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Effects of corn processing method on performance and carcass characteristics of finishing beef cattle fed diets containing sorghum wet distiller's grains plus solubles

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Introduction

As more grain is used for fuel alcohol production, sorghum wet distiller's grains plus solubles (**SWDGS**) will be increasingly available to feedlots in the High Plains area. Combinations of corn wet distiller's grains plus solubles (**CWDGS**) and dry-rolled corn (**DRC**) have shown positive associative effects in several studies (Erickson and Klopfenstein, 2006), with gain efficiency greater than for DRC-based diets, even when CWDGS was 50% of the dietary dry matter (DM). In contrast, Vasconcelos et al. (2007) reported that with steam-flaked corn (**SFC**)-based diets, adding 5, 10, and 15% of the dietary DM as SWDGS or 10% of the DM as CWDGS decreased ($P < 0.05$) average daily gain (**ADG**) and gain:feed ratio (**G:F**; linear effect of dietary SWDGS concentration). Performance with the 10% CWDGS diet did not differ from the 10% SWDGS diet. Because it is possible that decreasing the degraded intake protein (**DIP**) concentration with increasing SWDGS in these diets limited performance, Vasconcelos et al. (2007) conducted a second experiment in which cattle were fed diets containing 10% (DM basis) SWDGS with increasing concentrations of DIP to restore all or part of the DIP relative to the control (0% SWDGS) diet. Results showed that ADG was less with diets containing SWDGS, and DM intake (**DMI**) decreased linearly with increasing DIP concentration.

Most data available in the literature have evaluated wet distiller's grains in feedlot diets based on DRC. Thus, it could be invalid to compare results from those experiments with the results of Vasconcelos et al (2007), in which SFC-based diets were fed. Because data directly comparing SWDGS in diets based on different types of processed corn are not available, our objective was to determine the effects of corn processing method (DRC vs. SFC) on performance and carcass characteristics of finishing beef cattle fed diets with or without 15% (DM basis) SWDGS.

Experimental Procedures

All procedures used in this experiment followed standard protocols used at the Texas Tech University Burnett Center, and procedures involving animals were approved by the Texas Tech University Animal Care and Use Committee. A brief description of significant procedures follows.

Cattle. On May 24, 2007, 348 steers (primarily British x Continental breeding) were gathered off wheat pasture near Friona, TX, loaded in the morning, and delivered to the Burnett Center, arriving at approximately 1100. The cattle were housed 21 to 22 per Burnett Center soil-surfaced pen, with access (as-fed basis) to approximately 2.5 lb/steer of Sudangrass hay and 10 lb of a 65% concentrate starter

diet. The next day, beginning at approximately 0800, all cattle were taken through the Burnett Center working facilities for initial processing, which included: 1) placement in the ear of a uniquely numbered ear tag; 2) recording of coat color; 3) vaccination with Vista 3 SQ (Intervet, Millsboro, DE) and Vision 7 with SPUR, Intervet); and 4) treatment with Cydectin (Fort Dodge Animal Health, Overland Park, KS). After processing, cattle were returned to soil-surfaced pens. On June 1, all cattle were weighed to obtain a body weight (**BW**) for sorting purposes.

Experimental Design and Treatment and Pen Assignment. The BW data were entered into a spreadsheet and sorted in ascending order. Of the 348 steers available for use in the study, 50 were eliminated because of the presence of horns, bad temperament, and minor leg or hoof injuries. Thereafter, the 7 steers of lightest BW and 3 steers of heaviest BW were eliminated, leaving 288 steers, from which 160 were selected randomly to be used in the experiment, with the remainder used in an unrelated experiment. The 160 steers were blocked on the basis of BW into 10 groups of 16 steers each. On June 2, the cattle were physically sorted into their 10 assigned weight blocks (16 steers/block).

On June 12, the 160 steers were taken by block through the Burnett Center working facilities and implanted with Revalor S (Intervet). After implanting, cattle were sorted into 1 of 4 sorting pens, which represented their assigned Burnett Center pens (concrete, partially slotted floor pens; 9.5 ft wide x 18.33 ft deep). After sorting, cattle in each block were moved to their assigned pens. Finally, on June 18, all cattle were weighed individually in the working facility to start the experiment. Treatments (described in the following section) were assigned randomly to pens within blocks, resulting in a total of 10 pens (40 steers) per treatment.

