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Effects of replacing grass silage with forage pearl millet silage on milk yield, nutrient digestion, and ruminal fermentation of lactating dairy cows

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ABSTRACT

This study investigated the effects of dietary replacement of grass silage (GS) with forage millet silages that were harvested at 2 stages of maturity [i.e., vegetative stage and dough to ripe seed (mature) stage] on milk production, apparent total-tract digestibility, and ruminal fermentation characteristics of dairy cows. Fifteen lactating Holstein cows were used in a replicated 3 ×3 Latin square experiment and fed (ad libitum) a total mixed ration (60:40 forage:concentrate ratio). Dietary treatments included control (GS), vegetative millet silage (EM), and mature millet silage (MM) diets. Experimental silages comprised 24% of dietary dry matter (DM). Soybean meal and slow-release urea were added in millet diets to balance for crude protein (CP). Three additional ruminally fistulated cows were used to determine the effect of treatments on ruminal fermentation and total-tract nutrient utilization. Cows fed the GS diet consumed more DM (22.9 vs. 21.7 ± 1.02 kg/d) and CP (3.3 vs. 3.1 ± 0.19 kg/d), and similar starch (4.9 ± 0.39 kg/d) and neutral detergent fiber (NDF; 8.0 ± 0.27 kg/d) compared with cows fed the MM diet. Replacing the EM diet with the MM diet did not affect DM, NDF, or CP intakes. Cows fed the MM diet produced less milk (26.1 vs. 29.1 ± 0.79 kg/d), energy-corrected milk (28.0 vs.30.5 ± 0.92 kg/d), and 4% fat-corrected milk (26.5 vs. 28.3 ± 0.92 kg/d) yields than cows fed the GS diet. However, cows fed diets with EM and GS produced similar yields of milk, energy-corrected milk, and 4% fat-corrected milk. Feed efficiency (milk yield:DM intake) was greater only for cows fed the GS diet than those fed the MM diet. Milk protein yield and concentration were greater among cows fed the GS diet compared with those fed the EM or MM diets. Milk fat and lactose concentrations were not influenced by diet. However, milk urea N was lower for cows fed the GS diet than for those fed the MM diet. Ruminal NH_3-N was greater for cows fed the EM diet than for those fed the GS diet. Total-tract-digestibility of DM (average = 66.1 ± 3.3%), NDF (average = 55.1 ± 2.4%), CP (average = 63.6 ± 4.2%), and gross energy (average = 64.5 ± 2.6%) were not influenced by experimental diets. We concluded that cows fed GS and EM diets had comparable performance, whereas milk yield was significantly reduced with the MM diet, likely because reduced intakes of DM and net energy for lactation.
Key words: dairy cow, forage millet silage, grass silage, milk yield

INTRODUCTION

High-quality forages are essential to maximize milk production on dairy farms. However, in Canada's temperate regions, forage production is somewhat limited because of the extremely cold winters. Indeed, in these cold regions, the growing season with warm temperatures (above 15°C) is between 70 and 90 d only. Perennial forages such as alfalfa and grasses [i.e., tall fescue (*Festuca arundinacea* Schreb.), orchard grass (*Dactylis glomerata* L.), and brome grass (*Bromus inermis* L.)] are cultivated as mix stands to optimize yield and nutritive values of harvested forages. However, the recurrence of alfalfa winterkill frequently causes low yields and on-farm forage shortages, and the quality of grasses is often reduced due to delayed harvesting at advanced maturity stages during intermittent periods of drought or rain. In our previous study, we showed that, relative to corn silage, cows fed a high water-soluble carbohydrate (**WSC**) forage pearl millet silage had higher NDF intake, similar milk and milk fat yields, and similar feed efficiency (milk yield:DMI) but lower DMI and milk protein yield (Brunette et al., 2014). However, comparisons of forage millet silages with perennial grass silages are lacking.

Pearl millet [*Pennisetum glaucum* (L.) R.] is a tropical annual grass possessing the C4 photosynthetic pathway with high biomass yield, low N fertilizer requirement, drought resistance, and adaptable to low soil pH. Moreover, it has the capacity to grow rapidly in ideal climatic conditions (Maiti and Wesche-Ebeling, 1997).

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Pearl millet offers flexible harvest dates, an important factor influencing yield and nutritive values of most forages. In general, the nutritive values and digestibility of forages decline rapidly with advancement in maturity (Elizalde et al., 1999). However, millet harvested at d 96 had lower or similar NDF content compared with millet harvested at d 56 (Hassanat et al., 2006; LeBlanc et al., 2012), whereas in vitro digestibility of NDF was reduced by only 8% (Hassanat et al., 2006).

