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# Seasonal variation in the composition and melting behavior of milk fat

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## ABSTRACT

Dairy bulk tank milk was sampled during 1 yr from 2 conventional (C1 and C2) and 1 organic dairy (O1) for studying the seasonal variation as well as the variation between dairies in the composition and properties of milk fat. The composition of fatty acids (FA) as well as triglycerides (TAG) in milk fat was analyzed, and the melting properties of milk fat were analyzed by use of differential scanning calorimetry. The main differences in fat content and composition of FA in milk fat between dairies included a higher fat content, greater proportion of C18:0, and smaller proportion of C16:0 in milk from dairy C2, which could be associated with a higher frequency of Jersey herds supplying milk to this dairy. The organic milk was characterized by a higher proportion of C18:3 n3, C18:2 *cis*-9,*trans*-11, C6 to C14, a lower proportion of C18:1 *cis*-9, and a higher melting point of the low-melting fraction. The TAG composition showed a greater proportion of C24 to C38 TAG in milk fat from dairy O1 and a greater proportion of C52 to C54 TAG in milk fat from dairy C2, which was in accordance with the differences in FA composition. Melting point of the low-melting fraction was higher for milk fat from dairy O1 compared with dairies C1 and C2, whereas no differences between dairies were observed with respect to melting points of the medium- and high-melting fractions. The seasonal variation in FA composition was most pronounced for dairy O1 although similar patterns were observed for all dairies. During the summer, the content of C18:0 and C18:1 *cis*-9 in milk fat was greater, whereas the content of C14:0 and C16:0 was lower. In addition, the content of C18:2 *cis*-9,*trans*-11 and C18:1 *trans*-11 increased in late summer for dairy O1. The differential scanning calorimetry thermograms of individual milk fat samples could be divided into 3 groups by principal component analysis. For dairy O1, summer samples belonged to group 1, spring and autumn samples to group 2, and winter samples to group 3. For dairy C1 winter samples (group 2), were separated from other samples (group 1), and for dairy C2 all samples were in group 1. Individual melting points were related to FA composition, and the melting point of the low-melting fraction was positively correlated to the content of C14:0 and C16:0 in milk fat and negatively correlated to the content of C18:1 *cis*-9 and C18:0.

**Key words:** fatty acid composition, triglyceride composition, melting property

## INTRODUCTION

Fat is a main component in milk and has important nutritional and technological properties. However, the composition of milk fat is not constant, which provides both challenges and opportunities for the dairy industry. About 98% of milk fat is represented in the form of triglycerides (**TAG**), which are essentially esters of glycerol and FA. The properties of milk fat are, to a large extent, determined by the FA composition, which can vary significantly. Factors that influence FA composition include feed, stage of lactation, lactation number, breed, health status, and genetics. In milk fat, more than 400 different FA have been identified (Jensen, 2002), which are dominated by SFA (~70%), followed by MUFA and small amounts of PUFA. The FA in milk originate from different sources: de novo synthesis in the mammary gland, body fat reserves, FA from feed, and FA produced from bacteria in the rumen (Jensen, 2002).

Softer texture has been reported for dairy products (yogurt, ice cream, and cheese) when manufactured from milk rich in unsaturated fat (Chen et al., 2004; Couvreur et al., 2006; Hurtaud et al., 2010). Historically, it is known that butter produced during summer, when cows are grazing, is softer than butter produced from winter milk. This effect has been correlated to the changes in the FA composition over the season, where the unsaturated-to-saturated FA ratio increases during the summer, which is related to grazing (Toledo et al., 2002; Heck et al., 2009; Larsen et al., 2010). To obtain a more uniform texture of butter throughout the year, manufacturers can give the cream a season-dependent temperature treatment to manipulate fat crystal com-

