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Vitamins and selenium in bulk tank milk of organic and conventional dairy farms

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Introduction

The content of vitamins in milk is important for several reasons. Vitamin content is an important quality aspect of milk for human consumption, since milk is generally viewed as nutritious food and should contain sufficient amounts of naturally occurring vitamins. Some of the vitamins, such as vitamin A and E, also serve as antioxidants and has therefore a direct impact on the risk for oxidised flavour, one of the most common off-flavour problems in milk. Vitamin A, or rather its precursor (carotenoids), is also involved in a number of significant flavour components in the milk. The dairy cow milk is originally intended for the calf and the vitamin content should obviously be of importance for the well-being of the calf. Finally, vitamin E has a significant role in the immune response in the mammary gland, since it for instance protects phagocytes from cytotoxic attacks (Philpot & Nickerson, 1991), and it may also have other effects on the immune system. The level of vitamin E in milk has therefore been shown to be important for the defence against mastitis for the dairy cow (e.g. Smith et al., 1997).

The levels of vitamins and selenium in milk are directly affected by what is available in the feed offered to the cow. It can therefore be hypothesised that there are differences in milk composition between organic and conventional farms, since feeds and feed management are major differences between the types of farms. There are also indications that milk from these two types of farms differ in the content of E-vitamin and carotenoids (Nielsen et al., 2004) and in levels of selenium (Toledo & Andren, 2001; Toledo et al., 2002).

The aim of this study was to investigate whether there are differences in the concentration of vitamins and selenium in milk between organic and conventional farms in Sweden.

Material and methods

Farms that had more than 40 cows, were enrolled in the Swedish Official Milk Recording Scheme (SOMRS) and were geographically located in a region in the south-east of Sweden were eligible for inclusion in this study. Fifty-two eligible farms that had produced milk according to certified organic standards for at least two years were asked by mail to participate and 24 agreed. From these we randomly selected 20 farms. From the 283 eligible conventional farms we randomly selected 156 that were asked by mail to participate in the study. From the 32 farms that were positive to participate in the study we randomly selected 20. The farms were visited once in the spring and the autumn of 2005 and once in the spring of 2006. Farm and animal data were collected from the SOMRS and from questionnaires presented to the farmers at each visit. The farmers were instructed to sample bulk tank milk in December 2005, January and February 2006. The samples were stored frozen (-18°C) by the farmers and retrieved at the visit in the spring of 2006.

Concentrations of retinol, β-carotene and α-tocopherol in bulk milk were determined by HPLC after saponification and extraction into heptane-di-isopropyl ether (3:1, v/v) for retinol and β-carotene and into heptane for α-tocopherol. The procedures have been described previously for measuring retinol (Jensen, 1994) and β-carotene and α-tocopherol (Jensen & Nielsen, 1996) and were performed by Danish Institute of Agricultural Sciences, Tjele, Denmark. Selenium was determined after wet digestion using flow injection hydride generation atomic absorption spectrometry (Galgan & Frank, 1988, 1993) by the Swedish National Veterinary Institute, Uppsala, Sweden.

Statistical analyses of the associations between milk composition and type of farm (organic, conventional) were made using multilevel linear mixed models, where the repeated observations within herd was handled by including a random herd effect in all models. In addition to type of farm, the models also included the effects of month of sampling (Dec., Jan., Feb), breed composition of the farm (>90% Swedish Red Breed (SRB), >90% Swedish Holstein (SH), other), average milk yield (classified into thirds), amount (kg/d) of roughage given to cows in early lactation (classified into thirds) and weeks at pasture during the preceding pasture season (classified into thirds). The fit of the models were evaluated by examination of Pearson conditional residuals. All statistical analyses were performed using SAS version 9.1 (SAS Institute Inc., Cary, N.C., USA).

Results

Herd size was similar in the two types of farms, but the organic farms had lower milk production than the conventional farms, although the variation within type of farm was considerable (Table 1). The breed composition of the farms was also similar with 3/7/10 farms of the SH/SRB/other type and 2/7/11 in the organic and conventional groups, respectively. The organic farms provided higher amounts of roughage in the feed ration and allowed the cows to graze longer than the conventional farms (Table 1).

