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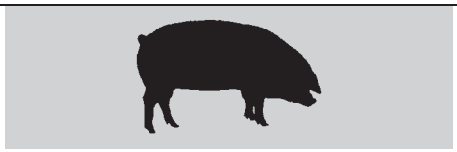

The effects of corn- or sorghum-based diets with or without sorghum dried distillers grains with solubles on lactating-sow and litter performance[1]

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ABSTRACT

A total of 140 sows and their litters were used to determine the effects of corn- or sorghum-based diets without or with 20% sorghum dried distillers grains with solubles (DDGS) on lactating-sow and litter performance. Sows were allotted to 1 of 4 dietary treatments on d 110 of gestation. Weaning age was 21 d. Treatments were arranged in a 2 × 2 factorial with main effects of grain source and sorghum DDGS. Litters were equalized to 13 pigs per treatment. Overall (d 0 to 21), a tendency ($P < 0.08$) for a DDGS × grain source interaction was observed as ADFI increased in corn-based diets when DDGS were added but decreased in sorghum-based diets. Sows fed sorghum-based diets had decreased ($P < 0.04$) lactation BW loss compared with those fed corn-based diets. Litter weaning weights tended to be reduced ($P < 0.06$) for sows fed diets containing DDGS compared with those fed diets without DDGS. Sows fed the sorghum-based diet with 20% sorghum DDGS had the lightest litter weaning weight compared with other treatments. Litter weight gain tended ($P < 0.09$) to decrease when sorghum DDGS were added to corn- or sorghum-based diets. No differences were observed in piglet survivability among all treatments. Overall, feeding sows corn- or sorghum-based diets (without DDGS) in lactation did not affect litter performance; however, the 4% decrease in litter weaning weight of sows fed sorghum with 20% sorghum DDGS needs to be taken into account when selecting ingredients for lactating sows.

Key words: lactation, litter, sorghum, sorghum dried distillers grains with solubles, sow

INTRODUCTION

In the Great Plains region of the United States, sorghum is grown because it is drought tolerant, and therefore, sorghum dried distillers grains with solubles (**DDGS**) are often available to swine producers because of larger acreage of sorghum in the area compared with other grain sources, and its use in ethanol production.

Grain sorghum is a suitable replacement for corn in swine diets and results in similar pig growth performance when formulated in nursery and finishing-pig diets (Shelton et al., 2004; Issa, 2009; Benz et al., 2011). Gestating sow performance is not affected by corn DDGS inclusion rates from 40 to 80% (Thong et al., 1978; Monegue and Cromwell, 1995), and lactating-sow performance is not affected by corn DDGS at an inclusion rate of 30% (Song et al., 2007; Greiner et al., 2008). Louis et al. (1991) observed no differences for lactation weight loss among sows fed corn- or sorghum-based diets; however, a reduction in litter weaning weights was observed for sows fed sorghum-based diets.

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Table 1. Dietary ingredient composition (as-fed basis)

Item, %	Corn	Sorghum	Sorghum DDGS[1]
DM	88.47	88.05	92.53
CP	8.10	8.61	32.05
Crude fat	2.96	2.72	9.23
Crude fiber	1.36	1.31	7.03
Ash	1.40	1.42	4.19

[1]Sorghum DDGS = sorghum dried distillers grains with solubles.

Corn DDGS have greater concentrations of GE than corn; however, energy digestibility is reduced in DDGS because of increased insoluble dietary fiber (Pedersen et al., 2007). Therefore, DDGS and corn have similar DE and ME values when fat content of the DDGS and corn are similar.

Research has been conducted on lactating sows using corn DDGS, but no research has been conducted to determine the feeding value of sorghum DDGS for lactating sows. Therefore, the objective of this study was to determine the effects of corn- or sorghum-based diets without or with 20% sorghum DDGS on lactating-sow and litter performance.

MATERIALS AND METHODS

All practices and procedures used in these experiments were approved by the Kansas State University Institutional Animal Care and Use Committee. This study was conducted at the Kansas State University Swine Teaching and Research Center in Manhattan. The facility is a totally enclosed, environmentally controlled, mechanically ventilated barn. The barn contains 29 farrowing crates (2.13 × 0.46 m for the sow and 2.13 × 0.48 m for the pigs) that are each equipped with a single feeder and nipple waterer.

