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Fatty acid composition, fat-soluble vitamin concentrations and oxidative stability in bovine milk produced on two pastures with different botanical composition

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ABSTRACT

Previous research has shown that grazing pastures compared to feeding preserved forages has large impact on milk fatty acid (FA) composition, but differences between grazing red clover (*Trifolium pratense* L.) or white clover (*Trifolium repens* L.) are small, whereas the herbage proportions of dicotyledon botanical families is positively correlated with the milk-fat proportions of total polyunsaturated FA when grazing pastures in the Alps. The objective of the present study was to investigate the influence of botanically different pastures on bovine milk composition and milk susceptibility to oxidation. Two groups of 8 multiparous Norwegian Red dairy cows [mean (standard deviation); 599 (45.1) kg body weight, 73 (15.0) d in milk, 29.9 (2.90) kg milk/d at experiment start] grazed either a short-term pasture (SP) or a long-term pasture (LP). Both pastures were organically managed, meaning that no artificial fertilizers or herbicides were applied. The SP was representative for pastures, which are frequently, i.e. at least every third year, renewed by soil tillage and seeding, whereas LP was representative for pastures, which are less frequently renewed. The SP contained mainly meadow fescue (*Festuca pratensis* Huds.), timothy (*Phleum pratense* L.) and red clover and LP contained smooth meadow grass (*Poa pratensis* L.), white clover and a variety of unsown species. Sixteen cows were blocked according to milk yield, days in milk and sire, and randomly within block allocated to the 2 dietary treatments with a daily pasture allowance of 15–20 kg dry matter per cow, supplemented with 3.0 kg barley (*Hordeum vulgare* L.) concentrate. Milk was sampled during the last week of 3 experimental periods and analysed for FA composition by gas chromatography, concentrations of fat-soluble vitamins by high performance liquid chromatography, and oxidative stability in a light-exposure experiment by measuring the formation of hydroperoxides and by front-face fluorescence spectroscopy. Pasture type had no effect on milk yield, milk gross composition, and only minor effects on milk FA composition. Milk from SP had higher concentration of α-tocopherol than LP. The formation of hydroperoxides in milk was lower for SP than LP after 24 h light

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exposure, but no differences were found after 48 h. Front-face fluorescence spectroscopy revealed slightly higher formation of components in the area of 409–480 nm wavelength for SP than LP, which may be related to milk-lipid oxidation. The experimental pastures differed mainly in herbage proportions of red clover and white clover and less in proportions of non-legume dicotyledons. This explains small differences in milk FA composition and milk susceptibility to oxidation.

1. Introduction

The aim of modulating the fatty acid (FA) composition in bovine milk fat is to decrease the proportions of saturated FA (SFA) and increase the proportions of other FA, e.g. C18:1c9, C18:2c9t11 and C18:3 n-3 in milk to improve its nutritive value for humans (Givens, 2005; Simopoulos, 2008).

Milk FA composition in dairy cows is known to be affected by botanical composition in silages (Lourenço et al., 2005). Compared to grass (*Poaceae*) based silages, silages based on mixed leys with grass and red clover (*Trifolium pratense* L.) or white clover (*Trifoilum repens* L.) increase the milk-fat proportions of C18:3 n-3 (Dewhurst et al., 2003). No or inverse effects on proportions of C18:3 n-3 are reported when cows graze red clover rich pastures compared to white clover rich pastures (Larsen et al., 2012; Wiking et al., 2010). Soder et al. (2006) found increasing milk-fat proportions of C18:2c9t11 for cows grazing more botanical diverse forage mixtures, however, C18:3 n-3 was not affected. It is suggested that the positive effect of red clover silage on C18:3 n-3 is related to the activity of polyphenole oxidase (EC 1.14.18.1) (Lee et al., 2004), however, oxygene is rapidly depleted in the rumen, limiting the activation of polyphenole oxidase during grazing (Lee et al., 2009). The effect of white clover on C18:3 n-3 is most likely related to increased rumen passage rate (Dewhurst et al., 2003). Collomb et al. (2002) found positive correlations between several dicotyledon families in pastures in the Alps and milk-fat proportions of PUFA, total conjugated linoleic acids and C18:1t-FA. Less is known about the effects of botanical diverse pastures compared to red clover rich pastures on milk FA composition.

