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Production performance and milk fatty acid profile in grazing dairy cows offered ground corn or liquid molasses as the sole supplemental nonstructural carbohydrate source

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ABSTRACT

The objective of this study was to compare the effects of ground corn or liquid molasses fed as the sole supplemental nonstructural carbohydrate (NSC) source on production performance, milk fatty acid (FA) profile, grazing behavior, and N metabolism in grazing dairy cows. A strip-grazing management system was used, with cows offered a new strip of fresh herbage after each milking, resulting in approximately 16 h of access to pasture daily. Animals were fed a diet formulated to yield an 86:14 forage-to-concentrate ratio consisting [dry matter (DM) basis] of 74% mixed grass-legume herbage, 12% mixed-mostly legume baleage, 12% NSC source, and 2% mineral-vitamin premix. Twenty Jersey cows averaging (mean ± standard deviation) 121 ± 73 d in milk in the beginning of the study were randomly assigned to 1 of 2 herbage supplementation treatments: (1) baleage plus ground corn (B+GC) or (2) baleage + liquid molasses (B+LM). Both NSC sources were fed at a flat rate of 1.6 kg of DM/cow daily. The study lasted from June to September for a total of 15 wk with data and sample collection conducted in wk 3, 7, 12, and 15. Milk samples for FA analysis were collected in wk 2, 4, 6, 8, 9, 11, and 13. Data were analyzed using the MIXED procedure of SAS (SAS Institute Inc., Cary, NC) for a randomized complete block design with repeated measures over time. Treatment × week interactions were observed for supplement DM intake, milk urea N, bite rate, urinary excretion of uric acid, and milk FA (e.g., 17:0, 18:0, *cis*-9,*trans*-11 18:2). Supplement DM intake was greatest in cows fed B+LM in wk 7, 12, and 15. Compared with cows fed B+GC, those fed B+LM had lower concentrations of milk urea N in wk 7 and 15. Milk yield, concentrations and yields of milk components, and plasma concentrations of essential AA, except Met, which was lowest with feeding B+LM, were not affected by supplementation. The plasma concentration of urea N was lowest with feeding B+LM. Cows fed B+GC spent more time grazing than those fed B+LM. Feeding B+GC increased *cis*-9 18:1 FA and most *trans*-18:1 FA in milk, whereas B+LM increased Σ odd-chain FA, Σ n-3 FA, and the *trans*-11 18:1 to *trans*-10 18:1 ratio, and decreased the n-6 to n-3 ratio. Based on current results, B+LM can entirely replace B+GC without negatively affecting milk yield or yields and concentrations of milk fat and true protein, while decreasing milk urea N, plasma urea N, and the milk *trans*-11 18:1 to *trans*-10 18:1 ratio, and increasing Σ n-3 FA.

Key words: grazing dairy cow, ground corn, liquid molasses, milk fatty acid

INTRODUCTION

Previous work demonstrated that ME supply was the single most limiting factor to support moderate to high milk yield under grazing conditions in the northeastern United States (Kolver and Muller, 1998; Soder et al., 2012; Hafla et al., 2016). Low herbage DMI and a high concentration of soluble protein relative to NSC in typical grass-legume pasture mixtures used in the Northeast are among factors that limit milk yield in grazing dairy cows (Bargo et al., 2003). Therefore, supplementation with NSC sources may be needed to increase milk yield and milk protein synthesis in dairy cows offered herbage-based diets.

There is ongoing interest in the use of sugarcane molasses in both conventional (Broderick and Radloff, 2004; Martel et al., 2011; Siverson et al., 2014) and organically certified (Soder et al., 2012; Brito et al., 2015; Ghedini et al., 2016) dairy systems in the United States. Soder et al. (2012) reported that organically certified dairies in the northeastern United States are

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feeding liquid molasses as the sole supplemental NSC source to grazing cows in amounts ranging (DM basis) from 1.1 to 2.4 kg/cow daily. Interestingly, liquid molasses is the only supplemental NSC source allowed to be used by organic dairy farmers who are currently shipping "grass-fed" milk to selected processors (e.g., Organic Valley, La Farge, WI) in the United States. However, inconsistent results in milk yield, nutrient utilization, BCS, and animal health have been reported when feeding moderate to high amounts of molasses to grazing (Soder et al., 2012; Higgs et al., 2013) and confined (Broderick and Radloff, 2004; Brito et al., 2015; Ghedini et al., 2016) dairy cows. Thus, these inconsistent results and limited data regarding the effects of ground corn or liquid molasses as the sole supplemental NSC source on milk yield and composition in grazing dairy cows warrant further investigation. There is also limited information about the effect of liquid molasses or ground corn on milk fatty acid (**FA**) profile throughout the grazing season.

