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Interactions of corn meal or molasses with a soybean-sunflower meal mix or flaxseed meal on production, milk fatty acid composition, and nutrient utilization in dairy cows fed grass hay-based diets[1]

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ABSTRACT

We investigated the interactions of corn meal or molasses [nonstructural carbohydrate (NSC) supplements] with a soybean-sunflower meal mix or flaxseed meal [rumen-degradable protein (RDP) supplements] on animal production, milk fatty acids profile, and nutrient utilization in dairy cows fed grass hay diets. Eight multiparous and 8 primiparous Jersey cows averaging 135 ± 49 d in milk and 386 ± 61 kg of body weight in the beginning of the study were randomly assigned to 4 replicated 4 × 4 Latin squares with a 2 × 2 factorial arrangement of treatments. Each period lasted 19 d with 14 d for diet adaptation and 5 d for data and sample collection. Cows were fed diets composed of mixed-mostly grass hay plus 1 of the following 4 concentrate blends: (1) corn meal plus a protein mix containing soybean meal and sunflower meal; (2) corn meal plus flaxseed meal; (3) liquid molasses plus a protein mix containing soybean meal and sunflower meal; or (4) liquid molasses plus flaxseed meal. Data were analyzed for main effects of NSC and RDP supplements, and the NSC × RDP supplement interactions. Significant NSC × RDP supplement interactions were observed for milk urea N, milk N efficiency, and the sums of milk saturated, monounsaturated, and polyunsaturated fatty acids. No effect of NSC supplements was observed for nutrient intake and milk yield. However, 4% fat-corrected milk (−0.70 kg/d) and energy-corrected milk (−0.60 kg/d) were significantly reduced in cows fed liquid molasses due to a trend to decreased concentration of milk fat (−0.17%). Diets with liquid molasses resulted in increased (+35%) concentration and yield of milk enterolactone, indicating that this mammalian lignan can be modulated by supplements with different NSC profiles. Overall, NSC and RDP supplements profoundly changed the milk fatty acid profile, likely because of differences in fatty acids intake, Δ^9-desaturase indices, and ruminal biohydrogenation pathways. Feeding liquid molasses significantly reduced plasma urea N (−1.2 mg/dL), urinary N excretion (−20 g/d), and N digestibility (−3.2 percentage units). Flaxseed meal significantly reduced yields of milk (−1.3 kg/d), milk fat (−90 g/d), and milk lactose (−60 g/d), but significantly increased the concentration and yield of milk enterolactone. Further research is needed to elucidate the negative responses of flaxseed meal on yields of milk and milk components.

Key words: grass hay, flaxseed meal, lactating dairy cow, liquid molasses

INTRODUCTION

There is a renewed interest in the use of sugarcane molasses in both conventional (Oelker et al., 2009; Martel et al., 2011; Siverson et al., 2014) and organic (Soder et al., 2012) dairy systems in the United States. Anecdotal claims in a case study conducted by Soder et al. (2012) suggest that organic dairy farmers in the northeastern United States are feeding liquid molasses as the sole energy supplemental source to forage-based diets in levels ranging from 1.1 to 2.4 kg/cow per day (DM basis) depending on milk yield, BCS, and breeding performance, with inconsistent results in animal production and health. Using the mean DMI of 18 kg/d calculated from a comprehensive survey of Wisconsin organic dairy farms (Hardie et al., 2014) and a concentration of 60% of total sugars in liquid molasses (value derived from the current study), the 1.1- to 2.4-kg range would be equivalent to 3.7 to 8.0% of added sugars from molasses, with the highest level exceeding the recommendation of 2.5 to 5.0% of added sugars in dairy diets (Firkins, 2010). Interestingly, previous research in which high amounts of dried molasses (up to 12% of diet DM or 4.6% added sugars) or liquid molasses (up to 9% of diet DM or 7.4% added sugars) were fed to dairy cows, milk production responded cubically or quadratically, whereas OM digestibility increased

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linearly or responded cubically (Broderick and Radloff, 2004). Because of these inconsistent results and lack of data regarding the effect of high dietary levels of liquid molasses, as the major NSC supplemental source, on milk production and nutrient utilization in cows fed grass hay-based diets, further research is needed to fill this knowledge gap.

