



J. Dairy Sci. 101:1–10
<https://doi.org/10.3168/jds.2017-13180>
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Inclusion of calcium hydroxide-treated corn stover as a partial forage replacement in diets for lactating dairy cows

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ABSTRACT

Chemical treatment may improve the nutritional value of corn crop residues, commonly referred to as corn stover, and the potential use of this feed resource for ruminants, including lactating dairy cows. The objective of this study was to determine the effect of prestorage chopping, hydration, and treatment of corn stover with $\text{Ca}(\text{OH})_2$ on the feeding value for milk production, milk composition, and dry matter intake (DMI). Multiparous mid-lactation Holstein cows ($n = 30$) were stratified by parity and milk production and randomly assigned to 1 of 3 diets. Corn stover was chopped, hydrated, and treated with 6% $\text{Ca}(\text{OH})_2$ (as-fed basis) and stored in horizontal silo bags. Cows received a control (CON) total mixed ration (TMR) or a TMR in which a mixture of treated corn stover and distillers grains replaced either alfalfa haylage (AHsub) or alfalfa haylage and an additional portion of corn silage (AH+CSsub). Treated corn stover was fed in a TMR at 0, 15, and 30% of the diet DM for the CON, AHsub, and AH+CSsub diets, respectively. Cows were individually fed in tiestalls for 10 wk. Milk production was not altered by treatment. Compared with the CON diet, DMI was reduced when the AHsub diet was fed and tended to be reduced when cows were fed the AH+CSsub diet (25.9, 22.7, and 23.1 $\pm$ 0.88 kg/d for CON, AHsub, and AH+CSsub diets, respectively). Energy-corrected milk production per unit of DMI (kg/kg) tended to increase with treated corn stover feeding. Milk composition, energy-corrected milk production, and energy-corrected milk per unit of DMI (kg/kg) were not different among treatments for the 10-wk feeding period. Cows fed the AHsub and AH+CSsub diets had consistent DMI over the 10-wk treatment period, whereas DMI for cows fed the CON diet increased slightly over time. Milk production was not affected by the duration of feeding. These data indicate that corn stover processing, prestorage hydra-

tion, and treatment with calcium hydroxide can serve as an alternative to traditional haycrop and corn silage in diets fed to mid-lactation dairy cows.

Key words: corn stover, alternative forage, milk fat

INTRODUCTION

Approximately 196 million tonnes of corn stover are produced annually in the United States, and sustainable removal is estimated to be 58.3 million dry tonnes (Graham et al., 2007). Quantities of harvestable corn stover are determined by land use for corn grain production, corn grain yield, soil tillage practices, soil erosion risks, and several other agronomic and economic factors (Watson et al., 2015). Recent data suggest that 30 to 60% of available corn stover could be removed annually for feed, biofuels production, and other uses without detrimental effects on land use or future crop yield (Johnson et al., 2006; Wilhelm et al., 2007; Donkin et al., 2013).

The use of corn stover as livestock feed has been limited due to inherently low digestibility. Diversion of corn stover into cellulosic biofuels production has resulted in innovation and improvements in corn stover harvesting and processing (Chang and Holtzapple, 2000; Donkin et al., 2013). Several biofuels-related technologies are adaptable and consistent with improving the digestibility of corn stover for use in ruminant diets. Furthermore, the potential use of crop residues, including corn stover, may provide strategies to maximize food production per land unit or serve as an alternative strategy to meet feed inventory needs when crop yields are compromised due to adverse climate or other challenges (USDA, 2013).

Treatment and processing of corn stover to optimize cellulosic ethanol production (Hsu et al., 1980; Chang and Holtzapple, 2000) are consistent with increasing the fermentable energy of plant biomass from low-quality feedstuffs for use by rumen bacteria. Alkaline hydrolysis using NaOH, NH_3 , $\text{Ca}(\text{OH})_2$, KOH, or CaO has been used to enhance the digestibility of corn stover and low-quality feeds (Klopfenstein and Owen, 1981;

Received May 17, 2017.

Accepted October 10, 2017.

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Watson et al., 2015). These biomass treatments alter the structure of plant fiber and consequently increase the yield of fermentable sugars for cellulosic ethanol production or rumen fermentation (Klopfenstein, 1978; Mosier et al., 2005). Calcium hydroxide appears to be a preferred treatment because it is less caustic and more economical than either sodium hydroxide or potassium hydroxide (Gandi et al., 1997).

