economic Analysis

For economic analysis, gain per pig placed, total feed cost per pig, revenue, and income over feed cost (IOFC) were calculated using 4 different low and high revenue and feed cost scenarios. Feed cost per lb of gain was calculated by dividing feed cost per pig by the total weight gained using a low and high feed cost scenario. Revenue per pig placed was determined by total gain times the dressing percentage (0.75) and then multiplied by a carcass price of $0.55 for the low scenario and $1.20 for the high scenario. Margin over feed cost was calculated by using the low or high revenue per pig placed minus the low or high feed cost per pig placed. Choice white grease and corn oil was assumed to cost $0.33/lb for the low feed cost scenario and $0.60/lb for the high feed cost scenario.

Statistical analysis

Growth performance data were analyzed using the lmer function of R (Version 4.0.0, R Foundation for Statistical Computing, Vienna, Austria) in a randomized complete block design with pen as the experimental unit and location as the blocking factor. Treatments were considered as a fixed effect and block as a random effect. Linear and quadratic effects for increasing fat level as well as main effects for fat source were tested, as well as any interactions. The model for backfat considered HCW as a covariate. The model for mortality and removal data specified a binomial distribution. Differences between treatments were considered significant at $P \leq 0.05$ and marginally significant at $0.05 < P \leq 0.10$.

Results and Discussion

For the chemical analysis, increasing fat in the diets from 0 to 3% increased acid hydrolyzed fat, regardless of fat source as expected (data not shown).

When looking at marketing weights, increasing fat in the diet from 0 to 3% led to a linear increase (linear, $P \leq 0.028$) in BW for the first and second cut. Increasing fat also led to a linear increase (linear, $P = 0.007$) in overall market weight.

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

There were no interactions between fat source and level for any growth performance response criteria. Thus, only main effects of fat source and level will be discussed. From d 0 to 65, increasing added fat from 0 to 3% in the diet increased (linear, $P < 0.001$) ADG and improved (linear, $P < 0.001$) F/G. There was no significant difference in ADFI observed during this period. There was also no main effect of fat source observed during this period.

From d 65 to 113, increasing added fat in the diet from 0 to 3% decreased (linear, $P < 0.001$) ADFI and improved (linear, $P < 0.001$) F/G. There were no significant differences in ADG or main effect of fat source observed during this period.

For overall growth performance (d 0 to 113), increasing dietary fat increased (linear, $P < 0.001$) ADG, decreased (linear, $P = 0.013$) ADFI, and improved (linear, $P < 0.001$) F/G. Like the individual phase data, no differences between fat sources were observed. There were also no observed differences ($P > 0.10$) in removals, mortality, or total removals and mortalities over the duration of the study.

For carcass characteristics, increasing fat in the diet increased (linear, $P < 0.001$) HCW and carcass yield. Increasing dietary fat from 0 to 3% also increased backfat (linear, $P = 0.017$). For carcass iodine value, there was a fat source × level interaction ($P < 0.001$) where iodine value increased linearly in pigs fed diets containing corn oil with only a small increase in iodine value when diets with choice white grease were fed.

For economics, increasing fat from 0 to 3% led to greater (linear, $P = 0.003$) gain per pig placed. Increasing added fat increased (linear, $P < 0.001$) feed cost for both the high and low feed cost scenarios, but also led to greater (linear, $P = 0.003$) revenue for the high and low pig price scenario. Increasing fat in the diet led to decreasing (linear, $P < 0.001$) IOFC in the high feed cost, low revenue scenario, and a tendency to increase ($P = 0.060$) IOFC in the low feed cost, high revenue scenario. There was no significant difference in IOFC for the high feed cost, high revenue and low feed cost, low revenue scenarios. It is recommended that producers utilize their own current ingredient prices to compare economics of these dietary options.

