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Chewing, rumen pool characteristics, and lactation performance of dairy cows fed 2 concentrations of a corn wet-milling coproduct with different forage sources[1]

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ABSTRACT

We used a novel corn wet-milling coproduct [CMP; approximately 70% dry matter, 28% crude protein, 36% neutral detergent fiber (NDF), and 18% nonstructural carbohydrates] in diets formulated to contain 18.4% forage NDF, 17.4% crude protein, 20.2% starch, and 3.7% sugar. Six primiparous, rumen-cannulated Jersey cows were assigned to a 6 × 6 Latin square design with a 2 × 3 factorial arrangement of treatments. Diets were formulated to contain 20 and 30% CMP with 3 forage sources [corn silage (CS) and 40.5% NDF, CS replaced with 10% alfalfa hay (AH) and 45.0% NDF, or CS replaced with 7% grass hay (GH) and 67.4% NDF], with each providing 18.4% forage NDF in the diet. Total-tract digestibilities of NDF, N, and organic matter were not affected by treatment. Similarly, no treatment effects were detected for kinetics of NDF disappearance in situ from CMP or respective forage source or for N disappearance in situ from CMP. Grass hay increased total and liquid pool size of rumen contents compared with AH (by 3.2 and 3.0 kg, respectively). Total time spent chewing increased in cows fed GH by over 35 min compared with those fed AH, partially due to a trend for increased minutes spent ruminating. Mean particle size of rumen contents also tended to be higher in the GH (0.55 mm) than AH (0.69 mm) diets. No effects on production of milk or milk components were detected, but dry matter intake (DMI) tended to decrease when CMP increased from 20 to 30%. Gross feed efficiency (fat-corrected milk/DMI) tended to be greater when cows were fed AH and GH compared with CS and was greater for AH than GH diets. In diets containing low starch, increasing CMP from 20 to 30% potentially maintained similar fat-corrected milk production with lower DMI. However, more consideration also should be given to interactions among forages with respect to fill, digestion, and passage of fiber with increased inclusion rates of CMP.
Key words: corn milling coproduct, forage source, rumination

INTRODUCTION

Our aims were to better characterize a novel corn-milling product (**CMP**) that is higher in CP and lower in NDF than the traditional corn-milling products, yet has relatively low starch concentration. This unground product has a physical form that is long enough to potentially provide effective fiber. Weiss (2012) concluded that CMP was best used to replace concentrate because milk fat production was decreased when the CMP replaced forage plus grain; the starch:forage NDF (**fNDF**) ratio was predictive for milk fat concentration. We reasoned that potential interactions of CMP inclusion rate with forage source can be postulated from studies with soybean hulls, which have similar degradation kinetics to corn gluten feed (Firkins, 1997). Grant (1997) summarized responses from several studies evaluating potential interactions of forage particle size and usage of soybean hull fiber. Because of the high concentration and potential digestibility of NDF from soybean hulls, retention time of the soybean hulls in the rumen is a critical factor influencing ruminal digestibility of total dietary NDF. Substitution of 25% of a silage mixture with coarsely chopped hay increased the percentage of long particles in the ventral rumen and helped retain soyhulls for more extensive ruminal NDF digestibility (Weidner and Grant, 1994). As with soybean hulls, we hypothesized that CMP would have a similar potential for ruminal NDF digestibility to increase if a portion of the corn silage (**CS**) was replaced by chopped hay to increase ruminal mat consistency and slow the passage rate of the highly degradable CMP particles.

Many nonforage fiber sources such as CMP are provided in a ration at about 20% (Stern and Ziemer,

