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Investigating ruminant digestive characteristics of finishing beef steers fed sorghum wet distillers grains treated with calcium hydroxide[1]

W. W. Gentry,* C. P. Weiss,* F. T. McCollum III,* PAS, B. E. Meyer,† N. A. Cole,† PAS, and J. S. Jennings,*[2] PAS

*Texas A&M AgriLife Research and Extension Service, Amarillo 79106; and †USDA-ARS Conservation and Production Research Laboratory, Bushland, TX 79012

ABSTRACT

Alkali treatment has been used to increase the digestibility of low-quality, fibrous crop residues. However, alkali treatment of the fiber fraction in distillers grains has only briefly been explored. Six ruminally cannulated steers (444 ± 4.0 kg of BW) were used to evaluate the effects of treating sorghum wet distillers grains plus solubles (SWDGS) with calcium hydroxide (CH) in finishing diets. Treatment diets were based on steam-flaked corn and included (1) 30% corn wet distillers grains plus solubles (CDG), (2) 30% SWDGS (SDG), or (3) 30% SWDGS treated with 2.27% CH (SDG-CH). Data were analyzed as a replicated Latin square with 3 dietary treatments and 3 periods using the MIXED procedure of SAS with animal within square as the experimental unit. No differences ($P = 0.47$) in DMI were observed. Steers consuming CDG had the greatest ($P < 0.01$) total ruminal VFA concentration, followed by SDG-CH, with SDG having the least. Steers consuming SDG had the greatest ($P < 0.01$) ruminal pH, followed by SDG-CH and then by CDG. Steers consuming SDG had the greatest ($P < 0.01$) ruminal acetate:propionate ratio, followed by SDG-CH, with CDG having the least. Steers consuming SDG-CH tended ($P = 0.07$) to have a greater apparent total-tract digestibility of NDF. No differences ($P \geq 0.15$) were observed in apparent total-tract digestibility of DM, OM, ADF, starch, or N. Treating SWDGS with CH increased the digestibility of fiber compared with untreated SWDGS in finishing diets.

Key words: calcium hydroxide, digestibility, distillers grains

INTRODUCTION

Ethanol plants in the upper Midwest use primarily corn grain, whereas ethanol plants in the southern Great Plains use both corn and sorghum grain. Sorghum is routinely grown in the southern Great Plains largely because the area receives less annual precipitation and sorghum requires less water than corn (Ahamadou et al., 2012). It is generally accepted that the feeding value of wet distillers grains (**WDG**) produced from the fermentation of sorghum is less than that of WDG produced from the fermentation of corn (Owens, 2008; May et al., 2010; Opheim et al., 2016). Owens (2008) suggested this may be partially due to the lower digestibility of the fiber fraction in sorghum wet distillers grains plus solubles (**SWDGS**) than in corn wet distillers grains plus solubles (**CWDGS**).

Chemical treatment of low-quality forage or crop residues increases DM and OM digestibility, which is the result of breaking hemicellulose and cellulose-lignin bonds in the fiber fraction of the crop residues (Klopfenstein, 1978). Shreck et al. (2015) fed diets based on dry-rolled corn with 40% WDG with solubles and 20% roughage either treated with calcium oxide (5% DM basis) or untreated to finishing beef steers and observed a 9.7 and 12.5% increase in ADG for steers consuming calcium oxide treated wheat straw and corn stover, respectively. The feeding value of SWDGS has the potential to be increased by chemical treatments used for forage. Berger et al. (1981) reported an 11 and 28% increase in the in situ digestibility of whole sorghum grain treated with 3 and 6% sodium hydroxide, respectively. In beef finishing diets, WDG frequently replace grain in the diet. As a result, starch is replaced by fiber, which makes fiber digestibility of WDG critical to its feeding value (MacDonald, 2011). Wet distillers grains are composed primarily of the grain seed coat, which has a lot of hemicellulose content after removal of starch (Berger et al., 1981). This makes WDG a good candidate for alkali treatment to increase fiber digestibility. Therefore, the objectives of this study were to evaluate the effects of treating SWDGS with calcium hydroxide (**CH**) on nutrient digestibility in diets based on steam-flaked corn (**SFC**).

The authors declare no conflict of interest.

[1] The mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the USDA.

[2] Corresponding author: jenny.jennings@ag.tamu.edu

MATERIALS AND METHODS

All procedures involving live animals were approved by the West Texas A&M University-CREET Animal Care and Use Committee (approval # 03–01–14). The live-animal portion of the experiment was conducted from August 8 to October 14, 2014.