Table 1. Overall means ($\bar{x}$), standard deviations (SD) and inter-quartile ranges (IQR) of farm characteristics according to farm type

	Organic (n=20)			Conventional (n=20)		
	$\bar{x}$	SD	IQR	$\bar{x}$	SD	IQR
Herd size, no. cows	65.8	20.0	51.3, 72.2	63.6	19.8	51.4, 72.1
365d milk yield, kg	8585	1065	7901, 9012	9472	961	8594, 10218
Roughage, kg/d	11.4	1.7	10.3, 12.7	8.8	0.8	8.5, 9.3
Pasture, weeks	19.8	4.9	18.5, 23.0	16.2	5.2	14.5, 20.0

Overall average levels of α-tocopherol, β-carotene, retinol and selenium were very similar in the two types of farms (Table 2).

Table 2. Overall means ($\bar{x}$), standard deviations (SD) and inter-quartile ranges (IQR) of vitamins and selenium in bulk milk samples according to farm type

	Organic (n=54)			Conventional (n=57)		
	$\bar{x}$	SD	IQR	$\bar{x}$	SD	IQR
α-tocopherol, µg/ml	0.82	0.22	0.66, 0.94	0.87	0.16	0.80, 0.97
β-carotene, µg/ml	0.18	0.05	0.16, 0.21	0.18	0.04	0.15, 0.21
Retinol, µg/ml	0.32	0.05	0.29, 0,35	0.32	0.07	0.30, 0.36
Selenium, µg/kg	12.6	5.4	9.0, 16.5	14.5	4.3	11.0, 17.0

The statistical analyses did not show any significant differences between organic and conventional farms in β-carotene, retinol or selenium concentration, and none of the other explanatory variables had any significant effects either. However, concentration of α-tocopherol was significantly lower in organic farms when adjusting for other effects in the model (Table 3).

Table 3. Results from the multivariable linear mixed model analysis of α-tocopherol concentration in bulk milk samples. Herd was included as a random effect

Variable	Level	N	Estimate	SE	p-value
Intercept		111	1.11	0.11	
Farm type	Organic	54	-0.18	0.08	0.03
	Conventional	57	ref		
Sampling month	December	45	ref		0.16
	January	29	0.05	0.03	
	February	37	-0.01	0.04	
Breed composition[a]	SH	13	0.05	0.08	0.77
	SRB	38	0.03	0.06	
	Other	60	ref		
Roughage, kg/d	-9.0	36	-0.21	0.11	0.08
	9.1-10.5	36	-0.13	0.10	
	10.6-	30	0.02	0.11	
	Missing info.	9	ref		
Pasture, weeks	-16	41	-0.04	0.07	0.57
	17-20	40	-0.07	0.07	
	21-	30	ref		
365d milk yield, kg	-8570	36	-0.10	0.07	0.16
	8571-9270	34	-0.13	0.07	
	9271-	38	ref		

[a]SH: >90% Swedish Holstein, SRB: >90% Swedish Red Breed

Discussion

We observed no major differences in vitamin levels between milk from organic and conventional dairy farms, which is in contrast to the higher levels of both A- and E-vitamin in organic milk found in Denmark (Nielsen et al., 2004). A possible explanation is that differences in feeds and feeding regimens between the two types of production systems are less pronounced in Sweden than in many other countries. Most Swedish dairy cow diets are based on grass/clover silage, an observation which is valid for both types of farms, at least within the geographic area under study. In contrast, diets on conventional farms in Denmark, for example, are to a much greater extent based on corn silage, while organic farms rely mostly on grass/clover silage.

The statistical model showed a significantly lower level of α-tocopherol in milk from organic farms. This is an effect of adjusting for differences in the amount of roughage given, because the difference between the types of farms became -0.05 and non-significant if the amount of roughage was excluded from the model. This indicates that organic dairy farms in Sweden are able to maintain the level of α-tocopherol in milk through an increased amount of high quality roughage and thus compensating for the possibly lower supplementation through concentrates that, according to the rules of the organic certification organisation, may not contain synthetic vitamins.

Toledo et al. (2002) found lower levels of selenium in milk from organic dairy farms in Sweden and our data indicate similar differences, although they were not statistically significant. Further studies, with detailed information on actual feeds used, is needed to find explanations for this possible difference between organic and conventional milk.

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