Kansas Agricultural Experiment Station Research Reports

Volume 10
Issue 6 *Swine Day*

Article 33

2024

Effect of Increasing 3% Oil Corn Dried Distillers Grains with Solubles on Nursery and Finishing Pig Growth Performance and Carcass Characteristics

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Funding Source

The authors would like to thank the team at JBS, Worthington, MN for help with carcass data collection.

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K-STATE Research and Extension

SWINE DAY 2024

KANSAS STATE UNIVERSITY SWINE INDUSTRY DAY 2024

Effect of Increasing 3% Oil Corn Dried Distillers Grains with Solubles on Nursery and Finishing Pig Growth Performance and Carcass Characteristics

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Summary

Two experiments were conducted to determine the effects of increasing 3% oil corn dried distillers grains with solubles (DDGS) on nursery and finishing pig performance. In exp. 1, a total of 355 barrows (DNA 200 × 400; initially 27.2 ± 0.40 lb) were used in a 21-d growth trial with four or five pigs per pen and 18 replicate pens per treatment. Pigs were fed a corn-soybean meal-based diet with 0, 10, 20, or 30% corn DDGS. Overall, final BW, ADG, and ADFI decreased (linear, $P < 0.05$) resulting in a tendency (quadratic, $P < 0.10$) for poorer F/G with increasing DDGS. Caloric efficiency tended (quadratic, $P < 0.10$) to decrease with increasing DDGS suggesting that the initial estimate for the NE of DDGS at 899 kcal/lb was underestimated. Using the observed performance, the NE of DDGS would need to be 1,006 kcal/lb for caloric efficiency to be equal across treatments. In exp. 2, a total of 684 pigs (DNA 241 × 600, initially 89.9 ± 1.20 lb) were used in a 97-d trial with nine or 10 pigs per pen and 18 replicate pens per treatment. Pigs were fed a corn-soybean meal-based diet with 0, 10, 20, or 30% DDGS. Overall, as DDGS increased, final BW and ADG decreased (linear, $P < 0.001$) while ADFI tended (linear, $P < 0.057$) to decrease, which results in poorer F/G (linear, $P < 0.001$). Caloric efficiency based on a live- or carcass –weight basis decreased (linear, $P \leq 0.058$) as DDGS increased. The NE of DDGS would need to be 1,001 kcal/lb for live weight, and 963 kcal/lb for carcass weight for caloric efficiency to be equal across treatments. For the final marketing event, carcass yield, HCW, and backfat depth decreased (linear, $P \leq 0.001$) as DDGS increased. Percentage lean and carcass IV increased (linear, $P < 0.001$) with increasing DDGS. Additionally, dry matter and N digestibility decreased (linear, $P < 0.001$) with increasing DDGS. In conclusion, increasing 3% oil DDGS in nursery and finishing pig diets negatively affected growth performance, carcass IV, and DM and N digestibility. Using caloric efficiency calculations, the NE content of 3% oil DDGS is estimated to be between 1,001 kcal/lb for live-weight and 963 kcal/lb for carcass-weight caloric efficiency for growing finishing pigs.

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Introduction

Corn dried distillers grains with solubles (DDGS) is a widely used alternative feed ingredient for use in U.S. swine diets. Today, more corn oil is extracted from the solubles at ethanol plants than in the past.[2] While conventional (high oil) DDGS have been thoroughly evaluated, there is limited data on DDGS with as little as 3% oil. Therefore, the objective of this study was to evaluate 3% oil DDGS on nursery and finishing pig growth performance and carcass characteristics.

Materials and Methods

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment.

Experiment 1 was conducted at the Kansas State University Segregate Early Weaning facility in Manhattan, KS. The facility has two identical barns that are completely enclosed and environmentally controlled. Pigs were placed in 4 × 4 ft pens that contain a four-hole dry self-feeder and a cup waterer for ad libitum access to feed and water.

Experiment 2 was conducted at the Kansas State University Swine Research and Teaching Center. The facility was totally enclosed and environmentally regulated. Each pen was equipped with a 2-hole dry, single-sided feeder and a 1-cup waterer to allow for ad libitum access to feed and water, and adjustable gates to allow 7.83 ft^2 of floor space per pig. Pens were located over a completely slatted concrete floor with a 4-ft pit underneath for manure storage.

