The effects of feeding sorghum dried distillers grains with solubles on finishing pig growth performance, carcass characteristics, and fat quality[1,2]

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ABSTRACT: The objective of this study was to determine the effects of feeding sorghum dried distillers grains with solubles (DDGS) in grain sorghum– or corn-based diets on pig growth performance, carcass characteristics, and carcass fat quality. A total of 288 finishing pigs (BW 58.8 ± 4.43 kg; Line TR 4 × 1050, PIC, Hendersonville, TN) were used in a 73-d study. Pigs were allotted to 1 of 6 dietary treatments with 6 pens of 8 pigs per treatment. Treatments included grain sorghum–based diets with 0%, 15%, 30%, or 45% sorghum DDGS (29.0% CP, 7.2% ether extract); a grain sorghum–based diet with 30% corn DDGS (25.7% CP, 8.7% ether extract); and a corn-based diet with 30% corn DDGS. The diets were formulated to 0.95%, 0.83%, and 0.71% standardized ileal digestible Lys in phases 1, 2, and 3, respectively, and were not balanced for energy. On d 73, a subsample of 72 pigs (1 barrow and 1 gilt/pen) was harvested at Kansas State University's Meats Laboratory. Carcass traits were calculated, as well as 10th-rib LM color, marbling and firmness, and fat color score. Fat samples from the 10th rib were collected and analyzed for fatty acid profile, which was used to calculate iodine value (IV). The remaining pigs were transported to a commercial packing plant (Triumph Foods, St. Joseph, MO) for carcass measurement and jowl IV determinations. Overall, increasing the dietary sorghum DDGS reduced (linear, $P < 0.01$) ADG and increased (linear, $P < 0.01$) back fat IV. Pigs fed increasing sorghum DDGS had decreased 10th-rib fat a* (less red) and b* (less yellow; $P < 0.01$ and 0.06, respectively). No differences were observed in growth performance or back fat IV among pigs fed corn- or grain sorghum–based diets with 30% corn DDGS. Pigs fed the grain sorghum–based diet with 30% corn DDGS had fat color that was more yellow (b*; $P < 0.03$) than that of pigs fed the grain sorghum–based diet with 30% sorghum DDGS. Pigs fed the grain sorghum–based diet with 30% sorghum DDGS also had decreased back fat IV ($P < 0.01$) and fat that was whiter (L*; $P < 0.02$) than that of those fed the grain sorghum–based diet with corn DDGS. Pigs fed grain sorghum with 30% sorghum DDGS had lower ($P < 0.01$) back fat IV than pigs fed corn with 30% corn DDGS. Feeding a grain sorghum–based diet with increasing sorghum DDGS reduces ADG when diets are not balanced for energy but, when fed at 30% of the diet, produces firmer pork fat than feeding a corn-based diet with 30% corn DDGS, which may be preferred for pork export markets.

Key words: corn, dried distillers grains with solubles, finishing pigs, sorghum

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INTRODUCTION

Grain sorghum is grown in the Great Plains region of the United States because of its ability to tolerate drought conditions. Because of the large production of grain sorghum and its use in ethanol production, sorghum dried distillers grains with solubles (**DDGS**) are equally as available to regional swine producers as corn DDGS in this geographic area.

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Grain sorghum has a feeding value of 96% to 100% that of corn and results in similar pig growth performance when fed to completely replace corn in swine diets (Shelton et al., 2004; Benz et al., 2011b). Sotak et al. (2014) found grain sorghum to be a suitable replacement for corn in nursery pig diets. However, increasing sorghum DDGS from 0% to 45% linearly reduced growth performance. Feoli (2008) also observed a reduction in growth performance when 30% sorghum DDGS was included in nursery pig diets.

Because of its unsaturated oil content, including corn DDGS in swine diets results in carcasses with a higher concentration of unsaturated fatty acids, thus decreasing pork fat firmness. However, grain sorghum contains a lower concentration of oil than corn, which creates a lower-oil DDGS product. Oil content of DDGS has been shown to be positively correlated with ADG and G:F of finishing pigs (Graham et al., 2014a,b). On the other hand, the decreased oil content in sorghum DDGS could have a lesser negative impact on pork fat quality than corn DDGS by decreasing the level of unsaturated fat the pig consumes. Although a large amount of information is available on the nutritional value of grain sorghum, little is known about sorghum DDGS. Therefore, the objective of this study was to determine the effects of feeding increasing sorghum DDGS in corn- or grain sorghum–based diets on growing-finishing pig growth performance, carcass characteristics, and fat quality.

MATERIALS AND METHODS

The protocol for these studies was approved by the Kansas State University Institutional Animal Care and Use Committee. The studies were conducted at the Kansas State University Swine Teaching and Research Center (Manhattan, KS).

The experiment was conducted in an environmentally controlled barn with mechanical ventilation. The room (26.8 × 23.2 m) in which the pigs were housed had thirty-six 2.4 × 3.1 m pens. Each pen was equipped with slatted floors, a 2-hole (40 cm each) self-feeder (Farmweld, Teutopolis, IL), and a cup waterer. Pigs had ad libitum access to feed and water throughout the trial. A computer feeding system (FeedPro; Feedlogic Corp., Wilmar, MN) was used to distribute and weigh pen feed deliveries.

The grain sorghum fed in this study was a red pericarp variety, and the corn grain fed was U.S. #2 yellow dent. The corn DDGS used were golden brown with L*, a*, and b* values of 70.5, 14.9, and 39.2, respectively. The sorghum DDGS were darker brown in color than the corn DDGS, with L*, a*, and b* values of 50.7, 16.6, and 24.9, respectively. The grain sorghum, corn, sorghum DDGS, and corn DDGS were analyzed (Ward Laboratories, Kearney, NE) for DM (method 934.01; AOAC, 2007), CP (method 990.03; AOAC, 2007), ether extract (method 920.39 A; AOAC, 2007), crude fiber (method 978.10; AOAC, 2007), ash (method 942.05; AOAC, 2007), ADF and NDF (Van Soest, 1963), and AA (University of Missouri–Columbia; method 982.30 E 9 (a, b, c); AOAC, 2007; Table 1). Composite samples of complete diets sampled at the feeder during each phase were used to measure bulk density (Seedburo model 8800; Seedburo Equipment, Chicago, IL). The bulk density of a material represents the mass per unit of volume (g/L; Table 2). Fatty acid analyses were conducted on the corn, grain sorghum, corn DDGS, and sorghum DDGS utilized in the study at the Kansas State University Analytical Lab (Manhattan, KS; Table 3; Sukhija and Palmquist, 1988). Standard ileal digestibility (**SID**) values for the sorghum DDGS were derived from Urriola et al. (2009). Metabolizable energy (2,900 kcal/kg; Noblet and Perez, 1993) and NE (1,970 kcal/kg; Noblet et al., 1994) for sorghum DDGS were calculated on the basis of its chemical composition. Standard ileal digestibility values for other ingredients as well as other nutrients and energy values were derived from NRC (1998).These values were then used in diet formulation to meet or exceed requirement estimates (NRC, 1998). The diets were formulated to 0.95%, 0.83%, and 0.71% SID Lys in phases 1, 2, and 3, respectively, and were not balanced for energy.