In conclusion, increasing fat from 0 to 3%, regardless of fat source, increased overall ADG, reduced ADFI, and improved F/G, regardless of fat source used. Increasing fat also increased HCW, carcass yield, and backfat, while pigs fed diets containing corn oil had higher carcass fat iodine values. When feed costs are high and revenue is low, the improvement in growth performance does not justify the extra diet cost from increasing added fat from 0 to 3% in the diet. However, adding fat in the diet is justifiable when feed costs are low and revenue is high, regardless of fat source used.

Table 1. Diet composition for phases 1, 2, and 3 (as-fed basis)[1]

	Phase 1			Phase 2			Phase 3		
Ingredient, % **Fat level, %:**	**0**	**1**	**3**	**0**	**1**	**3**	**0**	**1**	**3**
Corn	65.00	64.00	60.68	70.21	68.53	65.26	75.17	73.62	70.50
Soybean meal (46% CP)	22.40	22.20	23.50	17.25	17.80	19.05	12.40	12.90	14.00
Corn DDGS	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Fat source[2]	0.00	1.00	3.00	0.00	1.00	3.00	0.00	1.00	3.00
Limestone	0.95	0.95	0.95	0.95	0.95	0.95	0.93	0.93	0.93
Monocalcium phosphate (21%)	0.20	0.21	0.20	0.19	0.19	0.18	0.14	0.14	0.14
Salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Lys-HCl	0.50	0.57	0.58	0.50	0.54	0.54	0.49	0.50	0.51
DL-Met	0.11	0.15	0.16	0.08	0.11	0.12	0.05	0.06	0.07
L-Trp	0.04	0.05	0.05	0.04	0.05	0.05	0.04	0.04	0.04
L-Thr	0.15	0.19	0.19	0.14	0.16	0.17	0.13	0.14	0.15
L-Val	---	0.04	0.05	---	0.03	0.03	---	0.01	0.01
Vitamin and trace mineral premix	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Copper chloride	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Phytase[3]	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Total	100	100	100	100	100	100	100	100	100
Calculated analysis									
SID amino acids, %									
Lys	1.17	1.22	1.25	1.04	1.09	1.12	0.92	0.94	0.97
Ile:Lys	58	55	55	57	55	55	56	55	55
Met and Cys:Lys	58	58	58	58	58	58	58	58	58
Thr:Lys	63	63	63	63	63	63	64	64	64
Trp:Lys	19	19	19	19	19	19	19	19	19
Val:Lys	65	65	65	65	65	65	65	65	65
SID Lys:ME, g/Mcal	3.65	3.76	3.76	3.23	3.33	3.33	2.82	2.85	2.86
ME, kcal/lb	1,451	1,473	1,511	1,463	1,483	1,521	1,475	1,495	1,534
CP, %	18.91	18.77	19.12	16.88	17.03	17.36	14.97	15.09	15.37
Ca, %	0.60	0.60	0.60	0.58	0.58	0.59	0.55	0.55	0.55
Available P, %	0.30	0.30	0.30	0.29	0.29	0.29	0.28	0.28	0.28

[1]Pigs were fed on a feed budget with phases 1, 2, and 3, provided at 38, 91, and 102 lb per pig, respectively.
[2]Increasing levels of choice white grease or corn oil were added to the diets.
[3]Quantum Blue 5P (AB Vista, Marlborough, UK) was included at 907 FTU/lb and provided an estimated release of 0.12% for available P.

Table 2. Diet composition for phases 4, 5, and 6 (as-fed basis)[1]

