JOURNAL OF ANIMAL SCIENCE
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J Anim Sci 2010.88:2433-2443.
doi: 10.2527/jas.2009-2487 originally published online Apr 20, 2010;

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http://jas.fass.org/cgi/content/full/88/7/2433

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Corn or sorghum wet distillers grains with solubles in combination with steam-flaked corn: Feedlot cattle performance, carcass characteristics, and apparent total tract digestibility[1]

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ABSTRACT: Two studies were conducted to evaluate the effects of corn (CDG) and sorghum (SDG) wet distillers grains with solubles on feedlot cattle performance, carcass characteristics, and apparent total tract digestion of nutrients. In Exp. 1, 224 steers were used in a randomized complete block design (initial BW 391.1 ± 9.51 kg) and fed steam-flaked corn (SFC)-based diets consisting of (DM basis) 0% distillers grains (CON), 15% SDG, 30% SDG, 15% CDG, 30% CDG, 15% of a 50:50 blend of SDG and CDG, and 30% of a 50:50 blend of CDG and SDG. Decreased carcass-adjusted final BW and HCW ($P \leq 0.05$) were noted as the inclusion amount of distillers grains increased in the diet. Body weight gain efficiency did not differ among the CDG, 50:50 SDG and CDG blend, and CON treatments, but G:F was numerically less with either amount of SDG than for CON, and decreased ($P \leq 0.05$) as distillers grains were increased from 15 to 30%. Cattle fed CON had greater carcass yield grades than those fed the distillers grain diets ($P \leq 0.05$). In Exp. 2, crossbred beef steers (n = 36; initial BW 567.3 ± 53.1 kg) were used in a generalized randomized block design and fed SFC-based diets with 0% distillers grains (CON) and 15% (DM basis) CDG or SDG. Digestibility was determined with a pulse dose of Cr_2O_3. Feeding steers 15% CDG or SDG increased intakes of CP and NDF ($P \leq 0.05$), but intakes of DM, OM, and starch did not differ among treatments ($P \geq 0.07$). Apparent total tract digestibilities of DM, OM, CP, NDF, and starch ($P \geq 0.25$) did not differ among the 3 treatments. Fecal pH averaged over all sampling times was not affected by treatment, nor were average fecal pH values for prefeeding samples (0, 24, 48, and 72 h after the pulse dose) or for samples taken after feeding (12, 36, and 60 h after the pulse dose; $P \geq 0.11$). Results suggest that with 15% distillers grains in the DM, G:F was similar for cattle fed the CDG, 50:50 SDG and CDG blend, and CON diets. Feeding 30 vs. 15% distillers grains decreased G:F, but including 15% CDG or SDG in SFC-based diets did not affect apparent total tract digestibilities in feedlot steers.

Key words: beef cattle, digestibility, distillers grains with solubles, feedlot

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J. Anim. Sci. 2010. 88:2433–2443
doi:10.2527/jas.2009-2487

INTRODUCTION

Expansion of the ethanol industry into the Southern High Plains has prompted research to investigate the value in feedlot diets of wet distillers grains with solubles (**WDG**) derived from corn and sorghum. These coproducts of ethanol production often are economically attractive alternatives for use in beef finishing diets. Depenbusch et al. (2009) evaluated corn and sorghum distillers grains included as 15% in steam-flaked corn (**SFC**)-based diets and observed no differences in ADG, DMI, G:F, or digestion of DM and OM. Al-Suwaiegh et al. (2002) compared corn and sorghum distillers grains included at 30% in finishing dry-rolled corn (**DRC**)-based diets. Cattle fed sorghum distillers grains had less DMI than those fed corn distillers grains, but there were no differences in ADG or G:F. Uwituze et al. (2008) fed dry corn distillers grains with solubles at 25% in SFC-based diets. Apparent total tract digestion of DM, OM, starch, and CP by steers fed distillers grains was decreased compared with control cattle.

[1]Supported in part by funding from a subcontract with Texas AgriLife Research, College Station. The Jessie W. Thornton Chair in Animal Science Endowment at Texas Tech University also provided funding to support this research. We thank DSM Nutritional Products (Belvidere, NJ), Elanco Animal Health (Greenfield, IN), Fort Dodge Animal Health (Overland Park, KS), Intervet/Schering-Plough (Millsboro, DE), and Kemin Industries (Des Moines, IA) for supplying products used in this research. The efforts of K. Robinson and R. Rocha (Texas Tech Univ. Burnett Center) in assisting with the conduct of this research are greatly appreciated.

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Received September 14, 2009.
Accepted March 30, 2010.

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Few direct comparisons of cattle performance with diets containing wet corn (**CDG**) and sorghum (**SDG**) distillers grains with solubles are available in the literature, particularly with diets based on highly processed grain, such as SFC. Moreover, little is known about the feeding value of combinations of CDG and SDG, and estimates of digestibility in diets containing WDG are limited. We hypothesized that including WDG in SFC-based diets would yield comparable feedlot performance with an SFC control, that SDG would have a slightly lesser feeding value than CDG, and that blending SDG with CDG might improve feeding value relative to SDG. Thus, our objective was to evaluate the effects of adding 15 or 30% (DM basis) CDG, SDG, and a 50:50 blend of the 2 (**BDG**) as sources of energy and protein in SFC-based diets on feedlot cattle performance and carcass characteristics, and to assess apparent total tract digestibilities of nutrients in diets containing 15% CDG or SDG.

MATERIALS AND METHODS

All procedures involving live animals were approved by the Texas Tech University Animal Care and Use Committee.

Exp. 1

A randomized complete block design with a 2 × 3 + 1 factorial arrangement of treatments was used. Factors consisted of 2 concentrations of WDG (15 and 30%; DM basis) and 3 sources of WDG [SDG, CDG, and BDG, which was a 50:50 blend (DM basis) of SDG and CDG] compared with a 0% WDG control diet. Thus, the 7 dietary treatments were SFC-based diets containing no WDG (**CON**), and diets containing 15% CDG, 15% SDG, 15% BDG, 30% CDG, 30% SDG, and 30% BDG. All diets used SFC as the basal grain source and were formulated to meet or exceed nutrient requirements specified by NRC (1996). A supplement premix was formulated to provide monensin and tylosin [33 and 11 mg/kg, respectively (DM basis), Elanco Animal Health, Indianapolis, IN]. Diets were formulated to contain equivalent concentrations of ether extract, but the increased CP concentration in WDG compared with other components that it replaced in the diet resulted in greater CP concentrations in diets containing WDG (Table 1).