Animals and diets

Samples of the DDGS were collected and analyzed for DM, CP, ether extract, ADF and amino acids (Midwest laboratories, Omaha, NE and Ajinomoto Health and Nutrition laboratories, Eddyville, IA, Table 1). For both experiments, the experimental diets were corn-soybean meal-based with 0, 10, 20 or 30% DDGS (Table 2, Exp.1 and Table 3, Exp. 2). The initial NE content of the DDGS was estimated to be 899 kcal/lb and was based on the Graham et al. (2014)[3] prediction equation using the analyzed ether extract of the DDGS previously sourced from the same manufacturer (Kim et al., 2024).[4] All diets were manufactured at the Kansas State University O.H. Kruse Feed Technology Innovation Center, Manhattan, KS.

Experiment 1

A total of 355 barrows (DNA 200 × 400; initially 27.2 ± 0.40 lb) were used in a 21-d growth trial with four or five pigs per pen and 18 replicate pens per treatment. Pigs were weaned at 20 days of age and were fed common phase 1 and 2 diets for 20 days. Pens

[2] Espinosa, C. D., S. A. Lee, and H. H. Stein. 2019. Digestibility of amino acids, energy, acid hydrolyzed ether extract, and neutral detergent fiber, and concentration of digestible and metabolizable energy in low-oil distillers dried grains with solubles fed to growing pigs. Transl. Anim. Sci. 3:662-675. doi:10.1093/tas/txz025.

[3] Graham, A. B., R. D. Goodband, M. D. Tokach, S. S. Dritz, J. M. DeRouchey, S. Nitikanchana, and J.J Updike. 2014. The effects of low-, medium-, and high-oil dried distillers grains with solubles on growth performance, nutrient digestibility, and fat quality in finishing pigs. J. Anim. Sci. 92:3610–3623 doi:10.2527/jas2014-7678.

[4] Kim, et al. 2024. Effects of compound enzymes in nursery pigs fed diets of different nutrient density. 2024, Kansas State University Swine Industry Day Report of Progress.

of pigs were assigned to treatments in a completely randomized design and pigs were weighed and feed deliveries were recorded on d 9 and 21 to determine ADG, ADFI, and F/G. Caloric efficiency was calculated by multiplying total feed intake by dietary NE divided by total weight gain.

Experiment 2

A total of 684 pigs (DNA 241 × 600, initially 89.9 ± 1.20 lb) were used in a 97-d trial with nine or 10 pigs per pen and 18 replicate pens per treatment across two groups of pigs. Pens of pigs were assigned to treatments in a randomized complete block design with initial weight as the blocking factor. Pens of pigs were weighed and feed deliveries were recorded approximately every 14 d to determine ADG, ADFI, and F/G. The study was divided into three growing phases: phase 1 (90 to 133 lb), phase 2 (133 to 191), and phase 3 (191 to 307 lb). Caloric efficiency based on live weight was calculated by multiplying total feed intake by dietary NE divided by the total weight gain. Caloric efficiency based on carcass weight was calculated by dividing live weight caloric efficiency by carcass yield.

During phase 3, an indigestible marker, titanium dioxide (TiO_2), was incorporated into the diet at 0.5%. After feeding the marker for 7 d, fecal samples were collected from two pigs per pen. Samples were oven dried, ground, and analyzed for DM, N and TiO_2 for the calculation of apparent total tract digestibility (ATTD) of DM and N.

Three weeks prior to the final marketing event, the two heaviest pigs in each pen were selected and marketed. The remaining pigs at the end of the trial were tattooed with the specific pen identification number and marketed at a commercial abattoir (JBS Swift, Worthington, MN) for collection of carcass measurements [carcass yield, hot carcass weight (HCW), backfat depth, loin depth, and percentage lean].

For IV analysis, the two heaviest barrows in the pen were sampled in the first research group at the first marketing event. In the second group of pigs, the four barrows in each pen were selected for fat sample collection from the final marketing event. After harvest, the carcasses were held in a cooler for at least 5 hours before the fat samples were collected from the dorsal loin-butt junction. Individual samples were analyzed for IV using Bruker Tango Near Infrared Spectroscopy (NIR) located at the abattoir's laboratory.

