Effect of production system and geographic location on milk quality parameters

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Abstract

A main reason for the rapid increase in organic food consumption is the perception that organic foods have a superior nutritional composition and/or convey health benefits. However, there is currently limited scientific knowledge about the effect of production systems on food composition. The study reported here compared fatty acid profiles and levels of fat soluble antioxidants in milk from organic and conventional production systems in 5 geographic regions in Europe (Wales, England, Denmark, Sweden and Italy). Levels of nutritionally desirable mono- and poly-unsaturated fatty acids (vaccenic acid, CLA, α-linolenic acid) and/or a range of fat soluble antioxidants were found to be significantly higher in organic milk.

Introduction

Milk fat has historically been regarded as unhealthy, due to its relatively high content of saturated fat. However, more recently, beneficial health impacts such as reduced risk of cancer and cardiovascular disease have been associated with some of the mono and poly unsaturated fatty acids found in milk (e.g. Parodi, 2003). This includes α-linolenic acid (α-LA; the main omega-3 faty acid found in milk), conjugated linoleic acid (CLA) and vaccenic acid (VA). Milk has also been recognised as a source of certain fat soluble antioxidants (vitamin E and carotenoids) (Lindmark-Mansson & Arkesson, 2000). Higher intake of antioxidants is thought to protect against oxidative cell damage and reduced the risk of certain chronic diseases (Willcox *et al.,* 2004).

The fatty acid profile of milk fat can be influenced by dairy management practices, especially dietary composition (Jensen, 2002 and Walker *et al.,* 2004). Grazing and oil seed feed supplements were shown to increase the proportion of nutritionally desirable unsaturated fatty acids in milk (Walker *et al.,* (2004), but this was also shown to make milk fat more prone to oxidation, off-flavours and reduced shelf life (Chen *et*

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al., 2004). Less is known about the effect of management practices on the levels of fat soluble antioxidants in milk (Shingfield *et al.,* 2005; Noziere *et al.,* 2006).

Consumer perception that organic foods may have significant health benefits has been a major driver for the rapid increase in demand for organic food. However, there is currently little sound scientific evidence to support or reject these assumptions. Differences in animal husbandry between organic and conventional dairy systems could potentially result in differences in milk composition. For example, organic standards prescribe a minimum forage level (60 % of dry matter) in the diet of ruminants and the use of grass/clover swards instead of the pure rye grass swards commonly used in conventional dairy systems and prohibit routine antibiotic dry cow therapy (Dewhurst *et al.,* 2003). However, dairy husbandry systems also differ between geographic regions which may also affect milk composition.

The objective of the study was to quantify differences in milk composition (fatty acid profiles, fat soluble antioxidant levels) between organic and conventional farms in 5 geographic locations in Europe (Wales, England, Denmark, Sweden and Italy).

Materials and methods

Milk samples were collected from the bulk tanks of 50 commercial farms on 4 or 5 dates between June 2004 and May 2005. Farms could be categorised into 2 different systems of production (conventional high input and certified organic), in 5 geographic areas (Wales, England, Denmark, Sweden and Italy). Both systems were represented by 5 individual farms in each location, selected as being typical of each system in that area. Milk was frozen within 10 hours of sampling and kept at -20˚C until dispatched for analysis. In Wales 5 farms using a permanent grazing low input systems were also included in the survey. Only summaries of results from the conventional high input and organic systems in Wales, England, Denmark and Sweden are described here.

Details were recorded on all sampling dates for; cow and heifer numbers, recent calvings, mastitis and other health treatments, current feed and supplement use (including information on whether cows had access to pasture during the day and at night). Estimated grazing intakes were calculated by difference for each herd, with total dry matter intakes (DMI) estimated from average milk yields and assumed live weight (LW) (DMI = 0.025 LW+0.125 milk yield). Milk analysis was carried out at the Danish Institute for Agricultural Science, Folum, Denmark, fatty acids, α tocopherol and carotenoids (ß carotene, lutein and zeaxanthine), were assessed as described by Havemose *et al.,* (2006).