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1995); increasing the inclusion rate would require considerations related to energy density and DMI. Firkins et al. (2002) increased wet brewers grains up to about 26% of the diet through partial substitution for both grain and forage to decrease bulk fill limitation of DMI and potentially minimize negative associative effects (i.e., prevent a decrease in NDF digestibility) of wet brewers grains fiber. In that study, NE_L concentration decreased with increasing dietary concentration of brewers grains, but cows compensated by increasing DMI to maintain the same NE_L intakes and, therefore, lactation performance. A relatively narrow window of inclusion of physically effective NDF exists to maximize ruminal NDF digestibility while minimizing the risk for depressed DMI (Zebeli et al., 2012), and the ability to maximize NDF digestibility in diets formulated in these inclusion windows depends on limiting starch appropriately (Zebeli et al., 2010). We noted that decreasing DMI tended to occur between 20 and 30% inclusion rates (Boddugari et al., 2001; Mullins et al., 2010; Weiss, 2012). Thus, we reasoned that increasing from 20 to 30% inclusion of CMP prioritized the need to characterize potential interactions with the physical effectiveness of fNDF in moderately low-starch diets. Moreover, diluting corn starch and CS percentages of the total forage in diets should decrease risk for depressed milk fat when feeding CMP (Weiss et al., 2009). In CS-based diets, we assumed that we could increase the density of the rumen mat by feeding a highly physically effective fiber source, such as grass hay (**GH**). Compared with alfalfa hay (**AH**), GH should be less fragile and might stimulate chewing to a greater extent (Kammes and Allen, 2012a), but GH also could be more filling than AH.

We hypothesized that forage source would have minimal effect on production or the rumen environment, including volume of rumen contents when CMP was included at 20% of dietary DM; however, when CMP was increased to 30%, we expected that CS + AH would increase diet physical effectiveness and ruminal fluid weight more than would CS alone, but potentially less than CS + GH. We expected corresponding responses in rumination activity and for ruminal and total-tract NDF digestibilities. Our objectives were to assess the potential for interactions among CMP concentration and forage source for measures of rumination, rumen pool characteristics, and site of NDF digestibility (based on Dacron bag insertion and fecal spot sampling) and resultant influence on lactation performance by Jersey cows.

MATERIALS AND METHODS

Six ruminally cannulated primiparous Jersey cows were assigned to 1 of 6 diets in a 6 × 6 Latin square design with a 2 × 3 factorial arrangement of treatments. All procedures were approved by The Ohio State University Institutional Animal Care and Use Committee (Columbus). Cows were housed in a tie-stall barn and averaged 108 ± 20 DIM when the experiment began in March 2011. The trial ended in July 2011.

Diets contained either 20 or 30% CMP on a DM basis and 3 different forage combinations (Table 1). Forage was provided as corn silage only (CS), corn silage + 10% alfalfa hay (AH), or corn silage + 7% grass hay (GH). Grass hay was added to the GH rations to provide the same amount of fNDF as the AH rations. All rations were balanced for 18.4% fNDF and NSC (chemical analysis of starch plus sugars) at about 24% to maximize usability of the energy in CMP and prevent fill from limiting intake due to high levels of NDF. All diets were balanced to contain 16.4% CP and approximately 10.3% RDP using the Dairy NRC (2001) feed library, and slightly exceeded its prediction of RDP requirements (assumed to be a Jersey cow producing 24.2 kg of milk with 4.20% fat and 3.60% protein; DMI of 15.9 kg/d). The CMP was delivered about every 3 wk (coinciding with each experimental period and assessed by the statistical block for period for nutrient digestibilities) and stored on concrete in a hoop barn with an open side (facing east) for access by skid loader. We noted highly consistent nutrient composition between each CMP batch because the vendor (Cargill, Dayton, OH) blended the product and provided quality control to minimize differences among batches. A composite of each period's samples of CMP, CS, AH, and GH were submitted to Dairy One (Ithaca, NY) for analyses of NDF, ADF, CP, NFC (by difference calculation), starch, and 80% ethanol-soluble carbohydrates (Table 2).

Experimental periods were 21 d, except for the first period, which was 28 d to allow for adjustment to the new diets; the last 10 d were used for sampling and data collection. Diets were mixed once daily and fed twice daily to allow for 5% orts, except during sampling weeks, when orts were cut to 3% to reduce sorting against long particles. Cows had continuous access to water except in the holding pen or milking parlor. They were fed after returning to stalls to decrease cross-contamination of diets. Body weights were measured weekly after the a.m. milking and before feeding.

Video recording was conducted to assess chewing behavior. To minimize errors resulting from time spent outside of the stall and away from the camera, cows were monitored for 48 h during each period on d 11 through 15, with the exclusion of an hour spent outside of the stall twice per day for milking (0430 and 1600 h), during which time we assumed that cows were not ruminating. By forwarding the video in 5-min intervals,