Statistical analysis

For exp. 1, data were analyzed as a completely randomized design for one-way ANOVA with pen considered the experimental unit, treatment as the fixed effect, and barn as a random effect to account for animals being housed in two identical barns. For exp. 2, data were analyzed as a randomized complete block design for one-way ANOVA with pen considered the experimental unit, treatment as fixed effect, and block as a random effect. Hot carcass weight was used as a covariate for analysis of backfat depth, loin depth, and percentage lean. For both experiments, linear and quadratic contrast coefficients were used to compare the effect of increasing 3% oil DDGS and all models were fit using the lmer function from the lme4 package in R (version 4.1.1 (2021-08-10), R Foundation for Statistical Computing, Vienna, Austria). All results were considered significant at $P \leq 0.05$ and marginally significant between $P > 0.05$ and $P \leq 0.10$.

Results and Discussion

Experiment 1

Overall, for 27 to 55 lb pigs, final BW, ADG, and ADFI decreased (linear, $P < 0.05$) resulting in a tendency for poorer (quadratic, $P < 0.10$) F/G with increasing DDGS. Caloric efficiency tended to decrease (quadratic, $P < 0.10$) with increasing DDGS suggesting that the initial estimate for the NE of DDGS at 899 kcal/lb was underestimated. The NE of DDGS would need to be 1,006 kcal/lb for caloric efficiency to be equal across treatments.

Experiment 2

For growing and finishing pigs, body weight and ADG decreased (linear, $P < 0.001$) throughout all three phases of the study as DDGS inclusion was increased. Average daily feed intake decreased (linear, $P = 0.029$) in phase 1 and tended (linear, $P = 0.095$) to decrease in phase 2 as DDGS inclusion was increased. However, no difference in ADFI was observed in phase 3 between treatments. F/G worsened (linear, $P \leq 0.007$) in phase 1 and phase 2 with increasing DDGS inclusion, while no difference was observed in phase 3.

Overall, as DDGS increased, final BW and ADG decreased (linear, $P < 0.001$) and a tendency for a decrease in ADFI (linear, $P < 0.10$) was observed. Also, increasing DDGS worsened F/G (linear, $P < 0.001$). Caloric efficiency based on live- or carcass – weight bases increased (linear, $P \leq 0.058$) suggesting that our initial estimate for the NE of DDGS at 899 kcal/lb was underestimated. The NE of 3% oil DDGS would need to be 1,001 kcal/lb for live weight, and 963 kcal/lb for carcass weight for caloric efficiency to be identical across treatments.

For the final marketing event, carcass yield, HCW, and backfat depth decreased (linear, $P \leq 0.001$) as DDGS increased. Percentage lean and carcass IV increased (linear, $P < 0.001$) with increasing DDGS.

For the subset of pigs sampled from group 1 at the first marketing event for determination of carcass characteristics and IV, there were no differences in HCW, backfat depth, loin depth, and percentage lean among treatments (Table 6). Carcass IV increased (linear, $P < 0.001$) with increasing DDGS, ranging from 62.2% for pigs fed 0% DDGS to 72.3% for pigs fed 30% DDGS.

Fecal DM increased (linear, $P < 0.001$) while DM and N digestibility decreased (linear, $P < 0.001$) with increasing DDGS.

In conclusion, increasing 3% oil DDGS in nursery and finishing pig diets negatively affected growth performance, DM and N digestibility, and carcass traits. However, the economic justification of using 3% oil DDGS needs to be evaluated on a case-by-case basis.

Acknowledgments

The authors would like to thank the team at JBS, Worthington, MN for help with carcass data collection.

Brand names appearing in this publication are for product identification purposes only. No endorsement is intended, nor is criticism implied of similar products not mentioned. Persons using such products assume responsibility for their use in accordance with current label directions of the manufacturer.