Beef steers (Angus and Angus crossbred; n = 243 total) were purchased in Missouri and shipped to the Texas Tech University Burnett Center. On arrival in January 2008, cattle were weighed using a C & S Single-Animal Squeeze Chute (Garden City, KS) set on 4 electronic load cells (Rice Lake Weighing Systems, Rice Lake, WI; readability of ±0.45 kg; the chute scale was validated with 454 kg of certified weights before each use). In addition, cattle were vaccinated for clostridial and viral diseases (Vista 3 and Vision 7, Intervet/Schering-Plough Animal Health, Millsboro, DE), given an external parasiticide (Cydectin, Fort Dodge Animal Health, Overland Park, KS), and injected with 10 mg/kg of tilmicosin phosphate (Micotil, Elanco Animal Health). After processing, the steers were housed in soil-surfaced pens and adapted to a 75% concentrate diet. Steers were implanted with Ralgro (36 mg of zeranol, Intervet/Schering-Plough Animal Health) approximately 6 wk after arrival and then fed a quantity of the 75% concentrate diet sufficient to allow for an ADG of 0.9 kg/d for a 50-d period. At the end of this growing period, steers were weighed, and 224 steers were selected for use in the experiment. Selected steers were housed in soil-surfaced pens (4.9 m wide × 30.5 m in length; 4.9 m of bunk space), and feed intake was gradually increased to ad libitum, with the concentrate amount increased to 80%. Steers were stratified by ascending BW and assigned to 8 BW blocks of 28 steers each. Within each block, steers were assigned randomly to 1 of the 7 dietary treatments, which were then assigned randomly to partially slotted-floor pens (4 steers/pen; 2.9 m wide × 5.6 m deep; 2.4 m of linear bunk space). Thus, a total of 56 pens were used, with 8 pens/treatment. Six days before beginning the experiment, steers were implanted with Revalor-S (120 mg of trenbolone acetate and 24 mg of estradiol, Intervet/Schering-Plough Animal Health) and moved to their assigned pens. Cattle were weighed the morning before feeding, on May 8, 2009, to obtain an individual initial BW, after which the experimental diets were fed.

The SDG used in the experiment was obtained from a commercial ethanol plant in Portales, NM, delivered to the Burnett Center, and stored in a plastic silage bag for the duration of the experiment. Several composite samples of the product were collected from each load received during unloading and stored frozen for later analysis. Because the initial SDG product had a greater than expected moisture concentration, an additional supply of SDG was required to complete the experiment. This material was obtained from a commercial ethanol plant located in Levelland, TX, and the product was delivered to the Burnett Center and stored in a commodity barn under plastic tarps. The second source of SDG was fed for the final 28 d of the experiment, at which time the diets were reformulated to account for differences in DM between the new SDG and the previous source. The CDG was acquired from a commercial ethanol plant located in Hereford, TX. Procedures for sampling, compositing, and storing the CDG product were identical to those of the initial source of SDG. Samples of SDG and CDG were taken weekly during the experiment to determine DM content, and portions were stored frozen for nutrient analyses. Other dietary ingredients were sampled every other week during the experiment to determine DM content (forced-air oven for approximately 15 h at 100°C). Samples of feed from the 8 pens/treatment were collected weekly throughout the experiment and composited across cattle weighing periods. Composited feed samples were analyzed

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Table 1. Composition and analyzed nutrient content (DM basis) of the finishing diets fed during the experimental period in Exp. 1

	Treatment[1]						
Item	CON	CDG-15	CDG-30	SDG-15	SDG-30	BDG-15	BDG-30
Ingredient, %							
Steam-flaked corn	72.87	69.21	56.03	69.34	55.91	69.31	55.98
Corn WDG[2]	—	15.02	30.01	—	—	7.51	15.04
Sorghum WDG[2]	—	—	—	14.75	29.58	7.37	14.75
Alfalfa hay, ground	5.13	5.13	5.12	5.15	5.16	5.13	5.14
Cottonseed hulls	5.13	5.13	5.13	5.15	5.16	5.14	5.15
Cottonseed meal	5.50	—	—	—	—	—	—
Urea	0.90	0.51	0.11	0.40	0.10	0.45	0.09
Fat (yellow grease)	3.05	1.41	—	1.66	0.52	1.50	0.24
Molasses	4.01	—	—	—	—	—	—
Limestone	0.90	1.10	1.10	1.05	1.05	1.09	1.10
Min-Ad[3]	0.50	0.49	0.50	0.50	0.50	0.50	0.50
Supplement[4,5]	2.01	2.00	2.00	2.00	2.02	2.00	2.01
Analyzed composition,[6] %							
DM	82.1	67.4	57.0	64.9	53.9	64.8	55.9
CP	12.4	14.0	16.1	13.1	18.4	13.6	16.2
ADF	10.8	11.2	11.9	13.0	15.9	11.4	14.5
Ether extract	5.0	5.3	5.2	4.6	5.4	4.4	4.8
Ca	0.46	0.50	0.49	0.40	0.46	0.41	0.42
P	0.27	0.33	0.39	0.32	0.41	0.41	0.40
K	0.87	0.90	0.83	0.75	0.84	0.70	0.81
S	0.18	0.20	0.26	0.19	0.31	0.19	0.28

[1]CON = standard steam-flaked corn-based diet; CDG-15 = steam-flaked corn-based diet with 15% (DM basis) corn wet distillers grains with solubles (WDG); CDG-30 = steam-flaked corn-based diet with 30% (DM basis) corn WDG; SDG-15 = steam-flaked corn-based diet with 15% (DM basis) sorghum WDG; SDG-30 = steam-flaked corn-based diet with 30% (DM basis) sorghum WDG; BDG-15 = steam-flaked corn-based diet with 15% (DM basis) of a 50:50 (DM basis) blend of corn and sorghum WDG; BDG-30 = steam-flaked corn-based diet with 30% (DM basis) of a 50:50 (DM basis) blend of corn and sorghum WDG.

[2]The average DM of corn WDG (Quality Distillers Grains, Hereford, TX) and sorghum WDG (Abengoa Bioenergy, Portales, NM, and Levelland/Hockley County Ethanol LLC, Levelland, TX) during the experiment was 31.2 and 28.7%, respectively (SD = 1.49 and 0.98%, respectively).

[3]Min-Ad is a commercially available source of calcium-magnesium carbonate (supplied by Min-Ad Inc., Amarillo, TX).