Animals and Dietary Treatments

Six ruminally cannulated crossbred steers (444 ± 4.0 kg of BW) were used in a 3 × 3 replicated Latin square design with 21-d periods consisting of a 17-d adaptation period followed by a 4-d collection period. Dry matter composition of the distillers grains (**DG**) used in this study is listed in Table 1. Dietary treatments (Table 2) were SFC-based finishing diets with (1) 30% CWDGS (**CDG**), (2) 30% SWDGS (**SDG**), or (3) 30% SWDGS treated with 2.27% CH (**SDG-CH**). All values are expressed on a DM basis. The CH added to the SWDGS did not supply adequate calcium to meet animal requirements (NRC, 2000); therefore, limestone was added to all diets to satisfy calcium requirements. All WDG fed in this experiment were received in 1 d, and the SWDGS were mixed with the CH the same day it was received. To prepare SDG-CH, SWDGS were loaded into an 2.4-m^3 (84-ft^3) mixer equipped with loadcells (Roto-Mix IV 84–8, Roto-Mix, Dodge City, KS; Digi-Star, Fort Atkinson, WI, readability ±0.45 kg), and CH (CAS # 1305–62–0; Lhoist North America, Fort Worth, TX) was added at the rate of 2.67% (DM basis). The actual treatment rate was 2.27%, calculated from the difference in Ca content of SWDGS and CH-treated SWDGS (Table 1), and that CH contains 54.092% calcium. The CWDGS were stored in a large plastic ag bag (Ag-Bag Systems, St. Nazianz, WI), whereas SWDGS and CH-treated SWDGS were stored in sealed plastic drums with plastic liners and allowed to sit for 7 d before being fed, similar to methods described by Peterson et al. (2015). Diets were offered once daily at 0700 h in a quantity to achieve ad libitum intake. Steers were individually fed in 3.7 × 3.7 m outdoor, shaded concrete surface pens with a 2.4 × 3.7 m rubber mat placed for animal comfort. Pens were equipped with automatic water troughs (WaterMatic 150, Ritchie Industries, Conrad, IA) that were monitored twice daily for adequate operation and cleanliness. Pens were cleaned daily to eliminate manure build-up. Steers remained in the individual pens throughout the entire study. Animals were individually weighed (Trojan Livestock Handling Equipment, Weatherford, OK; Tru-Test Inc., Mineral Wells, TX; readability ±0.45 kg; validated with 454-kg certified weights before each use) at the beginning and end of each 21-d period.

Sampling

Sampling procedures were similar to those outlined by Weiss et al. (2017). Diet and ort samples were collected on d 17 through 21, weighed, and subsampled for nutrient analysis. Fecal output was estimated by dosing steers with a 5-g bolus of chromic oxide twice daily (0700 and 1900 h) via the ruminal cannula on d 13 through 21. Fecal samples were collected at 0600 and 1800 h on d 18 and 20 and at 1200 and 2400 h on d 19 and 21. Fecal samples were wet composited across the entire collection period by animal, and three 250-mL aliquots were collected from the wet composite and frozen at −4°C. Ruminal fluid samples also were collected on the same schedule and strained through 4 layers of cheesecloth, pH was immediately measured using a portable pH meter (VWR Symphony, model H10P, Radnor, PA), and three 50-mL aliquots were retained and frozen at −4°C. Sampling was conducted in this manner so the rumen cannula was only opened twice daily, with 12 h between, to reduce the amount of oxygen that entered the rumen environment and so the ruminal environment could stabilize between each sampling time point.

Diet and ort samples were dried at 55°C for 48 h in a forced-air oven (Despatch model LBB218–1; Despatch Industries, Minneapolis, MN), and fecal aliquots were lyophilized (Labconco, Kansas City, MO). Diet, ort, and fecal samples were ground in a Wiley mill (Model 4, Thomas Scientific, Swedesboro, NJ) to pass a 1-mm screen, and one-third was further ground through a Cyclotec mill (Cyclotec CT 193, Foss, Hoganas, Sweden) to pass through a 0.5-mm screen.

Laboratory Analysis

Laboratory DM of diet, ort, and fecal samples were determined by drying at 100°C for 24 h. Organic matter was determined by ashing samples in a muffle furnace (Thermolyne, model F-A730, Dubuque, IA) at 500°C for 6 h. Starch content of diet, ort, and fecal samples was determined using spectrophotometry (PowerWave-XS Spectrometer, Bio Tek US, Winooski, VT) after converting

Table 1. Dry matter composition and nutrient analysis of distillers grains from corn, sorghum, and calcium hydroxide–treated sorghum

	Source of distillers grains[1]		
Item	**CWDGS**	**SWDGS**	**CH-SWDGS**
DM, %	31.80	31.84	34.38
CP, %	31.08	32.60	32.10
NDF, %	29.53	28.20	28.30
ADF, %	15.60	23.75	25.00
Ether extract, %	12.10	10.70	10.20
Ca, %	0.08	0.15	1.38
P, %	0.83	0.87	0.89

[1]CWDGS = corn wet distillers grains plus solubles, SWDGS = sorghum wet distillers grains plus solubles, CH-SWDGS = calcium hydroxide–treated sorghum wet distillers grains plus solubles [2.27% $Ca(OH)_2$ DM basis].