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Effect of short-term versus long-term grassland management and seasonal variation in organic and conventional dairy farming on the composition of bulk tank milk

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ABSTRACT

Bulk tank milk from 28 dairy farms was sampled every second month for 2 yr to assess the effects of grassland management, production system and season on milk fatty acid (FA) composition, concentrations of fat-soluble vitamins, Se, and milk sensory quality. Grassland management varied in terms of time since establishment. Short-term grassland management (SG) was defined as establishment or reseeding every fourth year or more often, and long-term grassland management (LG) was defined as less frequent establishment or reseeding. Fourteen organic (ORG) dairy farms with either short-term or long-term grassland management were paired with 14 conventional (CON) farms with respect to grassland management. Within ORG farms, SG farms differed from LG farms in herbage botanical composition, but not in concentrate FA concentrations, dry matter intake, or milk yield. Within CON farms, herbage composition, concentrate FA concentrations, dry matter intake, and milk yield showed no or insignificant variations. The ORG farms differed from CON farms in herbage botanical composition, concentrate FA concentrations, concentrate intake, and milk yield. Compared with ORG-LG farms, ORG-SG farms produced milk fat with higher proportions of C10:0 and C12:0 associated with higher herbage proportions of legumes (*Fabaceae*) and lower proportions of other dicotyledon families. Compared with milk from CON farms, milk fat from ORG farms had higher proportions of most saturated FA and all n-3 FA, but lower proportions of C18:0 and C18:1 *cis*-9 associated with higher forage proportion and differences in concentrations of FA in concentrates. Compared with the outdoor-feeding periods, the indoor feeding periods yielded milk fat with higher proportions of most short-chain and medium-chain FA and lower proportions of most C18-FA associated with grazing and higher forage proportions. Milk concentrations of α-tocopherol and β-carotene were lower during the grazing periods. Inclusion of fishmeal in organic concentrates may explain higher Se concentrations in organically produced milk. Milk sensory quality was not affected in this study. In conclusion, grassland management had minor effects on milk composition, and differences between ORG farms and CON farms may be explained by differences in concentrate intake and concentrate FA concentrations. Milk produced on ORG farms versus CON farms and milk produced during the outdoor versus indoor feeding periods had potential health benefits due to FA composition. In contrast, the higher milk-fat proportions of saturated FA in milk from ORG farms may be perceived as negative for human health.
Key words: dairy farm, grassland management, production system, milk composition

INTRODUCTION

Consumption of dairy products has been claimed to have negative health effects in humans because milk fat has high proportions of SFA, which are understood to contribute to cardiovascular disease and obesity (Appleby et al., 1999; Insel et al., 2007). In contrast, new studies have revealed that high consumption of dairy products may help to prevent coronary heart disease, different types of cancer, and other chronic diseases, although the mechanisms are not understood (Kliem and Givens, 2011). Fat-soluble vitamins are important in human nutrition (Haug et al., 2007) and, besides their nutritional value, they may also improve the oxidative stability of milk fat with high proportions of PUFA (Al-Mabruk et al., 2004). Diet formulation may influence the milk-fat composition of grazing or silage-fed cows (Chilliard et al., 2001).

Grassland management is likely to affect sward botanical composition, which has been proven to affect milk FA composition (Dewhurst et al., 2003b; Lourenço et al., 2008). Sward botanical composition affects the

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concentrations of fat-soluble vitamins in forages, but also other factors, such as plant maturity (Danielsson et al., 2008) and preservation method (Lindqvist et al., 2012), are important. Milk concentrations of fat-soluble vitamins vary significantly and depend on diet, animal factors, such as breed (McDowell, 2000) and stage of lactation (Jensen et al., 1999), and supplementation. Forage Se concentrations have been reported inadequate to meet the dietary Se requirement in regions with low soil Se concentrations, and thus Se-enriched feed supplements are commonly used (Govasmark et al., 2005).

