C – Novel Foods at European Market

Changes in Ewe's Milk Composition in Organic versus Conventional Dairy Farms

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Abstract: The aim of this work was to determine the effect of organic production system on ewe's milk quality. Bulk tank ewe's milk from flocks of two production systems (organic and conventional) all of them from the same geographical area (Zamora, Spain) were used to investigate changes in physico-chemical properties including the composition in fatty acids. The metal contents (Fe, Cu, Zn, Mn, Se, Mo, Ba, As, Hg, Pb) and the presence of antibiotics and pesticides in the meat were also studied. The type of production system was seen to elicit a significant effect on pH, total acidity and on the fatty acid composition. Organic milk showed significantly higher values of mono- and polyunsaturated fatty acids, including CLA, while saturated fatty acids decreased. No residues of pesticides or antibiotics were found in any of the samples and regarding metal contents only Fe, Cu and Zn were detected and no differences were observed in their contents.

Keywords: milk composition; pesticides; antibiotics; fatty acids; organic production

INTRODUCTION

Organic dairy production is drawing increasing attention because of public concerns about food safety, animal welfare, and the environmental impacts of intensive livestock systems (Sundrum 2001). Among the distinctive features of organic livestock production is the enhancement of animal welfare and health through the prevention of disease, along with the non-use of synthetic chemicals (EU 2007). This is a method for achieving premium prices for livestock production and a way to convince consumers that better treatment is being given to both animals and the environment because organic livestock is supposed to use ecological resources in a more sustainable way (Edwards 2005). However, organic farming regulations restrict the use of concentrates and with more roughage in the diet and a lower intake of energy and protein from concentrates some changes in milk production and characteristics can be expected (Nauta *et al*. 2002; EU 2007). Previous works have shown that the fatty acid composition of milk varies owing to variations in feed factors, and sheep fed with forage show higher proportion of polyunsaturated fatty acids, especially CLA, than those fed with concentrates (Biondi *et al*. 2008).

However, the results concerning quality differences between organic and conventional foods are sometimes ambiguous because in most cases the products are purchased at the market and many variables may affect the final quality of the product, although higher contents of CLA, linolenic and vaccenic fatty acids have been reported (Bergamo *et al*. 2003). To our knowledge no data are available as regards compositional differences between organic and conventional ewe's milk. The aim of the present work was to determine the effect of organic production systems on the quality of ewe's milk owing to its economic relevance in the cheese-making industry.

MATERIALS AND METHODS

Bulk tank ewe's milk from flocks of two local breeds (Castellana and Churra) and two production systems (organic and conventional) all of them from the same geographical area (Zamora, Spain) were taken on the first week of February. On the day of collection an aliquot of milk samples were submitted to the Analysis Service of the Interprofessional Dairy Laboratory of the Junta de Castilla y León (Spain) (LILCYL; Palencia, Spain) and analysed for fat, protein and total solids (Milko Scan; Foss Analytical, Denmark). Milk were also analysed for pH (potentiometric method, CRISON Basic20), titratable acidity (Dornic method; Tamine & Robinson 1999) and lactose (IDF 1974). To measure the metal contents 2 ml of the samples were digested with 5 ml of nitric acid and 1 ml of hydrogen peroxide in a pressure reactor, using an Ethos Plus (Milestone) microwave device in two steps of 10 min applying 180°C until 1000 W. From the solution thus obtained Cu, Zn, Fe, As, Hg, Pb, Mn, Se, Mo and Ba were determined, measuring them by ICP-MS (Perkin Elmer, Elan 6000). The limit (sensitivity) of detection was 0.4 mg/kg. For pesticide analysis, a scan of organophosphates, carbamates and insecticides was performed using the ELISA method. For antibiotic determination, the EEC four-plate test was used (FPT) (The European Agency for the Evaluation of Medicinal Products 1998), detection focused on tetracyclins, beta-lactams, sulfamides, aminoglycosides, and macrolides.

Milk lipids were extracted (ISO 14156:2001) and the fatty acids were methylated (Murrieta *et al.* 2003) and analysed by gas chromatography (GC 6890 N, Agilent Technologies, USA) using a capillary column of 100 m × 0.25 mm × 0.20 µm (Supelco, Inc., Bellefonte, PA, USA). One microlitre was injected into the chromatograph, equipped with a split/splitless injector and a FID detector. The oven temperature program was 150°C increasing at 1°C/min up to 165°C then increasing at 0.20°C/min up to 167°C and then increasing 1.50°C up to 225°C where it was maintained for 15 min. Injector and detector temperatures were 250°C. The carrier gas was helium at 1 ml/min and split (20:1). Fatty acids were expressed as a proportion by total weight.

Data were analysed by one-way analysis of variance (ANOVA) (1995 Manugistics, Inc.).

RESULTS

The results relating to the physico-chemical characteristics of the milk depending on the production system are reported in Table 1. They show that the type of production system had a significant effect on the pH of milk which was higher in conventional production. Thus, acidity was significantly lower in this system. Fat, protein and lactose percentages in milk were unaffected by the production system, in agreement with previous results showing that the turning out of sheep to pasture did not affect these parameters (Biondi *et al.* 2008) and those of Bergamo *et al.* (2003) who failed to find significant differences in the fat content of organic buffalo milk samples. However, other works have found that protein content are higher in organic than in conventional cow's milk (Vicini *et al.* 2008).