Chemical treatment of low-quality forages has yielded mixed results in feeding studies with dairy cows. Alkaline hydrogen peroxide-treated wheat straw can replace 20% of the alfalfa haylage and corn silage in diets for lactating cows without negatively affecting milk production, composition, or feed intake, but greater inclusion of either 40 or 60% of the diet DM decreased milk production (Cameron et al., 1991). The combination of calcium oxide-treated corn stover and dried distillers grains can replace wild rye, corn silage, or corn grain to a level of 15% of diet DM without affecting DMI, milk production, or 4% FCM yield (Shi et al., 2015). However, replacing grain in the diet with alkali-treated corn stover at 13% of the diet DM reduced DMI and milk production (Cook et al., 2016a). Furthermore, the feeding value of traditional forages may be improved with alkali treatment (Cook et al., 2016b). Alkali treatment may potentiate the value of corn stover as an alternative feedstuff, but additional efforts are necessary to determine the level of inclusion and the portion of the diet that can be replaced without negative effects on DMI and lactation performance of dairy cows.

We hypothesized that calcium hydroxide-treated corn stover could replace a portion of traditional forages in diets fed to lactating dairy cattle. The objective of the current study was to determine the effect of replacing alfalfa haylage in the diet of dairy cows with calcium hydroxide-treated corn stover and the effect of further replacement of corn silage on DMI, milk production, and milk composition. We chose these forages because they are commonly used in diets fed to dairy cattle in the Midwest region of the United States.

MATERIALS AND METHODS

Treatment of Corn Stover with $\text{Ca}(\text{OH})_2$

Corn stover was harvested in large round bales and processed through a Haybuster Big Bite 1130 tub grinder (DuraTech Industries International Inc., Jamestown, ND) using a rectangular screen (11.4–19.1 cm) to create a theoretical chop length of 10.2 to 15.2 cm. Chopped corn stover was rehydrated with a slurry of $\text{Ca}(\text{OH})_2$ in water. The $\text{Ca}(\text{OH})_2$ slurry was uniformly sprayed onto the chopped corn stover as it was conveyed from the

chopper to achieve 6% $\text{Ca}(\text{OH})_2$ on an as-fed basis and a final moisture content of 50%. The chopped, hydrated, and calcium hydroxide-treated corn stover was immediately packed into an Ag-Bag horizontal plastic silo (St. Nazianz, WI) and stored anaerobically for a minimum of 2 wk before feeding. Samples of the untreated corn stover were collected at the time of processing, and samples of treated corn stover were collected at feeding. Samples of untreated and treated corn stover were analyzed using wet chemistry methods by DairyOne Forage Lab (Ithaca, NY). Samples were analyzed for DM, OM (method 942.05; AOAC International, 2012), and ether extract (method 2003.05; AOAC International, 2012). Nitrogen was measured by rapid combustion using a Macro Elemental (LECO Corporation, Saint Joseph, MI) nitrogen analyzer (AOAC International, 2000). To calculate CP, the nitrogen value was multiplied by 6.25. The ADF was determined per AOAC International (2000) method 973.18, lignin was determined by the method of Goering and Van Soest (1970), and NDF was determined using α -amylase and sodium sulfite (Van Soest et al., 1991). Starch was determined according to Bach Knudsen (1997; Biochemistry Analyzer, YSI Inc., Yellow Springs, OH). Minerals (Ca, P, Mg, K, Na, Fe, Zn, Cu, Mn, Mo, and S) were analyzed using an inductively coupled plasma radical spectrometer (Thermo Scientific, Waltham, MA). Predicted NE_L was calculated as previously described (Weiss, 1993), and NFC was determined by difference (NRC, 2001).

Animals and Handling

All procedures for animal care and use were approved by the Purdue University Animal Care and Use Committee. Mid-lactation multiparous Holstein cows ($n = 30$) were stratified by milk production and parity and randomly assigned to 1 of 3 diets. Cows were (mean $\pm$ SD) 123 ± 18 DIM, weighed 627 ± 61 kg, were producing 37.0 ± 8.6 kg of milk/d, and had a BCS of 2.91 ± 0.26 at the initiation of the experiment. All cows were housed in individual tiestalls at the Purdue University Dairy Research and Education Center, had free access to water, and were fed a TMR to meet or exceed NRC (2001) requirements for cows described above and producing milk containing 3.8% fat and 3.0% true protein. Feed was delivered once daily at 0800 h to achieve approximately 10% daily feed refusals. Dry matter intake was monitored on a common pre-experimental diet and was 23.4 ± 1.82 kg/d (mean $\pm$ SEM); there were no differences in pre-experimental DMI or milk production among cows based on their assigned experimental diets. Following 7 d of acclimation to the facilities, cows received a control TMR

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