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Effects of seasonal variation and winter supplementation of ground whole flaxseed on milk fatty acid composition of dairy cows in organic farms in the northeastern United States

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ABSTRACT

Fourteen organic dairy farms in the northeastern United States were used to evaluate (1) seasonal variation in bioactive milk fatty acid (FA) profile from 2012 to 2015 and (2) supplementation of ground whole flaxseed (GFLX) to maintain elevated concentrations of bioactive milk FA during the nongrazing season. During regular farm visits, milk, feed, and pasture samples were collected, and diet composition, milk yield, and milk composition were recorded. During winters of 2013 to 2014 and 2014 to 2015, 9 farms supplemented GFLX at 6% of diet DM to half of each herd (n = 238 cows per treatment). Milk samples were collected and pooled by treatment (GFLX or control). Data were analyzed using the MIXED procedure of SAS. A significant month × year interaction ($P < 0.05$) for n-3 FA showed an increase beginning in April of 2014 through the end of the study. The proportion of conjugated linoleic acid showed a seasonal pattern with greatest ($P < 0.05$) concentrations (1.32% of total milk FA) during the grazing season. Winter GFLX supplementation did not affect ($P > 0.15$) milk yield or concentrations of milk fat or protein; however, BCS tended ($P = 0.08$) to be greater for GFLX cows. Compared with the control diet, GFLX decreased ($P < 0.05$) total milk SFA by 3.1 percentage units and increased ($P < 0.05$) n-3 by 62% and total conjugated linoleic acid proportion by 9%. Although GFLX supplementation increased milk n-3, lesser effects on SFA and total conjugated linoleic acid proportions indicated that a greater level of winter supplementation is required to improve overall milk FA profile during the nongrazing season.

Key words: conjugated linoleic acid, flaxseed, grazing, n-3

INTRODUCTION

Bovine milk provides an excellent source of many nutrients essential to human health, including high-quality protein, vitamins, and minerals (Huth et al., 2006). Lactating dairy cows on pasture-based diets produce milk with enhanced concentrations of n-3 fatty acids (**FA**) and conjugated linoleic acid (**CLA**; Bargo et al., 2006; Soder et al., 2006; Brito et al., 2017), which may have beneficial effects on human health (Simopoulos, 2002; Lock and Bauman, 2004; Dilzer and Park, 2012). A survey of organic dairy farmers in the northeastern United States found that development of value-added dairy products, such as milk with enhanced concentrations of beneficial FA, was a high priority (Pereira et al., 2013). However, feeding conserved forages during the winter months generally decreases n-3 FA and CLA concentrations (Schroeder et al., 2003; Bargo et al., 2006). Therefore, organic dairy farmers are seeking dietary strategies to maintain high concentrations of beneficial FA during the winter months, when a greater proportion of conserved forages are fed compared with the grazing season.

Organic milk processors often rely on marketing strategies based on high concentrations of n-3 FA and CLA to sell organic milk (Benbrook et al., 2013, 2018), so year-round production of milk with enriched bioactive FA appears to be a viable option to consolidate and open new markets to the organic dairy industry. However, although researchers reported that use of extruded oilseeds (Dhi-

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man et al., 1999), flaxseed oil (Flowers et al., 2008; Brossillon et al., 2018), or ground whole flaxseed (**GFLX**; Resende et al., 2015) increased concentrations of bioactive FA in milk of confined and grazing dairy cows, results for milk production have been inconsistent such that broad recommendations have not been established. Therefore, the objectives of this study were (1) to assess seasonal variation of bioactive FA (e.g., n-3 and CLA) in milk from organically certified dairy cows in the northeastern United States over a 3-yr period and (2) to evaluate the use of GFLX supplementation to maintain concentrations of bioactive FA during the nongrazing season when an increased proportion of conserved forages and grain sources are fed on organic dairies in the northeastern United States.

MATERIALS AND METHODS

Care and handling of the animals used in this research were conducted as outlined in the guidelines of the Institutional Animal Care and Use Committees of the University of New Hampshire (IACUC Protocol no. 110605) and The Pennsylvania State University (IACUC Protocol no. 40124).