The sorghum, corn, and sorghum DDGS were analyzed for DM (AOAC 930.15), CP (AOAC 990.03), crude fat (AOAC 920.39), crude fiber (Ankom Method, Ankom Technology, Macedon, NY), and ash (AOAC 942.05) at the Kansas State University Analytical Laboratory (Manhattan, KS). Standard ileal digestibility values for the sorghum DDGS were derived from Urriola et al. (2009). These values were then used in diet formulation (Table 1). The grain sorghum fed in this study was a red-pericarp variety, and the corn grain fed was US #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. Bulk densities (g/L) were measured on the treatment diets (Table 2). When 20% sorghum DDGS were included in the corn- or sorghum-based diets, bulk density of the dietary treatment decreased.

Table 2. Bulk densities of experimental diets by farrowing group (as-fed basis)[1]

Bulk density, g/L	Corn and no DDGS	Corn and 20% sorghum DDGS	Sorghum and no DDGS	Sorghum and 20% sorghum DDGS
Group 1	741	666	781	678
Group 2	688	662	735	669
Group 3	672	620	752	649
Groups 4 and 5	759	666	801	688

[1]Bulk densities represent the mass per unit volume. DDGS = dried distillers grains with solubles.

A total of 140 sows (PIC 1050) and their litters were used. Sows were randomly allotted to 1 of 4 experimental diets throughout 5 farrowing groups using farrowing group as the blocking criteria. There were 7 sows per treatment with 4 treatments per farrowing group. The experiment was conducted with consecutive sow groups farrowing from September through January. During gestation, all sows were fed a corn-based diet with 20% corn DDGS. Feed amounts in gestation were assigned based on sow body condition (Young et al., 2004). Two sows were removed from the study for the sorghum-based diet and 1 sow from the sorghum-based diet with 20% sorghum-DDGS treatments because of feed refusals. An additional 1 and 2 sows were removed from the study for the sorghum and sorghum-DDGS treatments because of illness, respectively.

Treatments were arranged in a 2 × 2 factorial with main effects of grain source (corn vs. sorghum) and sorghum DDGS (0 vs. 20%; Table 3). Sows had ad libitum access to water throughout the study. Sows were switched to their experimental diets on d 110 of gestation, corresponding to their move to the farrowing house. Sows had restricted access to feed from d 110 until farrowing (2 kg). Sows were fed 2.7, 3.6, and 5.4 kg on d 0 of farrowing and subsequent 2 d, respectively. Sows had ad libitum access to feed for the remainder of the lactation period.

Average daily feed intake was determined by measuring total feed disappearance on d 0, 7, 14, and 21 and at weaning. The average age of the piglets was 21 d; however, piglet age ranged from 19 to 23 d of age. Therefore, total feed disappearance was measured on d 21 and at wean-

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

	Grain source			
	Corn		Sorghum	
Item	None	DDGS	None	DDGS
Ingredient, %				
Corn	66.20	51.85	—	—
Sorghum	—	—	67.05	52.80
Soybean meal, 46.5% CP	30.00	24.50	29.10	23.45
Sorghum DDGS	—	20.00	—	20.00
Monocalcium phosphate, 21% P	1.10	0.60	1.05	0.60
Limestone	1.40	1.66	1.44	1.68
Salt	0.50	0.50	0.50	0.50
Vitamin premix[2]	0.25	0.25	0.25	0.25
Trace-mineral premix[3]	0.15	0.15	0.15	0.15
Sow add pack[4]	0.25	0.25	0.25	0.25
Lysine HCl	0.03	0.13	0.08	0.18
Phytase[5]	0.14	0.14	0.14	0.14
Total	100	100	100	100
Calculated analysis				
Standardized ileal digestible amino acids				
Lysine, %	0.97	0.97	0.97	0.97
Isoleucine:lysine	76	79	80	81
Methionine:lysine	29	30	29	30
Met-and-Cys:lysine	60	61	58	59
Threonine:lysine	66	66	66	66
Tryptophan:lysine	22	21	23	22
Valine:lysine	85	90	88	91
Total lysine, %	1.10	1.13	1.08	1.12
CP, %	19.6	21.5	19.8	21.5
ME, kcal/kg	3,278	3,186	3,225	3,144
Ca, %	0.86	0.86	0.86	0.86
P, %	0.62	0.59	0.62	0.59
Available P,[6] %	0.43	0.43	0.43	0.43