[4]Supplement for the control (CON) diet contained (DM basis) 66.383% cottonseed meal; 0.500% Endox (Kemin Industries, Des Moines, IA); 0.648% dicalcium phosphate; 10% potassium chloride; 4.167% ammonium sulfate; 15.000% salt; 0.002% cobalt carbonate; 0.196% copper sulfate; 0.083% iron sulfate; 0.003% ethylenediamine dihydroiodide; 0.333% manganese oxide; 0.125% selenium premix (0.2% Se); 0.986% zinc sulfate; 0.010% vitamin A (1,000,000 IU/g); 0.157% vitamin E (500 IU/g); 0.844% Rumensin (176.4 mg/kg; Elanco Animal Health, Indianapolis, IN); and 0.563% Tylan (88.2 mg/kg; Elanco Animal Health). Concentrations in parentheses are expressed on a 90% DM basis.

[5]Supplement for the CDG, SDG, and BDG diets was the same as for the CON diet, with the following exceptions (DM basis): 54.790% cottonseed meal; 22% potassium chloride; and 3.760% urea.

[6]Samples were analyzed by SDK Laboratories (Hutchinson, KS).

for DM, S, CP, ADF, ether extract, Ca, and P (SDK Laboratories, Hutchinson, KS). Composite samples of CDG and SDG also were analyzed by the commercial laboratory for the same analyses as the diet samples (Table 2).

Feed Mixing and Feeding, Cattle Weighing, and Routine Management. From 0700 to 0730 h daily, estimates of the approximate quantity of orts remaining in the feed bunk were made for each of the 56 pens of cattle. Bunks were managed in an effort to maintain ≤0.45 kg of residual feed remaining before the next feeding. Diets were mixed in a 1.27-m^3-capacity paddle mixer (Marion Mixers Inc., Marion, IA) and transferred by a drag-chain conveyor to a tractor-pulled mixer/delivery unit (Roto-Mix 84-8, Roto-Mix, Dodge City, KS; scale readability of ±0.454 kg), which was used to deliver feed to each pen. The mixer was checked visually to ensure adequate cleanout and thereby decrease the potential for diet cross-contamination.

Steers were weighed at 35-d intervals during the experiment. Individual nonshrunk BW measurements (scale readability ±0.45 kg) were taken at the beginning of the experiment and immediately before shipment to slaughter. Intermediate BW (d 35 and 70) obtained during the course of the experimental period were collected using a platform scale (scale readability ±2.27 kg) that was validated with 454 kg of certified weights before each use. Before each day on which BW was measured, residual feed was removed from feed bunks and analyzed for DM content, and feed deliveries were adjusted for DM in the orts.

When approximately 60% of the steers in a BW block were deemed to have sufficient external fat cover to grade USDA Choice, they were shipped via commercial transport to a commercial abattoir located in Plainview, TX. There were 4 slaughter dates, which equated to 96, 123, 137, and 165 d on feed for the first, second, third, and fourth groups, respectively.

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Table 2. Analyzed nutrient content (DM basis) of wet distillers grains with solubles (WDG) included in the finishing diets in Exp. 1

	Composited arrival samples[2,3]		Weekly composite samples[2,3]	
Item,[1] %	CDG	SDG	CDG	SDG
CP	33.4	39.0	34.3	41.9
Ether extract	13.1	11.4	12.0	11.1
ADF	14.5	22.4	15.7	25.8
Ca	0.03	0.10	0.07	0.20
P	0.73	0.76	0.70	0.75
K	0.82	0.99	0.71	0.88
S	0.59	0.66	0.59	0.70

[1]Samples were analyzed by SDK Laboratories (Hutchinson, KS).

[2]Composited arrival samples = samples collected during coproduction unloading; weekly composite samples = samples collected weekly throughout the experiment; CDG = corn WDG; SDG = sorghum WDG.

[3]The average DM of corn WDG (Quality Distillers Grains, Hereford, TX) and sorghum WDG (Abengoa Bioenergy, Portales, NM, and Levelland/Hockley County Ethanol LLC, Levelland, TX) during the experiment was 31.2 and 28.7%, respectively (SD = 1.49 and 0.98%, respectively).

Carcass Evaluation. Carcass data included HCW, LM area, KPH, 12th-rib fat thickness, and calculated USDA yield grade (**YG**). Livers were classified as either not condemned or as A−, A, or A+ for the presence of abscesses (Brown et al., 1975). Hot carcass weights and dressing percent data for cattle that were identified as taken out of sequence and noted as having excessive carcass trim were excluded from analysis. After a 48-h chill, the carcasses were evaluated for marbling score, LM area, and USDA quality grade. The HCW was divided by the average dressing percent (62.43%) and multiplied by 0.96 to calculate an adjusted final BW. This value, along with initial BW for the finishing phase and days on feed, was used to calculate adjusted ADG and G:F.

Statistical Analyses. Performance and carcass data were analyzed as a randomized complete block design with a 2 × 3 + 1 factorial arrangement of treatments, with pen as the experimental unit. Data were analyzed using the MIXED procedure (SAS Inst. Inc., Cary, NC). The random effect of block was included in the model, with dietary treatment as a fixed effect. Treatment means were evaluated by preplanned, single-degree-of-freedom orthogonal contrasts. Contrasts were chosen to test whether diets with WDG differed from the CON diet and for differences in source of WDG (CDG vs. the average of SDG and BDG; and SDG vs. BDG), WDG inclusion amount (15 vs. 30%), and WDG source × WDG inclusion amount interactions. Blends of corn and sorghum are becoming increasingly available in the US High Plains; thus, the WDG source contrast was chosen to test whether CDG differed from products that contained increased sorghum (SDG and BDG). Given a significant WDG source contrast, the contrast of SDG vs. BDG is logical to further define the effect of sorghum concentration. The proportions of cattle grading USDA Choice or greater were analyzed as a binomial proportion using the GLIMMIX procedure of SAS, with block as a random effect and the same contrast statements as described previously. The α level was 0.05, and P-values between 0.05 and 0.10 were considered tendencies. Because of space limitations, significance levels in tables are expressed as $P < 0.05$ and $0.05 < P \leq 0.10$; however, observed P-values for contrasts are provided in the text.

Exp. 2

Treatments evaluated were the CON, 15% CDG, and the 15% SDG diets from Exp. 1 (Table 3). Vitamins, minerals, monensin, and tylosin (Elanco Animal Health) were provided by the same loose-meal premix used in Exp. 1. The CDG and SDG (from Portales, NM) used during the experiment were the same as described for Exp. 1.

The cattle (n = 36) used were processed in a manner similar to those in Exp. 1, weighed, stratified by BW, assigned randomly to block, and then housed in 3 soil-surfaced pens (each pen represented 1 of the 3 dietary treatments; 4.9 m wide × 30.5 m in length; 4.9 m of bunk space; 12 steers/pen) before the beginning of the experiment. Thus, 12 steers were in each of the 3 periods (12 replications/treatment). The steers were adapted to the diets for at least 21 d before being moved to individual pens, as described in the subsequent section.