A total of 288 finishing pigs (BW 58.8 ± 4.43 kg; Line TR4 × 1050, PIC, Hendersonville, TN) were used in a 73-d experiment. Pigs were allotted to 1 of 6 dietary treatments with 6 pens of 8 pigs (4 barrows and 4 gilts) per treatment. These dietary treatments were

Table 1. Analyzed nutrient composition of ingredients (as-fed basis)[1]

Item	Sorghum	Corn	Sorghum DDGS[2]	Corn DDGS
DM, %	86.12	86.22	89.64	89.00
CP, %	8.24	7.39	29.04	25.70
Crude fat, %	2.07	2.36	7.17	8.71
Crude fiber, %	1.74	1.72	5.28	5.62
Ash, %	1.29	1.31	4.24	4.23
ADF, %	2.8	2.4	21.2	10.9
NDF, %	4.3	5.5	27.4	26.7
AA, %				
Cys	0.13	0.14	0.44	0.43
Ile	0.28	0.22	1.04	0.88
Leu	0.95	0.76	2.94	2.65
Lys	0.21	0.22	0.73	0.86
Met	0.12	0.13	0.39	0.47
Thr	0.24	0.22	0.85	0.87
Trp	0.06	0.05	0.15	0.18
Val	0.37	0.32	1.34	1.21

[1]Values represent the mean of 1 composite sample. Diets were prepared using the analyzed values.

[2]Dried distillers grains with solubles.

Table 2. Bulk density of experimental diets (as-fed basis)[1]

Phase[2]	Bulk density, g/L					
	Grain sorghum diet, 0% DDGS	Grain sorghum diet, 15% sorghum DDGS	Grain sorghum diet, 30% sorghum DDGS	Grain sorghum diet, 45% sorghum DDGS	Grain sorghum diet, 30% corn DDGS	Corn diet, 30% corn DDGS
Phase 1	658	596	585	555	595	577
Phase 2	654	631	619	586	606	599
Phase 3	669	637	622	593	608	596

[1]Bulk density represents the weight per unit volume. Diet samples were taken from the feed hoppers during each phase. DDGS = dried distillers grains with solubles.

[2]Phase 1 was d 0 to 28, phase 2 was d 28 to 56, and phase 3 was d 56 to 73.

fed in 3 phases and included grain sorghum–based diets with sorghum DDGS included at 0%, 15%, 30%, or 45%; a grain sorghum–based diet with 30% corn DDGS; and a corn-based diet with 30% corn DDGS (Tables 4, 5, and 6). Pigs and feeders were weighed on d 0, 28, 56, and 73 to calculate ADG, ADFI, and G:F.

At the end of the study (d 73), the heaviest barrow and gilt were selected from every pen and were taken to the Kansas State University Meat Laboratory. Pigs were transported 10 min from the farm to the Meat Laboratory and withheld from feed for 12 h. Approximately 24 h after slaughter, HCW, fat depth, and LM area were measured, and LM color, marbling and firmness, and fat color score (HunterLab Miniscan XE Plus spectrophotometer; model 45/0 LAV, 2.54-cm-diam. aperture, 10° standard observer, Illuminant D65, Hunter Associates Laboratory Inc., Reston, VA) were taken at the 10th rib. Subjective visual loin and fat color scores were also evaluated using the National Pork Producers Council's color and marbling standards (National Pork Producers Council, 2000). Ultimate pH of the LM was analyzed and recorded (glass-tip probe model FC 200; meter model HI 9025, Hanna Instruments, Woonsocket, RI). Percentage purge loss was measured by weighing the whole packaged loin, blotting the loin dry after removing it from the package, then reweighing the dried loin and package. Percentage drip loss was calculated by weighing a 2.54-cm loin chop by placing it in a plastic bag and sealing it following fabrication. The chops were then stored for 24 h at 0°C to 4°C. Following storage, the loin chops were removed from the bag, blotted dry, and reweighed to determine drip loss. Fat samples from the 10th rib, midline of the carcass, were taken (all 3 fat layers) and were analyzed for fatty acid profile, and iodine value (**IV**) was calculated using these values. The back fat IV was calculated using the equation IV = [C16:1] × 0.95 + [C18:1] × 0.86 + [C18:2] × 1.732 + [C18:3] × 2.616 + [C20:1] × 0.785 + [C22:1] × 0.723 (NRC, 2012, Eq. [3] and [4]). The remaining pigs were transported 210 km to a commercial packing plant (Triumph Foods LLC, St. Joseph, MO) for standard carcass data collection

Table 3. Fatty acid analysis of dietary ingredients[1]

Item	Corn	Sorghum	Corn DDGS[2]	Sorghum DDGS[2]
Myristic acid (C14:0), %	0.11	0.07	0.08	0.09
Palmitic acid (C16:0), %	16.30	14.35	15.02	16.82
Palmitoleic acid (C16:1), %	0.63	0.01	0.34	0.57
Margaric acid (C17:0), %	0.16	0.16	0.13	0.13
Stearic acid (C18:0), %	1.71	2.25	2.13	1.84
Oleic acid (C18:1 *cis*-9), %	26.36	22.42	26.25	27.57
Vaccenic acid (C18:1n-7), %	2.10	1.06	1.44	1.99
Linoleic acid (C18:2n-6), %	55.77	47.33	50.86	46.70
α-Linolenic acid (C18:3n-3), %	2.55	1.52	1.91	2.41
Arachidic acid (C20:0), %	0.25	0.63	0.41	0.27
Gadoleic acid (C20:1), %	0.29	0.23	0.26	0.27
Eicosadienoic acid (C20:2), %	0.10	0.10	0.09	0.09
Arachidonic acid (C20:4n-6), %	0.12	0.06	0.06	0.08
Other fatty acids, %	1.98	1.36	1.03	1.17
Total SFA,[3] %	17.94	19.08	18.32	19.69
Total MUFA,[4] %	23.81	29.48	28.34	30.48
Total PUFA,[5] %	57.49	50.19	52.95	49.33
Total *trans* fatty acids,[6] %	1.52	2.55	1.98	2.53
UFA:SFA ratio[7]	4.85	4.18	4.44	4.05
PUFA:SFA ratio[8]	3.20	2.63	2.89	2.51
Iodine value,[9] g/100 g	121	114	118	114

[1]Expressed as a percentage of ether extract.

