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Production response of multiparous Holstein cows treated with bovine somatotropin and fed diets enriched with n-3 or n-6 fatty acids[1]

M. Carriquiry,*[2] W. J. Weber,* C. R. Dahlen,† G. C. Lamb,‡[3] L. H. Baumgard,§[4] and B. A. Crooker*[5]
*Department of Animal Science, University of Minnesota, St. Paul 55108-6118
†Northwest Research and Outreach Center, University of Minnesota, Crookston 56716-5000
‡North Central Research and Outreach Center, University of Minnesota, Grand Rapids 55744-3361
§Department of Animal Sciences, University of Arizona, Tucson 85721-0038

ABSTRACT

Multiparous cows (n = 59) were blocked by expected calving date and previous milk yield and assigned randomly to treatments to determine the effects of bovine somatotropin (bST; Posilac, Monsanto Animal Agricultural Group, St. Louis, MO) and source of dietary fat on production responses. Diets were provided from calving and included whole, high-oil sunflower seeds [SS; 10% of dietary dry matter (DM); n-6:n-3 ratio of 4.6] as a source of linoleic acid (18:2) or a mixture of Alifet-High Energy and Alifet-Repro (AF; Alifet USA, Cincinnati, OH; 3.5 and 1.5% of dietary DM, respectively; n-6/n-3 ratio of 2.6) as a source of protected n-3 fatty acids. Diets contained 181 versus 188 g of crude protein and 183 versus 186 g of acid detergent fiber/kg of DM and 1.54 versus 1.66 Mcal of net energy for lactation at the actual DM intake for SS versus AF, respectively. Cows received 0 or 500 mg of bST every 10 d from 12 to 70 d in milk (DIM) and at 14-d intervals through 280 DIM. The 2 × 2 factorial combination of diet (SS or AF) with or without bST administration resulted in treatments designated as SSY, SSN, AFY, and AFN, respectively. Data were analyzed as repeated measures using mixed model procedures to determine the effects of diet, bST, and their interactions. Yield of 3.5% fat-corrected milk was not altered by diet, but was increased by 4.0 ± 1.9 kg/d from 12 to 70 DIM and by 5.1 ± 1.2 kg/d from 12 to 280 DIM by bST. Treatment did not affect DM intake or energy balance (EB) nadir. There was an interaction of bST and diet on EB because AF decreased the impact of bST on overall EB and allowed AFY cows to reach a positive EB earlier than SSY cows. Gross feed efficiency adjusted for body weight change was greater for bST-treated cows (1.03 vs. 1.15 ± 0.03 kg of fat-corrected milk/Mcal of net energy for lactation). Circulating insulin-like growth factor-I concentrations were increased by bST (85 vs. 125 ± 8 ng/mL). Body weight, body condition score, and backfat thickness were reduced by bST, but differences between treated and nontreated cows did not differ by 280 DIM. Results indicate cows responded to bST administration in early lactation, but the magnitude of the response was greater after 70 DIM. Source of dietary fat had a minimal effect on most production measurements, but relative to SS, AF decreased the impact of bST on overall EB. Results support the premise that bST administration prolongs the delay in postpartum tissue replenishment.
Key words: somatotropin, n-3 fatty acid, lactation

INTRODUCTION

Increased magnitude and prolonged duration of negative energy and nutrient status during early lactation can prevent cows from reaching their true genetic potential to produce milk and can be detrimental to several physiological functions, including reproduction (Lucy and Crooker, 2001). Attempts to minimize the severity of negative energy balance (**EB**) have included the addition of supplemental dietary fats in early lactation. Evidence suggests that supplemental, dietary rumen-protected fat enriched in n-3 fatty acids can provide a concentrated source of energy and specific fatty acid precursors for the synthesis or inhibition of reproductive hormones and prostaglandins (Staples et al., 1998). Additional possible benefits of protected dietary fat include an increased amount of desirable lipids and a decreased ratio of n-6 to n-3 fatty acids in milk and tissue. These changes could improve animal

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[2]Current address: Facultad de Agronomía, Avda. Garzón 810, 12900 Montevideo, Uruguay.
[3]Current address: University of Florida-NFREC, 3925 Highway 71, Marianna, FL 32446-8091.
[4]Current address: Department of Animal Science, Iowa State University, Ames, IA 50011-3150.
[5]Corresponding author: crook001@umn.edu

performance, increase the functional food value of dairy products, and potentially provide beneficial effects on human health.