The outer fiber-containing layer of flaxseed is the richest source of polyphenolic compounds known as lignans (Adlercreutz and Mazur, 1997) and classified as phytoestrogens (Stopper et al., 2005), with secoisolariciresinol diglucoside (**SDG**) accounting for over 95% of total flaxseed lignans (Thompson et al., 1991). The rumen appears to be the major site for conversion of SDG into the mammalian lignans enterodiol and enterolactone according to previous research (Côrtes et al., 2008; Gagnon et al., 2009; Zhou et al., 2009). There is growing interest in promoting the inclusion of SDG-rich foods in human diets due to the potential human health benefits of enterolactone and enterodiol, including prevention of cardiovascular diseases, hypercholesterolemia, breast and prostate cancers, menopausal symptoms, and osteoporosis (Murkies et al., 1998; Adlercreutz, 2002).

It is hypothesized that feeding carbohydrate supplements (e.g., corn meal vs. liquid molasses) with different NSC profiles (i.e., starch vs. sucrose) and rates of ruminal degradation could affect the microbial conversion of flaxseed meal-SDG into enterolactone, thus resulting in different milk output of this mammalian lignan. It is also hypothesized that feeding corn meal or liquid molasses in combination with a soybean-sunflower meal mix or flaxseed meal could lead to NSC × RDP supplement interactions, with potential implications on milk production, milk FA profile, and nutrient utilization in dairy cows. The objectives of the current study were to investigate interactions of corn meal or liquid molasses with a soybean-sunflower meal mix or flaxseed meal as the major NSC or RDP supplements on milk production and composition, plasma concentration of the antioxidant enzymes superoxide dismutase (**SOD**) and glutathione peroxidase (**GPx**), and nutrient utilization in dairy cows fed grass-fed based diets.

MATERIALS AND METHODS

Care and handling of the animals used in the current study were conducted as outlined in the guidelines of the University of New Hampshire Institutional Animal Care and Use Committee (IACUC Protocol # 091102). The 76-d long experiment was conducted at the University of New Hampshire Burley-Demeritt Organic Dairy Research Farm (43°10′N, 70°99′W) from March 8 to May 24, 2010.

Animals, Experimental Design, and Diets

Eight multiparous Jersey cows averaging (mean ± SD) 170 ± 40 DIM, 431 ± 20 kg of BW, and 15.6 ± 1.6 kg of milk/d, and 8 primiparous Jersey cows averaging 107 ± 36 DIM, 351 ± 59 kg of BW, and 13.7 ± 1.9 kg of milk/d at the beginning of the study were used. Animals were randomly assigned to treatment sequences in a replicated 4 × 4 Latin square design with a 2 × 2 factorial arrangement of treatments. Distribution of animals to squares was done to balance for differences in DIM, milk production, and parity, resulting in 2 squares of primiparous cows (square 1 = 79 ± 17 DIM and 13.4 ± 0.85 kg of milk/d; square 2 = 118 ± 14 DIM and 14.1 ± 2.9 kg of milk/d) and 2 squares of multiparous cows (square 3 = 144 ± 28 DIM and 14.6 ± 0.87 kg of milk/d; square 4 = 199 ± 22 DIM and 16.2 ± 1.8 kg of milk/d). Treatment sequences within each Latin square were balanced for carryover effects in subsequent periods. Each period lasted 19 d with 14 d for diet adaptation and 5 d for data and sample collection. Cows were fed diets formulated to yield (DM basis) a 70:30 forage to concentrate ratio across treatments and were composed of a mixed-mostly grass hay plus 1 of the following 4 concentrate blends: (1) corn meal plus a protein mix containing soybean meal and sunflower meal (**CM**); (2) corn meal plus flaxseed meal (**CM+FX**); (3) liquid molasses plus a protein mix containing soybean meal and sunflower meal (**MOL**); or (4) liquid molasses plus flaxseed meal (**MOL+FX**). Animals were housed in 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) opened to a 478-m^2 cement-floor outdoor lot (total pen area = 610 m^2) allowing cows to walk freely to comply with the USDA National Organic Program "Pasture Rule" (USDA-AMS, 2010), which calls for year-round access to the outdoors for all ruminant animals. A roof-covered feeding station equipped with electronic recognition Calan doors system (American Calan Inc., Northwood, NH) was located at the end of the cement-floor lot.

Nutrient composition of the feedstuffs used in the current experiment is shown in Tables 1 and 3, and ingredient and nutrient composition of the concentrate mixes are shown in Tables 2 and 3. The forage was cut on September 25, 2009 (second cutting), from 2 fields with similar botanical composition using a flail-type mower centerline conditioner (model FC353RGC, Kuhn North America Inc., Brodhead, WI), tedded (model GA7302DL, Kuhn), and field-wilted to about 85% DM, which was attained approximately 72 h after cutting. Dried forage was then harvested as hay using a large round baler with a crop cutter (model BR740A; New