Treatments. The SWDGS was transported from Portales, NM to the Burnett Center and packed into plastic silage bags for storage during the experiment. The 4 treatments were arranged in a 2 x 2 factorial and consisted of diets based on either DRC or SFC with or without SWDGS: 1) **DRC-0** = DRC-based diet with no added SWDGS; 2) **SFC-0** = SFC-based diet with no added SWDGS; 3) **DRC-15** = DRC-based diet with 15% (DM basis) SWDGS; and 4) **SFC-15** = SFC-based diet with 15% SWDGS. All diets were formulated to contain 14.5% crude protein and equal concentrations of fat (Table 1). Rumensin (30 g/ton), Tylan (10 g/ton), and vitamins and minerals were supplied by a premix that was included as 3.0% of the dietary DM. The SFC was flaked to a bushel weight of 30 lb (387 g/L). The cattle had been gradually adapted to a 90% concentrate diet (similar to the SFC-0 diet, but with approximately 13.5% CP) before the experiment began.

Feeding, Weighing, Routine Management, Feed Sampling, and Carcass Measurements. Feed bunks were evaluated visually each day of the experiment to determine the quantity of feed to offer to each pen. The bunk management approach was designed to allow for 0 to 0.5 lb of feed remaining in the feed bunk at the morning evaluation. After the amount of feed to be provided to each pen was determined, a sufficient quantity of each diet (all ingredients except the SWDGS for diets containing SWDGS) to supply the feed for all the pens on a given treatment was mixed in the feed mill. The mixing order for diets (DRC-0, SFC-0, DRC-15, and SFC-15) was constant throughout the experiment. After

mixing, each diet was conveyed to a tractor-pulled, PTO-driven mixer unit. Because the SWDGS would not flow through the feed mill system, for diets containing SWDGS, the required quantity of SWDGS was added separately to the mixer unit with a front-end loader. The feed for each pen on a given treatment was delivered using the scales on the mixer unit (readability ± 1 lb). Cleanout of the mixer was monitored to ensure that cross-contamination of diets was minimized. Samples of dietary ingredients were taken once every other week (3 times each week for the SWDGS) during the experiment to determine DM content. Samples of mixed feed from the 10 pens/treatment were collected weekly throughout the experiment and composited within weighing periods. Composited feed samples were analyzed for DM, crude protein, acid detergent fiber, ether extract, Ca, P, K, and S by SDK Laboratories, Hutchinson, KS.

Steers were weighed at 35-d intervals. Individual BW measurements (scale readability ± 1 lb; calibrated with 1,000 lb of certified weights before use) were taken in the morning before feeding at the start of the experiment and just before shipment to slaughter. All other weights were pen-based (scale readability ± 5 lb; calibrated with 1,000 lb of certified weights before use). At each weighing day, feed bunks were swept, and any feed remaining in the bunks was weighed and its DM content determined. When approximately 60% of the steers in a weight block were deemed to have sufficient finish to grade USDA Choice (based on BW and visual appraisal of external fat cover), they were sent via commercial transport to the Cargill Meat Solutions slaughter facility at Plainview, TX for collection of carcass data.

Carcass Evaluation. Personnel from the Texas Tech University Meat Laboratory collected carcass data, including longissimus muscle area, marbling score, percentage of kidney, pelvic, and heart fat, and fat thickness at the 12th rib. Yield grade was calculated, and quality grade was determined from marbling score and maturity data.

Statistical Analyses. Performance data from the randomized complete block design were analyzed with pen as the experimental unit. The MIXED procedure of SAS (SAS Inst. Inc., Cary, NC) was used for computations, and the model included the fixed effect of treatment and the random effect of block. Pen means for ADG, daily DMI, and carcass measurements were included in the data file. The ADG was calculated on both a live-weight and carcass-adjusted basis. Final BW for the carcass-adjusted data was calculated from the hot carcass weight divided by the average dressing percent for cattle in all treatment groups. The G:F was computed as the quotient of ADG (live- or carcass-adjusted basis) divided by daily DMI. Carcass quality grade data (% of Choice or greater carcasses in each pen) were analyzed using the GLIMMIX procedure of SAS as a binomial proportion (same model as performance data).

Results

Cattle Performance

Statistical analyses indicated that the interaction between grain processing method and SWDGS inclusion in the diets was not significant ($P \geq 0.20$) for any performance variable. Consequently, only main-effect means were compared (Table 2).