[2]Dried distillers grains with solubles.

[3]Total SFA = [C8:0] + [C10:0] + [C12:0] + [C14:0] + [C16:0] + [C17:0] + [C18:0] + [C20:0] + [C22:0] + [C24:0]; brackets indicate concentration.

[4]Total MUFA = [C14:1] + [C16:1] + [C18:1 *cis*-9] + [C18:1n-7] + [C20:1] + [C24:1]; brackets indicate concentration.

[5]Total PUFA = [C18:2n-6] + [C18:3n-3] + [C18:3n-6] + [C20:2] + [C20:4n-6]; brackets indicate concentration.

[6]Total *trans* fatty acids = [C18:1 *trans*] + [C18:2 *trans*] + [C18:3 *trans*]; brackets indicate concentration.

[7]UFA:SFA = (total MUFA + total PUFA)/total SFA.

[8]PUFA:SFA = total PUFA/total SFA.

[9]Calculated as iodine value = [C16:1] × 0.95 + [C18:1] × 0.86 + [C18:2] × 1.732 + [C18:3] × 2.616 + [C20:1] × 0.785 + [C22:1] × 0.723; brackets indicate concentration.

Table 4. Phase 1 diet composition (as-fed basis)[1]

Item	Grain sorghum diet: 0% DDGS	15% Sorghum DDGS	30% Sorghum DDGS	45% Sorghum DDGS	30% Corn DDGS	Corn diet, 30% corn DDGS
Ingredient, %						
Grain sorghum	76.20	63.10	50.20	36.90	51.05	—
Soybean meal (46.5% CP)	20.85	19.25	17.45	15.85	16.50	17.65
Corn, grain	—	—	—	—	—	49.90
Sorghum DDGS	—	15.00	30.00	45.00	—	—
Corn DDGS	—	—	—	—	30.00	30.00
Monocalcium P (21% P)	0.90	0.55	0.20	—	0.25	0.30
Limestone	0.90	1.03	1.15	1.30	1.20	1.20
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin premix[2]	0.15	0.15	0.15	0.15	0.15	0.15
Trace mineral premix[3]	0.15	0.15	0.15	0.15	0.15	0.15
L-Lysine HCl	0.31	0.31	0.31	0.30	0.31	0.29
DL-Methionine	0.12	0.08	0.04	—	0.01	—
L-Threonine	0.08	0.04	0.01	—	0.02	0.02
Total	100	100	100	100	100	100
Calculated analysis						
Standardized ileal digestible AA, %						
Lys	0.95	0.95	0.95	0.95	0.95	0.95
Ile:Lys	62	68	73	79	68	67
Met:Lys	35	33	31	29	29	30
Met and Cys:Lys	58	58	58	58	58	59
Thr:Lys	60	60	60	64	60	60
Trp:Lys	17.0	17.0	17.0	17.0	17.0	17.0
Val:Lys	70	78	86	93	81	80
Total Lys, %	1.04	1.07	1.10	1.13	1.12	1.12
CP, %	17.3	19.4	21.5	23.7	21.0	20.9
ME, kcal/kg	3,272	3,212	3,153	3,086	3,280	3,318
NE, kcal/kg	2,156	2,121	2,087	2,048	2,172	2,238
Ca, %	0.60	0.59	0.58	0.60	0.58	0.60
P, %	0.56	0.55	0.53	0.56	0.53	0.54
Available P, %	0.27	0.27	0.27	0.31	0.27	0.27

[1]Diets were fed in meal form from d 0 to 28 of the experiment. DDGS = dried distillers grains with solubles.

[2]Vitamin premix provided per kilogram of complete feed: 11,023 IU of vitamin A, 1,377 IU of vitamin D, 44.1 IU of vitamin E, 4.4 mg of vitamin K, 0.04 mg of vitamin B_{12}, 50.0 mg of niacin, 27.6 mg of pantothenic acid, and 8.3 mg of riboflavin.

[3]Trace mineral premix provided per kilogram of complete feed: 16.5 mg of Cu from $CuSO_4$·5H2O, 0.30 mg of I as C2H2(NH2)2·2HI, 165 mg of Fe as FeSO4H2O, 39.7 mg of Mn as MnSO4·H2O, 0.30 mg of Se as Na2SeO3, and 165 mg of Zn as ZnSO4.

and jowl fat IV. Jowl fat IV was calculated using near-infrared spectroscopy (Bruker MPA, Multi-Purpose Analyzer; Bruker Daltonics, Bremen, Germany) using the equation of Cocciardi et al. (2009).

Pigs were withheld from feed 12 h before harvest. Immediately after evisceration, HCW, back fat, and loin depth measurements were obtained for each carcass. Carcass yield was calculated by dividing HCW by live weight obtained from the Kansas State University's farm before loading to the Triumph Foods packing plant. Fat depth and loin depth were measured with an optical probe inserted approximately 7 cm from the dorsal midline between the third and fourth last ribs (counting from the posterior end of the carcass).

Data were analyzed in a completely randomized design with pen as the experimental unit. Analysis of variance was used with the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). Single degrees of freedom contrasts were used to compare 1) the grain sorghum– and corn-based diets with 30% corn DDGS, 2) the grain sorghum diet with 30% sorghum DDGS and the corn-based diet with 30% corn DDGS, and 3) linear and quadratic effects of increasing sorghum DDGS (0%, 15%, 30%, and 45%). Results were considered significant at $P \leq 0.05$ and a trend at $P \leq 0.10$.