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position and size, which defines the spreadability of the butter. Effects of changes in FA composition have been extensively studied from a nutritional point of view, whereas the technological properties have received much less attention. Texture of butter and other dairy products may be analyzed by rheological or sensory methods; however, the texture is affected by processing conditions as well as the composition of the raw milk. Differential scanning calorimetry (**DSC**) studies have been performed to determine the crystallization and melting behavior of isolated milk fat, as these properties determine the physiochemical and sensory properties of dairy products with a great content of fat, and an increased content of unsaturated FA has been shown to decrease melting points and increase proportion of low-melting TAG (Couvreur et al., 2006; Ortiz-Gonzalez et al., 2007; Smet et al., 2010; Buldo et al., 2013). By use of extruded linseed feeding (60% of concentrate), Smet et al. (2010) reported a decrease in SFA in milk fat, from 71 to 61%, accompanied by a decrease in melting points of 3.8, 1.6, and 1.7°C of the low-, medium-, and high-melting fractions, respectively. In addition, the low-melting TAG increased from 32 to 44% and the medium- and high-melting TAG decreased. Based on cream samples from individual cows from different farms, Buldo et al. (2013) reported that the melting point of the lowest melting fraction is positively correlated to the concentration of C16:0 and negatively correlated to the concentration of C18:1 *cis*-9 in milk fat. Ortiz-Gonzalez et al. (2007) altered the milk FA composition by abomasal infusion of various oils and reported a positive relationship between the concentration of C16:0 in milk fat and the melting point of the high melting fraction, whereas the concentration of C18:2 was negatively correlated to the melting point of the high-melting fraction.

The objective of the current work was to study the effect of season on the FA composition in both Danish conventional and organic milk and how this affects melting properties. Furthermore, the study aimed to relate the FA and TAG composition to the melting point pattern of milk fat by using multivariate data analysis. The main seasonal variation in feeding is generally the use of grazing during summer, which affects milk FA composition. Raw milk was sampled from 3 Danish dairies over a period of 12 mo at least once a month, with higher frequencies during spring and autumn. The milk fat was analyzed for FA composition, as well as TAG composition, and melting behavior of crystallized milk fat was investigated with DSC. The seasonal variations in FA and TAG composition were correlated to variations in the melting behavior. The main hypotheses of the present study were that organic milk fat differed from conventional milk fat in FA composition as well as melting properties, and that the seasonal variation in these parameters was more pronounced for organic milk, as grazing is compulsory in Danish organic farming, whereas grazing is only practiced by a limited number of conventional dairy farmers.

## MATERIALS AND METHODS

### Milk Sampling

Conventional bulk tank milk from 2 Danish dairies (**C1** and **C2**) was collected from January 2010 to December 2010. Furthermore, organic bulk tank milk from 1 Danish dairy (**O1**) was collected from March 2010 to December 2010. Milk was sampled from raw milk silo tanks with agitation, where the incoming milk is stored until standardization and processing at least once a month, with a higher frequency during spring and autumn. Milk was sampled at the dairies in the morning, transported directly to the laboratory, analyzed for total fat content by use of a Milkoscan FT2 (Foss Electric, Hillerød, Denmark), and divided into subsamples, which were kept at −20°C until analysis.

Samples were grouped according to 6 periods of sampling, defined as January to February (period 1; calendar wk 1–8), March to April (period 3; calendar wk 9–15), May to June (period 5; calendar wk 16–23), July to August (period 7; calendar wk 24–36), September to October (period 9; calendar wk 37–44), and November to December (period 11; calendar wk 45–52). Periods 1, 3, and 11 included winter feeding; period 5 covered early grazing; and periods 7 and 9 covered regrowth and late regrowth of pastures. In organic farming, a compulsory use of grazing exists when climatic conditions allow (European Council, 2007), and the beginning of the grazing period was determined as the third Sunday of April (www.okodag.dk). During winter and under winter-like weather conditions, which is not unusual from November to March, animals cannot be kept outside unless all animals have access to dry bedding (Foedevarestyrelsen, 2011); thus, the grazing period was assumed to end by the end of October. No registration of feed composition was conducted, as milk samples were dairy bulk tank milk samples.

### Analysis of FA Composition and TAG Composition

For analysis of FA composition, milk fat was isolated by centrifugation and subsequently methylated by use of sodium methylate, as described previously, except that heptane was used as solvent instead of pentane (Larsen et al., 2013). Methyl esters were analyzed by gas chromatography and relative amounts of individual FA were calculated by use of external standards

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