Management, Feeding, and Weighing Procedures. After the 21-d treatment adaptation period noted above, 12 steers (4 selected randomly from each pen) were placed in individual soil-surfaced pens (4.9 m wide × 30.5 m in length; 4.9 m of bunk space), and allowed to adapt to the pen and to individual feeding for 7 d. Cattle were separately housed in soil-surfaced pens so that the feed intake of each animal could be measured. From 0700 to 0730 h daily, estimates of the approximate quantity of unconsumed feed remaining in the feed bunk were made for each steer. Diets (milled as described for Exp. 1) were weighed on a platform scale (90-kg capacity and 0.45-kg readability; Ohaus Corp., Pine Brook, NJ) into buckets (189.3-L), and delivered

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once daily at approximately 0800 h. Once the cattle were consuming feed ad libitum, adjustments to the feed delivery for each pen were made with a target of 0 to 0.45 kg of residual feed in the bunk when it was checked in the morning. When residual feed was present during the collection phase, it was weighed and dried at 105°C for 24 h and subtracted from the feed delivered. After the 7-d adaptation period, the 12 steers were restrained in a hydraulic working chute and received an oral dose (via a balling gun) of a gelatin capsule (Torpac Inc., Fairfield, NJ) that contained Cr_2O_3 (10 g/steer for block 1; 20 g/steer for blocks 2 and 3, respectively) as an indigestible marker to measure fecal output. After dosing, cattle were returned to their assigned pen. Fecal samples were taken every 12 h for the next 3 d, resulting in a total of 6 fecal samples/animal. At collection times, the cattle were moved out of their pen, and if an animal defecated, a fresh sample was collected immediately as it was being moved to the working facility. Otherwise, the steers were restrained in the squeeze chute, and a fecal grab sample was collected by inserting the fingers of a gloved hand into the rectum of the animal and gently palpating the rectum to induce defecation. A portable pH meter (IQ150NP, Hach Co., Loveland, CO) was used to measure fecal pH of each sample immediately after collection. After completion of the fecal sampling period for the first group of steers, a second group of 12 steers was housed individually, and the feeding and collection procedures were repeated as described above, after which the third and final group was sampled in the same manner. On d 0 (time of Cr_2O_3 dosing) for each block, cattle were weighed using the C & S Single-Animal Squeeze Chute to determine their initial BW, which averaged 567.3 ± 53.1 kg.

Laboratory Analyses. Fecal samples from each animal and diet samples were composited within each of the 3 collection periods and oven-dried at 55°C for 2 d. Dried fecal samples and composite diet samples were ground in a Wiley mill (Thomas Scientific, Swedesboro, NJ) to pass a 2-mm screen. Approximately 0.5 ± 0.05 g of ground samples of diet composites and each fecal sample were dried at 105°C for 24 h to determine DM, after which the samples were heated to 600°C for 8 h to determine OM. The method of Williams et al. (1962) was used to analyze Cr in fecal samples. Chromium concentrations in each fecal sample were measured by atomic absorption spectrophotometry with an air-plus-acetylene flame (AA-6300, Shimadzu Corp., Kyoto, Japan).

Fecal composites for each animal were pooled by adding 1.5 ± 0.05 g of each dry, ground fecal sample collected for each animal. Approximately 0.5 ± 0.05 g of the composite fecal sample for each animal and each diet was placed into aluminum boats for N analysis (FP-200, Leco Corporation, St. Joseph, MI) using AOAC official method 992.15 (AOAC, 1995). Determination of NDF was conducted using an Ankom 200 Fiber Analyzer (Ankom Technology, Fairport, NY) according to the procedures of Van Soest et al. (1991; as modified by Ankom Technology). Approximately 0.5 ± 0.05 g of the composite fecal sample for each animal and each diet was placed into individual F57 filter bags (Ankom Technology) and heat sealed. When determining NDF in samples, heat-stable α-amylase (Ankom Technology) was added to fecal samples (dried at 55°C for 2 d) to remove any residual starch in the samples.

For determination of total starch, ground composite fecal and diet samples were dried at 55°C. Samples were analyzed in duplicate by placing approximately 0.20 ± 0.01 g of diet sample or approximately 1.0 ± 0.01 g of fecal sample in a 125-mL Erlenmeyer flask. Deionized water (50 mL) was added, and the flasks were covered with aluminum foil and placed in a boiling water bath

Table 3. Composition and analyzed nutrient content (DM basis) of finishing diets with 15% corn or sorghum wet distillers grains with solubles (WDG) fed to beef cattle during Exp. 2

	Treatment[1]		
Item	CON	CDG-15	SDG-15
Ingredient, %			
Steam-flaked corn	72.99	69.55	69.51
Corn WDG[2]	—	14.62	—
Sorghum WDG[2]	—	—	14.52
Alfalfa hay, ground	5.14	5.15	5.17
Cottonseed hulls	5.20	5.21	5.22
Cottonseed meal	5.45	0.50	—
Urea	0.90	0.50	0.40
Fat (yellow grease)	3.02	1.40	1.65
Molasses	3.92	—	—
Limestone	0.89	1.09	1.04
Min-Ad[3]	0.50	0.46	0.50
Supplement[4]	1.99	1.99	1.99
Analyzed composition, %			
DM	82.0	69.3	63.3
OM	96.0	95.6	95.7
CP	14.3	16.5	16.5
Ether extract	6.9	7.1	6.7
NDF	19.3	24.1	22.8
ADF	9.5	10.3	10.9
Starch	53.5	45.4	46.9

[1]CON = standard steam-flaked corn-based diet; CDG-15 = steam-flaked corn-based diet with 15% (DM basis) corn WDG; SDG-15 = steam-flaked corn-based diet with 15% (DM basis) sorghum WDG.

[2]The average DM of the corn WDG (Quality Distillers Grains, Hereford, TX) and sorghum WDG (Abengoa Bioenergy, Portales, NM) during the experiment was 30.5 and 26.7%, respectively (SD = 1.40 and 1.05%, respectively).

[3]Min-Ad is a commercially available source of calcium-magnesium carbonate (supplied by Min-Ad Inc., Amarillo, TX).

