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Abomasal Infusion of Butterfat Increases Milk Fat in Lactating Dairy Cows

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ABSTRACT

The objective of this study was to compare the effects of abomasal infusion of butterfat containing all fatty acids (FA) present in milk, including the short- and medium-chain FA, with infusion of only the long-chain FA (LCFA) present in milk, on the FA composition and milk fat yield in lactating dairy cows. Eight rumen-fistulated Holstein cows, in early lactation (49 ± 20 days in milk) were used in a replicated 4 × 4 Latin square design. Treatments were abomasal infusion of the following: 1) no infusion (control), 2) 400 g/d of butterfat (butterfat), 3) 245 g/d of LCFA (blend of 59% cocoa butter, 36% olive oil, and 5% palm oil) providing 50% of the 16:0 and equivalent amounts of C18 FA as found in 400 g of butterfat, and 4) 100 g/d of conjugated linoleic acid (CLA, negative control), providing 10 g of *trans*-10, *cis*-12 CLA. Fat supplements were infused in equal portions 3 times daily at 0800, 1400, and 1800 h during the last 2 wk of each 3-wk experimental period. Daily dry matter intake and milk production were unaffected by the infusion treatments. Butterfat infusion increased milk fat percentage by 14% to 4.26% and milk fat yield by 21% to 1,421 g/d compared with controls (3.74% and 1,178 g/d). Milk fat percentage and fat yield were decreased by 43% by CLA. Milk protein percentage was higher (3.70%) in CLA-infused cows than in control (3.30%), butterfat (3.28%), or LCFA (3.27%) treatments. Although LCFA had no effect on fat synthesis, abomasal infusion of butterfat increased milk fat percentage and yield, suggesting that the availability of short- and medium-chain FA may be a limiting factor for milk fat synthesis.
Key words: lactating dairy cow, milk fat synthesis, de novo fatty acid

INTRODUCTION

The current milk component pricing system was introduced by the Federal Milk Marketing Administration in 2000. Accordingly, there has been a shift in the producer payment from the historic system based on the volume of milk (adjusted for fat content) to one based primarily on the amounts of milk fat and protein produced. The milk component pricing system provides a powerful economic incentive for dairy producers to produce high value milk components, namely fat and protein. Milk component yields are driven by both milk volume and component concentration. The diet of the dairy cow has no effect on milk lactose and mineral content (Sutton, 1989). Compared with milk fat responses, only modest effects of diet have been reported on milk protein concentration (Sutton, 1989). Milk fat is the milk component most easily manipulated by diet (Sutton, 1989). Reports in the literature have shown that milk fat percentage and yield can be reduced up to 46% (Piperova et al., 2000; Peterson et al., 2003) by milk fat-depressing diets containing high levels of grain and polyunsaturated fatty acids (**PUFA**).

In contrast, very few studies have demonstrated consistent ways to increase milk fat concentration. Abomasal infusion of mostly saturated long-chain fatty acids (**LCFA**) tended to increase milk fat yield compared with infusion of mostly unsaturated fatty acids (**FA**) or mixtures of both (Drackley et al., 1992). Abomasal infusion of canola, soybean, or sunflower oil did not significantly affect milk fat percentage in lactating cows but changed milk FA profile reflecting the FA composition of the infused oils (Christensen et al., 1994). Inclusion of fats and oils in the diet of lactating cows usually decreases the proportion of de novo FA produced by the mammary gland (Clapperton and Banks, 1985; LaCount et al., 1994).

Short- and medium-chain FA (6:0 to 14:0, plus 50% of 16:0), constitute 50% of total milk FA and originate from de novo FA synthesis in the mammary gland (Palmquist and Jenkins, 1980). These FA are essential for the formation of milk triacylglycerols (Moore and Christie, 1979) and for maintaining the fluidity of milk fat (Barbano and Sherbon, 1980). With exception of oleic acid, which is produced from stearic acid by the Δ^9-desaturase system in the mammary gland, the LCFA in milk are derived from dietary sources (Palmquist and

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Jenkins, 1980). Experiments with milk fat-depressing diets in lactating cows have demonstrated that yields of short- and medium-chain FA synthesized de novo were reduced to a greater extent than LCFA yields (Loor and Herbein, 1998; Chouinard et al., 1999; Baumgard et al., 2002). These observations suggest that provision of short- and medium-chain FA via dietary means might enhance milk fat content, reducing the need for de novo synthesis.

