J. Dairy Sci. 92:4865–4875
doi:10.3168/jds.2008-1674

Fatty acid composition of milk from multiparous Holstein cows treated with bovine somatotropin and fed n-3 fatty acids in early lactation[1]

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ABSTRACT

Multiparous cows (n = 59) were blocked by expected calving date and previous milk yield and assigned randomly to treatments to determine effects of bovine somatotropin (bST; Posilac, Monsanto Animal Agricultural Group, St. Louis, MO) and source of dietary fat on milk fatty acid composition during the first 140 d in milk. Diets were provided from calving and included whole, high-oil sunflower seeds (SS; 10% of dietary dry matter; n-6/n-3 ratio of 4.6) as a source of linoleic acid or a mixture of Alifet-High Energy and Alifet-Repro (AF; Alifet USA, Cincinnati, OH; 3.5 and 1.5% of dietary dry matter, respectively; n-6/n-3 ratio of 2.6) as a source of protected n-3 fatty acids (15.7% 18:3, 1.3% 20:5, and 1.3% 22:6). Treatments were derived from a 2 × 2 combination of supplemental fat source (SS, AF) and with 0 (SSN, AFN) or 500 (SSY, AFY) mg of bST administered every 10 d from 12 to 70 d in milk and at 14-d intervals thereafter. Milk fatty acid composition was determined in samples collected from 32 cows (8 complete blocks) during wk 2, 8, and 20 of lactation. Data were analyzed as repeated measures using mixed model procedures to determine the effects of diet, bST, week of lactation, and their interactions. Proportions of 18:3 (4.02 vs. 3.59 ± 0.16%), 20:5 (0.52 vs. 0.41 ± 0.02%), and 22:6 (0.11 vs. 0.02 ± 0.02%) were greater and the n-6/n-3 fatty acid ratio (7.40 vs. 8.80 ± 0.30) was reduced in milk from cows fed AF compared with SS. Proportions of de novo-synthesized fatty acids increased and preformed fatty acids decreased as lactation progressed, but bST administration delayed this shift in origin of milk fatty acids. Transfer efficiency of 18:3, 20:5, and 22:6 from AF to milk fat averaged 36.2, 4.9, and 5.2%, respectively. These efficiencies increased as lactation progressed, but were delayed by bST. Apparent mammary Δ^9-desaturase activity and milk conjugated linoleic acid (*cis*-9, *trans*-11 conjugated linoleic acid) content increased through the first 8 wk of lactation. Based on the product-to-substrate ratio of 14:1/14:0 fatty acids in milk, there was an interaction of diet and bST because bST decreased apparent Δ^9-desaturase activity in SSY cows but increased it in AFY cows (0.10, 0.09, 0.08, and 0.09 ± 0.01 for SSN, SSY, AFN, and AFY, respectively). Feeding Alifet-Repro increased n-3 fatty acids in milk and bST prolonged the partitioning of dietary fatty acids into milk fat.

Key words: bovine somatotropin, n-3 fatty acid, milk fat

INTRODUCTION

Supplemental dietary fats are included in dairy cow rations to increase energy density of the diet, to improve reproduction (Staples et al., 1998; Mattos et al., 2000) and immune function (Lessard et al., 2004), and to increase the functional food value of dairy products (Lock and Bauman, 2004). Milk fatty acid composition affects organoleptic qualities, has important roles in milk processing, and may affect human health. Although not supported (Prentice et al., 2006), some epidemiological evidence indicates that a reduced proportion of saturated fatty acids (**SFA**) and a decreased n-6/n-3 fatty acid ratio in human diets would help reduce the risk of cardiovascular diseases and cancer (Kang, 2005). Potential beneficial health effects of *cis*-9, *trans*-11 18:2 (a conjugated linoleic acid; **CLA**) and *trans*-11 18:1 (vaccenic acid; **VA**) were demonstrated in cell and animal models, including reduced incidence of cancer, atherosclerosis, obesity, and diabetes and im-

Received September 1, 2008.
Accepted June 19, 2009.
[1]This work was supported in part by a Doctoral Dissertation Research Grant from the Graduate School at the University of Minnesota, a Hueg-Harrison Fellowship, and a Sigma Delta Epsilon Fellowship all awarded to M. Carriquiry. Support for the study was also provided by the Agricultural Experiment Stations at the University of Arizona (project number ARST-136339-H-24-130) and University of Minnesota (project number 16-46).
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proved modulation of the immune response (Bauman et al., 2006).

Milk and milk products contribute up to 30% of the total fat intake by humans (Mansbridge and Blake, 1997). Although milk is the main source of CLA in the human diet (Bauman et al., 2006), only 4% of the fatty acids in milk are polyunsaturated (**PUFA**; Mansbridge and Blake, 1997). As milk production and management intensity have increased, the proportion of fresh forages in typical diets for dairy cows has decreased and the dietary n-6/n-3 fatty acid ratio has increased from 0.5 to 6 (Ponter et al., 2006). There have been recent efforts to increase n-3 PUFA in dairy cow diets and dairy products in an attempt to improve cow health and fertility and to increase the perceived healthfulness of dairy products.

