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Effects of ruminal or duodenal supply of fish oil on milk fat secretion and profiles of *trans*-fatty acids and conjugated linoleic acid isomers in dairy cows fed maize silage

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Abstract

Milk fat secretion and profiles of conjugated linoleic acids (CLA) and *trans*-18:1 isomers in milk fat due to a ruminal or duodenal supply of fish oil (FO; EPA = 22% of total fatty acids, DHA = 7%) were evaluated using six lactating Holstein cows with cannulas in their rumen and duodenum. Cows were fed a control diet based on corn silage (66% of DM), or the control plus 300 mL FO/d into the rumen (FO-R) or duodenum (FO-D) for 4 weeks in a replicated 3 × 3 Latin square design. Dry matter intake was higher with the control (19.8 kg/d), intermediate with FO-D (18.0 kg/d), and lower with FO-R (16.2 kg/d). Yield of milk (22.7 kg/d), lactose (1.09 kg/d), or crude protein (0.70 kg/d) was not affected by treatments. Content of crude protein, true protein, and casein was lower in response to FO-R compared with the control. Despite similar jugular concentration compared with the control, jugular–mammary venous difference for β-OH-butyrate was 54% lower with FO-R or FO-D. Milk fat content and yield were lowest with FO-R (25 g/kg, 567 g/d) compared with FO-D (32 g/kg, 737 g/d) or the control (35 g/kg, 783 g/d). Percentage of *trans*5-, *trans*6 + 7 + 8-, *trans*9-, *trans*10-, *trans*11-,

Abbreviations: CLA, conjugated linoleic acid; EPA, eicosapentaenoic acid, 20:5*n*-3; DPA, docosapentaenoic acid, 22:5*n*-3; DHA, docosahexaenoic acid, 22:6*n*-3; VA, vaccenic acid (*trans*11-18:1); 9/11CLA, *cis*9,*trans*11-isomer of CLA; 10/12CLA, *trans*10,*cis*12-isomer of CLA

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*trans*12-, and *trans*13 + 14-18:1 in milk fat was greater due to FO-R (0.05, 0.44, 0.48, 1.8, 9.2, 0.70, and 0.82%, respectively) compared with the control or FO-D (0.02, 0.22, 0.19, 0.27, 1.1, 0.35, and 0.40%). Although 18:0 and *cis*9-18:1 percentage was markedly lower in response to FO-R, percentage of *cis*11-, *cis*13-, and *cis*15-18:1 was greater compared with the control or FO-D. *Cis*9,*trans*11-CLA (87–95% of total CLA) averaged 3.2% in response to FO-R compared with 0.51% for control or FO-D. *Trans*10,*cis*12-18:2 was not detected. Among non-conjugated 18:2 isomers, *cis*9,*cis*12-18:2 was lower but *cis*9,*trans*13-, *trans*9,*cis*12-, and *trans*11,*cis*15-18:2 greater when FO-R was compared with the control or FO-D. There was high correlation ($r = 0.94$–0.99) among data obtained by GLC versus HPLC for most *trans*-18:1 isomers and *cis*9,*trans*11-18:2, suggesting GLC alone with our chromatographic conditions provided adequate separation of isomers. Milk 20:5*n*-3 (EPA) and 22:6*n*-3 (DHA) were 0.08 and 0.04% with the control, increased to 0.36 and 0.17% with FO-R, and were 1.47 and 0.47% with FO-D. Data indicate, ruminal supply of FO led to hydrogenation of EPA and DHA and enhanced percentage of various *trans*-18:1, *cis*-18:1, non-conjugated 18:2, and *cis*9,*trans*11-18:2 in milk fat. Combined increases in *trans*-18:1 along with reduced availability of 18:0 for endogenous synthesis of *cis*9-18:1 may play a key role in reduced milk fat synthesis in cows fed fish oil.

Keywords: Fish oil; *Trans*-fatty acids; Conjugated linoleic acids; Long-chain *n*-3 fatty acids; Milk fat

1. Introduction

Long-chain *n*-3 fatty acids, which have been associated with a decrease in the risk of heart disease, account for less than 1% of total fatty acids in typical milk fat (Chilliard et al., 2001). In contrast, milk fat is the richest natural source of the *cis*9,*trans*11- isomer (9/11) of conjugated linoleic acid (CLA) a potent anticarcinogen in rodent and human cancer cell lines (Pariza et al., 2001). Although milk concentrations of eicosapentaenoic [20:5*n*-3 (EPA)] and docosahexaenoic acid [22:6*n*-3 (DHA)] are low, it could be a significant source for people whose consumption of fish is inadequate (Visioli et al., 2000; Bauman et al., 2001) provided that a portion of EPA and DHA escape ruminal biohydrogenation.

Economic factors also may be an incentive for farmers to produce fat-modified milk. In the European Community, the present quota system and value of milk components encourages to increase the protein to fat ratio. Dietary modification seems most promising as a management strategy to alter milk fatty acid composition and total fat production in the short term (Chilliard et al., 2000). As a concomitant effect when fish oil is fed alterations in ruminal metabolism of dietary 18:2*n*-6 and 18:3*n*-3, which are present in basal diet, may contribute to a substantial increase in duodenal flows of *trans*-18:1 isomers and their incorporation into milk fat (Wonsil et al., 1994; Loor et al., 2003). Elevation in milk fat *trans*-18:1 could be one of the causes of the inhibitory effect of fish oil supplementation on milk fat secretion (Wonsil et al., 1994; Chilliard et al., 2001).

Specific isomers of *trans*-18:1 and CLA have been implicated in diet-induced milk fat depression. *Trans*10-18:1 percentage in milk fat was highly correlated with reduced milk fat yield in cows fed a high-starch diet supplemented with corn oil (Griinari et al., 1998)