Effect of dairy management on quality characteristics of milk

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***Abstract* - The objective of the study was (i) to compare the nutritional composition of milk produced in organic and conventional production systems taking into consideration: different proportions of grass or grass silage, maize silage and different amount of concentrate (cereals), and (ii) to define the variation in content of pro- and antioxidants in milk in relation to regional variation, feeding and season. The feeding regime from 25 farms from Denmark, 20 farms from Sweden and 25 farms from United Kingdom was registered and milk samples were collected and analysed for the content of antioxidants and fatty acid composition. The daily milk production was significantly higher in the conventional milk production systems in the two Scandinavian countries compared with the United Kingdom. Milk from the conventional low input production system in United Kingdom has significantly higher amount of fatty acids and antioxidants derived from the high amount of pasture in the diet, where in contrast the conventional production systems in Denmark and Sweden had significantly higher content of fatty acids derived from maize silage. The data overall indicated differences between the milk composition as a consequence of the feeding composition in different systems and countries.** [1]

Introduction

The composition and functional properties of cow's milk are important to dairy farmers, manufacturers and consumers, and can be altered in three ways: by cow nutrition and management, by cow genetics, and by dairy manufacturing technologies. The contribution of fatty acids to milk fat production is dependent upon feed intake, diet composition, and stage of lactation. Some of the most important ways to manipulate the feed intake of the cows are by altering the content of starch relative to fibre in the diet, by altering the amount and composition of long chain fatty acids in the diet, and/or by changing the energy balance in the diet. Especially pasture-based compared to total mixed rations have significant differences in these factors, which leads to differences in milk fat composition (Kolver and Muller, 1998). Fatty acids from pasture-based diet are normally polyunsaturated, which gives higher concentration of polyunsaturated fatty acids in the milk. High intake of starch is associated with higher level of *de novo* synthesis in the mammary gland, which derive milk with higher amount of saturated fatty acids. Biohydrogenation in the rumen of unsaturated fatty acids, as linoleic acid and linolenic acid, gives high amounts of saturated and monounsaturated fatty acids (Jenkins, 1993; Bauman and Griinari, 2001; Walker *et al.*, 2004). Biohydrogenation is, however, incomplete, and smaller amounts of oleic acid, isomers of CLA, linoleic acid, and linolenic acid leave the rumen. The action of delta-9-desaturase in the mammary gland converts a high proportion of stearic acid and trans-vaccenic acid to oleic acid and C18:2 (c9,t11) CLA (Griinari *et al.*, 2000). Both linoleic and linolenic acid contribute to CLA production via the desaturation of trans-vaccenic acid in the mammary gland, and for this reason, there is normally observed positive linear relationship between the concentration of CLA and trans-vaccenic acid in milk fat (Walker *et al.*, 2004). Antioxidants as α-tocopherol and carotenoids are in the mammary gland incorporated in the fat globule membrane and thereby follow the fat globules to the milk. This article considers the effect of changing cow nutrition and management, and its effect on the composition of cow's milk.

Results and discussion

There were significant differences in the feeding regimes of the milk production systems between Denmark, Sweden and United Kingdom. The organic and conventional low input milk production in United Kingdom used significantly more pasture than organic and conventional milk production systems in Denmark and Sweden and in the conventional milk production in United Kingdom. Particularly, the feed in the conventional low input milk production system nearly consisted of pasture alone. The organic and conventional milk production in Denmark used very high amounts of maize silage, compared to the two systems in Sweden ($P<0.0001$). Cereals made up a large part of the feed in organic and conventional milk production systems in Sweden compared to Denmark and United Kingdom ($P<0.0001$) and the amount of concentrates was high in all systems except in organic and conventional low input production systems in United Kingdom. Overall, milk production systems of the United Kingdom used high amounts of pasture, and the milk production systems in the Scandinavian countries used high amounts of grass silage, maize silage, and cereals. The daily milk production in the conventional low input and organic milk production systems in United Kingdom was significantly lower than in the other five milk production systems evaluated in the survey ($P=0.0025$). This agreed with the literature, which emphasize that a high amount of pasture in the diet derives a reduced daily milk yield (Kolver and Muller, 1998). When looking at the vitamins and antioxidants, as α-tocopherol and carotenoids, the content in milk from organic and conventional low input production systems in United Kingdom were significantly higher than in other production systems ($P=0.0218$). As emphasized in the literature (Walker *et al.*, 2001), milk from production systems using high amount of pasture, such as milk from the organic and