RESULTS

Chemical Analysis

As expected, the concentrations of nutrients in grain sorghum DDGS and corn DDGS were

Table 5. Phase 2 diet composition (as-fed basis)[1]

Item	Grain sorghum diet					Corn diet,
	0% DDGS	15% Sorghum DDGS	30% Sorghum DDGS	45% Sorghum DDGS	30% Corn DDGS	30% Corn DDGS
Ingredient, %						
Grain sorghum	79.85	66.80	53.75	40.45	54.80	—
Soybean meal (46.5% CP)	17.30	15.70	14.05	12.30	12.95	13.85
Corn grain	—	—	—	—	—	53.90
Sorghum DDGS	—	15.00	30.00	45.00	—	—
Corn DDGS	—	—	—	—	30.00	30.00
Monocalcium P (21% P)	0.85	0.48	0.10	—	0.15	0.20
Limestone	0.90	1.03	1.15	1.30	1.18	1.15
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin premix[2]	0.15	0.15	0.15	0.15	0.15	0.15
Trace mineral premix[3]	0.15	0.15	0.15	0.15	0.15	0.15
L-lysine HCl	0.29	0.28	0.28	0.28	0.28	0.26
DL-methionine	0.09	0.05	0.01	—	—	—
L-threonine	0.07	0.03	—	—	—	—
Total	100	100	100	100	100	100
Calculated analysis						
Standardized ileal digestible AA, %						
Lys	0.83	0.83	0.83	0.83	0.83	0.83
Ile:Lys	67	70	76	82	70	68
Met:Lys	34	31	29	30	30	32
Met and Cys:Lys	58	58	58	61	60	63
Thr:Lys	60	60	62	66	61	61
Trp:Lys	17.0	17.0	17.0	17.0	17.0	17.0
Val:Lys	73	81	90	99	85	84
Total Lys, %	0.91	0.94	0.97	1.00	0.99	1.00
CP, %	15.8	17.9	20.1	22.2	19.5	19.4
ME, kcal/kg	3,272	3,212	3,153	3,084	3,283	3,325
NE, kcal/kg	2,166	2,131	2,097	2,057	2,183	2,256
Ca, %	0.58	0.56	0.55	0.59	0.54	0.55
P, %	0.53	0.51	0.50	0.54	0.49	0.50
Available P, %	0.25	0.25	0.25	0.30	0.25	0.25

[1]Diets were fed in meal form from d 28 to 56 of the experiment. DDGS = dried distillers grains with solubles.

[2]Vitamin premix provided per kilogram of complete feed: 11,023 IU of vitamin A, 1,377 IU of vitamin D, 44.1 IU of vitamin E, 4.4 mg of vitamin K, 0.04 mg of vitamin B_{12}, 50.0 mg of niacin, 27.6 mg of pantothenic acid, and 8.3 mg of riboflavin.

[3]Trace mineral premix provided per kilogram of complete feed: 16.5 mg of Cu from CuSO4·5H2O, 0.30 mg of I as C2H2(NH2)2·2HI, 165 mg of Fe as FeSO4H2O, 39.7 mg of Mn as MnSO4·H2O, 0.30 mg of Se as Na2SeO3, and 165 mg of Zn as ZnSO4.

approximately 3 times the concentrations of nutrients in their respective grain sources. Grain sorghum had less palmitic acid (C16:0) than corn, but corn had concentrations of palmitic acid similar to those of corn DDGS or sorghum DDGS. Corn and corn DDGS had similar concentrations of oleic acid (C18:1 *cis*-9), but grain sorghum had lower concentrations of oleic acid than sorghum DDGS. As expected, the corn and corn DDGS had greater concentrations of linoleic acid (C18:2n-6) and PUFA but lower SFA, MUFA, and *trans* fatty acid concentrations than grain sorghum and sorghum DDGS (Table 3). These differences in fatty acid composition resulted in the corn and corn DDGS having greater IV than the grain sorghum and sorghum DDGS. As the amount of dietary DDGS increased, bulk density of the diet decreased (Table 2).

Growth Performance

Overall (d 0 to 73), increasing sorghum DDGS (0%, 15%, 30%, or 45%) resulted in decreased (linear, $P < 0.04$) ADG, ADFI, and final BW with no change in G:F (Table 7). Growth performance of pigs fed the corn- and grain sorghum–based diets with 30% corn DDGS was similar, as was the performance of pigs fed the grain sorghum–based diets with either 30% sorghum or corn DDGS.

Carcass Characteristics

Carcass data for pigs taken to the commercial packing plant (Triumph Foods) showed that sorghum DDGS decreased (linear, $P < 0.01$) back fat depth but had no effect on loin depth, resulting in increased (linear, $P < 0.01$) fat-free lean index (**FFLI**; Table 7). Hot carcass

Table 6. Phase 3 diet composition (as-fed basis)[1]

Item	Grain sorghum diet: 0% DDGS	15% Sorghum DDGS	30% Sorghum DDGS	45% Sorghum DDGS	30% Corn DDGS	Corn diet, 30% corn DDGS
Ingredient, %						
Grain sorghum	83.35	70.30	57.25	43.80	58.20	—
Soybean meal (46.5% CP)	13.55	11.90	10.25	8..55	9.20	10.10
Corn grain	—	—	—	—	—	57.30
Sorghum DDGS	—	15.00	30.00	45.00	—	—
Corn DDGS	—	—	—	—	30.00	30.00
Monocalcium P (21% P)	0.75	0.40	0.05	—	0.10	0.15
Limestone	0.88	1.00	1.13	1.30	1.18	1.15
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin premix[2]	0.13	0.13	0.13	0.13	0.13	0.13
Trace mineral premix[3]	0.13	0.13	0.13	0.13	0.13	0.13
L-lysine HCl	0.26	0.25	0.25	0.25	0.26	0.23
DL-methionine	0.07	0.03	—	—	—	—
L-threonine	0.06	0.02	0.02	0.01	—	—
Chromic oxide	0.50	0.50	0.50	0.50	0.50	0.50
Total	100	100	100	100	100	100
Calculated analysis						
Standardized ileal digestible AA, %						
Lys	0.71	0.71	0.71	0.71	0.71	0.71
Ile:Lys	65	73	80	87	73	71
Met:Lys	33	31	30	33	33	34
Met & Cys:Lys	58	58	60	66	65	68
Thr:Lys	62	62	67	70	63	63
Trp:Lys	17.0	17.0	17.0	17.0	17.0	17.0
Val:Lys	76	86	96	106	90	89
Total Lys, %	0.78	0.81	0.84	0.87	0.86	0.87
CP, %	14.3	16.4	18.6	20.7	18	17.9
ME, kcal/kg	3,258	3,199	3,139	3,069	3,267	3,311
NE, kcal/kg	2,166	2,131	2,097	2,055	2,183	2,260
Ca, %	0.54	0.53	0.52	0.58	0.52	0.53
P, %	0.49	0.48	0.47	0.52	0.47	0.47
Available P, %	0.23	0.23	0.23	0.30	0.23	0.23

[1]Diets were fed in meal form from d 56 to 73 of the experiment. DDGS = dried distillers grains with solubles.

