J. Dairy Sci. 95:3569–3578
http://dx.doi.org/10.3168/jds.2011-5163

Milk fatty acid composition and production performance of Danish Holstein and Danish Jersey cows fed different amounts of linseed and rapeseed

M. K. Larsen,*[1] L. Hymøller,† D. B. Brask-Pedersen,† and M. R. Weisbjerg†
*Department of Food Science, and
†Department of Animal Science, AU Foulum, Aarhus University, Blichers Allé 20, PO Box 50, DK-8830 Tjele, Denmark

ABSTRACT

Fat supplements are used in diets for dairy cows to increase energy intake and milk production and the fatty acid composition of the feed affects milk fatty acid composition. A total of 74 Danish Holstein and 41 Danish Jersey cows were divided into 4 groups and the cows within each group were fed a mixed ration supplemented with 0, 3.5, 6.8, or 10.2% of dry matter of a linseed:rapeseed (1:3) mixture during lactation wk 6 to 30. Milk yield, fat, and lactose contents were not affected by treatments for Danish Holsteins, whereas these parameters increased when increased amounts of oilseeds were fed to Danish Jerseys. For both breeds, milk protein content decreased when increased amounts of oilseeds were fed. The milk fatty acid composition showed higher concentrations of saturated fatty acids and lower concentrations of unsaturated fatty acids in milk fat from Danish Jerseys compared with Danish Holsteins. Increased amounts of oilseeds in feed increased milk fat concentration of all C18 fatty acids except C18:2 n-6, whereas the content of C6 to C14, C11 to C17, and in particular, C16, decreased. This effect was more pronounced for Danish Holsteins than for Danish Jerseys. The apparent recovery of C18:2 n-6 and C18:3 n-3 decreased when increased amounts of oilseeds were fed; however, this was most likely due to increased amounts of fatty acid from feed used for other energy demands than milk production. It was concluded that up to 6.8% of oilseed supplementation can be fed without production problems and, in many cases, with positive production responses, including an improved milk fatty acid profile.
Key words: oilseed, milk production, milk fatty acid composition

Received November 21, 2011.
Accepted March 9, 2012.
[1]Corresponding author: mette.larsen@agrsci.dk

INTRODUCTION

Fats are used in diets for high-producing dairy cows to increase energy intake and milk production. Furthermore, the FA composition of the produced milk can be manipulated by altering the FA composition of fats in the feed. The presence of particular FA in foods has attracted public interest, because a high intake of SFA has been associated with elevated concentrations of blood cholesterol in humans and increased risk of coronary heart diseases (Lunn and Theobald, 2006). A specific preventive effect of α-linolenic acid (C18:3 n-3) on coronary heart diseases has been shown (Ascherio et al., 1996), and milk enriched with n-3 PUFA and oleic acid (C18:1 *cis*-9) has been shown to decrease the risk of cardiovascular diseases (Carrero et al., 2004). A specific decrease in the content of palmitic acid (C16:0) in milk is desired in combination with an increase in the content of *cis* MUFA and *cis* PUFA (Givens, 2010).

The FA composition of milk consists of a range of FA. Short- and medium-chain SFA (C4 to C14) originate from mammary de novo synthesis; C16:0 may originate from this de novo synthesis or from feed. Longer-chain FA in milk (mainly C18 FA) originate from feed or from mobilized body fat. Mammary desaturation of SFA is the main source of *cis*-9 MUFA (Grummer, 1991). Polyunsaturated FA derive from feed; however, biohydrogenation of dietary unsaturated FA by rumen bacteria before intestinal absorption causes the degree of saturation of the FA absorbed in ruminants to be higher than the degree of saturation of FA consumed (Weisbjerg et al., 1992; Jenkins, 1993; Doreau and Ferlay, 1994). The main PUFA in feed and linoleic and linolenic acid are usually biohydrogenated to a very high degree. Doreau and Ferlay (1994) compared several studies and found that the percentage of biohydrogenation of linoleic acid ranged from 70 to 95% and the percentage of biohydrogenation of linolenic acid from 85 to 100%. A marked increase in the supply of absorbable PUFA in the small intestine would, therefore, require a relatively large intake of unsaturated FA, unless the degree of hydrogenation in the rumen is effectively reduced.

Feeding dairy cattle large amounts of unsaturated FA has a negative effect on rumen function; for example, by decreasing the fiber digestibility and the acetate-to-propionate ratio (Chilliard, 1993; Harvatine and Allen, 2006), but at the same time decreasing methane losses (Beauchemin et al., 2007). The severity of these negative effects is determined by different factors such as the quantity of fat per se and the composition of the fat source with respect to FA chain length and degree of saturation (Weisbjerg et al., 1992; Harvatine and Allen, 2006); for example, unsaturated FA are toxic to protozoa and cellulolytic bacteria (Jenkins, 1993), and oils have a more negative effect on the rumen environment than do oilseeds and cakes (Jenkins, 1993).