	Phase 4			Phase 5			Phase 6		
Ingredient, % Fat level, %:	**0**	**1**	**3**	**0**	**1**	**3**	**0**	**1**	**3**
Corn	77.16	77.03	74.01	79.62	77.29	74.28	88.20	87.03	84.60
Soybean meal (46% CP)	10.65	9.65	10.65	8.35	9.70	10.70	9.80	9.95	10.35
Corn DDGS	10.00	10.00	10.00	10.00	10.00	10.00	---	---	---
Fat source[2]	0.00	1.00	3.00	0.00	1.00	3.00	0.00	1.00	3.00
Limestone	0.90	0.90	0.90	0.85	0.83	0.83	0.75	0.75	0.75
Monocalcium phosphate (21%)	0.11	0.09	0.09	---	---	---	0.20	0.20	0.20
Salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Lys-HCl	0.41	0.48	0.48	0.40	0.40	0.40	0.31	0.32	0.33
DL-Met	---	0.03	0.04	---	---	0.01	---	---	---
L-Trp	0.03	0.03	0.04	0.03	0.03	0.03	0.02	0.02	0.02
L-Thr	0.09	0.13	0.13	0.09	0.09	0.10	0.08	0.08	0.09
L-Val	---	---	---	---	---	---	---	---	---
Vitamin/trace mineral premix	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Copper chloride	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Phytase[3]	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Total	100	100	100	100	100	100	100	100	100
Calculated analysis									
SID amino acids, %									
Lys	0.81	0.84	0.86	0.75	0.78	0.80	0.68	0.69	0.70
Ile:Lys	59	55	55	59	59	59	61	60	59
Met and Cys:Lys	58	58	58	60	59	58	61	60	58
Thr:Lys	64	64	64	65	65	65	66	66	66
Trp:Lys	19	19	19	19	19	19	19	19	19
Val:Lys	70	66	65	71	71	70	72	71	69
SID Lys:ME, g/Mcal	2.49	2.53	2.54	2.29	2.36	2.36	2.04	2.04	2.04
ME, kcal/lb	1,479	1,503	1,542	1,487	1,505	1,544	1,500	1,520	1,561
CP, %	14.26	13.81	14.04	13.37	13.82	14.06	12.01	11.99	11.99
Ca, %	0.53	0.52	0.52	0.48	0.48	0.48	0.48	0.48	0.48
Available P, %	0.27	0.26	0.26	0.24	0.24	0.24	0.24	0.24	0.24

[1]Pigs were fed on a feed budget with phases 4 and 5 provided at 107 and 90 lb per pig, respectively. Phase 6 was provided for the remainder of the study.
[2]Increasing levels of choice white grease or corn oil were added to the diets.
[3]Quantum Blue 5P (AB Vista, Marlborough, UK) was included at 907 FTU/lb and provided an estimated release of 0.12% for available P.

Table 3. Effects of fat source and level on growth performance, carcass characteristics, and carcass iodine value of finishing pigs[1]

			Choice white grease		Corn oil				*P* =[2,3]	
	Fat source:								Fat level	
Item	Fat level, %:	0	1	3	1	3	SEM	Source	Linear	Quadratic
BW, lb										
d 0		62.4	62.3	62.4	62.4	62.4	1.17	0.975	0.974	0.966
d 65		193.6	195.2	199.4	196.5	201.1	2.09	0.339	< 0.001	0.997
d 113[4]		265.9	270.6	266.2	271.0	274.1	3.48	0.206	0.492	0.289
Market weights										
Cut 1[5] (d 92)		278.9	280.3	289.7	284.3	287.7	2.44	0.545	< 0.001	0.941
Cut 2[5] (d 104)		285.7	286.6	291.8	287.8	291.5	3.26	0.848	0.028	0.847
Overall market weight[6]		277.5	279.6	283.0	281.5	284.7	2.51	0.331	0.007	0.623
d 0 to 65										
ADG, lb		2.01	2.03	2.09	2.05	2.12	0.021	0.219	< 0.001	0.897
ADFI, lb		4.61	4.53	4.47	4.48	4.53	0.067	0.915	0.182	0.195
F/G		2.30	2.23	2.14	2.19	2.13	0.021	0.143	< 0.001	0.050
d 65 to 113										
ADG, lb		2.12	2.14	2.15	2.16	2.17	0.027	0.426	0.301	0.546
ADFI, lb		6.94	6.77	6.57	6.89	6.71	0.072	0.046	< 0.001	0.821
F/G		3.27	3.16	3.06	3.19	3.09	0.029	0.262	< 0.001	0.343
Overall (d 0 to 113)										
ADG, lb		2.05	2.07	2.11	2.09	2.14	0.019	0.183	< 0.001	0.795
ADFI, lb		5.45	5.34	5.23	5.35	5.32	0.065	0.321	0.013	0.353
F/G		2.66	2.58	2.48	2.56	2.49	0.020	0.884	< 0.001	0.098
Removals, %		4.8	4.9	4.0	5.4	3.0	1.10	0.725	0.201	0.395
Mortality, %		2.0	2.9	1.7	1.9	1.7	0.71	0.557	0.655	0.490
Total removals and mortalities, %		6.8	7.9	5.7	7.4	4.8	1.33	0.545	0.185	0.255
Carcass characteristics										
HCW, lb		198.3	199.8	203.9	201.9	205.5	1.94	0.224	< 0.001	0.780
Yield, %[7]		71.7	71.6	71.7	71.9	72.0	0.08	0.425	< 0.001	0.075
Fat, in.[7]		0.93	0.92	0.94	0.92	0.94	0.006	0.580	0.016	0.104
Iodine value[8]		69.21	69.87	71.64	72.81	79.91	0.260	< 0.001	< 0.001	<0.001