[2]Vitamin premix provided per kilogram of complete feed: 11,023 IU of vitamin A, 1,377 IU of vitamin D, 44.1 IU of vitamin E, 4.4 mg of vitamin K, 0.04 mg of vitamin B_{12}, 50.0 mg of niacin, 27.6 mg of pantothenic acid, and 8.3 mg of riboflavin.

[3]Trace mineral premix provided per kilogram of complete feed: 16.5 mg of Cu from CuSO4·5H2O, 0.30 mg of I as C2H2(NH2)2·2HI, 165 mg of Fe as FeSO4H2O, 39.7 mg of Mn as MnSO4·H2O, 0.30 mg of Se as Na2SeO3, and 165 mg of Zn as ZnSO4.

weight decreased (linear, $P < 0.04$) with increasing sorghum DDGS inclusion, but carcass yield was similar among treatments. Jowl IV increased (linear, $P < 0.01$) with increasing sorghum DDGS. In pigs fed the corn-based diet with 30% corn DDGS inclusion, jowl IV was greater ($P < 0.01$) than in those fed the grain sorghum–based diet with 30% corn DDGS. Pigs fed grain sorghum–based diets with 30% sorghum DDGS had decreased ($P < 0.04$) jowl fat IV compared with pigs fed the grain sorghum–based diets with 30% corn DDGS or pigs fed the corn-based diet with 30% corn DDGS.

Carcass data for pigs slaughtered at the Kansas State University Meat Laboratory showed that increasing sorghum DDGS inclusion had no effect on HCW, carcass yield, purge loss, or drip loss; however, pH tended ($P < 0.06$) to increase with increasing DDGS inclusion (Table 8). Increasing sorghum DDGS inclusion had no effect on back fat thickness or 10th-rib LM, color, firmness, or marbling. Increasing sorghum DDGS decreased 10th LM a* (linear, $P < 0.03$) and tended to decrease b* (linear, $P < 0.06$). For back fat samples collected at the 10th rib, a* decreased (linear, $P < 0.01$) and b* tended to increase (linear, $P < 0.06$) as sorghum DDGS increased. Surprisingly, pigs fed the corn-based diet with 30% corn DDGS inclusion had a decreased b* ($P < 0.03$) compared with pigs fed the grain sorghum–based diet with 30% sorghum DDGS.

Carcass measurements such as HCW, 10th-rib fat depth, and LM area did not differ among pigs fed grain sorghum– and corn-based diets with 30% corn DDGS

Table 7. Effects of feeding sorghum dried distillers grains with solubles (DDGS) on finishing pig growth performance and carcass characteristics[1]

	Treatment[2]							Probability, $P <$				
Item	A	B	C	D	E	F	SED	Linear DDGS[3]	Quadratic DDGS[3]	Grain source[4]	DDGS source[5]	Trt C vs. Trt F[6]
Initial BW, kg	58.7	58.7	58.9	58.8	58.7	58.8	3.38	0.94	0.96	0.94	0.91	0.98
d 0 to 73												
ADG, kg	1.05	1.02	0.99	0.99	1.02	1.02	0.02	0.01	0.53	0.88	0.19	0.88
ADFI, kg	3.18	3.13	3.05	3.08	3.06	3.04	0.07	0.04	0.40	0.77	0.89	0.99
G:F	0.329	0.325	0.326	0.322	0.335	0.336	0.01	0.26	0.92	0.89	0.15	0.88
Final BW, kg	134.6	132.6	130.4	129.5	133.3	132.4	5.64	0.04	0.74	0.73	0.26	0.43
Carcass characteristics[7]												
Jowl iodine value	69.6	71.2	72.1	74.5	73.8	75.2	0.93	0.01	0.40	0.10	0.04	0.01
10th-rib back fat,[8] mm	26.2	24.1	23.4	22.8	23.2	22.6	0.98	0.01	0.23	0.54	0.81	0.35
10th-rib loin depth, cm[8]	5.9	5.9	5.8	5.8	5.9	6.0	0.22	0.44	0.84	0.90	0.39	0.29
FFLI, %[8,9]	48.8	49.5	49.8	50.0	49.9	50.1	0.38	0.01	0.22	0.54	0.82	0.36
HCW, kg	96.9	94.4	93.5	91.5	94.3	94.4	2.63	0.04	0.86	0.99	0.70	0.67
Carcass yield,[10] %	71.8	71.4	71.6	71.3	71.4	71.4	0.68	0.55	0.88	0.97	0.81	0.77

[1]A total of 288 pigs (Line TR4 × 1050, PIC, Hendersonville, TN) were used in the 73-d trial with 36 pens and 6 replications per diet.

[2]Treatments A–D are grain sorghum–based diets with 0%, 15%, 30%, and 45% sorghum DDGS, respectively. Treatment E is a grain sorghum–based diet with 30% corn DDGS; treatment F is a corn-based diet with 30% corn DDGS.

[3]Contrasts compare only grain sorghum–based diets.

[4]Grain sorghum with 30% corn DDGS vs. corn with 30% corn DDGS (treatment [Trt] E vs. Trt F).

[5]Grain sorghum with 30% sorghum DDGS vs. sorghum with 30% corn DDGS (Trt C vs. Trt E).

[6]Grain sorghum with 30% sorghum DDGS vs. corn with 30% corn DDGS (Trt C vs. Trt F).

[7]Values are the means of 6 pigs per pen and 6 pens per treatment collected at the Triumph Foods LLC packing plant (St. Joseph, MO).

[8]Carcass characteristics adjusted using HCW as a covariate.

[9]Fat-free lean index; FFLI = 50.767+ (0.035 × HCW, kg) − (8.979 × back fat, mm).

[10]Yield percentage was calculated by dividing HCW by live weight before transport to the packing plant (Triumph Foods, LLC., St Joseph, MO).

or in pigs fed grain sorghum–based diets with either corn or sorghum DDGS. Pigs fed the grain sorghum diet with 30% corn DDGS had 10th-rib LM area that tended ($P < 0.08$) to be firmer and to have more marbling than those fed the corn diet with 30% corn DDGS.

Pigs fed grain sorghum with 30% sorghum DDGS had fat color with a greater L* (more white) and lower b* ($P < 0.03$) than pigs fed grain sorghum with 30% corn DDGS. Pigs fed the corn-based diet with 30% corn DDGS had fat color with a decreased b* ($P < 0.01$) and tended to have decreased a* ($P < 0.08$) compared with pigs fed the grain sorghum–based diet with 30% corn DDGS; however, no differences were observed for fat color among pigs fed the grain sorghum–based diet with 30% sorghum DDGS compared with those fed the corn-based diet with 30% corn DDGS.

