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Review article

Managing Mediterranean pastures in order to enhance the level of beneficial fatty acids in sheep milk ☆

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Abstract

This paper updates our knowledge on the effects of the botanical composition and management of Mediterranean pastures on the fatty acid composition of sheep milk and cheese. It focuses on the effects of the forage species and its phenological phase on: (i) the fatty acid profile of the forage, and (ii) the milk fatty acid composition. Here we refer specifically to putatively beneficial fatty acids (mono- and poly-unsaturated fatty acids (PUFA)), including conjugated linoleic acid (CLA, C18:2 *c*-9, *t*-11) and vaccenic acid (C18:1 *t*-11). A database was set up compiled from the results of various studies carried out by our research group and this was statistically analysed. Both the forage species ($P < 0.05$) and its phenological phase ($P < 0.08$) affected the content of linoleic acid, a precursor of CLA in the forage. The PUFA level in milk was higher in ewes grazing pure legumes and grass–legume mixtures than in those grazing pure grass pastures. When the pasture mixture also contained a daisy plant (*Chrysanthemum coronarium*), the CLA and vaccenic acid levels were even higher. Linoleic (C18:2; *c*-9, *c*-12) linolenic (C18:3; *c*-9, *c*-12, *c*-15) CLA (C18:2; *c*-9, *t*-11) and vaccenic acid (C18:1; *t*-11) levels in milk decreased from the vegetative (early-mid lactation) to the reproductive phase (late lactation). The Δ^9 desaturase activity (estimate by C14:1/C14:0 ratio), which is involved in the conversion of vaccenic acid to CLA in the mammary gland, supports the hypothesis that the lower the substrate supply the higher the endogenous CLA synthesis. Finally, no marked differences were found in the fatty acid composition of milk and cheese from dairy sheep. Guidelines for managing the nutrition of grazing sheep to increase the unsaturated fatty acid content in milk are discussed.

Keywords: Fatty acids; CLA; Milk; Cheese; Sheep; Grazing

1. Introduction

Ruminant fats from meat and dairy products are an important part of human diet today (Chilliard et al., 2000). For example, in the UK some 46% of total fat consumption comes from meat and dairy

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products (Salter et al., 2002; Salter, 2003). However, although ruminant products may be low in fat, it is often in saturated form. For example, of total fatty acids in intramuscolar lamb fat, approximately 53% are saturated fatty acids (SFA), 34% mono-unsaturated fatty acids (MUFA) and 13% polyunsaturated fatty acids (PUFA) (Morbidini et al., 2001). On the other hand, data from sheep milk showed that the SFA level tends to be high while MUFA and PUFA are low in comparison with body fat. The figures are 66% SFA, 28% MUFA and 6% PUFA (Carta et al., 2003; Cabiddu et al., 2003a). Current research is oriented towards reducing the amount of SFA and increasing beneficial PUFA, and in particular linolenic acid (C18:3 *c*-9, *c*-12, *c*-15) and the longer chain PUFA, i.e. eicosapentaenoic acid (C20:5$n-3$; *c*-5, *c*-8, *c*-11, *c*-14, *c*-17) and docosahexaenoic acid (C22:6$n-3$; *c*-4, *c*-7, *c*-10, *c*-13, *c*-16, *c*-19) (Demeyer and Doreau, 1999).

This is of great importance for humans as well as for ruminants because they are unable to synthesize $n-6$ and $n-3$ PUFA, and so these essential fatty acids must be supplied by the diet. In particular, it is well known that $n-3$ fatty acids have anti-inflammatory and anti-thrombosis functions and play a very important role in the prevention and treatment of coronary heart disease (Ip et al., 1999).

However, one of the limitations when manipulating the fatty acid composition of ruminant products is that glycerol based dietary lipids are extensively hydrolysed by rumen microorganisms, which leads to the formation of free fatty acids (Demeyer and Doreau, 1999). Once the ester bond has been cleaved free unsaturated fatty acids are rapidly hydrogenated by microorganisms into more highly saturated end products, as a result of bio-hydrogenation. This causes the SFA concentration of the ruminant product to increase (Harfoot and Hazlewood, 1988). Bio-hydrogenation takes place to a variable extent. Kucuk et al. (2001) found that in sheep bio-hydrogenation of C:18:2$n-6$ (*c*-9, *c*-12) and C18:3$n-3$ (*c*-9, *c*-12, *c*-15) ranged between 90–96.3% and 93.6–95.9%, respectively. Linoleic acid is often incompletely bio-hydrogenised. As a result different mono-unsaturated fatty acids are formed, among which vaccenic acid (C18:1 *t*-11) is the most prominent. This partial bio-hydrogenation also causes conjugated linoleic acids (CLA) to be formed, among which C18:2 *c*-9, *t*-11 is the most dominant isomer. The production of *c*-9, *t*-11 CLA increases as linoleic acid (*c*-12, *c*-15) intake increases, which suggests that the capacity of microbes to complete the bio-hydrogenation process may be blocked by the high levels of unsaturated fatty acids (UFA) (Loor et al., 2002).

Increasing the supply of $n-3$ PUFA in the diet is one of the most important ways of improving the PUFA composition of ruminants' milk or meat. Many authors have reported that pasture plays a key role in improving the health benefits from milk and dairy products in dairy cows (Griinari and Baumann, 1999; Boland et al., 2001; Chilliard et al., 2000). Kelly et al. (1998) and Dhiman et al. (1999) showed that if cows only consumed pasture the CLA concentration in milk fat was double that of cows fed in stalls (22.1 mg/g versus 8.9 mg/g of fat and 1.08% versus 0.46% of total FA, respectively). The same trend was observed for the PUFA content of milk (C18:2 *c*-9, *c*-12; C18:3 *c*-9, *c*-12, *c*-15).

Green plants are the primary dietary source of PUFA $n-3$ fatty acids and are an alternative to fat supplements such as fish oil or oilseeds in animal feed (Mansbridge and Blake, 1997). Fresh grass contains low levels of lipid extract but 50–75% of $n-3$ fatty acid (C18:3 *c*-9, *c*-12, *c*15). This varies depending on various factors, such as the stage of maturity and amount of light available to the plants (Dewhurst and Scollan, 1998; Cabiddu et al., 2003b).

While there is a great deal of information on temperate forage species fed to dairy cattle, there is little information on how Mediterranean forage species affect the fat composition of milk and cheese in dairy sheep. Dairy sheep feeding in Mediterranean regions is mainly based on the use of pastures consisting of temperate species. The quality of these species is high during the vegetative phase (Molle et al., 2002, 2003). Different studies have been recently carried out in Sardinia (Italy), which analyse how pasture management can affect the fatty acid composition of sheep milk. Recent results showed that pasture management, the forage species and the vegetative stage can affect the fatty acid composition of sheep milk (Addis et al., 2002a; Cabiddu et al., 2003b). The current paper summarises the results of these studies and integrates them with the few existing results reported in the literature on this subject.