[4]Supplement for the control (CON) diet contained (DM basis) 66.383% cottonseed meal; 0.500% Endox (Kemin Industries, Des Moines, IA); 0.648% dicalcium phosphate; 10% potassium chloride; 4.167% ammonium sulfate; 15.000% salt; 0.002% cobalt carbonate; 0.196% copper sulfate; 0.083% iron sulfate; 0.003% ethylenediamine dihydroiodide; 0.333% manganese oxide; 0.125% selenium premix (0.2% Se); 0.986% zinc sulfate; 0.010% vitamin A (1,000,000 IU/g); 0.157% vitamin E (500 IU/g); 0.844% Rumensin (176.4 mg/kg; Elanco Animal Health, Indianapolis, IN); and 0.563% Tylan (88.2 mg/kg; Elanco Animal Health). Supplement for the CDG-15 and SDG-15 diets was the same as for the CON diet, with the following exceptions (DM basis): 54.790% cottonseed meal; 22% potassium chloride; and 3.760% urea.

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for 90 min to gelatinize the sample. The flasks were cooled to room temperature, and 50 mL of an acetate buffer solution (0.2 *M*; pH 4.5 ± 0.1) and 1 mL of a glucoamylase enzyme (Valley Research, South Bend, IN; 833 glucose activity units/g) solution containing 0.6 g of enzyme/100 mL were added to the flask, after which the flask and contents were covered with aluminum foil to prevent evaporative loss and incubated in a 60°C water bath for 24 h. After removal from the water bath, the contents of the flask were mixed and allowed to settle while the flasks cooled to room temperature. A standard curve was prepared from a glucose stock solution (100 mg of glucose/mL) to provide concentrations of 0, 50, 100, 150, and 200 mg of glucose/100 mL. The glucose concentrations in standards and samples were determined as described by Galyean (1997), taking a 0.1-mL aliquot from each flask and adding 4 mL of an *ortho*-toluidine reagent (Webster et al., 1971) to a 6-mL disposable glass test tube. Tubes were then mixed on a vortex mixer and placed in a 100°C boiling water bath for 15 min, after which the tubes were cooled in tap water for 15 min. The contents were vortexed, and the absorbance was read on a spectrophometer at 630 nm (Beckman DU-50, Beckman Instruments Inc., Irvine CA). Samples of pure corn starch were evaluated in each starch analysis, and recovery in these samples averaged 94.8%.

Calculations. The algebraic method described by Galyean (1993) was used to estimate fecal output by dividing the dose of Cr by the area under the external marker excretion curve. Area under the curve for Cr excretion was calculated by trapezoidal summation, and fecal output per hour was calculated as the total dose of Cr (μg) divided by the area under the curve (μg of Cr/g of fecal DM × h). Apparent total tract digestion of DM, OM, CP, NDF, ADF, and starch were calculated as follows: [(intake of nutrient − fecal output of nutrient)/intake of nutrient] × 100.

Statistical Analyses. Digestibility estimates were analyzed using the MIXED procedure of SAS for a generalized randomized block design. Steer was the experimental unit. The model included the fixed effect of treatment and the random effects of block and block × treatment. Treatment means were separated using the PDIFF option, protected by a significant *F*-test ($P < 0.05$). Means with *P*-values between 0.05 and 0.10 were considered tendencies. Two steers were removed from analysis (1 from block 2, treatment CDG; and 1 from block 3, treatment SDG) because their DMI was more than 2 SD less than the overall mean of the animals used in the study.

RESULTS AND DISCUSSION

Exp. 1

Dietary chemical composition data (Table 1) generally agreed with values expected from formulation. Diets were formulated for equivalent ether extract concentrations; however, the analyzed value for 15% BDG was less than that of the other diets, presumably reflecting sampling variation. Diets were not balanced for CP, and as expected, diets containing 30% WDG were greater in CP than the CON diet. Similarly, ADF concentrations increased in the diets as the percentage of WDG increased, particularly for the SDG diets, with 30% SDG being the greatest, followed by 15% BDG and 15% SDG. These increases also were expected because of the greater ADF content of WDG than of corn grain and the greater ADF content of SDG than of CDG (Table 2). Klopfenstein et al. (2008) stated that when feedlot diets include distillers grains, there is an increase in fiber, protein, and fat and a decrease in starch. Because distillers grains have increased concentrations of CP, replacing a portion of the supplemental CP source(s) in the diet is one way to decrease the overall cost of the diet. In addition, because of the increased moisture content of WDG, it is an effective "conditioning agent," which makes the replacement of molasses or similar liquid products feasible. Nonetheless, because distillers grains contain a much greater percentage of ether extract than the ingredients it replaces, balancing the diets for ether extract is necessary to avoid large differences in ether extract and thereby energy concentrations. Diet formulation was based on chemical composition of samples analyzed during the initial unloading of the WDG product (Table 2). In addition, a composite of WDG samples collected weekly throughout the experiments was analyzed for chemical composition. Arrival samples did not include the SDG from the second plant used during the final 28 d of the experiment; however, the composite of weekly samples would reflect the contribution of this source.

Initial BW (Table 4) did not differ among treatments ($P = 0.44$; Table 4). Final BW and carcass-adjusted final BW did not differ as a result of WDG source ($P = 0.13$); however, BW was greater for CON cattle than those fed WDG ($P = 0.03$). In addition, cattle fed 15% WDG diets had greater final BW and carcass-adjusted final BW than cattle fed 30% WDG diets ($P = 0.04$). Present results for BW data agree with those of Leibovich et al. (2009), who reported greater final BW and carcass-adjusted final BW for control cattle fed an SFC-based diet than for those fed SDG as 15% of the dietary DM. Moreover, Vasconcelos et al. (2007) reported a linear decrease in carcass-adjusted final BW with increasing concentrations of SDG (5, 10, and 15% of dietary DM) in beef cattle finishing diets. In contrast to the present findings, Al-Suwaiegh et al. (2002) reported, in DRC-based diets that were not balanced for ether extract, that cattle fed 30% SDG or CDG had greater final BW than those fed diets without WDG.

Cattle fed the CON diet had greater DMI from d 0 to 35 and from d 0 to 70 ($P = 0.04$ and $P = 0.004$, respectively) than those fed the WDG-based diets. In addition, there was a tendency for cattle fed CON diets to have greater DMI for every cumulative period (d 0 to end; Table 4) than cattle fed the WDG diets ($P =$

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Table 4. Effects of wet distillers grains with solubles (WDG) type and amount on performance by finishing beef steers in Exp. 1