Protecting fats and FA against microbial activity reduces the degree of biohydrogenation of unsaturated FA and the negative effect of fat supplementation on cell wall degradation of ingested plant material. However, the effects of the existing protection technologies are limited or very costly (Jenkins and Bridges, 2007). Offering oilseeds to ruminants instead of oils provides natural protection against biohydrogenation of lipids in the rumen (Ekeren et al., 1992).

The aim of the present study was to investigate the response in FA composition of the produced milk, feed intake, milk yield, and BW changes when feeding dairy cows of 2 different breeds [Danish Holstein (**DH**) and Danish Jersey (**DJ**)] increasing levels of unsaturated fat from a mixture of linseed and rapeseed during wk 6 to 30 of lactation. Linseed and rapeseed were chosen because they can be grown under Northern European conditions and because the major FA of linseeds, C18:3 n-3, was expected to increase milk fat content of this FA.

Table 1. Mixed ration composition (% of DM) calculated from the feed intake in the different treatment groups

	Treatment			
Mixed ration composition	F0	F1	F2	F3
Grass clover silage	31.0	31.2	30.5	30.7
Corn silage	31.9	32.6	32.0	32.2
Soybean meal, extracted	7.8	7.9	7.8	7.9
Rapeseed meal, extracted	5.0	5.1	5.0	5.1
Barley, rolled	10.0	6.7	3.3	—
Linseed	—	0.9	1.7	2.6
Rapeseed	—	2.6	5.1	7.6
Concentrate (in AMS unit)[1]	12.9	11.5	13.1	12.5
Vitamin and mineral mixture[2]	1.0	1.0	1.0	1.0
Salt (NaCl)	0.5	0.5	0.5	0.5

[1]AMS = automatic milking system.

[2]Composition of vitamin and mineral mixture (per kilogram): vitamin A 566,000 IU; vitamin D3 101,600 IU; α-tocopherol 1,029.2 mg; D-α-tocopherol 757.7 mg; calcium 290 g; magnesium 62 g; sulfur 39 g; manganese 3,843 mg; copper 1,385 mg; zinc 6,667 mg; iodine 198.3 mg; cobalt 31.2 mg; selenium 27.9 mg.

MATERIALS AND METHODS

Animals and Experimental Design

Animal experiments complied with the Danish Ministry of Justice Law No. 726 (September 9, 1993) concerning experiments with animals and care of experimental animals. A total of 115 cows of the DJ or DH breed were allocated to different treatments according to lactation number (first and later) and expected calving date. Cows were allocated to 4 different concentrations of fat (**F0**, **F1**, **F2**, and **F3**) in a mixed ration (**MR**) during wk 6 to 30 of lactation. During wk 0 to 5 of lactation, all cows were fed the F0 ration, which was a standard low-fat dairy ration.

Housing and Management

Experiments were carried out at the Danish Cattle Research Centre (Tjele, Denmark) during 2009. Cows were kept in a loose-housing system with slatted floors and cubicles with mattresses. A free cow-traffic system was applied for access to an automatic milking system (**AMS**) from DeLaval AB (Tumba, Sweden). Within the dairy unit, cows were organized in 3 groups (AMS groups), 1 with DJ cows and 2 with DH cows, and each group had access to 1 automatic milking unit (**AMU**) equipped with a device for automatic measurement of milk yield and milk sampling. Additionally the AMU were equipped with a device for concentrate feeding and weighing of concentrate refusals at the end of each cow visit. Below each AMU, a platform scale from Danvægt A/S (Hinnerup, Denmark) for automatic recording of cow BW was installed. For automatic recording of MR intake, the Insentec RIC system (Insentec BV, Marknesse, the Netherlands) was used. The facilities and management procedures at the Danish Cattle Research Centre are described in detail by Bossen et al. (2009) and Bossen and Weisbjerg (2009).

Feeds and Mixed Rations

Four different corn and grass clover silage-based MR were used to obtain 4 fat levels (treatments F0, F1, F2, and F3) where barley was partly or totally substituted with ground rapeseed (double-low variety) and linseed (3:1) on a DM basis, as shown in Table 1. The chemical composition of individual ingredients is shown in Table 2.

Data Collection

Information on MR intake, concentrate intake, milk yield, milk composition, BW, and BCS was obtained as