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Inclusion of brown midrib dwarf pearl millet silage in the diet of lactating dairy cows

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ABSTRACT

Brown midrib brachytic dwarf pearl millet (*Pennisetum glaucum*) forage harvested at the flag leaf visible stage and subsequently ensiled was investigated as a partial replacement of corn silage in the diet of high-producing dairy cows. Seventeen lactating Holstein cows were fed 2 diets in a crossover design experiment with 2 periods of 28 d each. Both diets had forage: concentrate ratios of 60:40. The control diet (CSD) was based on corn silage and alfalfa haylage, and in the treatment diet, 20% of the corn silage dry matter (corresponding to 10% of the dietary dry matter) was replaced with pearl millet silage (PMD). The effects of partial substitution of corn silage with pearl millet silage on dry matter intake, milk yield, milk components, fatty acid profile, apparent total-tract digestibility of nutrients, N utilization, and enteric methane emissions were analyzed. The pearl millet silage was higher in crude protein and neutral detergent fiber and lower in lignin and starch than the corn silage. Diet did not affect dry matter intake or energy-corrected milk yield, which averaged 46.7 ± 1.92 kg/d. The PMD treatment tended to increase milk fat concentration, had no effect on milk fat yield, and increased milk urea N. Concentrations and yields of milk protein and lactose were not affected by diet. Apparent total-tract digestibility of dry matter decreased from 66.5% in CSD to 64.5% in PMD. Similarly, organic matter and crude protein digestibility was decreased by PMD, whereas neutral- and acid-detergent fiber digestibility was increased. Total milk *trans* fatty acid concentration was decreased by PMD, with a particular decrease in *trans*-10 18:1. Urinary urea and fecal N excretion increased with PMD compared with CSD. Milk N efficiency decreased with PMD. Carbon dioxide emission was not different between the diets, but PMD increased enteric methane emission from 396 to 454 g/d and increased methane yield and intensity. Substituting corn silage with brown midrib dwarf pearl millet silage at 10% of the diet dry matter supported high milk production in dairy cows. When planning on farm forage production strategies, brown midrib dwarf pearl millet should be considered as a viable fiber source.
Key words: dairy cow, methane, milk fat, pearl millet silage

INTRODUCTION

Dairy farms in the northeast United States rely on homegrown forages for the foundation of their rations (Wolf, 2003). The amount and quality of the harvested forage affect profitability and hence viability of dairy farms, particularly of smaller farms (<200 cows), which may have fewer economies of scale or opportunity to purchase additional hectares (Gillespie et al., 2010). Corn silage has qualities (e.g., high yield, simplicity of harvest, high energy content) that make it a popular forage for dairy cows in the United States. However, the long growing season of corn may prevent double cropping with a winter annual such as triticale in some areas that have shorter growing seasons.

Pearl millet is a warm-season annual grass that has a shorter growing season than corn (65 d vs. 130 d, respectively) and may be more practical for double cropping strategies in certain northern geographic regions and years (e.g., abnormally wet spring seasons that delay corn planting). Additionally, pearl millet is drought tolerant and has a high water use efficiency which is a particularly important trait for crops planted after winter annual cereals (cover crops) that may decrease the available soil moisture (Maman et al., 2003; Zegada-Lizarazu and Iijima, 2005). Furthermore, inclusion of pearl millet in a cropping plan may reduce corn disease pressure by rotating away from continuous corn every few years (Thomison et al., 2011). To support high milk

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production of lactating dairy cows, the harvested forage must be highly digestible (Van Soest, 1994). There is a brown midrib (**BMR**) phenotype with lower lignin content and increased digestibility in certain pearl millet varieties (Cherney et al., 1990; Mustafa et al., 2004; Hassanat et al., 2007).

Messman et al. (1992) reported that milk yield (**MY**) of mid-lactation dairy cows was maintained when pearl millet replaced corn silage in the diet. In another study with lactating cows, MY was unaffected but yield of ECM was increased by feeding pearl millet silage at 35% of the diet DM instead of corn silage (Amer and Mustafa, 2010). On the other hand, in an experiment by Brunette et al. (2014), MY responses to 2 pearl millet cultivars were inconsistent; feeding regular pearl millet silage decreased MY, but feeding sweet pearl millet silage did not affect MY when both were compared with corn silage. A more recent study by Brunette et al. (2016) compared grass silage with either pearl millet silage harvested in either the vegetative or mature stage. They reported no differences in MY between the grass and pearl millet silage harvested in the vegetative stage, but they did see a decrease in MY by the pearl millet harvested at the mature stage. To the authors' knowledge, no studies have investigated feeding BMR pearl millet to lactating cows.