	Treatment[1]								
Item	CON	CDG-15	CDG-30	SDG-15	SDG-30	BDG-15	BDG-30	SEM[2]	Contrast[3]
Initial BW, kg	391	393	391	393	391	390	390	1.4	NS
Final BW,[4] kg	609	600	588	600	587	594	584	6.9	DG*, LV*
Adjusted final BW,[5] kg	613	601	592	599	588	593	577	6.5	DG*, LV*
ADG,[4] kg									
d 0 to 35	2.28	2.21	2.22	2.14	2.06	2.17	2.18	0.064	DG†
d 0 to 70	2.11	1.99	1.88	1.97	1.83	1.86	1.85	0.058	DG*, LV†
d 0 to end[6]	1.54	1.47	1.42	1.48	1.40	1.44	1.40	0.050	DG*
Adjusted,[5] d 0 to end	1.57	1.47	1.45	1.46	1.40	1.43	1.33	0.044	DG*
Daily DMI, kg/steer									
d 0 to 35	8.77	8.54	8.64	8.59	8.23	8.44	8.36	0.132	DG*
d 0 to 70	9.63	8.98	9.11	9.37	9.01	8.88	9.02	0.172	DG*
d 0 to end[6]	9.80	9.20	9.34	9.71	9.51	9.06	9.30	0.211	DG†, BL*
G:F[4]									
d 0 to 35	0.260	0.259	0.256	0.249	0.250	0.258	0.260	0.0053	BL†
d 0 to 70	0.219	0.221	0.207	0.210	0.203	0.210	0.205	0.0040	DG*, GS†, LV*
d 0 to end[6]	0.157	0.160	0.152	0.153	0.148	0.159	0.150	0.0029	LV*, BL†
Adjusted,[5] d 0 to end	0.161	0.161	0.155	0.150	0.148	0.158	0.144	0.0026	DG*, GS*, LV*, BI*
Calculated NE values[7]									
NE_m, Mcal/kg of DM	2.09	2.16	2.08	2.06	2.04	2.15	2.07	0.022	GS*, BL*, LV*
NE_g, Mcal/kg of DM	1.42	1.48	1.42	1.40	1.38	1.48	1.41	0.019	GS*, BL*, LV*

[1]CON = standard steam-flaked corn-based diet; CDG-15 = steam-flaked corn-based diet with 15% (DM basis) corn WDG; CDG-30 = steam-flaked corn-based diet with 30% (DM basis) corn WDG; SDG-15 = steam-flaked corn-based diet with 15% (DM basis) sorghum WDG; SDG-30 = steam-flaked corn-based diet with 30% (DM basis) sorghum WDG; BDG-15 = steam-flaked corn-based diet with 15% (DM basis) of a 50:50 (DM basis) blend of corn and sorghum WDG; BDG-30 = steam-flaked corn-based diet with 30% (DM basis) of a 50:50 (DM basis) blend of corn and sorghum WDG.

[2]Pooled SE of treatment means, n = 8 pens/treatment.

[3]Orthogonal contrasts: DG = control vs. the average of all other diets; GS = the average of the CDG-15 and CDG-30 diets vs. the average of the SDG-15, SDG-30, BDG-15, and BDG-30 diets; BL = the average of the SDG-15 and SDG-30 diets vs. the average of the BDG-15 and BDG-30 diets; LV = the average of the CDG-15, SDG-15, and BDG-15 diets vs. the average of the CDG-30, SDG-30, and BDG-30 diets; BI = the interaction of contrast BL with contrast LV.

[4]The ADG data for d 0 to 35 and d 0 to 70 were not shrunk; however, a 4% shrink was applied to final BW and adjusted final BW for calculation of ADG from d 0 to end and adjusted, d 0 to end. No shrink factor was applied to initial BW data in any calculations.

[5]Adjusted final BW equaled HCW divided by average dressing percent (62.43%). Adjusted BW 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.

[6]Cattle in the blocks through 1 through 3, 4 through 6, 7, and 8 were on feed for 165, 137, 123, and 96 d, respectively, resulting in an average of 140.63 d on feed.

[7]Dietary NE values calculated from performance data using energy requirement equations for maintenance and shrunk BW gain from NRC (1996).

*$P \leq 0.05$; †$0.05 < P \leq 0.10$; NS = $P > 0.10$.

0.06). Cattle fed SDG had greater overall DMI than those fed BDG (d 0 to end; $P = 0.05$). These findings agree with those of Larson et al. (1993), with DRC-based diets, and those of May (2008), with SFC-based diets, in which DMI decreased linearly with increasing SDG. In the current study, diets containing SDG had a greater concentration of ADF and a decreased DM content, which presumably diluted the dietary energy concentration. Thus, the greater DMI observed by cattle fed SDG vs. CDG or BDG diets might have reflected compensation for dilution of the dietary energy concentration in the SDG diets.

There were no significant differences in ADG as a result of WDG source; however, CON cattle had greater ADG throughout the experimental period than those fed diets that contained WDG ($P = 0.05$; Table 4). There was a tendency for cattle fed 15 vs. 30% WDG to have greater ADG from d 0 to 70 ($P = 0.09$), but the difference was not significant over the entire feeding period. Leibovich et al. (2009) and Vasconcelos et al. (2007) also reported decreased ADG with inclusion of 15% SDG compared with cattle fed control diets.

From d 0 to 35 and during the overall feeding period, there was a tendency for cattle fed BDG to have greater G:F than those fed SDG ($P = 0.08$ and $P = 0.09$, respectively; Table 4). Cattle fed the CON diet had greater G:F than the average of those fed WDG diets for d 0 to 70 and for the adjusted d 0 to end periods ($P = 0.03$ and $P = 0.01$, respectively). This response was largely a result of a decreased G:F with the SDG diets and the 30% WDG diets because the 15% CDG and BDG diets had G:F values that were similar to those of the CON diet. There was a tendency for improved G:F with CDG vs. SDG and BDG for d 0 to 70 ($P = 0.06$). Greater G:F also was noted with the 15 vs. 30% WDG diets for the d 0 to 70, d 0 to end, and adjusted d 0 to end periods ($P \leq 0.01$). An interaction was detected ($P = 0.03$) between SDG vs. BDG and WDG amount

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Table 5. Effects of wet distillers grains with solubles (WDG) type and amount on carcass characteristics of finishing beef steers in Exp. 1

	Treatment[1]								
Item	CON	CDG-15	CDG-30	SDG-15	SDG-30	BDG-15	BDG-30	SEM[2]	Contrast[3]
HCW, kg	399	391	385	389	383	385	375	4.2	DG*, LV*
Dressing percent	62.9	62.6	62.9	62.3	62.3	62.3	61.7	0.31	DG†, GS*
LM area, cm^2	82.2	84.1	81.2	84.1	80.4	80.4	80.1	1.41	LV*
12th-rib fat, cm	1.09	0.94	0.84	0.91	0.94	0.91	0.86	0.057	DG*
KPH, %	2.52	2.26	2.32	2.57	2.78	2.61	2.47	0.119	GS*
Yield grade	3.33	2.97	2.99	3.00	3.23	3.15	3.01	0.109	DG*, BI†
Marbling score[4]	418.8	422.9	414.3	415.4	418.7	401.0	414.0	10.94	NS
Choice or greater, %	56.2	56.2	62.5	52.1	59.4	47.9	66.7	9.27	NS
Select or less, %	43.8	43.8	37.5	47.9	40.6	52.1	33.3	9.27	NS
Abscessed livers,[5] %	3.1	9.4	3.1	0.00	6.3	0.00	9.4	—	NS