Table 1. Chemical analysis of DDGS (as-fed basis)[1,2]

Nutrient	Corn DDGS, %
Dry matter	89.05
Crude protein	29.70
Ether extract	3.18
Acid detergent fiber	10.50
Ash	4.30
Total AA	
Arg	1.18
Cys	0.55
His	0.83
Ile	0.98
Leu	3.14
Lys	0.86
Met+Cys	1.16
Thr	1.11
Trp	0.25
Val	1.36

[1] Values represent the means of two samples analyzed in duplicate (Midwest Laboratories, Omaha, NE and Ajinomoto Health and Nutrition Laboratories, Eddyville, IA).
[2] Analysis for mycotoxins was also performed (NDSU Veterinary Diagnostic Laboratory, North Dakota) with all major mycotoxin levels being below detectable levels except for a low level of Fumonisin (0.674 ppm).

Table 2. Composition of experimental diets (as-fed basis, Exp. 1)[1]

	DDGS, %			
Item	**0**	**10**	**20**	**30**
Ingredient, %				
Corn	64.32	57.73	51.14	44.55
Soybean meal (47.7% CP)	32.12	28.82	25.51	22.21
DDGS	---	10.00	20.00	30.00
Monocalcium P (21% P)	1.00	0.78	0.53	0.28
Calcium carbonate	0.90	1.03	1.18	1.31
Sodium chloride	0.35	0.35	0.35	0.35
L-Lys-HCl	0.43	0.48	0.53	0.58
DL-Met	0.18	0.15	0.13	0.10
L-Thr	0.17	0.16	0.15	0.13
L-Trp	0.03	0.03	0.03	0.03
L-Val	0.09	0.08	0.05	0.04
Vitamin premix	0.25	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15	0.15
Phytase[2]	0.03	0.03	0.03	0.03
Calculated analysis				
SID amino acids, %				
Lys	1.30	1.30	1.30	1.30
Ile:Lys	58	58	58	58
Leu:Lys	120	129	138	148
Met:Lys	36	35	34	34
Met & Cys:Lys	58	58	58	58
Thr:Lys	63	63	63	63
Trp:Lys	19	19	19	19
Val:Lys	70	70	70	70
His:Lys	38	39	40	41
Total Lys, %	1.45	1.47	1.49	1.52
NE NRC, kcal/lb	1,098	1,077	1,055	1,034
SID Lys:NE, g/Mcal	5.37	5.48	5.59	5.70
CP, %	21.4	22.1	22.8	23.5
Ca, %	0.72	0.72	0.72	0.72
STTD, P %	0.47	0.47	0.47	0.47
Ca:P	1.18	1.16	1.17	1.16

[1] Diets were fed for 21 d starting at approximately 27.2 ± 0.40 lb BW.
[2] Ronozyme HiPhos 2700 (DSM Nutritional Products, Inc, Parsippany NJ) provided an assumed 0.11% release of STTD P with 306 FTU/lb inclusion in the final diet.

Table 3. Composition of experimental diets (as-fed basis, Exp. 2)[1]

