Evolution of fat soluble vitamin content of ewe's milk from conventional semi-extensive and organic production systems

ISABEL REVILLA[1], CARLOS PALACIOS[2], CRISTINA HIDALGO[3], RAMÓN ALVAREZ [4], PILAR RODRÍGUEZ[5]

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Abstract

During a 12-month study, bulk-tank milk was collected once a month from organic (O) (n=3) and conventional semi-extensive (CSE) (n=5) ewe dairy farms. CSE is the conventional production system most similar to the organic one because they both involve a part-time grazing system. Organic ewe's milk had significantly higher contents of α-tocopherol and γ-tocopherol and, consequently, of total tocopherol, possibly due to the higher green pasture intake (1,02 vs 0.48 kg sheep^{-1} day^{-1}) and the lower milk yield (53.5 vs 88.7 L). Although milk from CSE showed higher values for retinol there was no statistically significant difference. The sampling month significantly affected retinol levels, which tended to increase from February to May. Moreover, γ-tocopherol contents were higher in the autumn and winter months and during this period the organic samples showed higher levels of this compound. A seasonal effect was observed for α-tocopherol only in the case of the organic samples that showed an increase from March to June.

Introduction

Previous works have provided contradictory results about the difference in vitamin content between organic and conventional milk and dairy products. Some studies have reported higher fat-soluble vitamin contents in organic milk and milk products (Bergamo *et al*., 2003), while other studies have found higher levels on conventional farms, attributable to increased supplementation in concentrate feeds (Ellis *et al*., 2007), or no differences when both the organic and conventional production system had similar fresh-forage-based diets (Butler *et al*., 2008). Taking into account that all these studies were carried out on dairy cows, the aim of the present work was to quantify differences in the fat-soluble vitamin content of ewe's milk collected from organic and conventional semi-extensive production systems because both involve part-time grazing activities by the animals. A further aim was to follow their evolution throughout the year due to changes in the feeding regime of the grazing animals.

Material and methods

Ninety-six milk samples were collected from eight commercial flocks located in Castile & Leon (northwest Spain) and categorized in two different production systems: conventional semi-extensive (five flocks) and organic (three flocks complying with EC 834/2007 Directive). All farms were visited monthly from February 2011 to January 2012, when farm production data were obtained from an interview and from farm record analyses, including flock management and feeding practices (Table 1). All farms have three-four lambing periods a year and hence all the farms had similar proportions of ewes in early lactation on all sampling dates.

[1] Universidad de Salamanca, Spain, www.usal.es, eMail irevilla@usal.es.
[2] Universidad de Salamanca, Spain, www.usal.es, eMail carlospalacios@usal.es.
[3] Universidad de León, Spain. www.unileon.es, eMail cristina.hidalgo@unileon.es
[4] Universidad de León, Spain. www.unileon.es, eMail ramon.alvarez@unileon.es
[5] Universidad de León, Spain. www.unileon.es, eMail pilar.rodriguez@unileon.es

Table 1: Mean values (SD) of production and management system parameters

	Conventional		Organic	
Herd size (milking sheeps)	743.50	(457.64)	686.50	(301.93)
Live weight of sheeps (kg)	56.75	(5.56)	51.5	(0.71)
% of primiparous sheeps	18.25	(2.87)	19.50	(3.54)
Dry matter intake (kg sheep^{-1} day^{-1})	1.75	(1.94)	1.99	(0.85)
Diet composition				
Forage (proportion DMI)	0.84	(0.07)	0.65	(0.20)
Fresh forage	0.29	(0.45)	0.22	(0.11)
Maize silage	0.00	(0.00)	0.04	(0.05)
Straw	0.01	(0.03)	0.01	(0.01)
Alfalfa	0.35	(0.45)	0.08	(0.11)
Other silage	0.34	(0.42)	0.66	(0.04)
Concentrate (proportion DMI)	0.16	(0.07)	0.35	(0.20)
Cereals	0.49	(0.24)	0.88	(0.16)
Proteic concentrates	0.19	(0.04)	0.00	(0.00)
Other concentrates	0.25	(0.27)	0.12	(0.16)
Supplements (g sheep-1 day-1)	75.98	(63.69)	19.04	(8.68)
Pasture (kg sheep-1 day-1)	0.48	(1.37)	1.02	(0.24)

Conventional semi-extensive (CSE) production is a part-time grazing system in which the sheep pass 54% of their time on pasture land. The diet is based on alfalfa and fresh forage complemented with commercial concentrate. The milk yield is 88.7 L a year per animal. Semi-extensive systems only buy 25% of the feeding material.