[1]CON = standard steam-flaked corn-based diet; CDG-15 = steam-flaked corn-based diet with 15% (DM basis) corn WDG; CDG-30 = steam-flaked corn-based diet with 30% (DM basis) corn WDG; SDG-15 = steam-flaked corn-based diet with 15% (DM basis) sorghum WDG; SDG-30 = steam-flaked corn-based diet with 30% (DM basis) sorghum WDG; BDG-15 = steam-flaked corn-based diet with 15% (DM basis) of a 50:50 (DM basis) blend of corn and sorghum WDG; BDG-30 = steam-flaked corn-based diet with 30% (DM basis) of a 50:50 (DM basis) blend of corn and sorghum WDG.

[2]Pooled SE of treatment means; n = 8 pens/treatment.

[3]Orthogonal contrasts: DG = control vs. the average of all other diets; GS = the average of the CDG-15 and CDG-30 diets vs. the average of the SDG-15, SDG-30, BDG-15, and BDG-30 diets; BL = the average of the SDG-15 and SDG-30 diets vs. the average of the BDG-15 and BDG-30 diets; LV = the average of the CDG-15, SDG-15, and BDG-15 diets vs. the average of the CDG-30, SDG-30, and BDG-30 diets; BI = the interaction of contrast BL with contrast LV.

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

[5]Sum of A−, A, and A+ liver abscess scores.

*$P \leq 0.05$; †$0.05 < P \leq 0.10$; NS = $P > 0.10$.

for the carcass-adjusted G:F d 0 to end period, which was characterized by little effect of WDG amount in the SDG diets but by decreased G:F as BDG increased from 15 to 30% of the diet.

The results of the current experiment are similar to those of Vasconcelos et al. (2007) and Leibovich et al. (2009), who reported decreased G:F with 15% inclusion of SDG (DM basis) compared with no SDG. Nonetheless, our findings are not consistent with much of the previous research with WDG, in which the results of several experiments indicated greater G:F with inclusion of WDG in finishing diets (Firkins et al., 1985; Larson et al., 1993; Ham et al., 1994). Contrasting results presumably reflect differences in the type of distillers grains fed (e.g., CDG vs. SDG), differences in the WDG from plant to plant, and the fact that experiments showing positive responses have generally been conducted with diets based on DRC.

Dietary NE values (Table 4) were calculated from performance data using equations from NRC (1996) as described by Vasconcelos and Galyean (2008). Feeding CDG resulted in greater dietary NE_m and NE_g values than feeding SDG and BDG ($P = 0.05$). Moreover, cattle fed BDG diets had greater NE_m and NE_g values than those fed the SDG diets ($P < 0.01$), and feeding 15% WDG resulted in greater calculated NE_m and NE_g concentrations than feeding 30% WDG ($P \leq 0.01$). Using performance data, Al-Suwaiegh et al. (2002), Ham et al. (1994), and Lodge et al. (1997) reported greater NE_g values for distillers grain-based diets than for the control diets without distillers grains.

A decrease in HCW was observed for CON cattle vs. WDG ($P \leq 0.01$; Table 5). Moreover, as WDG was increased from 15 to 30% of the dietary DM, HCW decreased ($P = 0.03$). This result is supported by the findings of Vasconcelos et al. (2007), who reported a linear decrease in HCW as SDG was increased from 0 to 15%. Leibovich et al. (2009) also reported greater HCW for control cattle that were not fed SDG than for cattle fed diets with 15% SDG.

Dressing percent tended to be greater for cattle fed the CON diet than for cattle fed diets containing WDG ($P = 0.09$; Table 5). In addition, feeding CDG vs. SDG or BDG resulted in greater dressing percent and decreased KPH ($P = 0.04$ and $P \leq 0.01$, respectively). Leibovich et al. (2009) noted similar findings and reported that inclusion of 15% SDG decreased dressing percent with both SFC- and DRC-based diets. In the present study, LM area was greater in cattle fed 15 vs. 30% WDG ($P = 0.05$). In contrast, Corrigan et al. (2009) reported no change in LM area or KPH as a result of inclusion of CDG in finishing diets, and Leibovich et al. (2009) also found no effect on LM area from adding 15% SDG to finishing diets.

Cattle fed the CON diet had more 12th-rib fat and a greater calculated YG than those fed any of the WDG diets ($P = 0.01$ and 0.02, respectively; Table 5). There was a tendency for an interaction between the effect of source and amount of WDG for YG ($P = 0.09$; Table 5), in which YG increased as SDG increased from 15 to 30% but decreased with increasing BDG in the diet. Corrigan et al. (2009) reported quadratic effects

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Table 6. Intake and apparent total tract digestibility for feedlot steers fed finishing diets with 15% (DM basis) corn or sorghum wet distillers grains with solubles (WDG)

	Treatment[1]				
Item	CON	CDG-15	SDG-15	SEM[2]	*P*-value[3]
Intake, kg/d					
DM	8.5	8.9	8.5	0.30	0.60
OM	8.2	8.5	8.2	0.29	0.63
CP	1.2[a]	1.5[b]	1.4[b]	0.46	0.02
NDF	1.7[a]	2.1[b]	1.9[b]	0.07	0.01
Starch	4.6[c]	4.0[d]	4.0[d]	0.15	0.07
Apparent total tract digestibility, %					
DM	75.2	72.4	74.7	2.31	0.89
OM	77.9	74.9	77.1	2.10	0.86
CP	66.8	70.1	68.9	2.76	0.92
NDF	34.1	38.0	40.6	5.56	0.93
Starch	98.5	97.1	97.9	0.45	0.25

[a,b]Within a row, means that do not have a common superscript differ, $P < 0.05$.

[c,d]Within a row, means that do not have a common superscript differ, $P < 0.10$.

[1]CON = standard steam-flaked corn-based diet; CDG-15 = steam-flaked corn-based diet with 15% (DM basis) corn WDG; SDG-15 = steam-flaked corn-based diet with 15% (DM basis) sorghum WDG.

[2]Pooled SE of treatment means, n = 11 to 12 steers/treatment.