Body Weight. Initial BW did not differ among treatments (average = 876.8 lb). Live- and carcass-adjusted final BW did not differ as a result of grain processing method, but BW was greater for steers fed diets without SWDGS ($P \leq 0.04$) than for those fed the 15% SWDGS diets.

Average Daily Gain. No differences were noted between DRC- and SFC-based diets for either live-basis or carcass-adjusted ADG for the overall feeding period (d 0 to end). Conversely, treatments with 15% SWDGS resulted in lower ADG than those without the coproduct ($P \leq 0.02$).

Dry Matter Intake. As expected, DMI was less with SFC-based diets than for DRC-based diets ($P < 0.01$). Despite lower DMI ($P = 0.03$) for the initial 70 d of the trial by steers fed the 15% SWDGS diets, inclusion of SWDGS in the diets did not affect DMI for the overall feeding period.

Gain Efficiency. Feeding DRC-based and 15% SWDGS diets decreased G:F ($P < 0.01$). The improved efficiency for steers fed SFC-based diets suggests that more starch was available in these diets compared with the DRC-based diets.

Carcass Characteristics

No significant interactions ($P \geq 0.20$) between corn processing method and SWDGS inclusion were noted for any carcass characteristics (Table 3), except for marbling score and % Choice or greater carcasses.

Fat thickness ($P = 0.03$) and yield grade ($P = 0.02$) were greater for steers fed SFC-based diets (Table 3). On the other hand, LM area was greater ($P = 0.08$) in carcasses of steers fed DRC-based diets. Inclusion of 15% SWDGS resulted in lower hot carcass weight ($P = 0.01$) and dressing percent ($P = 0.03$) than noted for the 0% SWDGS diets.

Comparison of the simple effects for marbling score and % Choice or greater carcasses (Table 4) indicated that carcasses from steers fed the SFC-0 diet had a lower marbling score ($P < 0.06$) than carcasses from cattle fed the DRC-0 and SFC-15 diets. Percentage of cattle that graded Choice or greater also was least for steers fed the SFC-0 diet. Reasons for these interactions are not clear.

Conclusions

Inclusion of 15% SWDGS in finishing diets did not result in an interaction with grain processing method for any cattle performance measurement and most carcass characteristics. Steam-flaking corn (30 lb/bushel) resulted in similar ADG to dry-rolling corn; however, DMI was less with diets based on SFC. Consequently, cattle fed SFC-based diets were more efficient than cattle fed DRC-based diets. This finding is consistent with the results of previous studies (Zinn, 1987; Owens et al., 1997), in which steam flaking corn increased the net energy value of the diet by improving starch digestibility.

When SWDGS was included in the diets, DMI was similar to diets with no added SWDGS; however, cattle fed diets without SWDGS had greater ADG and thereby greater G:F than treatments with 15% SWDGS. Similarly, in a previous study in our laboratory, Vasconcelos et al (2007) found that ADG decreased linearly as concentration of SWDGS increased from 0 to 15% in a SFC-based diet. In the present study, addition of SWDGS resulted in lower hot carcass weight than noted with the 0% SWDGS treatment, which also agrees with the findings of Vasconcelos et al. (2007).

We conclude that the response to 15% (DM basis) SWDGS in finishing diets is not affected by dry rolling or steam flaking the corn portion of the diet. Moreover, including 15% SWDGS decreased G:F to approximately the same extent as replacing SFC with DRC.

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Acknowledgments

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Table 1. Composition and analyzed nutrient content (DM basis) of diets based on dry-rolled or steam-flaked corn, with or without sorghum wet distiller's grains plus solubles (SWDGS)[1]

	Corn processing method:	Dry-rolled		Steam-flaked	
Item	SWDGS concentration, %:	0	15	0	15
Ingredient					
Corn		70.31	69.40	70.29	69.39
Sorghum WDGS[2]		-	14.93	-	14.94
Alfalfa hay, ground		2.56	2.56	2.55	2.55
Cottonseed hulls		7.57	7.57	7.58	7.58
Cottonseed meal		8.45	-	8.46	-
Urea		1.05	0.45	1.06	0.45
Fat		3.05	2.02	3.04	2.02
Molasses		3.93	-	3.94	-
Supplement[3,4]		3.08	3.07	3.08	3.07
Analyzed composition					
DM, %		85.74	67.10	82.53	64.63
CP, %		15.19	16.32	14.78	16.39
ADF, %		10.94	13.59	11.06	14.59
EE, %		6.57	6.47	5.70	6.67
Ca, %		0.57	0.56	0.64	0.62
P, %		0.36	0.35	0.33	0.35
K, %,		0.8	0.80	0.80	0.89
S, %		0.21	0.23	0.20	0.24

[1]Corn was either dry rolled or steam flaked (30 lb/bushel), and SWDGS concentration was either 0 or 15% of dietary DM.