Carcass Fatty Acid Composition

Increasing sorghum DDGS reduced (linear, $P < 0.01$) palmitic (C16:0), stearic (C18:0), and oleic (C18:1 *cis*-9) fatty acids in back fat (Table 9). On the other hand, linoleic (C18:2n-6) and linolenic (C18:3n-3) concentrations increased (linear, $P < 0.01$). As a result, SFA and MUFA decreased (linear, $P < 0.01$), and PUFA and back fat IV increased (linear, $P < 0.01$) with increasing sorghum DDGS.

Pigs fed the corn-based diet with 30% corn DDGS inclusion had greater ($P < 0.05$) concentrations of C18:1 *cis*-9 and MUFA than pigs fed the grain sorghum–based diet with 30% corn DDGS (Table 9). Pigs fed the corn-based diet with 30% corn DDGS inclusion had decreased ($P < 0.03$) concentrations of C14:0, C16:0, C18:3n-3, and total *trans* fatty acids compared with pigs fed the grain sorghum–based diet with 30% sorghum DDGS inclusion. Pigs fed the grain sorghum diet with corn DDGS inclusion had greater concentrations ($P < 0.01$) of C18:1 *cis*-9, C18:1n-7, and MUFA, whereas pigs fed diets with sorghum DDGS had greater concentrations ($P < 0.01$) of C18:2n-6, C20:2, and PUFA than pigs fed diets with corn DDGS.

Increasing sorghum DDGS increased (linear, $P < 0.01$) jowl IV. A tendency ($P < 0.10$) for higher jowl IV was observed in pigs fed the corn-based diet with 30% corn DDGS inclusion when compared with those fed the grain sorghum–based diet with 30% corn DDGS inclusion. Furthermore, pigs fed the grain sorghum–based diet with 30% sorghum DDGS inclusion had decreased ($P < 0.01$) jowl IV compared with pigs fed the grain sorghum– or corn-based diet with 30% corn DDGS inclusion.

Table 8. Effect of feeding sorghum dried distiller's grains with solubles (DDGS) on finishing pig carcass measurements[1]

Item	Treatment[2] A	B	C	D	E	F	SED	Probability, $P <$ Linear DDGS[3]	Quadratic DDGS[3]	Grain source[4]	DDGS source[5]	Trt C vs. Trt F[6]
Carcass measurements[7]												
Live wt, kg	135.1	136.5	133.7	137.8	135.6	137.1	4.07	0.68	0.64	0.73	0.65	0.42
HCW, kg	101.8	102.2	99.9	101.7	101.0	100.2	2.46	0.74	0.68	0.74	0.65	0.91
Carcass yield, %	74.05	74.45	74.74	74.29	73.78	74.61	0.58	0.87	0.62	0.18	0.81	0.83
Purge loss, %	4.14	3.84	4.07	4.54	4.52	4.77	0.82	0.58	0.51	0.76	0.59	0.40
Drip loss, %	3.14	3.31	3.24	3.00	2.89	2.92	0.33	0.34	0.62	0.94	0.30	0.33
pH	5.61	5.63	5.65	5.65	5.65	5.65	0.02	0.06	0.39	0.83	0.77	0.94
Back fat												
First rib, mm[2]	43.7	42.2	42.6	40.6	40.6	42.8	1.87	0.14	0.84	0.23	0.28	0.90
10th rib, mm[2]	24.6	27.3	25.8	23.2	25.0	24.0	2.44	0.47	0.14	0.68	0.76	0.47
Last rib, mm[2]	27.7	26.3	25.0	26.9	26.8	25.5	2.30	0.64	0.31	0.57	0.43	0.82
Last lumbar, mm[2]	19.5	21.6	21.0	19.6	20.5	21.4	1.28	0.96	0.06	0.45	0.66	0.15
10th-rib loin characteristics												
Loin muscle area, mm[2]												
Color	2.38	2.08	2.21	2.21	2.04	2.17	0.24	0.62	0.39	0.60	0.49	0.86
Firmness	1.50	1.25	1.50	1.67	1.50	1.08	0.22	0.29	0.19	0.07	1.00	0.07
Marbling	1.25	1.17	1.25	1.21	1.33	1.08	0.14	0.92	0.83	0.08	0.55	0.23
Loin eye color[8]												
L*	59.88	59.91	60.25	59.44	60.18	58.41	1.01	0.76	0.56	0.09	0.94	0.08
a*	10.92	10.84	10.76	10.09	10.69	10.09	0.36	0.03	0.26	0.11	0.84	0.07
b*	16.69	16.52	16.68	15.88	16.45	15.83	0.37	0.06	0.23	0.10	0.53	0.03
Fat color[8]												
L*	84.79	85.40	85.66	85.42	83.93	84.90	0.70	0.34	0.40	0.18	0.02	0.29
a*	3.33	3.40	2.97	2.39	3.24	2.67	0.31	0.01	0.15	0.08	0.40	0.34
b*	11.14	11.05	10.90	10.60	11.55	10.63	0.29	0.06	0.61	0.01	0.03	0.36

[1]Values represent the mean of 6 observations (1 barrow and 1 gilt) per treatment slaughtered at the Kanas State University Meat Laboratory.

[2]Treatments A–D are grain sorghum–based diets with 0%, 15%, 30%, and 45% sorghum DDGS, respectively. Treatment E is a grain sorghum–based diet with 30% corn DDGS; treatment F is a corn-based diet with 30% corn DDGS.

[3]Contrasts compare only grain sorghum–based diets.

[4]Grain sorghum with 30% corn DDGS vs. corn with 30% corn DDGS (treatment [Trt] E vs. Trt F).

[5]Grain sorghum with 30% sorghum DDGS vs. sorghum with 30% corn DDGS (Trt C vs. Trt E).

[6]Grain sorghum with 30% sorghum DDGS vs. corn with 30% corn DDGS (Trt C vs. Trt F).

[7]Carcass characteristics adjusted using HCW as a covariate.

[8]CIE L* is on a scale of 0 to 100 (0 = black; 100 = white); CIE a* is the degree of redness; CIE b* is the degree of yellowness.

DISCUSSION

Grain sorghum has been shown to be a suitable replacement for corn in several experiments (Shelton et al., 2004; Benz et al., 2011b; Sotak et al., 2014). The results of the study herein observed no differences among pigs fed a grain sorghum–based diet with 30% corn DDGS and a corn-based diet with 30% corn DDGS. Stein and Shurson (2009) reviewed several studies evaluating increasing corn DDGS on pig performance and generally found no negative effects up to an inclusion of 30% corn DDGS in the diet. That review would have encompassed research on DDGS before widespread implementation of the oil extraction process. As a result, data in the review would have evaluated growth studies using DDGS likely with greater than 10% oil, which has been shown to have a similar ME as corn (Stein 2007). Therefore, many of the studies observing similar growth performance of pigs fed corn diets and those fed corn DDGS were comparing diets containing similar ME concentrations. This similarity would help explain why numerous studies have not observed a decrease in growth or G:F when adding DDGS to diets, whereas some recent studies with low- to medium-oil DDGS have (Graham et al., 2014a,b).