Compared with conventionally produced milk, organically produced milk has higher fat proportions of C18:3n-3 (Butler et al., 2008; Collomb et al., 2008a), C18:1 *trans*-11 and C18:2 *cis*-9,*trans*-11 (Jahreis et al., 1996; Collomb et al., 2008a), PUFA (Ellis et al., 2006; Collomb et al., 2008a), and lower proportions of n-6 FA (Butler et al., 2008; Collomb et al., 2008a;), C18:0, C18:1 *cis*-9, and MUFA (Jahreis et al., 1996; Collomb et al., 2008a). The concentrations of α-tocopherol and β-carotene are higher in organic than conventional milk during the outdoor feeding period, but not during the indoor feeding period in the study of Butler et al. (2008). Ellis et al. (2007) reported no differences for these vitamins, but found less retinol in organic milk. The concentrations of α-tocopherol and β-carotene are higher in summer milk than in winter milk (Lindmark-Månsson et al., 2003; Ellis et al., 2007). In these studies, the authors suggest a positive effect of grazing compared with feeding silage on fat-soluble vitamins in milk, however, the role of forage type and total diet needs further investigations.

Sward age and composition on dairy farms vary according to conditions that complicate soil tillage necessary for reseeding, such as climate, slope, stone content, field size, or economic costs. The time span after reseeding and other grassland management factors may affect grassland botanical composition (Hopkins, 1986), which, together with differences in dietary supplementation, affect milk FA composition (Dewhurst et al., 2003b), concentrations of fat-soluble vitamins (Bolstad et al., 2007), and Se concentrations in milk. Although previously cited studies indicate specific effects of botanical composition on milk FA and fat-soluble vitamins, to our knowledge no attempts have been made to investigate the effect of botanical composition at the level of farming systems (Ellis et al., 2007; Butler et al., 2008; Collomb et al., 2008a).

The objectives of the present study were to compare the effects of long-term versus short-term grassland management in organic and conventional production systems, compare organic and conventional production systems, and assess seasonal variation on FA composition, fat-soluble vitamin concentrations, sensory quality, and Se concentration in bulk tank milk.

MATERIALS AND METHODS

Experimental Design

Twenty-eight dairy farms in central Norway participated in the study in 2007 and 2008. Seven organic (**ORG**) farms with short-term grassland management (**SG**), referred to as ORG-SG farms, were paired with 7 conventional (**CON**) farms with SG, referred to as CON-SG farms, and 7 ORG farms with long-term grassland management (**LG**), referred to as ORG-LG farms, were paired with 7 CON farms with LG, referred to as CON-LG farms. Grassland management was defined as SG when the grassland fields of a farm were renewed every fourth year or more frequently and as LG when the fields were renewed less frequently. Fields were renewed by soil tillage and seeding. Organic and conventional farms were paired on location and calving pattern, based on information from local extension services. The organic farms were certified by the Norwegian certification body Debio (Bjørkelangen, Norway) according to the EU standards for organic farming (European Commission, 2006). In brief, the standards for organic farming require a minimum forage intake in total DMI (50% in the first 3 mo of lactation increasing to 60% thereafter) and all feeds have to be grown organically (i.e., without the use of synthetic pesticides and synthetic N fertilizers). Fertilization with animal manure is limited to 170 kg of N/ha and year. All farms participated in the Norwegian Dairy Herd Recording System and delivered milk to the same dairy company (TINE Norwegian Dairies SA, Oslo, Norway). On all farms, forages were fed ad libitum and allocated concentrate amounts were based on individual milk yields.

On-Farm Analysis, Sampling, and Data Collection

Data on farm characteristics (Table 1) were collected in farmer interviews and milk production data were collected from the Norwegian Dairy Herd Recording System. Herbage botanical composition before first cut silage in 2007 was estimated on 4 selected fields on each farm by the dry-weight-rank method (Mannetje and Haydock, 1963), modified by Jones and Hargreaves (1979). The selected fields represented overall grassland use including fields that were cut, cut and grazed in combination, or only grazed. Silage and concentrates were sampled twice in each indoor feeding period (February 2007, October 2007, February 2008, December 2008) on each farm. Two milk samples were taken in each sampling month (February, April, June, August,