One could reason that a fat containing the FA composition identical to milk fat would provide the ideal fat supplement for milk fat production. Alternatively, if short- and medium-chain FA are not limiting, then a fat supplement containing only LCFA with a composition identical to that found in milk fat would be ideal for meeting the needs of FA that are typically absorbed from the diet. These conceptual approaches were used as means to potentially increase milk fat synthesis. The objective of this study was to compare the effects of abomasal infusion of butterfat containing all FA present in milk, including the short- and medium-chain FA, with infusion of only the long-chain FA present in milk, on the FA composition and milk fat yield in lactating dairy cows.

MATERIALS AND METHODS

Animals, Experimental Design, Treatment, and Sampling

All procedures for this experiment were conducted under a protocol approved by the University of Maryland Institutional Animal Care and Use Committee. Eight rumen-fistulated multiparous Holstein cows in early lactation (49 ± 20 DIM) were used in a replicated 4 × 4 Latin square design balanced for carryover effects. Treatments were abomasal infusion of the following: 1) no infusion (control); 2) 400 g/d of butterfat as a source of short- and long-chain FA (butterfat); 3) 245 g/d of a LCFA mixture providing 50% of the 16:0 and equivalent amounts of C18 FA as found in 400 g of butterfat (LCFA); and 4) 100 g/d of commercial conjugated linoleic acid (**CLA**) mixture providing 10 g of *trans*-10, *cis*-12 CLA/d, which served as a negative control.

In the LCFA treatment, only 50% of the palmitic acid found in the butterfat was included, because 50% of palmitic acid is thought to be synthesized de novo (Palmquist and Jenkins, 1980). The LCFA mixture was a blend of 59% cocoa butter, 36% olive oil (Unilever, Englewood Cliffs, NJ), and 5% palm oil (GloryBee Foods Inc., Eugene, OR). In the butterfat treatment, butter oil was prepared from commercially available unsalted butter (Wellsley Farms, Natick, MA) melted at 37°C and separated from the protein coagulate by filtering. The CLA mixture was provided by Vitrus Nutrition (Corcoran, CA). Amounts of postruminally infused individual FA in the LCFA mixture and butterfat are shown in Figure 1. The FA composition of the fat supplements is presented in Table 1.

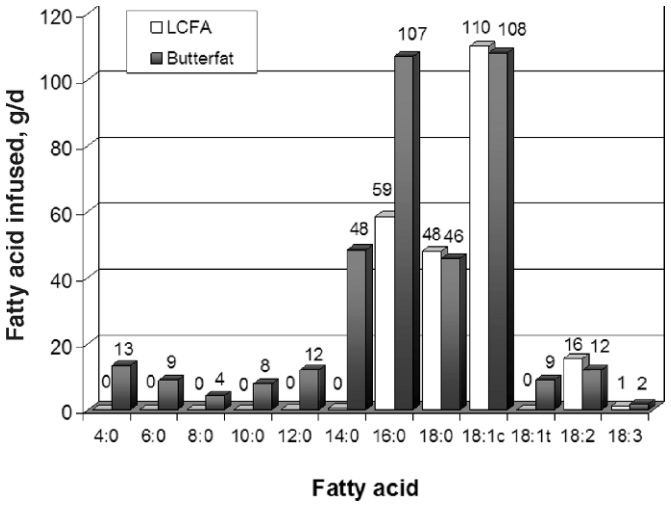

Figure 1. Fatty acid composition of postruminally infused butterfat and long-chain fatty acid (LCFA) mixture.

Experimental periods were 3 wk. The first week of each period was without fat infusion to reduce carryover effects. This was followed by 2 wk of abomasal infusion. The fat was infused via tygon tubing (0.48-cm i.d, 0.64-cm o.d; VWR Scientific, Bridgeport, NJ) that passed through the ruminal cannula, the rumen, the omasum, and into the abomasum, where the line was maintained using a 10-cm circular plastisol flange. The fat mixtures were liquified at 50°C in air oven and mixed well before infusion. The amount of each FA mixture was divided into equal portions and manually infused 3 times a day (133.33 g of butterfat, 81.6 g of LCFA, and 33.33 g of CLA at 0800, 1400, and 1900 h). Actual amounts of infused fat were recorded each day. Patency and location of the infusion line inside the cow were checked on alternate days.

Cows were housed in individual tie stalls and were fed a basal diet containing 55% forage and 45% concentrate (DM basis) to meet NRC (2001) nutrient specifications for a 650-kg cow producing 40 kg of milk containing 3.7% milk fat and 3.1% milk protein. Ingredient and chemical composition of the basal diet is given in Table 2. Diets were fed as TMR once daily at 0800 h. Forage and ingredient DM were measured weekly, and the TMR was adjusted accordingly to maintain a constant forage-to-concentrate ratio on a DM basis. Amounts of feed offered and refused were recorded once daily. Cows were milked twice a day at 0600 and 1600 h, and milk production was recorded electronically at each milking. Samples for milk composition and FA