	Phase 1				Phase 2				Phase 3[2]			
	DDGS, %				DDGS, %				DDGS, %			
Item	**0**	**10**	**20**	**30**	**0**	**10**	**20**	**30**	**0**	**10**	**20**	**30**
Ingredient, %												
Corn	71.67	64.92	58.24	51.56	80.65	73.91	67.15	60.11	86.85	80.24	73.44	66.36
Soybean meal (47.7% CP)	25.49	22.35	19.13	15.91	16.88	13.74	10.60	7.48	10.89	7.59	4.45	1.33
DDGS	---	10.00	20.00	30.00	---	10.00	20.00	30.00	---	10.00	20.00	30.00
Calcium carbonate	0.83	0.98	1.13	1.28	0.78	0.93	1.08	1.25	0.75	0.90	1.05	1.23
Monocalcium P (21.5% P)	0.73	0.48	0.25	0.00	0.55	0.30	0.05	---	0.50	0.25	0.00	0.00
Sodium chloride	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
L-Lys-HCl	0.35	0.40	0.44	0.49	0.33	0.37	0.42	0.46	0.30	0.35	0.39	0.44
DL-Met	0.09	0.06	0.04	0.01	0.06	0.03	---	---	0.03	---	---	---
L-Thr	0.12	0.10	0.09	0.07	0.10	0.08	0.07	0.05	0.10	0.08	0.07	0.05
L-Trp	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.03	0.03
L-Val	0.04	0.03	---	---	0.02	---	---	---	---	---	---	---
Vitamin premix	0.15	0.15	0.15	0.15	0.13	0.13	0.13	0.13	0.10	0.10	0.10	0.10
Trace mineral premix	0.15	0.15	0.15	0.15	0.13	0.13	0.13	0.13	0.10	0.10	0.10	0.10
Phytase[3]	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Total	100	100	100	100	100	100	100	100	100	100	100	100
Calculated analysis												
SID amino acids, %												
Lys	1.08	1.08	1.08	1.08	0.85	0.85	0.85	0.85	0.68	0.68	0.68	0.68
Ile:Lys	60	60	60	60	60	60	60	60	60	60	60	60
Leu:Lys	131	142	153	165	143	157	172	186	158	175	193	211
Met:Lys	32	31	31	30	32	31	30	33	32	31	34	37
Met & Cys:Lys	56	56	56	56	58	58	59	62	61	61	65	69
Thr:Lys	62	62	62	62	63	63	63	63	67	66	67	67
Trp:Lys	19	19	19	19	19	19	19	19	19	19	19	19
Val:Lys	70	70	70	71	70	70	72	75	71	73	76	79
His:Lys	40	42	43	44	42	43	45	46	44	45	47	49
Total Lys, %	1.21	1.23	1.26	1.28	0.96	0.98	1.00	1.03	0.77	0.80	0.82	0.84
NE NRC, kcal/lb	1,120	1,098	1,076	1,054	1,145	1,123	1,102	1,077	1,162	1,141	1,119	1,094
SID Lys:NE, g/Mcal	4.38	4.46	4.55	4.65	3.37	3.43	3.50	3.58	2.65	2.70	2.76	2.82
CP, %	18.6	19.4	20.1	20.9	15.1	15.9	16.7	17.5	12.7	13.5	14.3	15.1
Ca, %	0.60	0.61	0.62	0.62	0.52	0.52	0.53	0.58	0.47	0.47	0.48	0.54
P, %	0.52	0.53	0.54	0.54	0.45	0.45	0.45	0.50	0.41	0.41	0.42	0.47
STTD, P %	0.40	0.40	0.40	0.40	0.34	0.34	0.34	0.38	0.32	0.32	0.32	0.36
Ca:P	1.15	1.15	1.15	1.16	1.15	1.15	1.16	1.16	1.14	1.15	1.15	1.14

[1] Phase 1 was fed from 90 to 133 lb, phase 2 from 133 to 191 lb, and phase 3 from 191 to 307 lb, respectively.[2] For determination of total tract digestibility of DM and N, 0.5% of TiO_2 was added to the diet and fed for 9 days.

[3] Ronozyme HiPhos 2700 (DSM Nutritional Products, Inc, Parsippany NJ) provided an assumed 0.11% release of STTD P with 306 FTU/lb inclusion in the final diet.

Table 4. Effects of increasing 3% oil DDGS on growth performance of late nursery pigs, Exp. 1[1]

	DDGS, %					*P* =	
Item	**0**	**10**	**20**	**30**	**SEM**	**Linear**	**Quadratic**
BW, lb							
d 0	27.2	27.2	27.2	27.1	0.40	0.827	0.856
d 21	55.2	54.7	54.7	53.2	0.76	0.033	0.375
d 0 to 21 (Overall)							
ADG, lb	1.33	1.31	1.31	1.24	0.021	0.004	0.248
ADFI, lb	1.99	1.97	1.96	1.91	0.050	0.051	0.747
F/G	1.50	1.50	1.50	1.54	0.024	0.031	0.088
Caloric efficiency, live weight, kcal/lb	1,646	1,615	1,579	1,596	25.4	0.004	0.095

[1] A total of 355 barrows (DNA 200 × 400; initially 27.2 ± 0.40 lb) were used in a 21-d growth study with four or five pigs per pen and 18 replications per treatment. Common diets were fed from d 0 to 20 after weaning.