Commercial use of bST is limited to cows that are more than 8 wk in lactation, in part because early studies indicated that milk yield and IGF-I response to bST were greater when cows were in positive energy and nutrient balance (Bauman, 1999) and because bST studies submitted to the US Food and Drug Administration for evaluation initiated treatment in the ninth week of lactation. Prolonged administration of bST to multiparous cows in early lactation can substantially increase circulating IGF-I concentrations and yields of milk and FCM before 70 DIM and during the entire treatment period (Carriquiry et al., 2008a). In addition, beneficial effects of bST administration on reproductive performance could include IGF-I-induced improvements in ovarian function and embryonic growth and development (Lucy, 2000).

Therefore, there is considerable potential for the combined, early lactation use of supplemental dietary fat enriched with n-3 fatty acids and administration of bST to increase production, improve reproductive performance, and enhance the functional food value of dairy products. Our objectives were to determine the effects of bST and dietary fat enriched with n-3 fatty acids on lactational performance and utilization of protein and energy.

MATERIALS AND METHODS

Animals, Experimental Design, and Treatments

Animal procedures were approved by the University of Minnesota Institutional Animal Care and Use Committee. Fifty-nine multiparous cows (29 in their second lactation and 30 in their third, fourth, or fifth lactation) were housed in tie-stall facilities at the Northwest Research and Outreach Center (Crookston, MN) of the University of Minnesota. Cows were fed a dry cow diet (Table 1) beginning 3 wk before their expected calving date. Cows were blocked by expected calving date (<60-d interval within any block) and previous 305-d mature-equivalent milk yield (<2,900-kg range within any block) and assigned randomly to 1 of 4 treatments in a 2 × 2 factorial arrangement of bST (0 or 500 mg/injection; Posilac, Monsanto Animal Agricultural Group, St. Louis, MO) and source of supplemental dietary fat. Supplemental dietary fat was provided as whole sunflower seeds or as a 3.5:1.5 mixture of Alifet-High Energy and Alifet-Repro (Alifet USA, Cincinnati, OH) and represented 10 and 5% of dietary DM, respectively (Table 1). Sunflower seeds are a source of linoleic acid. Alifet-High Energy is a microcrystallized rumen-inert energy concentrate made from animal fat (99%) rich in saturated fatty acids (57% stearic acid; 25% palmitic acid). Alifet-Repro is a microcrystallized rumen-inert fat (flaxseed oil and fish oil) enriched with the n-3 fatty acids linolenic (15.7%, 18:3), eicosapentaenoic (**EPA**, 1.3%, 20:5), and docosahexaenoic (**DHA**, 1.3%, 22:6) acids. The n-6/n-3 fatty acid ratio of the sunflower seed (**SS**) and the Alifet (**AF**) diets were 4.6 and 2.6, respectively. Treatment diets (Table 1) were formulated to be isocaloric and isonitrogenous and to meet the needs of a 680-kg Holstein cow with a peak milk yield of 55 kg/d at 70 DIM (NRC, 2001). Treatments derived from the 2 × 2 factorial arrangement of diet (SS, AF) and 0 (**N**) or 500 mg (**Y**) of bST were designated **SSN**, **SSY**, **AFN**, and **AFY**, and there were 15, 16, 15, and 13 cows/treatment, respectively.

Administration of bST was initiated on 12 ± 3 DIM and continued at 10-d intervals through 70 ± 3 DIM and at 14-d intervals thereafter through 280 DIM. Cows consumed the treatment diets from calving to at least 150 DIM. From 150 to 280 DIM, if daily milk yield decreased to less than 32 kg and BCS was ≥3.0 units for any cow, the cow was switched to a diet that did not contain supplemental dietary fat (Table 1). For all diets, the as-fed contributions of each ingredient were adjusted weekly to account for changes in DM content of fermented feeds. The amount of feed offered each day was adjusted regularly to allow 5 to 10% refusals. Cows were offered diets as TMR once daily between 0900 and 1200 h and had continuous access to feed and water except during milking.

Data and Sample Collection and Analyses

Cows were milked 2 times per day at approximately 0400 and 1600 h and daily yields were determined from individual milk weights. Milk samples from 2 consecutive milkings were obtained weekly during the first 4 wk of lactation (**WOL**) and at 4-wk intervals thereafter until 280 DIM. Milk samples were preserved with potassium dichromate upon collection and were analyzed for fat, protein, and lactose by infrared analyses and for SCC by a cell counter (Stearns DHIA Laboratories, Sauk Centre, MN).

Amounts of feed offered and refused were recorded daily to determine feed intake. Samples of haylage, corn silage, and high-moisture shelled corn were collected weekly and samples of concentrates were obtained when new shipments were received. Samples were composited within 3-mo intervals or by silo if the source changed within an interval. Composites were analyzed by near-infrared analysis (Dairy One Cooperative Inc., Ithaca, NY; Table 2). Samples of each shipment of Alifet were obtained and individual fatty acid compositions were