Therefore, the hypothesis of this study was that BMR brachytic dwarf pearl millet silage could serve as alternative forage to partially substitute corn silage in lactating dairy cow rations in the northeastern United States. The objective of the experiment was to partially replace corn silage with BMR dwarf pearl millet silage at 10% of the diet DM and investigate the effects on DMI, MY, milk components and fatty acid (**FA**) profile, nutrient digestibility, N utilization, and enteric methane (CH_4) emissions in lactating dairy cows.

MATERIALS AND METHODS

Crops and Silages

The forages were grown in Centre County, Pennsylvania, at approximately 40° N latitude on Hagerstown soil. Brown midrib dwarf pearl millet (*Pennisetum glaucum* 'Exceed'; King's Agriseeds, Ronks, PA) was planted on June 15, 2016, with a no-till drill (John Deere 1590; Moline, IL) at a seeding rate of 22.4 kg/ha and a 19-cm row spacing. The field was sprayed with glyphosate and fertilized with 44.8 t/ha of dairy manure contributing 42 kg/ha of ammonium N and 177 kg/ha of organic N. An additional 73 kg of N/ha from a 30% urea and ammonium nitrate liquid fertilizer was applied before planting. Soybeans were grown in the field the previous year. A John Deere 945 mower with a flail conditioner was used to mow the crop on August 3, 2016, at the flag leaf visible stage at a height of 11.5 cm. After wilting to a target 30% DM, the forage was gathered and chopped using a John Deere 6750 harvester on August 5, 2016. Chop length was set to 25 mm. The millet was ensiled without inoculant in a 2.4-m-diameter plastic silage bag (Up North Plastics, Cottage Grove, MN).

The silage corn (DKC 52–61; 102-d relative maturity; DeKalb, St. Louis, MO) was not specifically grown for the current experiment but was from the forage source normally fed to the dairy herd at The Pennsylvania State University. The corn for silage was planted between May 1 and May 10, 2015, at a rate of 79,000 seeds/ha. It was planted with a no-till drill (John Deere 1590) into fields fertilized with dairy manure as stated above. An additional 43 kg/ha of N was applied as 30% urea and ammonium nitrate liquid before planting and 67 kg/ha of N in the same form as a side-dress application. Corn silage harvest was conducted between September 24 and September 28, 2015, at a target DM of 38% with a 19-mm chop length and ensiled in an upright concrete silo.

Animals and Diets

All animals were cared for according to procedures approved by The Pennsylvania State University's Institutional Animal Care and Use Committee. Seventeen mid-lactation Holstein dairy cows (MY = 50 ± 4.2 kg; 2.5 ± 0.62 lactations; DIM = 66 ± 20 d; BW = 630 ± 71 kg at the beginning of the experiment) were used in the feeding experiment, and an additional 4 cows were used in the in situ analysis. The experiment was a crossover design with 2 periods of 28 d each; 21 d were allowed for adaptation to the diet, and the last 7 d of each period were for data and sample collection. Cows were allocated to 8 groups of 2 cows each, plus 1 spare cow, based on DIM, MY, and parity. One cow got mastitis at the end of the first sampling period. Therefore, we decided to also collect samples from the spare cow for the second period. Cows within a group were randomly assigned to 1 of 2 diets as described below. All cows were housed in the tiestall barn of The Pennsylvania State University's Dairy Research and Teaching Center. Diets were mixed and fed from a Rissler model 1050 TMR mixer (I. H. Rissler Manufacturing LLC, Mohnton, PA). Cows were fed once daily around 8 a.m. to yield approximately 5 to 10% refusals. Feed was pushed up 3 times throughout the day. The cows were milked twice daily at 7 a.m. and 6 p.m.

Two different diets (Table 1) were fed to the cows during the experiment: a control diet (**CSD**), based on corn silage and alfalfa haylage, or a pearl millet silage