Dietary unsaturated fatty acids (**UFA**) normally undergo extensive biohydrogenation in the rumen. Therefore, to increase absorption of UFA and subsequent incorporation into tissues and milk, UFA need to be protected from rumen microbial metabolism. Linolenic (18:3), eicosapentaenoic (20:5, **EPA**), and docosahexaenoic (22:6, **DHA**) acids in Alifet-Repro (Alifet USA, Cincinnati, OH) are partially protected from biohydrogenation (Carriquiry et al., 2008). Therefore, feeding Alifet-Repro could increase postruminal availability and incorporation of these fatty acids into milk fat.

Contributions of the primary components (fat, protein, lactose, TS, and SNF) of milk generally do not differ between bST-treated and untreated cows during a full lactation (Bauman and Vernon, 1993). Nevertheless, administration of bST can reduce the proportion of short- and medium-chain fatty acids and can increase the proportion of long-chain fatty acids when cows are treated with bST in early (Lormore et al., 1990) or mid to late (Eppard et al., 1985) lactation. Similarly, proportions of SFA decrease and UFA increase when cows are treated with bST (Eppard et al., 1985; Lormore et al., 1990). The objectives of this study were to determine the effects of bST and dietary fat enriched with n-3 fatty acids on fatty acid content of milk fat during the first 140 DIM.

MATERIALS AND METHODS

Animals, Experimental Design, and Treatments

Detailed descriptions of the diets, animal management, data and sample collection and analyses, and production responses have been reported (Carriquiry et al., 2009). Briefly, multiparous cows (n = 59) were fed the same dry cow diet beginning 3 wk before their expected calving date. Cows were blocked by expected calving date and previous milk yield (305-d mature-equivalent milk yield) and assigned randomly to 1 of 4 treatments in a 2 × 2 factorial arrangement of bST (0 or 500 mg/injection) and source of supplemental dietary fat. Treatment diets contained either whole, high-oil sunflower seeds (**SS**; 10% of dietary DM) as a source of linoleic acid (18:2; dietary n-6/n-3 ratio = 4.6) or a mixture of Alifet-High Energy (Alifet USA) and Alifet-Repro (**AF**; 3.5 and 1.5% of dietary DM, respectively) as a source of n-3 fatty acids (dietary n-6/n-3 ratio = 2.6). Alifet-High Energy is a microcrystallized rumen-inert energy concentrate made from animal fat (99%) rich in SFA (57% stearic acid, 18:0; 25% palmitic acid, 16:0). Alifet-Repro is a microcrystallized rumen-inert fat (flaxseed oil and fish oil) that is enriched with the n-3 fatty acids linolenic (18:3; 15.7%), EPA (20:5; 1.3%), and DHA (22:6; 1.3%).

Treatment diets were fed as TMR and were formulated to meet the nutritional needs (NRC, 2001) of the cows. Diets were composed primarily of alfalfa haylage, corn silage, high-moisture shelled corn, soybean meal, and distillers dried grains with solubles (25, 25, 18, 12, and 6% of DM, respectively). The treatment diets contained 60% DM, 18.5% CP, 18.5% ADF, 28% NDF, and 8.2% ether extract. Diets were designed to differ only in the type of fatty acids they contained and were formulated to contain similar amounts of NE_L (1.68 and 1.71 Mcal/kg, respectively) at a predicted peak DMI of 29.9 kg/d (4.7× maintenance; NRC, 2001), but $NE_{L\text{-Actual DMI}}$ values throughout the study were 1.54 and 1.66 Mcal/kg for SS and AF, respectively. Dietary content of all other major components differed by less than 4% between diets (Carriquiry et al., 2009).

Treatment diets were offered from calving, and administration of bST (Posilac, Monsanto Animal Agricultural Group, St. Louis, MO) was initiated on 12 ± 3 DIM and continued at 10-d intervals through 70 ± 3 DIM and at 14-d intervals thereafter. Treatments from the 2 × 2 factorial arrangement of diets (SS, AF) with 0 (**N**) or 500 mg (**Y**) of bST per injection were designated **SSN**, **SSY**, **AFN**, and **AFY**, and there were 15, 16, 15, and 13 cows per treatment, respectively.

Cows were milked 2 times per day and milk weights were recorded at each milking. Milk samples were collected to determine fat, protein, lactose, and SCC (605/360 Combi-Foss instrument, Foss Electric, Hillerød, Denmark) at a commercial laboratory (Stearns DHIA Laboratories, Sauk Centre, MN). Evening milk samples from a subset of cows (32 of 59 cows, 8 complete blocks) were collected during wk 2, 8, and 20 of lactation, stored at −20°C without preservative, and analyzed for fatty acid composition. Amounts of feed offered and refused were recorded daily to determine feed intake. Samples of feed ingredients and diets were