[1]Diets were fed in meal form beginning on d 3 before farrowing. 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 $CuSO_4 \cdot 5H_2O$, 0.30 mg of I as $C_2H_2(NH_2)_2 \cdot 2HI$, 165 mg of Fe as $FeSO_4H_2O$, 39.7 mg of Mn as $MnSO_4 \cdot H_2O$, 0.30 mg of Se as Na_2SeO_3, and 165 mg of Zn as $ZnSO_4$.

[4]Sow add pack provided the following nutrients per kilogram of complete diet: 22 IU of vitamin E; 0.22 mg of biotin; 1.65 mg of folic acid; 5 mg of pyridoxine (as pyridoxine HCl); 551 mg of choline (as choline Cl); 50 mg of L-carnitine; and 0.20 mg of chromium (as chromium picolinate).

[5]Natuphos classic (BASF Corp., Florham Park, NJ) provided (per kilogram of complete diet) 300 phytase units of phytase.

[6]Phytase provided 0.08% available P to the diet.

ing. Sow weights were measured as the sows were placed in the farrowing house on d 110 of gestation, within 24 h after farrowing, and at weaning.

After birth, pigs were weighed and processed. Mummified and stillborn pigs were also recorded to calculate total born and live born piglets. Pigs were cross-fostered within 24 h after farrowing to standardize litter size within dietary treatments. Pigs were weighed after fostering to measure fostered litter weight. Litters were weighed at weaning to determine litter weight gain and survivability.

Data were analyzed as a randomized complete block design with sow as the experimental unit and farrowing group as the blocking criteria. The study was analyzed using the MIXED procedure in SAS (SAS Institute Inc., Cary, NC). Single-degree-of-freedom contrasts were used to make comparisons between the (1) interaction of DDGS × grain source, (2) corn- and sorghum-based diets, and (3) effects of 20% sorghum DDGS. Differences among treatments were considered significant at $P \leq 0.05$ and a trend at $0.05 < P \leq 0.10$.

Table 4. The effects of sorghum dried distillers grains with solubles (DDGS) on lactating-sow and litter performance[1,2]

Item	Corn and no DDGS	Corn and 20% sorghum DDGS	Sorghum and no DDGS	Sorghum and 20% sorghum DDGS	SED[3]	Probability, $P <$ DDGS × grain source[4]	Control vs. DDGS[5]	Corn vs. sorghum[6]
Sows, n	35	35	32	32				
ADFI, kg								
d 0 to 7[4]	5.19[a,x]	5.43[a,x]	5.88[b,y]	5.31[a,x]	0.31	0.06	0.44	0.18
d 7 to 14	6.04	6.13	6.44	6.02	0.26	0.17	0.37	0.43
d 14 to weaning	6.11	6.27	6.61	6.36	0.28	0.30	0.81	0.13
d 0 to weaning[4]	5.76	5.93	6.30	5.88	0.24	0.08	0.46	0.15
Sow backfat, mm								
Entry	14.2	14.3	13.9	13.7	0.87	0.80	0.72	0.49
Change	−1.4	−1.3	−1.7	−2.2	0.62	0.39	0.65	0.15
Sow BW, kg								
Postfarrow	248.1	243.8	240.8	244.2	6.59	0.40	0.93	0.46
Weaning	233.8	229.9	229.9	234.5	6.45	0.35	0.93	0.93
Change[6]	−14.3[a]	−13.9[a]	−11.0[b]	−9.7[b]	2.65	0.86	0.65	0.04
Piglets								
Litter size, no.								
Fostered	12.6	13.0	12.6	12.7	0.24	0.69	0.28	0.75
Weaned	11.8	12.1	11.8	11.8	0.29	0.38	0.48	0.58
Piglet BW, kg								
Fostered litter	19.2	20.6	21.4	19.3	1.22	0.23	0.68	0.62
Litter weaning	73.6	73.0	73.4	70.2	2.90	0.53	0.34	0.46
Pig weaning	6.3[y]	6.0[x]	6.3[y]	6.0[x]	0.43	0.74	0.06	0.72
Litter weaning gain	55.4[a]	53.0[a]	54.0[a,x]	48.1[b,y]	3.54	0.47	0.09	0.20
Survivability,[7] %	93.7	93.1	93.7	92.8	1.84	0.11	1.00	0.70

[a,b]Within a row, means without a common superscript differ ($P < 0.05$).