Table 5. Effects of increasing 3% oil DDGS on growth performance of finishing pigs[1]

	DDGS, %					*P* =	
Item	**0**	**10**	**20**	**30**	**SEM**	**Linear**	**Quadratic**
BW, lb							
Initial	90.1	89.8	89.9	89.7	1.20	0.692	0.981
Phase 1	133.5	133.3	132.7	130.6	1.73	0.007	0.221
Phase 2	193.1	192.5	191.1	186.5	1.78	< 0.001	0.744
Final	313.4	310.4	306.4	298.9	3.36	< 0.001	0.244
Wt gain, lb/pig placed[2]	214.8	215.3	211.8	201.7	37.64	< 0.001	0.004
Phase 1							
ADG, lb	2.37	2.38	2.35	2.24	0.030	< 0.001	0.007
ADFI, lb	4.69	4.74	4.64	4.58	0.080	0.029	0.178
F/G	1.98	1.99	1.98	2.05	0.021	0.017	0.108
Phase 2							
ADG, lb	2.57	2.53	2.50	2.41	0.029	< 0.001	0.355
ADFI, lb	6.51	6.55	6.49	6.38	0.065	0.095	0.193
F/G	2.53	2.59	2.60	2.64	0.023	< 0.001	0.840
Phase 3							
ADG, lb	2.38	2.37	2.31	2.28	0.030	0.003	0.657
ADFI, lb	7.67	7.63	7.56	7.54	0.070	0.128	0.881
F/G	3.23	3.22	3.28	3.31	0.048	0.112	0.541
Overall							
ADG, lb	2.44	2.43	2.38	2.32	0.019	< 0.001	0.090
ADFI, lb	6.60	6.61	6.54	6.47	0.058	0.057	0.440
F/G	2.70	2.72	2.74	2.80	0.020	< 0.001	0.391
Caloric efficiency, live weight, kcal/lb	3,108	3,071	3,035	3,024	22.8	0.003	0.544
Caloric efficiency, carcass weight, kcal/lb	4,174	4,141	4,107	4,104	31.4	0.058	0.587
Carcass characteristics, final marketing event							
Yield, %	74.4	74.2	73.9	73.7	0.01	< 0.001	0.857
HCW, lb	233.0	229.8	226.3	219.9	2.69	< 0.001	0.291
Backfat depth, in[3]	0.76	0.73	0.73	0.69	0.013	0.001	0.863
Loin depth, in[3]	2.66	2.61	2.58	2.62	0.026	0.157	0.052
Lean, %[3]	55.2	55.6	55.5	56.2	0.23	0.007	0.460
IV, mg/g[4]	61.1	64.4	67.0	69.7	0.48	< 0.001	0.505
Digestibility							
Fecal dry matter, %	24.32	25.00	25.71	26.94	0.554	0.002	0.622
DM digestibility, %	81.57	77.18	76.12	72.34	0.651	< 0.001	0.637
N digestibility, %	83.48	79.25	78.39	75.17	0.879	< 0.001	0.533

[1] A total of 684 pigs (DNA 200 × 400; initially 89.9 ± 1.20 lb) were used.
[2] Total wt gain ÷ total pig placed per pen.
[3] Adjusted using HCW as a covariate.
[4] Iodine value was collected from four pigs per pen at the final marketing event from the second group. Fat samples were collected from the dorsal loin-butt junction and were immediately chilled and later analyzed for iodine value using Near Infrared Spectroscopy (NIR).

Table 6. Effect of increasing 3% oil DDGS on carcass characteristics and iodine value (IV) of pigs at first marketing event[1]

	DDGS, %					*P* =	
Item	**0**	**10**	**20**	**30**	**SEM**	**Linear**	**Quadratic**
Pigs, n	18	18	17	18	---	---	---
HCW, lb	200.4	207.9	206.9	206.9	3.85	0.231	0.403
Backfat depth, in[2]	0.75	0.80	0.75	0.83	0.038	0.262	0.826
Loin depth, in[2]	2.47	2.41	2.37	2.34	0.084	0.726	0.844
Lean, %[2]	54.8	53.8	54.4	53.1	0.74	0.197	0.863
IV, mg/g	62.2	64.6	67.0	72.3	0.48	< 0.001	0.504

[1] On d 75 of the experiment, iodine value was collected from the two heaviest barrows per pen at the first marketing event from the first group. Data from 71 carcasses were collected at the plant and used for this analysis. Fat samples were collected from the dorsal loin-butt junction and were immediately chilled and later analyzed for iodine value using Near Infrared Spectroscopy (NIR).
[2] Adjusted using HCW as a covariate.