The majority of published studies have compared millet silages with corn silages. Data regarding the performance of lactating dairy cows fed pearl millet silage is limited. Messman et al. (1992) reported no effect on milk yield or milk fat concentration but lower DMI and milk protein levels when lactating cows were fed pearl millet silage (harvested after 66 d of growth; 23% DM) in replacement of alfalfa silage plus corn silage. Moreover, feed intake, milk yield, and feed efficiency were similar when lactating cows were fed pearl millet (harvested at 80 d of growth; 27% DM) silage in replacement of corn silage (Amer and Mustafa, 2010). However, milk production and milk protein levels were lower when cows were fed diets containing pearl millet silage (30% DM) compared with temperate corn silage (Kochapakdee et al., 2002).

Unlike other Gramineae forages, the WSC content of sweet millet increases with advancing maturity (LeBlanc et al., 2012). High WSC is highly desirable because it improves the ensilability of forages by accelerating lactic acid production (Adesogan et al., 2004), and it increases the efficiency of ruminal microbial protein (Merry et al., 2006) and N utilization (Miller et al., 2001). Therefore, the objectives of this study were to evaluate the effects of replacing grass silage as a forage constituent in a TMR with high WSC forage millet silages that were harvested at 2 different stages of maturity—early boot stage (vegetative or early millet; **EM**) and dough to ripe seed stage (mature millet; **MM**)—on milk yield, milk composition, apparent total-tract nutrient digestibility, and ruminal fermentation characteristics of lactating dairy cows.

MATERIALS AND METHODS

Forage Material and Ensiling

Forage pearl millet was seeded on May 31, 2013, in a sandy loam soil at the MacDonald Campus Farm of McGill University (Ste Anne de Bellevue, Quebec, Canada; 45°N, 73°W). Millet seeds were provided by Bélisle Solution Nutrition Inc. (Saint-Mathias-sur-Richelieu, QC, Canada). A presowing supply of 100 kg of urea N/ha (46% N) was applied evenly to the fields. Millet fields were harvested at 2 intervals in 2013: on August 5 (65 d), at early boot stage (EM) approximately 1.83 m high, and on September 17 (108 d), at dough to ripe seed stage (MM) approximately 3.66 m high. Early and mature millets were chopped to a theoretical length of 12 mm using, respectively, a New Holland forage harvester (model 900; New Holland, PA) and a John Deere self-propelled forage harvester with camper head (harvester model series 7380, corn header model series SPFH 770, John Deere, Moline, IL). Harvested millets were ensiled under high pressure into horizontal Ag-Bag silos (2.1 m in diameter; AgBag, Miller-St. Nazianz Inc., St. Nazianz, WI) for approximately 8 mo for EM and 6 mo for MM.

In this study, the first cut (at early boot stage) of a 4-yr-old alfalfa-grass field containing >90% of a mixture of grasses [tall fescue (*Festuca arundinacea* Schreb.), orchard grass (*Dactylis glomerata* L.), and brome grass (*Bromus inermis* L.)] was used as control silage (grass silage, **GS**). Grass silage was stored for 8 mo. The initial WSC content of the parental crops (fresh forages) of GS, EM, and MM (n = 3 samples) were 60 ± 6.67, 149.7 ± 8.02, and 138.5 ± 13.23 g/kg, respectively. The DM contents for fresh GS, EM, and MM were 27.7% ± 0.43, 21.6% ± 1.64, and 31.5% ± 0.65, respectively. Chemical composition and fermentation characteristics of experimental silages are shown in Table 1.

Experimental Design and Cows

All animal procedures were approved by the Animal Care Committee of the Faculty of Agriculture and Environmental Sciences of McGill University. Fifteen primiparous lactating Holstein cows (BW: 620 ± 79.9 kg) in early to mid lactation (DIM: 134 ± 64.1 d) producing 30.7 ± 6.0 kg/d (average ± SD) of milk before the trial were used in a replicated 3 × 3 Latin square experiment with 21-d periods (14 d of diet adaptation and 7 d of data collection). Fifteen cows were blocked into 5 groups of 3 by parity, milk yield, and DIM, and treatments were distributed within each block. Cows were housed in tiestalls and provided with free access to water.

Milk Production and Milk Compositions

Cows were milked twice daily at 0500 and 1700 h, and milk yields were recorded by cow. Milk samples were collected on d 16 and 17 of each data collection period at both milkings and combined by cow according to volume. Milk samples was analyzed for fat, protein, lactose, and MUN using an infrared analyzer (Valacta, Sainte-Anne-de-Bellevue, Canada) according to AOAC (1990; method no. 972.16). Milk TS were determined according to AOAC (1990; method no. 925.23).