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The effects of extruded flaxseed supplementation to high-yielding dairy cows on milk production and milk fatty acid composition

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ABSTRACT

The objectives of this study were to determine the effects of extruded flaxseed supplementation to high-yielding dairy cows on milk yield and fatty acid profile. One-hundred Israeli-Holstein dairy cows averaging 150 days in milk (DIM) were stratified into two treatment groups on the basis of milk production, DIM and parity. The treatments were: (1) control—cows were fed a lactating-cows diet; and (2) extruded flaxseed (EF)—cows were fed a lactating-cows diet which included an extruded supplement at 40 g/kg dry matter (DM) that contained flaxseed and wheat bran at 700 and 300 g/kg, respectively. The average daily milk yield was 2.7% higher in the EF group than in the control group (45.4 and 44.2 kg/d, respectively; $P<0.0001$), the fat content was lower in the EF group (34.1 and 36.3 g/kg, respectively; $P<0.03$), and fat yield was unaffected. The α-linolenic acid (ALA; C18:3 n-3) in milk fat was 3.1 times, eicosapentaenoic acid (EPA; C20:5 n-3) 2.4 times, and docosapentaenoic acid (DPA; C22:5 n-3) twice as high in the EF group as in the control group ($P<0.0001$). The overall n-3 fatty acids (FA) concentration and yields were 2.8 times as great in the EF group as in the control group (10.9 and 3.9 g/kg and 16.7 and 6.0 g/d, respectively; $P<0.0001$). The saturated FA (SFA) content in milk fat was 36 g/kg lower in the EF group than in the control (622 and 658 g/kg of FA; $P<0.0001$). On

Abbreviations: ADF, acid detergent fiber; ALA, α-linolenic acid; aNDF, neutral detergent fiber; CLA, conjugated linolenic acid; DIM, days in milk; DM, dry matter; DPA, docosapentaenoic acid; EF, extruded flaxseed; EPA, eicosapentaenoic acid; FA, fatty acids; MUFA, mono-unsaturated fatty acids; NE_L, net energy for lactation; PUFA, polyunsaturated fatty acids; SFA, saturated fatty acids; USFA, unsaturated fatty acids.

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the average, the EF increased the proportion of mono-unsaturated FA (MUFA) by 10% and polyunsaturated FA (PUFA) by 11.8% compared with the control. The n-6:n-3 FA ratio was decreased by the EF supplementation from 11.9 in the control group to 4.2 in the EF group (P<0.0001). In conclusion, feeding an extruded supplement containing 700 g/kg of EF, at a DM rate of 40 g/kg, increased the milk yield and decreased the fat percentage. The n-3 FA concentration and yield in milk fat were 2.8 times as high and the n-6:n-3 ratio was 2.8 times lower in the EF group than in the controls. The SFA proportion decreased and the MUFA and PUFA proportions increased in response to EF supplementation.

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1. Introduction

In recent years fatty acids (FA) have been recognized as major regulators in biological tissues. They are the main components of cell membranes and their composition influences the functioning of the cell membranes. Fatty acids are involved in several biological systems and processes: the immunological system (Prescott and Calder, 2004), blood coagulation and vascular resistance, enzyme activities, cell proliferation and differentiation, and receptor expression (Clandinin et al., 1991). The omega-3 (n-3) FAs are potent participants in the above pathways (Deckelbaum et al., 2006). The long chain length and the presence of the double bond on three carbon atoms endow these FAs with distinct characteristics that confer them unique biological capabilities. The n-3 FAs, especially eicosapentaenoic (EPA; C20:5 n-3) and docosahexaenoic (DHA; C22:6 n-3) FAs are associated with reduced susceptibility to cardiovascular diseases (Breslow, 2006).

In westernized societies the consumption of omega-6 (n-6) polyunsaturated FA (PUFA) has increased and the ratio of n-6 to n-3 PUFA has increased from 1:1 in primitive human diet to 10:1 in the modern human diet (Wathes et al., 2007). In France, the n-6:n-3 ratio in animal products, *i.e.*, milk, eggs and meats, consumed by human populations increased from 2:1 in 1960 to 9.1 in 2000 (Ailhaud et al., 2006). Diets with lower n-6:n-3 ratios are considered healthier for humans, and there has been interest in decreasing this ratio in human foodstuffs. Traditionally, milk and milk products have formed one of the main components of human nutrition, and the annual consumption of milk ranges from 180 down to less than 50 kg per capita in various societies (Haug et al., 2007). Linoleic (C18:2 n-6) and linolenic (C18:3 n-3; ALA) acids are the prominent PUFAs in milk fat, and the overall PUFA content in the FA of dairy milk ranges between 50 and 60 g/kg. In the liver these two essential fatty acids may be converted to longer-chain fatty acids by desaturation and elongation enzyme systems (Wathes et al., 2007).

In ruminants, unsaturated fatty acids that reach the rumen are, to a large extent, converted to saturated FAs (SFAs) by biohydrogenation activity of microflora, and several processes have been developed to protect unsaturated FAs (USFAs) from ruminal biohydrogenation. Calcium salts of fatty acids and prilled fats are the most commonly protected fats in dairy herds. Heat treatment of grains, such as extrusion at high temperatures, was suggested as a method for protecting PUFAs from biohydrogenation activity in the rumen (Chouinard et al., 1997); the hypothesis was that the heating process might encapsulate or tie up the FA fraction of grains. Flaxseed and its oil are the most widely available botanical source of n-3 FAs that contain >500 g of α-linolenic acid (ALA; C18:3 n-3) per kilogram of total FA, and they also contain a high proportion of C18:2 n-6. Feeding of protected flaxseed oil to dairy cows could increase the n-3 FA content and decrease the n-6:n-3 ratio in milk fat. However, the method of protecting fat from ruminal biohydrogenation influences the efficiency of transfer of FAs into the milk and, among other things, determines the degree of n-3 FA enhancement in milk, as reported by Gonthier et al. (2005).

The objectives of the present study were to determine the effects of feeding a supplement containing extruded flaxseed to high-yielding dairy cows on their yields of milk and milk components, and on the FA profiles of plasma and milk fat.

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