[2]The average DM of SWDGS during the experiment was 26.6% (standard deviation = 1.22).

[3]Supplement for the 0% SWDGS diets contained (DM basis): 27.841% cottonseed meal; 0.500% Endox (Kemin Industries, Des Moines, IA); 35.088% limestone; 0.432% dicalcium phosphate; 6.667% potassium chloride; 14.493% MIN-AD (MIN-AD Corp, Amarillo, TX); 3.559% magnesium oxide; 2.778% ammonium sulfate; 10.000% salt; 0.001% cobalt carbonate; 0.131% copper sulfate; 0.056% iron sulfate; 0.002% ethylenediamine dihydroiodide; 0.222% manganese oxide; 0.083% selenium premix (0.2% Se); 0.657% zinc sulfate; 0.007% vitamin A (1,000,000 IU/g); 0.105% vitamin E (500 IU/g); 0.562% Rumensin (176.4 mg/kg; Elanco Animal Health, Indianapolis, IN); and 0.375% Tylan (88.2 mg/kg; Elanco Animal Health). Concentrations in parenthesis are expressed on a 90% DM basis.

[4]Supplement for the SWDGS diets contained (DM basis): 12.984% cottonseed meal; 0.500% Endox; 35.088% limestone; 0.432% dicalcium phosphate; 20.667% potassium chloride; 14.493% MIN-AD; 3.635% urea; 3.559% magnesium oxide; 10.000% salt; 0.001% cobalt carbonate; 0.131% copper sulfate; 0.056% iron sulfate; 0.002% ethylenediamine dihydroiodide; 0.222% manganese oxide; 0.083% selenium premix (0.2% Se); 0.657% zinc sulfate; 0.007% vitamin A (1,000,000 IU/g); 0.105% vitamin E (500 IU/g); 0.562% Rumensin (176.4 mg/kg); and 0.375% Tylan (88.2 mg/kg). Concentrations in parenthesis are expressed on a 90% DM basis.

Table 2. Effects of corn processing method and concentration of sorghum wet distiller's grains plus solubles (SWDGS) on performance by finishing beef steers

	Corn processing method[1]			SWDGS concentration, %[1]			
Item	DRC	SFC	*P*-value[2]	0	15	*P*-value[2]	SE[3]
Initial BW, lb	877.7	875.8	0.64	875.4	878.1	0.51	21.09
Final BW, lb	1,297.4	1,300.8	0.80	1,313.7	1,284.5	0.04	18.66
Adjusted final BW, lb[4]	1,298.1	1,299.9	0.91	1,319.4	1,278.6	0.01	17.90
ADG, lb							
d 0 to 35	4.13	4.23	0.61	4.60	3.76	<0.01	0.125
d 0 to 70	3.83	3.89	0.64	4.11	3.61	<0.01	0.088
d 0 to 105	3.62	3.65	0.81	3.78	3.49	0.02	0.085
d 0 to end[5]	3.44	3.49	0.64	3.59	3.33	0.02	0.079
Adjusted, d 0 to end[4]	3.44	3.48	0.72	3.64	3.28	<0.01	0.081
Daily DMI, lb/steer							
d 0 to 35	19.88	18.67	<0.01	20.34	18.21	<0.01	0.172
d 0 to 70	21.55	20.02	<0.01	21.15	20.42	0.03	0.323
d 0 to 105	21.90	20.60	<0.01	21.40	21.09	0.41	0.399
d 0 to end[5]	22.04	20.54	<0.01	21.38	21.21	0.66	0.394
G:F							
d 0 to 35	0.207	0.225	0.02	0.226	0.207	0.01	0.0051
d 0 to 70	0.177	0.194	<0.01	0.195	0.177	<0.01	0.0027
d 0 to 105	0.165	0.177	<0.01	0.177	0.166	<0.01	0.0022
d 0 to end[5]	0.156	0.170	<0.01	0.168	0.157	<0.01	0.0021
Adjusted, d 0 to end[4]	0.156	0.169	<0.01	0.170	0.155	<0.01	0.0026

[1]Corn was either dry rolled (DRC) or steam flaked (SFC; 30 lb/bushel), and SWDGS concentration was either 0 or 15% of dietary DM. No corn processing method x SWDGS concentration interactions were detected ($P \geq 0.20$).