Diets in this study were not balanced for energy; therefore, as sorghum DDGS increased, ME and, to a greater extent, NE decreased because the sorghum DDGS had lower ME than sorghum grain and the greater fiber content of the sorghum DDGS would likely increase its heat increment. Therefore, with an inclusion rate up to 45% of the diet, the linear reduction in ADG in the present study would be expected because of the low energy content in the sorghum

Table 9. Effect of feeding sorghum dried distillers grains with solubles (DDGS) on back fat fatty acid profile[1]

Item	Treatment[2] A	B	C	D	E	F	SED	Probability, $P <$ Linear DDGS[3]	Quadratic DDGS[3]	Grain source[4]	DDGS source[5]	Trt C vs. Trt F[6]
Myristic acid (C14:0), %	1.45	1.41	1.37	1.31	1.34	1.28	0.04	0.01	0.81	0.12	0.45	0.03
Palmitic acid (C16:0), %	25.17	24.83	23.87	22.77	23.22	22.90	0.42	0.01	0.22	0.45	0.14	0.03
Palmitoleic acid (C16:1), %	2.33	2.26	1.96	1.93	1.87	1.84	0.11	0.01	0.83	0.76	0.43	0.27
Margaric acid (C17:0), %	0.50	0.48	0.56	0.54	0.58	0.49	0.04	0.14	0.99	0.04	0.61	0.12
Stearic acid (C18:0), %	13.51	13.11	12.68	11.67	12.21	12.08	0.50	0.01	0.40	0.80	0.35	0.24
Oleic acid (C18:1 *cis*-9), %	40.68	39.91	38.30	37.53	36.19	37.42	0.53	0.01	1.00	0.03	0.01	0.10
Vaccenic acid (C18:1n-7), %	3.37	3.23	3.00	3.00	2.73	2.76	0.09	0.01	0.28	0.67	0.01	0.01
Linoleic acid (C18:2n-6), %	9.39	10.99	14.24	17.04	17.76	17.20	0.57	0.01	0.24	0.45	0.01	0.01
α-Linolenic acid (C18:3n-3), %	0.56	0.60	0.74	0.84	0.71	0.64	0.73	0.01	0.21	0.10	0.53	0.03
Arachidic acid (C20:0), %	0.27	0.28	0.26	0.24	0.25	0.26	0.04	0.07	0.23	0.76	0.76	1.00
Gadoleic acid (C20:1), %	0.85	0.89	0.82	0.49	0.76	0.81	0.01	0.10	0.22	0.27	0.15	0.74
Eicosadienoic acid (C20:2), %	0.53	0.61	0.73	0.82	0.85	0.88	0.04	0.01	0.81	0.55	0.01	0.01
Arachidonic acid (C20:4n-6), %	0.10	0.11	0.12	0.13	0.11	0.10	0.01	0.01	0.50	0.34	0.46	0.09
Other fatty acids, %	1.29	1.29	1.35	1.69	1.42	1.34	0.06	0.05	0.89	0.23	0.49	0.60
Total SFA,[7] %	41.12	40.32	38.93	36.74	37.82	37.22	0.78	0.01	0.21	0.44	0.16	0.04
Total MUFA,[8] %	47.31	46.39	44.17	43.34	41.63	42.91	0.63	0.01	0.92	0.05	0.01	0.05
Total PUFA,[9] %	10.55	12.24	15.74	18.77	19.38	18.77	0.80	0.01	0.20	0.45	0.01	0.01
Total *trans* fatty acids,[10] %	0.80	0.85	0.99	1.07	0.95	0.87	0.05	0.01	0.68	0.09	0.46	0.02
UFA:SFA ratio[11]	1.41	1.45	1.54	1.69	1.61	1.66	0.05	0.01	0.18	0.46	0.15	0.03
PUFA:SFA ratio[12]	0.26	0.30	0.40	0.51	0.51	0.50	0.03	0.01	0.16	0.73	0.01	0.01
Iodine value, [13] g/100 g	58.66	60.72	64.78	69.23	68.66	68.61	1.23	0.01	0.12	0.93	0.01	0.01

[1]All values are on a DM basis taken at the 10th rib and expressed on a percentage of ether extract basis.

[2]Treatments A–D are grain sorghum–based diets with 0%, 15%, 30%, and 45% sorghum DDGS, respectively. Treatment E is a grain sorghum–based diet with 30% corn DDGS; treatment F is a corn-based diet with 30% corn DDGS.

[3]Contrasts compare only grain sorghum–based diets.

[4]Grain sorghum with 30% corn DDGS vs. Corn with 30% corn DDGS (Trt E vs. Trt F).

[5]Grain sorghum with 30% sorghum DDGS vs. sorghum with 30% corn DDGS (Trt C vs. Trt E).

[6]Grain sorghum with 30% sorghum DDGS vs. corn with 30% corn DDGS (Trt C vs. Trt F).

[7]Total SFA = [C8:0] + [C10:0] + [C12:0] + [C14:0] + [C16:0] + [C17:0] + [C18:0] + [C20:0] + [C22:0] + [C24:0]; brackets indicate concentration.

[8]Total MUFA = [C14:1] + [C16:1] + [C18:1 cis-9] + [C18:1n-7] + [C20:1] + [C24:1]; brackets indicate concentration.

[9]Total PUFA = [C18:2n-6] + [C18:3n-3] + [C18:3n-6] + [C20:2] + [C20:4n-6]; brackets indicate concentration.

[10]Total *trans* fatty acids = [C18:1 *trans*] + [C18:2 *trans*] + [C18:3 *trans*]; brackets indicate concentration.

[11]UFA:SFA = (total MUFA + total PUFA)/total SFA.

[12]PUFA:SFA = total PUFA/total SFA.

[13]Calculated as iodine value = [C16:1] × 0.95 + [C18:1] × 0.86 + [C18:2] × 1.732 + [C18:3] × 2.616 + [C20:1] × 0.785 + [C22:1] × 0.723; brackets indicate concentration.

DDGS diets. Graham et al. (2014b) fed finishing pigs diets with increasing corn DDGS with 7.4% oil (similar to the oil content in the sorghum DDGS used in this study) and observed a linear decrease in ADG.

