

Effects of Feeding Camelina (Seeds or Meal) on Milk Fatty Acid Composition and Butter Spreadability

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ABSTRACT

The nutritional and rheological properties of butter depend on the fatty acid composition of milk. Therefore, feeding oilseeds rich in unsaturated fatty acids is likely to affect butter properties. The aim of this trial was to examine to what extent feeding the linolenic acid-rich cruciferous plant camelina can affect the fatty acid composition of dairy products and the properties of butter. A control diet composed of 60% corn silage-based ration and completed with high-energy and nitrogenous concentrates was compared with 2 experimental diets designed to provide the same amount of polyunsaturated fatty acids via either camelina seed (630 g/d, CS diet) or camelina meal (2 kg/d, CM diet). The diets were isoenergetic and isonitrogenous. The trial followed a double 3 × 3 Latin-square design with 4-wk periods on 6 Holstein dairy cows. The camelina diets tended to decrease dry matter intake but did not have a significant effect on milk production. They generated a slight decrease in milk protein and a strong decrease in milk fat yield and content. The CM diet led to a stronger decrease in fat content. Camelina generated a greater proportion of monounsaturated fatty acids, notably C18:1 *trans* isomers, including *trans*-10 and *trans*-11 C18:1, which increased by 11.0- and 2.6-fold, respectively, with the CM diet. Camelina also led to an increase in conjugated linoleic acids, particularly rumenic acid, *cis*-9, *trans*-11 C18:2. Camelina did not affect parameters of buttermaking except churning time with milk from CM fed cows, which was longer. The butters of camelina diets were softer at all temperatures tested, especially with the CM diet. In conclusion, feeding camelina can modify milk fatty acid profile and butter spreadability.

Key words: camelina, false-flax, fatty acid composition, butter

INTRODUCTION

The nutritional, organoleptic, and rheological (hardness, spreadability, melting) properties of dairy products are largely dependent on the fatty acid (FA) composition of milk, particularly polyunsaturated fatty acids. The FA composition can be modulated by feeding of the dairy cows. A number of trials have studied the effects on milk FA composition of supplementing diets with lipids from oilseeds, vegetable oils, or calcium soaps of vegetable oil (Chilliard et al., 2001).

Camelina, a cruciferous plant and a member of the mustard family, is a very old European oil crop; its history goes back to the Bronze Age (Putnam et al., 1993). Camelina, popularly known as false flax or gold-of-pleasure is an annual or overwintering herb originating in the region from the Mediterranean to Central Asia and is very adaptable to climate and soil type. It presents a similar FA profile to flaxseed and is rich in linolenic acid. The camelina oil contains 20 to 40% C18:3, 10 to 20% C18:2, 12 to 25% C18:1, 13 to 21% C20:1, and between 2 and 5% C22:1. Research has demonstrated further benefits of the camelina oil in skincare products, in the production of soaps and soft detergents, in the production of interesting lipopeptides and lipoaminoacids, and in the production of paints (Bonjean and Le Goffic, 1999). The plant has been shown to have only modest agro-input requirements, and can fit with in rotational strategies. The protein-rich camelina pressed cake is also a valuable livestock food. This oilseed meal still contains 10% oil, 13% fiber, 5% minerals, and 45% protein (Bonjean and Le Goffic, 1999). The aim of this trial was to quantify the effects of supplementing a corn silage-based diet with polyunsaturated FA derived from either whole-seed camelina (CS) or camelina meal (CM) on the composition and butter-making properties of the milk.

MATERIALS AND METHODS

Treatments, Experimental Design, Animals, and Feeding

The trial was conducted according to a double 3 × 3 Latin square design using 6 Holstein dairy cows. Each

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Table 1. Major fatty acid composition (%) of the lipid content of camelina seed and meal.