[x,y]Within a row, means without a common superscript tend to differ ($P < 0.10$).

[1]A total of 140 sows (PIC 1050) and their litters were used to determine the effects of sorghum DDGS on lactating-sow and litter performance. There were 2 and 1 sows removed from the sorghum-based basal diet because of feed refusal and illness, respectively. There were 1 and 2 sows removed from the sorghum-based diet with 20% sorghum DDGS because of feed refusal and illness, respectively.

[2]Farrowing group was used as the blocking factor.

[3]SED = SE of the difference.

[4]DDGS × grain source interaction.

[5]Basal diets versus diets with 20% sorghum DDGS.

[6]Corn grain versus sorghum grain.

[7]Survivability was calculated by dividing the weaned litter size by the fostered litter size.

RESULTS AND DISCUSSION

There was a tendency for a DDGS × grain source interaction for ADFI from d 0 to 7 ($P = 0.06$) and overall ($P = 0.08$; Table 4). The decrease in feed consumption the first 7 d of the study observed for sows fed the sorghum-based diet with 20% sorghum DDGS could also be due to the transition from the corn-based diet with 20% corn DDGS to the lactation diet. This result is similar to the report of Wilson et al. (2003) of a decrease in feed intake during the first 7 d when DDGS were not fed during gestation. Sows fed the basal corn diet consumed less feed than those fed the corn diet with 20% sorghum DDGS, but sows fed the basal sorghum diet consumed more feed than those fed the sorghum diet with 20% sorghum DDGS (Table 5). No differences were observed in sow ADFI from d 7 to 14 or d 14 to weaning. For overall (d 0 to 21) ADFI, a tendency ($P < 0.08$) was observed for a DDGS × grain source interaction, with consumption mirroring the trend on d 7. These results are in agreement with research conducted by Louis et al. (1991), who observed a reduction in feed intake for sows fed sorghum-based diets compared with those fed corn-based diets. The crude fiber in the sorghum DDGS was almost double that of the corn DDGS

Table 5. Main effects of grain source and dried distillers grains with solubles (DDGS) on lactating-sow and litter performance[1,2]

	Grain source			DDGS			Probability, *P* <	
Item	Corn	Sorghum	SED[3]	0%	20%	SED	Grain source[4]	0% vs. 20% DDGS[5]
Sows								
ADFI, kg								
d 0 to 7	5.31	5.60	0.21	5.53	5.37	0.21	0.18	0.44
d 7 to 14	6.09	6.23	0.18	6.24	6.08	0.18	0.43	0.37
d 14 to wean	6.19	6.49	0.20	6.36	6.32	0.20	0.13	0.81
d 0 to wean	5.85	6.09	0.17	6.03	5.91	0.17	0.15	0.46
Sow BF, mm								
Entry	14.3	13.8	0.60	14.1	14.0	0.60	0.49	0.72
Change	−1.3	−2.0	0.43	−1.6	−1.8	0.43	0.15	0.65
Sow BW, kg								
Post-farrow	245.9	242.5	4.56	231.8	232.2	4.46	0.46	0.93
Weaning	231.8	232.2	4.46	231.8	232.2	4.46	0.93	0.93
Change[4]	−14.1[a]	−10.4[b]	1.83	−12.6	−11.8	1.83	0.04	0.65
Piglets								
Litter size, n								
Fostered	12.7	12.6	0.17	12.6	12.8	0.17	0.75	0.28
Weaned	11.9	11.8	0.20	11.8	11.9	0.20	0.58	0.48
Piglet BW, kg								
Foster	19.9	20.3	0.84	20.3	20.0	0.84	0.62	0.68
Litter weaning	73.3	71.8	2.01	73.5	71.6	2.01	0.46	0.34
Pig weaning	6.2	6.1	0.14	6.3	6.0	0.14	0.72	0.06
Litter weaning gain[5]	54.2	51.1	2.40	54.7[x]	50.5[y]	2.43	0.20	0.09
Survivability,[6] %	94.3	93.8	1.27	94.1	94.1	1.27	0.70	1.00

[a,b]Within a row, means without a common superscript differ ($P < 0.05$).