All the samples, regardless of the production system employed, were free of pesticides and none contained antibiotics. This was expected in the samples from the organic milk. In the case of the

Table 1. Means (standard deviation) of the compositional parameters evaluated in ewe's milk depending on the production system

	Conventional	Organic	*P*
Physico-chemical parameters			
pH	6.73 (0.02)	6.69 (0.03)	0.0817
Acidity[a]	18.50 (0.57)	21.25 (2.62)	0.0871
Fat (%)	7.60 (0.31)	7.16 (0.70)	0.2938
Protein (%)	5.46 (0.31)	5.55 (0.36)	0.2938
Lactose (%)	4.37 (0.14)	4.39 (0.17)	0.8832
Metal contents (mg/l)			
Fe	19.45 (17.15)	14.67 (6.05)	0.6187
Cu	2.10 (1.40)	2.02 (1.36)	0.9415
Zn	3.00 (3.53)	4.35 (1.48)	0.6679

[a]ml 0.1N NaOH/ml milk

samples from conventional milk, this finding was also expected because the traditional system is strictly regulated. On analysing the contents of heavy metals, the presence of As, Hg, Pb was not detected in any sample because the animals (organic and conventional) had been reared in a rural environment free of pollutants. Concentrations of Mn, Mo and Ba were lower than the sensitivity of the method. The presence of Cu, Zn and Fe was observed and the organically produced milk did not show significant differences for these metals in agreement with the results observed for Fe and Cu (Hermansen *et al*. 2005) although those authors find that organic cow's milk had lower values for Zn.

Table 2 shows the fatty acid composition of milk according to the production system used. The differences observed between organic and conventional ewe's milk are attributable to the higher amount of grass in the organic ewes' diet, because the results obtained are in agreement with those seen when grass *versus* concentrate feeding regimes were compared (Valvo *et al*. 2005; Biondi *et al*. 2008). The higher availability of long-chain fatty acids from a grass diet decreases the percentage of short- and medium-chain fatty acids in milk fat (Chilliard *et al*. 2000). Among the short-chain fatty acids, a weak response of almost all the fatty acids was observed, except for capric acid, although in previous works myristic and palmitic acids were the most affected (Valvo *et al*. 2005; Biondi *et al*. 2008). In this work, the long-chain saturated fatty acid stearic acid tended to increase, although the differences were not statistically significant, as observed by Valvo *et al*. (2005). The most important variations in the milk fat profile were seen for unsaturated fatty acids, the organic milk having significantly higher values of oleic acid while the higher contents of myristoleic and palmitoleic acids obtained were not statistically significant, in contrast with previous results that reported no differences for oleic acid and significantly higher levels for the other two acids (Valvo *et al*. 2005). These previous works also showed that linoleic acid tends to decrease when ewes are fed with grass, while linolenic acid shows the opposite

Table 2. Means (standard deviation) of the fatty acids (g/100 g of milk fat) evaluated in ewe's milk depending on the production system

Fatty acid	Conventional	Organic	*P*
C4:0 (butiric)	2.68 (0.92)	2.87 (1.34)	0.8237
C6:0 (caproic)	3.71 (0.39)	3.19 (0.64)	0.2149
C8:0 (caprilic)	6.22 (0.58)	4.81 (1.00)	0.0526
C10:0 (capric)	21.04 (2.16)	15.68 (2.88)	0.0250
C12:0 (lauric)	10.58 (1.03)	8.80 (1.14)	0.0612
C14:0 (miristic)	16.37 (1.30)	15.72 (1.18)	0.4870
C14:1 (miristoleic)	0.34 (0.10)	0.37 (0.03)	0.5897
C16:0 (palmitic)	17.35 (1.06)	17.85 (2.08)	0.6841
C16:1 (palmitoleic)	1.14 (0.30)	1.38 (0.07)	0.1802
C18:0 (stearic)	4.73 (2.24)	6.93 (2.15)	0.2056
C18:1n9t (elaidic)	0.56 (0.20)	0.92 (0.24)	0.0620
C18:1 (oleic)	11.93 (2.97)	18.02 (3.53)	0.0387
C18:2n6 (linoleic)	1.96 (0.10)	2.15 (0.24)	0.1989
C18:3n3 (linolenic)	0.87 (0.17)	0.85 (0.09)	0.8741
ΣCLA	0.52 (0.17)	0.79 (0.04)	0.0276
Saturated FA	82.71 (3.09)	75.89 (4.24)	0.0410
Monounsaturated FA	13.98 (3.03)	20.70 (3.71)	0.0313
Polyunsaturated FA	3.36 (0.11)	3.79 (0.24)	0.0182

behaviour. However, in this case no significant differences were observed for either acid. The amount of linolenic acid in herbage depends on the season and herbage variety, and sometimes pasture feeding does not increase the percentage of linolenic acid in cow's milk (Chilliard *et al.* 2000). The significant higher content of CLA isomers in the organic milk is in agreement with the literature referring to pasture-feeding ewes and has been reported to be characteristic of organic dairy products (Bergamo *et al.* 2003). A higher intake of grass allows animals to ingest higher quantities of α-linolenic acid, and cis-9, trans-11 CLA could be an intermediate in its biohydrogenation (Kay *et al.* 2005).

According to the results, the sum of saturated fatty acids was statistically higher in conventional than in organic milk, and the sum of monounsaturated and polyunsaturated fatty acids was higher in organic milk, a result consistently observed in grass-feeding ewes. These results support the notion that organic products are healthier, due to a better fatty acid profile characterised by higher amounts of unsaturated fatty acids, especially CLA.

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