Fatty acid	Camelina seed	Camelina meal
Palmitic acid, C16:0	8.3	10.3
Oleic acid, C18:1	17.8	19.9
Linoleic acid, C18:2	27.6	28.5
Linolenic acid, C18:3	46.3	41.3

experiment was conducted over a 4-wk period, and measurements were taken during the final week of each period. The dairy cows were individually fed and produced 38.3 ± 2.8 kg of milk containing $3.40 \pm 0.83\%$ fat content and $2.81 \pm 0.18\%$ true protein content at trial initiation. The cows were at 70 ± 15 DIM at the start of trial.

Three diets were compared. The control diet was a corn silage-based diet supplemented with high-energy concentrate and soybean meal. The 2 experimental diets included either camelina seeds (false-flax seeds) or camelina meal (false-flax meal; Limagrain, Chappes, France). The CS diet provided 630 g/d of camelina seeds, and the CM diet provided 2 kg/d of camelina meal. Camelina seed and meal were supplied in quantities calculated to provide the cattle with the same amounts of polyunsaturated FA, that is, around 240 g/cow per d. These oilseed supplements contain, on average, 90.7% of unsaturated FA, of which 71.8% are polyunsaturated FA (Table 1). The diets consisted of 58% corn silage. The energy concentrate and soybean meal were then adjusted to cover 100% of energy and nitrogen requirements: camelina seed was added as a substitute for the energy concentrate, whereas camelina meal was added as a substitute for part of the soybean meal and the energy concentrate. Cows received supplements of 300 g/d of minerals 5-25-5 (P-Ca-Mg) to cover mineral requirements. Tables 2 and 3 give feed composition and nutritional values. The animals were fed twice daily at 0800 and 1700 h. The

camelina seed and meal were carefully mixed with the corn silage.

Measurements

The amounts of feed and orts were weighed daily. The DM content of corn silage was determined (80°C , 48 h) every 3 d to adjust the proportion of corn silage in the diets. To calculate DMI, the composition of orts was assumed similar to the offered diet. For chemical analyses, oven-dried samples of corn silage were pooled over each period, whereas concentrates, camelina seed and meal, and minerals were sampled weekly, and the samples were pooled over the whole experimental period. All the samples were ground with a 3-blade knife mill through a 0.8-mm screen. Organic matter content was determined by ashing for 6 h at 500°C . Total feed N content was determined by the Dumas method (Association Française de Normalisation, 1997). Feed ADF, NDF, and crude fiber were analyzed according to the method initially described by Van Soest et al. (1991) on a Fibersac analyzer (Ankom Technology, Fairport, NY). Fat content was measured by ether extraction (Apper-Bossard et al., 2006). Fat composition of camelina seed and meal was determined by gas chromatography with flame-ionization detector adapted from the method described by Wolff and Fabien (1989). The cows were weighed at the beginning and at the end of each experimental period.

To characterize the effects of camelina on rumen fermentation, ruminal fluid (50 mL) was pumped out from the ventral sac of the rumen, before the morning meal (0800 h) and 3 h later on the last day of each period. At each collection time, pH was measured immediately and the samples were strained through 6 layers of cheesecloth. Eight milliliters of strained rumen fluid was mixed with 0.8 mL of 5% (vol/vol) orthophosphoric acid containing 1% (wt/vol) mercury chloride and kept at -20°C until VFA analysis by gas chromatography (Jouany, 1982). For ammonia analysis, 4

Table 2. Chemical composition and nutritional value of feeds

Item	DM, %	CP	Fat	NDF	ADF	PDIN ¹	PDIE ²	NE _L , Mcal/kg of DM
			g/kg of DM					
Corn silage	35.8	63	30	404	208	39	65	1.55
Energy concentrate	89.0	115	27	335	135	81	106	1.70
Soybean meal 48	88.0	527	16	162	90	374	254	2.01
Camelina meal (CM)	91.3	411	132	269	144	257	125	2.02
Camelina seed (CS)	88.7	270	378	286	151	177	108	2.58

¹PDIN = protein digested in the small intestine supplied by rumen-undegraded dietary protein and by microbial protein from rumen-degraded organic matter (INRA, 1989).

²PDIE = protein digested in the small intestine supplied by rumen-undegraded dietary protein and by microbial protein from rumen-fermented organic matter (INRA, 1989).

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