On-Farm Data Collection

Fourteen certified organic dairy farms in Pennsylvania (n = 3), New York (n = 3), Vermont (n = 3), Maine (n = 3), and New Hampshire (n = 2) participated in this study from 2012 to 2015. At the initiation of the study in spring of 2012, farmers were surveyed to describe their farms and overall management practices.

Farm visits occurred twice monthly during the grazing season of each year and once monthly during the winter season. During the 3-yr data collection period, pasture samples were collected in Maine between the dates of June 14 and October 25, in New Hampshire from May 30 to October 11, in Vermont from May 15 to October 31, in New York from May 2 to October 15, and in Pennsylvania from May 5 to November 16.

Data collection during each farm visit included pasture samples (during the grazing season) and year-round samples of any conserved forages (hay, corn silage, haylage, baleage) and concentrates being fed. Pasture samples were collected for nutrient analysis by clipping a 15 × 100 cm sward area at ground level in 15 different locations just before cows were turned out into that pasture. Pasture samples, conserved forages, and concentrates from each farm were dried in a forced-air oven for 48 h at 60°C, composited by sample type and farm visit, and ground (1-mm screen of a Wiley mill; Thomas Scientific, Swedesboro, NJ) before shipment to an independent laboratory (Dairy One Forage Analysis Laboratory, Ithaca, NY) for analysis of CP, ADF, NDF, Ca, P, Mg, K, and S. Net energy for lactation was estimated according to the NRC (2001). Forages were analyzed using near-infrared reflectance spectroscopy (Foss NIR Systems Model 6500 with Win ISI II v1.5, Laurel, MD), and grain samples were analyzed using wet chemistry following methods reported by Resende et al. (2015). Quantities of conserved forages and any concentrate feeds being fed were recorded during each farm visit. In addition, records were collected on bulk tank weights, number of cows and milkings included in the bulk tank weight, and milk components (as reported on most recent milk check). Average daily milk yield per cow was calculated by dividing the number of cows milked by the bulk tank weight and number of milkings in the tank. When reliable data for milk yield and components were not available from the farmer, Dairy Herd Improvement Association (DHIA; http://www.dhia.org) data from a sample date not exceeding 7 d from the farm visit were used. Finally, a milk sample was taken from the agitated bulk tank during each farm visit, transported on ice, and stored at −80°C for FA analysis.

The following equations (NRC, 2001) were used to estimate DMI of pasture for each sampling date, based on known amounts and energy concentrations of nonpasture feeds consumed, energy value of pasture, and milk yield and components.

$$\text{DMI from pasture} = \text{pasture NE}_l \text{ (Mcal/kg)} \div [\text{NE}_l \text{ output (Mcal)} - \text{NE}_l \text{ from nonpasture feeds (Mcal)}],$$

where pasture and nonpasture feed NE_l estimates were obtained from Dairy One analysis and total amount (kg) of nonpasture feed consumed was reported at each farm visit, where

$$\text{NE}_l \text{ output (Mcal)} = [\text{NE}_l \text{ for maintenance (Mcal)} + \text{NE}_l \text{ for activity (Mcal)}] \div [100 + \text{NE}_l \text{ for milk (Mcal)}],$$

$$\text{NE}_l \text{ for maintenance (Mcal)} = (\text{kg of BW} \times 0.75)^{0.08},$$

$$\text{NE}_l \text{ for activity (Mcal)} = \text{NE}_l \text{ for maintenance} \times 0.10,$$

$$\text{NE}_l \text{ for milk (Mcal)} = 0.4536 \times [0.36 + (0.096 \times \text{milk fat \%})] \times \text{kg of milk}.$$

During 15 farm visits to farm 12 over the 3 grazing seasons, total conserved feed amounts consumed were unavailable. On this farm, significant amounts of feed refusals were found in the feed bunk, and on 5 of the visits during the grazing season, milk fat and protein concentrations were inverted, thereby interfering with the use of the energy balance equation reported above. This farm had recently transitioned to certified organic dairy production, and the owner was working to optimize milk yield through the use of conserved forages and concentrates while still meeting the USDA National Organic Program "Pasture Rule" requirement, which calls for a minimum of 30% DMI from pasture for at least 120 d during the grazing season (USDA-AMS, 2010). It is also important to note that this