Organic (O) production is also a grazing system but differs from the semi-extensive system in that the sheep pass 82% of their time on pasture land. The diet composition is based on conserved and fresh forage complemented, when necessary, with a certified organic mixture, which in our case was mainly cereals. This system has a lower milk yield (53.5 L) and is less dependent on external inputs than CSE.

Samples were taken from stirred bulk milk from all farms between the 27th and the 28th of each month from February 2011 until January 2012. Samples were immediately frozen and kept at -20ºC. To estimate the fat-soluble vitamins, samples were heated (30ºC), homogenized and subjected to alkaline hydrolysis according to the method proposed by Herrero-Barbudo *et al.* (2005) but adding ascorbic acid and using δ-tocopherol as internal standard. The mixture was vortexed and methanolic KOH (40%) was added. The mixture was heated to 70ºC and shaken (200 rpm) for 40 min. Samples were cooled and extracted using n-hexane:dicloromethane (5:1)/isopropanol (4/1) four times. The organic phases were pooled, washed, evaporated under a nitrogen flow, reconstituted in acetonitrile/methanol (85/15), and filtered. Samples were analysed using the UPLC column, equipment, and flow and temperature regimes described in the method proposed by Chauveau-Duriot *et al.*, (2010). However, owing to the characteristics of the samples two separate isocratic chromatographic methods were employed. The mobile phase for retinol was acetonitrile:methanol (85:15)/isoporonanol:water (50:50) 80/20, with λ_{exc}=325 and λ_{em}=475nm. The mobile phase for the different tocopherols analysed was acetonitrile:methanol (85:5)/isopropanol 90/10, with λ_{exc}=295 and λ_{em}=390 nm.

The statistical significance of each factor was calculated using the GLM method. (Statgraphics Plus Manugistics, Inc., Rockville MD).

Results and Discussion

Although both organic and conventional semi-extensive production systems involve grazing on pasture land, the yearly mean concentrations of α and γ-tocopherol, and consequently the total tocopherol (Table 2) content, were significantly higher in the organic samples, in agreement with previous works (Slots *et al.*, 2008). However, these findings differ from other works that failed to find significant differences in 12-month studies, as in our case (Ellis *et al.,* 2007), or when both the conventional and organic production systems included animals fed with similar diets (Butler *et al*., 2008; Fall and Emanuelson, 2011). In this sense, Butler *et al*. (2008) did not find significantly higher contents of α-tocopherol on comparing organic vs. low-input dairy cow production systems (the latter of which uses production methods similar to those used in organic farming) during fresh forage-based feeding periods, although the organic milk had higher contents of the natural RRR α-tocopherol isomer, the only isomer synthesized by plants. Regarding retinol, although the semi-extensive production system afforded higher contents of this compound the difference between conventional and organic ewe's milk was not significant, as reported by Fall and Emanuelson (2011). Higher contents of retinol (Bergamo *et al*., 2003) and vitamin A (Ellis *et al.,* 2007) have been reported in conventional milk, possibly owing to increased vitamin A supplementation in concentrate feeds.