[2]Observed significance levels for corn processing method or SWDGS concentration main-effect comparisons.

[3]Pooled standard error of main-effect means, n = 20 pens/main-effect mean.

[4]Adjusted final BW equaled hot carcass weight divided by average dressing percent (62.19%). Adjusted gain (d 0 to end) was calculated from the adjusted final BW and the initial BW, and adjusted G:F (d 0 to end) was calculated as the ratio of adjusted ADG to d 0 to end DMI.

[5]Cattle in the blocks through 1 through 4 were on feed for 133 d, whereas cattle in the blocks 4 through 8 were on feed for 112 d, resulting in an average of 122.5 d on feed.

Table 3. Effects of corn processing method and concentration of sorghum wet distiller's grains plus solubles (SWDGS) on carcass characteristics of finishing beef steers

	Corn processing method[1]			SWDGS concentration, %[1]			
Item	DRC	SFC	*P*-value[2]	0	15	*P*-value[2]	SE[3]
Hot carcass weight, lb	807.3	808.4	0.91	820.6	795.2	0.01	11.13
Dressing percent	62.23	62.16	0.77	62.47	61.91	0.03	0.233
LM area[4], sq. in.	12.70	12.29	0.08	12.68	12.31	0.10	0.212
12th rib fat, in.	0.53	0.59	0.03	0.55	0.57	0.36	0.018
KPH, %[4]	3.32	3.37	0.68	3.32	3.37	0.69	0.162
Yield grade	3.69	3.96	0.02	3.79	3.87	0.48	0.106
Marbling score[4,5]	430.5	427.1	0.73	426.5	431.1	0.63	8.04
Choice or greater[5], %	63.75	56.25	0.34	58.75	61.25	0.78	-
Select or less[6], %	36.25	43.75	-	41.25	38.75	-	-
Abscessed livers[7], %	7.50	7.50	0.98	5.00	10.00	0.98	-

[1]Corn was either dry rolled (DRC) or steam flaked (SFC; 30 lb/bushel), and SWDGS concentration was either 0 or 15% of dietary DM. No corn processing method x SWDGS concentration interactions were detected ($P \geq 0.20$), except as noted below for marbling score and quality grade data.

[2]Observed significance levels for corn processing method or SWDGS concentration main-effect comparisons.

[3]Pooled standard error of main-effect means, n = 20 pens/main-effect mean.

[4]LM = longissimus muscle; KPH = kidney, pelvic, and heart fat; Marbling score: 300 = Slight[0]; 400 = Small[0]; 500 = Modest[0].

[5]Corn processing method x SWDGS concentration interaction ($P = 0.04$ for marbling score; $P = 0.06$ for Choice or greater and Select or less).

[6]*P*-values for Select or less are identical to the Choice or greater values.

[7]Sum of A-, A, and A+ liver abscess scores.

Table 4. Simple-effect means for variables that showed a significant ($P \leq 0.06$) corn processing method x sorghum wet distiller's grain plus solubles (SWDGS) interaction[1]

	Corn processing method:	Dry-rolled		Steam-flaked		
Item	SWDGS concentration, %:	0	15	0	15	SE[2]
Marbling score[3]		440.3[a]	420.8[ab]	412.7[b]	441.5[a]	10.56
Choice or greater, %		70.00[a]	57.50[ab]	47.50[b]	65.00[ab]	-
Select or less, %		30.00	42.50	52.50	35.00	-

[1]Corn was either dry rolled (DRC) or steam flaked (SFC; 30 lb/bushel), and SWDGS concentration was either 0 or 15% of dietary DM.

[2]Pooled standard error of simple-effect means, n = 10 pens/simple-effect mean.

[3]Marbling score: 300 = Slight[0]; 400 = Small[0]; 500 = Modest[0].

[a,b]Row means with different superscripts differ, $P < 0.06$.