Linear mixed effects models (Crawley, 2002) were used with production system and geographic location as fixed factors, individual farms as a random factor and sampling date as either a linear or quadratic factor. The most appropriate model was used to generate ANOVA results. All proportion data were arcsine transformed prior to statistical analysis, but means presented were calculated from non-transformed data.

Results and discussion

A number of differences were identified between farms due to location and production system. For example, the proportion of grass or grass clover forage was generally higher in the UK (compared to S, DK and I) and higher in organic compared to conventional farms in each country. On the other hand, maize silage and concentrate feeds were major dietary components in Italian, Swedish and Danish herds. Organic cows received lower levels of concentrate feed resulting in a higher proportion of their diets dry matter supplied as forage. Differences in dairy diets between systems were highly significant for all countries ($p<0.001$).

On the whole, fatty acid profiles and antioxidant levels were within the range reported in review articles (Jensen, 2002; Walker *et al.* 2004; Shingfield *et al.,* 2005; Noziere *et al.,* 2006). There were significant differences in milk fatty acid and fat soluble antioxidant profiles between countries and between organic and conventional production (Fig. 1). Milk from organic herds tended to have higher levels of the nutritionally desirable fatty acids (α-LA, VA and CLA) and antioxidants with the largest differences tending to be for UK milk, although α-LA showed considerable elevation in organic milk from all countries. However, Swedish organic milk had lower CLA levels.

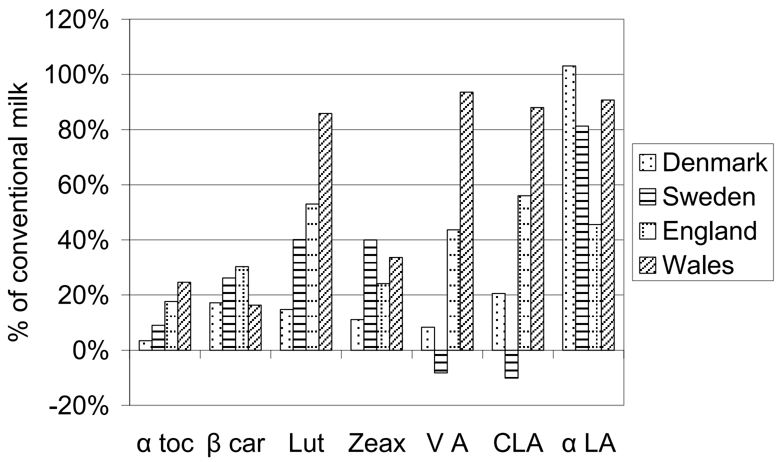

Figure 1 Composition of organic relative to conventional milk:
(α toc - α tocopherol, β car- , β carotene, Lut - lutein, Zeax – zeaxanthine)

Higher levels of α-LA and/or CLA in organic milk were also reported in several previous in Germany (Jahreis *et al.,* 1997), Italy (Bergamo *et al.,* 2003) and the UK (Ellis *et al.* 2006). CLA levels are known to increase with the proportion of fresh grass intake, while high proportions of maize silage and cereal based concentrates reduced milk CLA content (Jensen, 2002; Walker *et al.,* 2004; Dhiman *et al.,* 2005). Cutting grass for housed animals (zero-grazing) also reduces milk CLA and αLA content by 50 and 30% respectively compared to grazing (Offer (2002).

Higher levels of nutritionally desirable compounds in both organic and conventional milk from the UK were probably caused by the relatively high level of grass(/clover) in the diet and a longer grazing season in the UK. In contrast, dairy systems in DK, S and Italy used high levels of silage maize and concentrate in the diet, which is thought to reduce levels of nutritionally desirable compounds. The higher levels of fat soluble antioxidants in milk from organic production would be expected to increase the oxidative stability of milk, but whether this can compensate for higher levels of unsaturated fatty acids (especially with respect to sensory quality and shelf life) will have to be determined in future studies.

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