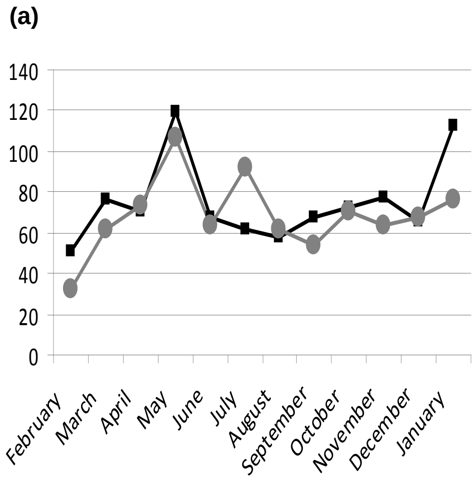
Table 2: Man values (SD) of vitamin contents expressed in μg/100 g of milk

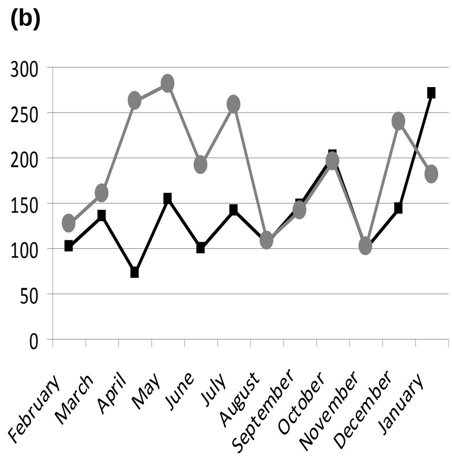
	Production system (PS)		Significance		
	Conventional	Organic	PS	Month	PSxMonth
Retinol	74.90 (3.32)	68.58 (5.94)	ns	***	ns
α-tocopherol	139.77 (13.40)	187.96 (23.98)	*	ns	ns
γ-tocopherol	9.16 (0.75)	12.84 (1.34)	**	**	ns
Total tocopherol	148.92 (13.50)	200.56 (24.16)	*	ns	ns
Total vitamin	223.83 (15.40)	269.14 (27.56)	ns	ns	ns

Ns: not significant, ***p<0.01, **p<0.05, *<0.1

Previous works have reported that vitamin supplements have a relatively minor effect on α-tocopherol contents, and that the 3R isomers from green forage are the main contributors to the total tocopherol content (Butler *et al*., 2008). Others, such as Jensen *et al*. (1999), have suggested that fibre-rich organic diets may improve fat-soluble vitamin concentrations by decreasing milk yield. In this case, although both the conventional and organic systems involved grazing the organic milk had higher tocopherol contents but not lower levels of retinol, perhaps due to both the higher intake of pasture (1,02 vs 0.48 kg sheep^{-1} day^{-1}) (Table 1) and the lower milk yield (53.5 vs. 88.7 L).

The effect of sampling month was also considered and was found to be significant for retinol and γ-tocopherol, while the production system-month interaction was not significant (Table 2). The evolution of retinol, α and γ-tocopherol contents is shown in Figure 1. The retinol content (Fig. 1a) tended to increase from February to May, when there is more green pasture available, after which it underwent a strong decrease. This increase in the retinol content during the spring season was more clearly observed for organic milk samples that also showed minimum values for retinol during the autumn and winter months. Regarding γ-tocopherol (Fig. 1c), its levels were higher from September to February. During those months, the organic samples had higher contents than the conventional ones, but also in some summer months. This could be due to the lower milk yield of organic ewe's herds during this period when there is less pasture available. Indeed, organic milk showed higher levels of α-tocopherol from April to July (Fig. 1b) due to the higher amount of green pasture in the organic ewe's diet. This is in agreement with the higher contents of α-tocopherol found in cow's organic milk in the spring months (Butler *et al*., 2008).





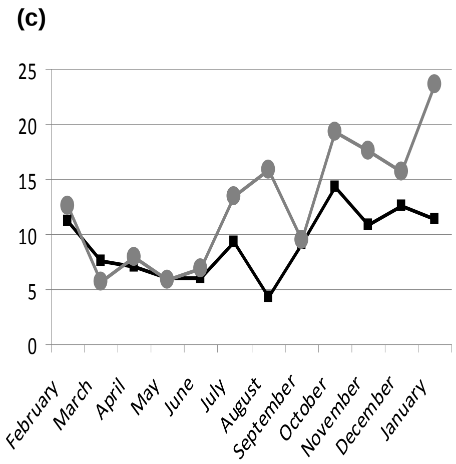


Figure 1. Evolution of retinol (a), α-tocopherol (b) and γ-tocopherol (c) for conventional (■) and organic (●) systems expressed in in μg/100 g of milk

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