continued

Table 3. Effects of fat source and level on growth performance, carcass characteristics, and carcass iodine value of finishing pigs[1]

	Fat source:		Choice white grease		Corn oil				*P* =[2,3]	
									Fat level	
Item	Fat level, %:	0	1	3	1	3	SEM	Source	Linear	Quadratic
Economics, $/pig placed										
Gain		206.68	207.92	213.43	210.54	216.02	2.409	0.262	0.003	0.956
Feed cost (Hi)[9]		74.44	75.76	80.45	76.25	81.72	1.051	0.328	< 0.001	0.469
Feed cost (Lo)[10]		44.50	45.28	47.72	45.56	48.47	0.627	0.336	< 0.001	0.604
Revenue (Hi)[11]		186.01	187.13	192.09	189.49	194.42	2.168	0.262	0.003	0.956
Revenue (Lo)[12]		85.25	85.77	88.04	86.85	89.11	0.994	0.262	0.003	0.956
IOFC (HiF-HiR)		111.57	111.37	111.64	113.24	112.70	1.429	0.307	0.835	0.709
IOFC (HiF-LoR)		10.81	10.01	7.59	10.60	7.39	0.606	0.719	< 0.001	0.275
IOFC (LoF-LoR)		40.76	40.49	40.32	41.29	40.64	0.597	0.348	0.565	0.707
IOFC (LoF-HiR)		141.51	141.85	144.37	143.93	145.96	1.691	0.275	0.060	0.923

[1]A total of 2,011 pigs (PIC 1050 × DNA 600; initially 62.4 ± 4.6 lb) with 21 to 27 pigs per pen and 16 replications per treatment were used in a 113-d finishing trial.
[2]Linear and quadratic contrasts were evaluated based on increasing fat in the diet.
[3]There was no fat source × level interactions observed ($P > 0.10$) in any growth performance criteria.
[4]Values represent weights at final marketing.
[5]Eight of the heaviest pigs were marketed from each pen.
[6]Weighted average of all marketing events.
[7]Adjusted using HCW as a covariate.
[8]Fat source × level interaction ($P < 0.001$).
[9]Feed cost (Hi): corn was valued at $6.50/bu ($232/ton), soybean meal at $420/ton, DDGS at $260/ton, fat at $0.60/lb.
[10]Feed cost (Lo): corn was valued at $3.30/bu ($118/ton), soybean meal at $281/ton, DDGS at $163/ton, fat at $0.33/lb.
[11]Revenue/pig placed (Hi) = (total gain/pig placed × 0.75) × $1.20.
[12]Revenue/pig placed (Lo) = (total gain/pig placed × 0.75) × $0.55.