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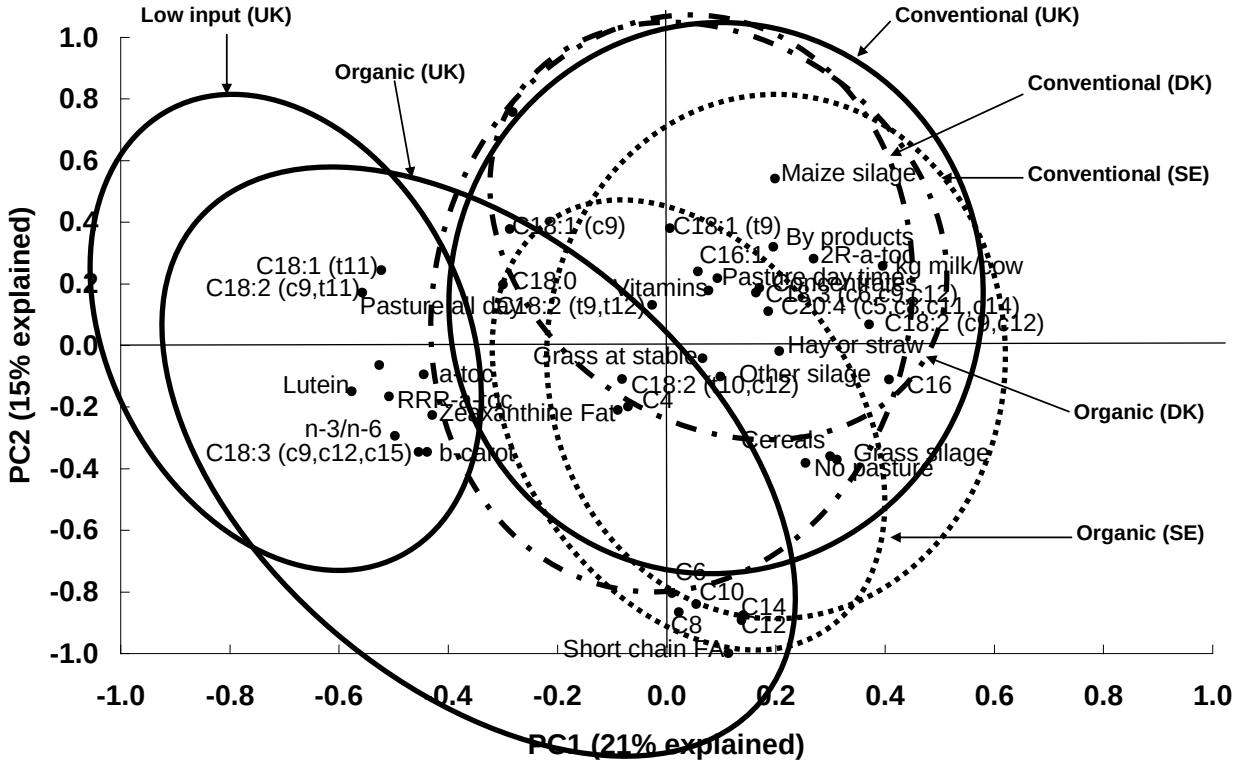

Figure 1. Principal component analysis loading plot for the components in the feed and milk obtained from Denmark (-·-·-), Sweden (·····) and United Kingdom (—).

conventional low input production systems, also had high content of C18:1 (t11), C18:2 (c9,t11) CLA and from the organic and C18:3 (c9,c12,c15). This content was significantly higher in milk conventional low input systems in United Kingdom (P<0.0001 for both variables) than in the other systems. Also a significant linear relationship between pasture and C18:1 (t11) and between pasture and C18:2 (c9,t11) CLA in Denmark (P<0.0001 for both fatty acids) and in Sweden (P=0.0004 for both fatty acids) was observed. In United Kingdom there seemed to be a correlation between the farms using pasture all day and the content of C18:1 (t11) and C18:2 (c9,t11) CLA in the milk. The content of C18:1 (c9) did not differ during the survey, but the content of C18:2 (c9,c12) was significantly higher in milk from the organic and conventional milk production systems from Denmark and Sweden and in milk from conventional high input systems from United Kingdom compared with the other systems (P=0-0023). A linear correlation between maize silage and the content of C18:2 (c9,c12) in milk was observed in Denmark (P<0.0001) which corresponds with the literature (Walker *et al.*, 2001). The different data obtained from the feeding regime and from the milk composition were also plotted in a loading plot by principal component analysis (Figure 1). The circles illustrate the different farm types in the different countries and the placement of the farm types in the plot relative to the composition of the feed and milk. The conventional low input and organic production systems in United Kingdom deviated by correlating to pasture and the components in the milk relevant to pasture. The other five systems were more isolated in a cluster, which correlated to maize silage, grass silage and cereals. There seemed to be a tendency towards a correlation between the conventional systems and maize silage, the synthetic isomers of α-tocopherol (2R-a-toc) and C18:2 (c9,c12). On the contrary, the organic milk production systems correlated with cereals, grass silage and short chain fatty acids.

Conclusions

Different feeding regimes in the three countries, with pasture as the main part of the diet in some countries and maize silage as a main part along with pasture in the diet in other countries, had a huge impact on the composition of milk from these production systems.

Acknowledgement

The authors gratefully acknowledge from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities, for the Integrated Project QUALITYLOWINPUTFOOD,FP6-FOOD-CT-2003- 506358 and Gitte Hald Kristiansen and Ivan Nielsen at Danish Institute of Agricultural Sciences, Department of Food Science for assistance in the laboratory.

References

Bauman, D.E. and Griinari, J.M. (2001). Regulation and nutritional manipulation of milk fat: low-fat milk syndrome. *Livestock Production Science* **70:** 15-29.

Griinari J.M., Cori, B.A., Lacy, S.H., Chouinard, P.Y., Nurmela, K.V.V. and Bauman, D.E. (2000). Conjugated linoleic acid is synthesized endogenously in lactating diary cows by Delta (9)-desaturase. *Journal of Nutrition* **130:** 2285-2291.

Jenkins, T.C. (1993). Lipid metabolism in the rumen. Symposium: Advances in ruminant lipid metabolism. *Journal of Dairy Sicence* **76:** 3851-3863.

Kolver, E.S. and Muller, L.D. (1998). Performance and nutrient intake of high producing holstein cows consuming pasture or total mixed ration. *Journal of Dairy Science* **81:** 1403-1411.

Walker, G.P., Dunshea, F.R. and Doyle, P.T. (2004). Effects of nutrition and management on the prediction and compo-

sition of milk fat and protein: a review. *Australian Journal of Agricultural Research* **55:** 1009-1028.