Forage concentrations of fat-soluble vitamins are affected by forage botanical composition and stage of maturity in plants (Danielsson et al., 2008). Milk susceptibility to oxidation is decreased by antioxidants like α-tocopherol from forage or supplements (Al-Mabruk et al., 2004). In fresh milk, stored in containers without sufficient light barrier, off-flavours can appear already after 1 d of storage under fluorescent lighting (Moyssiadi et al., 2004). More knowledge is needed on how pasture botanical composition affects milk susceptibility to oxidation.

The objectives of the present experiment were to assess the effects of grazing a newly established grass-red clover pasture or an older pasture with a variety of sown and unsown plant species on FA composition, concentrations of fat-soluble vitamins and oxidative stability in bovine milk.

The hypotheses were (1) that the newly established pasture contains more red clover and less white clover and non-legume dicotyledons than the older pasture and (2) that the higher proportions of non-legume dicotyledons in the older pasture increase milk-fat proportions of C18:1t-FA, C18:2c9t11 and C18:3 n-3, (3) which in turn increase milk susceptibility to oxidation in milk produced on older pastures.

2. Materials and methods

2.1. Cows, feeds, experimental design and feed sampling

Sixteen multiparous Norwegian Red dairy cows in mid-lactation participated in a grazing experiment in Ås, Norway, at the Animal Production Experimental Centre (59.67°N, 10.75°E; 50 m a.s.l.), Norwegian University of Life Sciences. At experiment start the cows weighed 599 (standard deviation 45.1) kg body weight, had 2.7 (0.39) points body condition score, were 73 (15.0) d in milk and milked 29.9 (2.90) kg/d. The cows were blocked on the basis of pre-experimental milk yields, days in milk and sire, and allocated randomly to 2 groups of 8 cows. The grazing experiment was conducted with a continuous design with three 3-week experimental periods with the last week in each period as a sampling week (21–27 June, 26 July–1 August and 30 August–5 September 2008).

Each group of cows was assigned to one of 2 pasture types, differing in seed mixture and year of establishment. The first pasture, established in August 2007 [seed mixture: 7.5 kg/ha timothy (*Phleum pratense* L., var. 'Grindstad'), 15.0 kg/ha meadow fescue (*Festuca pratensis* Huds., var. 'Fure') and 3.5 kg/ha red clover (var. 'Bjursele')] and fertilised with 29 t/ha cattle manure was defined as short-term pasture (SP). In May 2008, 2.5 kg/ha of red clover seeds was reseeded. The second pasture, established in July 2003 [28 kg/ha seed mixture: timothy, perennial ryegrass (*Lolium perenne* L.), white clover, smooth meadow grass (*Poa pratensis* L.) with a cover crop of 170 kg/ha barley (*Hordeum vulgare* L.), oats (*Avena sativa* L.) and common vetch (*Vicia sativa* L.)] and fertilised with 30 t/ha cattle manure in autumn 2007 was defined as long-term pasture (LP). The 8 cows of each group grazed together and between experimental periods both groups grazed together on a pasture similar to LP. Both feed production and cow management (without certification) followed the standards for organic farming (Council of European Union, 2007).

Both pastures were divided into 4 paddocks, averaging 0.66 ha for SP and 0.92 ha for LP, and rotationally grazed. Pre-grazing herbage mass, measured 5 cm above ground level, was measured with a calibrated rising plate metre (MD, Stjørdal, Norway) before a new paddock was grazed and daily in the last week of each period. After a paddock was grazed post-grazing herbage mass was measured