The objectives of the current study were to evaluate the effects of ground corn or liquid molasses as the sole supplemental NSC source on milk yield and composition, milk FA profile, grazing behavior, and N metabolism in dairy cows offered mixed grass-legume herbage as the major forage source. We hypothesized that compared with ground corn, liquid molasses would better match herbage RDP, resulting in increased milk yield and decreased MUN and plasma urea N (**PUN**) because sucrose is more rapidly degraded in the rumen than starch. We also hypothesized that these 2 NSC sources would lead to marked changes in milk FA profile because of expected differences between ground corn and liquid molasses on intake of 18-C FA and ruminal fermentation processes.

MATERIALS AND METHODS

The University of New Hampshire Institutional Animal Care and Use Committee approved all experimental procedures (IACUC# 100414). The experiment was carried out at the University of New Hampshire Burley-Demeritt Organic Dairy Research Farm (Lee, NH; 43°10′N, 70°99′W) from June 7 to September 19, 2010, for a total of 15 wk or 105 d.

Animals, Experimental Design, and Diets

Ten multiparous organically certified Jersey cows averaging (mean ± SD) 21.3 ± 4.1 kg of milk/d, 65 ± 57 DIM, and 415 ± 25 kg of BW, and 10 primiparous organically certified Jersey cows averaging 12.8 ± 5 kg of milk/d, 177 ± 33 DIM, and 346 ± 19 kg of BW in the beginning of the study were used. Animals were fed a diet formulated to yield an 86:14 forage-to-concentrate ratio using the NRC (2001) ration evaluation software. The forage portion of the diet was formulated to contain (DM basis): 74% mixed grass-legume herbage and 12% mixed-mostly legume baleage, which was cut and preserved in plastic-wrapped bales as previously described (Resende et al., 2015). Fresh herbage was supplemented with baleage plus ground corn (**B+GC**) or baleage + sugarcane liquid molasses (**B+LM**), with the NSC sources offered at a daily flat rate of 1.6 kg of DM/cow formulated at 12% of diet DM. A mineral and vitamin premix (formulated at 2% of diet DM) containing (as fed, /kg) 104 g of Ca, 40 g of Mn, 52 g of Zn, 8,270 mg of Fe, 13,200 mg of Cu, 950 mg of I, 1,136 IU of vitamin A, 340 IU of vitamin D, and 5,681 IU of vitamin E was available to all cows while on pasture and at the barn.

Cows were paired (n = 10 pairs) and each pair was balanced by parity, DIM, and milk yield. Within pair, cows were randomly assigned to B+GC or B+LM supplementation to an herbage-based diet. Cows assigned to the B+GC treatment averaged (mean ± SD) 17.7 ± 5.4 kg of milk/d, 131 ± 82 DIM, and 376 ± 45 kg of BW, whereas those assigned to the B+LM treatment averaged 17.7 ± 4.4 kg of milk/d, 112 ± 66 DIM, and 385 ± 39 kg of BW in the beginning of the study. With the exception of milk samples for FA analyses (see below), all remaining data and samples were collected during wk 3 (June 21 to 27), wk 7 (July 19 to 25), wk 12 (August 23 to 29), and wk 15 (September 13 to 19).

After each milking, cows had access to a bedded-pack barn with dried pine shavings as bedding material and were maintained in the same pen separated from the remaining cows in the herd. The bedded area (132 m^2) opens to a 478-m^2 concrete-floor outdoor lot (total pen area = 610 m^2) and a roof-covered feeding station equipped with electronic recognition Calan doors system (American Calan Inc., Northwood, NH) located at the opposite end of the bedding. Before each feeding, baleage was placed into 121-L containers (Rubbermaid Commercial Products, Saratoga Springs, NY) and weighed on a portable digital scale (Rubbermaid Pelouze Digital Receiving Scale) with 0.1-kg readability. Both NSC supplements and baleage were offered twice daily at approximately 0630 and 1630 h. Ground corn was placed in small feed tubs and offered to the cows concomitantly with baleage, whereas liquid molasses was top-dressed on the baleage as cows refused to consume it directly from the tubs. Orts were collected daily before the morning and afternoon feedings and weighed as done for the baleage. Supplement intake (i.e., B+GC or B+LM) was recorded by subtracting the amount of orts from that of supplement offered