[x,y]Within a row, means without a common superscript tend to differ ($P < 0.10$).

[1]A total of 140 sows (PIC 1050) and their litters were used to determine the effects of sorghum DDGS on lactating-sow and litter performance. There were 2 and 1 sows removed from the sorghum-based basal diet because of feed refusal and illness, respectively. There were 1 and 2 sows removed from the sorghum-based diet with 20% sorghum DDGS due to feed refusal and illness, respectively.

[2]Farrowing group was used as the blocking factor.

[3]SED = SE of the difference.

[4]Main effects of corn grain versus sorghum grain.

[5]Main effects of DDGS level (0% vs. 20%).

[6]Survivability was calculated by subtracting the weaned litter size from the fostered litter size.

source. Because the sorghum DDGS had more dietary crude fiber than the corn DDGS, it is likely the sorghum DDGS had greater concentrations of insoluble and soluble dietary fiber. Pedersen et al. (2007) determined corn DDGS had approximately 35% insoluble fiber and 6% soluble dietary fiber. Therefore, the decrease in ADFI observed may be caused by increased fiber present in sorghum-based diets or from a reduction in palatability as sorghum DDGS increased.

No differences were observed among the sows fed corn- or sorghum-based diets with no DDGS compared with those fed corn- or sorghum-based diets with 20% sorghum DDGS for backfat (**BF**) at entry to the farrowing house, postfarrowing weight, sow weaning weight, lactation weight change, or lactation BF change. A decrease ($P < 0.04$) in lactation weight change was observed for sows fed the corn-based basal diet compared with those fed the sorghum-based basal diet. The reduction in lactation weight change for sows fed the corn-based basal diet compared with those fed the sorghum-based basal diet are not in agreement with research reporting no differences in lactation weight change for sows fed corn- or sorghum-based diets (Diggs et al., 1965; Cousins et al., 1981; Louis et al., 1991). Sows fed sorghum-based diets also had a numerical increase ($P = 0.15$) in lactation BF loss compared with those fed corn-based diets. The

increase in BF loss may be due to the greater concentration of dietary crude fiber and a subsequent reduction in energy and increase in gastrointestinal-tract endogenous losses.

No differences in fostered litter size or weaned litter size were observed, nor for pig survivability, among the dietary treatments. Additionally, no differences were observed for litter weaning weight, but a numerical decrease was observed for sows fed 20% sorghum DDGS. A tendency ($P < 0.06$) for a 0.3-kg decrease in individual pig weaning weights was observed for sows fed diets containing 20% sorghum DDGS. Furthermore, a tendency ($P < 0.09$) for decreased litter weaning weight gain was observed for sows fed diets with 20% sorghum DDGS. The litter weaning weight-gain reduction was numerically greater for sows fed the sorghum-based diet with 20% sorghum DDGS compared with those fed the corn-based diet with 20% sorghum DDGS. Previous research reported sows fed a corn-based diet weaned heavier litters than those fed a sorghum-based diet (Louis et al., 1991). The decrease in litter weaning weight observed by Louis et al. (1991) agrees with the results of this study, where although not significant, there was a 6% decrease in litter weaning weight gain from sows fed sorghum-based diets compared with those fed corn-based diets. In addition, there were trends ($P < 0.10$) for reduced pig weaning weight and litter weaning weight gain when sows were fed diets with 20% sorghum DDGS compared with sows fed diets without DDGS.

IMPLICATIONS

Feeding sows corn- versus sorghum-based diets (without DDGS) in lactation did not statistically affect litter performance, but a 6% reduction in litter weight gain in sows fed sorghum-based diets was observed. Furthermore, there was a 4% decrease in litter weaning weight of sows fed sorghum with 20% sorghum DDGS. Overall, these factors need to be taken into account when selecting ingredients for lactating sows.

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