In addition, the decrease in ADG for pigs fed grain sorghum–based diets with increasing sorghum DDGS could also be due to the decrease in bulk density limiting ADFI. Sorghum DDGS typically contains greater ADF and lower NDF than corn DDGS (Sotak et al., 2014). Therefore, the decrease in ADFI and subsequent reduction in ADG also could be due to the linear increase in ADF as well as a reduction in dietary NE in the grain sorghum–based diets.

The oil concentrations of the sorghum and corn DDGS were lower in this experiment compared with oil values reported by Feoli (2008), NRC (2012), and Sotak et al. (2014), but this difference may be the result of increased oil extraction by ethanol plants. Furthermore, the corn DDGS contained more oil than the sorghum DDGS. Graham et al. (2014a) observed oil content of DDGS to be a significant variable in explaining the differences in growth performance of pigs fed low-, medium-, and high-oil DDGS.

The ADF values for the sorghum DDGS and corn DDGS are in agreement with data reported by Urriola et al. (2010) and NRC (2012) but lower than data reported by Spiehs et al. (2002), Urriola et al. (2009), and Sotak et al. (2014). However, NDF values for sorghum and corn DDGS were lower than those in previous research (Urriola et al., 2009, 2010; NRC, 2012;

Sotak et al., 2014). The lower fiber concentrations observed in this study may be driven by differences in the composition of the original grains used to produce ethanol (NRC, 2012).

The addition of higher-fiber ingredients, such as DDGS, to swine diets increases endogenous N losses, decreases transit time in the gut, and decreases apparent total tract digestibility (**ATTD**) of certain nutrients (Urriola and Stein., 2010). It is estimated that the ATTD of fiber in pigs is less than 50% (Urriola et al., 2010), therefore reducing growth performance when higher-fiber ingredients are formulated in swine diets. However, fiber digestibility is related to the age of the pig, with growing pigs fermenting fiber better than young pigs and sows fermenting fiber better than growing pigs (Varel et al., 1988; Dierick et al., 1989; Varel and Yen, 1997). The increase in endogenous N losses is caused by greater secretions and less reabsorption in the pig's intestinal tract (Schulze et al., 1994), which may be caused by the fiber's "scratch factor." When higher-fiber ingredients, such as DDGS, are fed, the reduction in transit time of digesta through the digestive tract (Bastianelli et al., 1996; Schneeman, 1998; Bindelle et al., 2008) may be caused by increased dietary bulk. This increase in dietary bulk may also decrease feed intake until the pig's intestinal tract adapts to the greater fiber concentration (Kyriazakis and Emmans, 1995; Wilfart et al., 2007).

Feoli (2008) observed pigs fed corn-based diets with 0% or 40% sorghum DDGS had reduced ADG and G:F compared with those fed the basal corn diet. The reduction in ADG in our study agrees with the findings by Feoli (2008), but we did not observe a change in G:F among pigs fed the grain sorghum–based basal diet and pigs fed the grain sorghum–based diet with either 30% corn or sorghum DDGS. Linneen et al. (2008) conducted a study in a commercial research facility to determine the optimal level of corn DDGS on growing and finishing pig performance and carcass characteristics. In the first experiment, Linneen et al. (2008) fed corn-based diets with 0%, 5%, 10%, or 20% DDGS with 6% added choice white grease in all diets. A linear reduction in ADG and ADFI was observed in pigs fed diets containing DDGS, but G:F tended to improve. Additionally, back fat and FFLI tended to decrease as DDGS increased. These growth performance and carcass characteristic results agree with our findings, with the exception that the tendency for improved G:F may have been due to differences in added fat levels between the experiments.

Along with a reduction in growth performance, increasing sorghum DDGS in finishing pig diets worsened fat quality as measured by IV. Because DDGS have a greater concentration of unsaturated fatty acid (**UFA**), the fat IV linearly increases as DDGS increase. Because of the decrease in fat saturation associated with increasing DDGS, several commercial packing plants have placed limits on the maximum fat IV allowed, thereby limiting producers' use of DDGS in swine diets. Xu et al. (2010) conducted a study to evaluate the growth performance, carcass characteristics, and fat quality of grower-finisher pigs fed corn-based diets with increasing DDGS. Pigs were fed corn-based diets with 0%, 10%, 20%, or 30% corn DDGS. Xu et al. (2010) found back fat and jowl IV linearly increased as corn DDGS increased in the corn-based diets, which agrees with the linear increase in back fat and jowl IV found in the present study. Furthermore, we observed a reduction in both jowl and back fat IV in dietary treatments containing sorghum DDGS compared with those containing corn DDGS. The reduction in fat IV was expected because sorghum DDGS have a lower crude fat concentration than corn DDGS and contain less UFA. Our results agree with previous research conducted on the effect of DDGS on carcass fat composition (Benz et al., 2011a). Benz et al. (2010, 2011a) found higher concentrations of UFA in pigs fed diets containing DDGS, causing them to have higher jowl and back fat IV, and they found pigs fed corn-based diets had higher back fat IV than those fed grain sorghum–based diets.

Because a growing percentage of U.S. pork is exported to international markets, sorghum DDGS may have an important role in the future of swine diets because of its ability to produce pork fat that is lighter in color and less yellow. Previous research conducted to determine the effects of diet composition on fat color found no differences when feeding barley or yellow or white corn, but the barley-based diet was found to produce harder fat compared with yellow and white corn–based diets (Lampe et al., 2006). Xu et al. (2010) observed no differences for fat a* for pigs fed increasing corn DDGS, but pigs fed DDGS had darker fat (L*) and increased yellowness (b*) compared with pigs fed the corn-based control diet. Pigs fed increasing sorghum DDGS had back fat that was less red (a*) and yellow (b*); however, no differences were observed for fat lightness (L*). Furthermore, pigs fed diets containing sorghum DDGS had lighter fat (L*) with decreased yellowness (b*) compared with those fed corn DDGS. Positive ramifications of feeding sorghum DDGS could be found in packing plants because of the potential for higher fat quality because of lower IV and lighter fat color.

In conclusion, the economic value of decreased ADG must be evaluated when considering adding sorghum DDGS to finishing pig diets. Because grain sorghum contains less oil than corn, sorghum DDGS will also contains less oil than corn DDGS, which will affect its energy concentration. The decrease in pig growth performance, likely as a result of decreased energy content in sorghum DDGS, will need to be offset by a reduction in diet cost; therefore, its inclusion needs to be evaluated on an income over feed cost basis.

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