[3]*P*-value of the *F*-test for treatment.

of CDG on YG, with cattle fed 20 or 30% CDG having greater YG and 12th-rib fat than those fed 0 and 40% CDG. Vasconcelos et al. (2007) reported a linear increase in YG as inclusion of SDG increased. In the present study, the greater YG and 12th-rib fat observed for the CON cattle likely reflects the greater ADG, DMI, final BW, and HCW of these cattle. There were no differences among treatments in the present study for marbling score, percentages of carcasses grading USDA Choice or greater, or incidence of liver abscess ($P \geq 0.14$; Table 5).

Numerous studies have attempted to quantify the feeding value of WDG in finishing beef diets, with variable results. Our results illustrate that WDG can be included at moderate amounts (up to 15%) in SFC-based diets with comparable performance, at least in terms of G:F, to diets without WDG. Previous research has suggested that feed efficiency is improved with inclusion of WDG; however, most previous studies were conducted with diets containing DRC as the basal grain source. With respect to source of WDG, the calculated NE values for BDG diets were greater than the values for SDG diets and were numerically similar to those of the CON and CDG diets. The reason for the improved response by blending CDG and SDG to produce BDG is not clear, but it provides evidence for a positive associative effect that deserves further investigation.

Exp. 2

Feeding steers 15% CDG or SDG compared with CON increased ($P < 0.05$) intakes (Table 6) of CP and NDF. In addition, steers fed 15% CDG or SDG tended ($P < 0.10$) to consume less starch than CON cattle (Table 6). These tendencies for increased intakes of CP and NDF and decreased starch intake reflect the dietary concentrations of these components (Table 3). Intake of DM and OM did not differ among the 3 treatments (*F*-test, $P \geq 0.17$; Table 6).

Apparent total tract digestion of DM, OM, CP, NDF, and starch did not differ among treatments (*F*-test, $P \geq 0.25$; Table 6). The present results are similar to those reported by Depenbusch et al. (2009), May et al. (2009b), and Vander Pol et al. (2009). Depenbusch et al. (2009) measured total tract digestibility in cattle fed corn or sorghum distillers grains (wet and dry) included at 15% in SFC-based diets, and observed no differences in digestibility of DM and OM among treatments. May et al. (2009b) fed diets with 0 or 25% dried distillers grains and observed no differences in apparent total tract digestion of DM, OM, NDF, and starch. Similarly, Vander Pol et al. (2009) reported no differences in apparent total tract digestibility of DM, OM, NDF, and starch between cattle fed a control diet and those fed 40% WDG. The results from Exp. 2 contrast with observations reported by Uwituze et al. (2008) and Corrigan et al. (2009), who observed decreased apparent total tract digestion of DM and OM in diets with distillers grains. The decreased dietary concentration (15%) of CDG and SDG in the current study compared with the greater concentrations of distillers grains (25 and 40%, respectively) used by Uwituze et al. (2008) and Corrigan et al. (2009) may account for the contrasting results.

Mean fecal pH values over sampling times were not affected by treatment (*F*-test, $P = 0.52$; Table 7). Similarly, average fecal pH of samples taken after feeding did not differ among treatments (*F*-test, $P = 0.97$; 12, 36, and 60 h after the pulse dose of marker; Table 7). In contrast, a nonsignificant trend was noted for decreased fecal pH with CDG and SDG diets in fecal pH of samples taken before feeding (*F*-test, $P = 0.105$; 0, 24, 48,

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Table 7. Fecal pH characteristics of feedlot steers finishing diets with 15% (DM basis) corn or sorghum wet distillers grains with solubles (WDG)

	Treatment[1]				
Fecal pH	CON	CDG-15	SDG-15	SEM[2]	*P*-value[3]
Average pH	6.44	6.40	6.33	0.051	0.52
Prefeeding pH[4]	6.43	6.33	6.23	0.054	0.11
Postfeeding pH[5]	6.46	6.49	6.47	0.063	0.97

[1]CON = standard steam-flaked corn-based diet; CDG-15 = steam-flaked corn-based diet with 15% (DM basis) corn WDG; SDG-15 = steam-flaked corn-based diet with 15% (DM basis) sorghum WDG.

[2]Pooled SE of treatment means, n = 11 to 12 steers/treatment.

[3]*P*-value of the *F*-test for treatment.

[4]Prefeeding pH = average of fecal pH samples taken 0, 24, 48, and 72 h after the pulse dose of Cr_2O_3.

[5]Postfeeding pH = average of fecal pH samples taken 12, 36, and 60 h after the pulse dose of Cr_2O_3.

and 72 h after the pulse dose; Table 7). May et al. (2009a) reported that feeding 15% CDG decreased fecal pH in feedlot steers. Differences in collection methods between the 2 studies might be partially responsible for differences in results. Recently, Leupp et al. (2009) found that when concentration of dried distillers grains increased in 70% concentrate diets from 0 to 60% (DM basis), postruminal digestion of OM increased linearly. Perhaps if more fiber escapes ruminal fermentation in WDG diets, a decreased fecal pH could result from greater hindgut fermentation. Further evaluation of the postruminal and ruminal digestion of nutrients, particularly starch and fiber, in diets containing WDG is needed. In a companion study to the present experiment, May et al. (2010) estimated IVDMD of substrates containing 15 or 30% SDG or CDG compared with a control substrate without WDG. Including WDG in the substrate decreased IVDMD, and substrates containing 15% WDG were more digestible than those containing 30%. In addition, substrates containing CDG were more digestible than the SDG substrates. Possibly in vivo ruminal digestion of diets containing WDG is less than in non-WDG diets, with compensatory digestion occurring in the lower small intestine and large intestine.

Digestibility results from Exp. 2 generally support the lack of major differences in G:F and calculated NE values noted in Exp. 1. Nonetheless, not all the treatments in Exp. 1 were represented in Exp. 2, and further research is needed to evaluate the digestibility of diets containing WDG. Given the performance differences noted between SDG and BDG, the effect of BDG on nutrient digestibility would be of particular interest.

Overall, results of Exp. 1 indicate that G:F ratio decreased as WDG inclusion increased from 15 to 30% in the diet (DM basis). Replacing various feed ingredients (e.g., portions of cottonseed meal, urea, SFC, supplemental fat, and all the molasses) in SFC-based diets with 15% WDG (DM basis) resulted in G:F similar to the CON diet. Despite the similar G:F for WDG and CON diets, a decrease was observed for shrunk live BW, carcass-adjusted final BW, and HCW as inclusion of WDG increased in the diet, which reflected the decreased DMI for diets containing WDG compared with the CON diet. Including 15% CDG or SDG in SFC-based diets did not affect apparent total tract digestibility in feedlot steers, but further research is needed to evaluate digestibility of blends of CDG and SDG as well as site and extent of nutrient digestion when WDG is added to finishing diets.

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