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Factors Influencing the Content of Vitamins A and E in Sheep and Goat Milk

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Abstract

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The content of lipophilic vitamins A and E was determined in samples of sheep and goat milk of different breeds coming from 9 farms in central, eastern, and southern Bohemia. Samples were collected throughout the period of lactation (from April to September). Vitamins A and E were determined by HPLC using DAD and FLD detectors. Vitamin A was determined in all samples but only α-tocopherol (out of various forms of vitamin E) was detected in all samples. The total average content of vitamins A and E in raw milk of all sheep breeds during lactation was 0.93 ± 0.07 and 2.93 ± 0.87 mg/kg, levels of these vitamins in goat milk were 0.79 ± 0.08 and 1.29 ± 0.35 mg/kg, respectively. The results showed a significantly medium and strong correlation between the content of vitamin A and E and the content of fat (R^2 = 0.57 and 0.75, respectively). The year did not have any statistically significant influence on the content of monitored vitamins. The content of both vitamins is dependent on the phase of lactation. The levels of vitamins A and E were significantly lower in the early phase and significantly higher in the late phase of lactation. The amount of monitored vitamins slightly decreased during pasteurisation. A strong decrease in the content of both vitamins was observed during the first two weeks after milk storage in a freezing box at the temperature of –20°C (about 11–55%).

Keywords: retinol; tocoferols; goat; sheep; storage; pasteurisation; lactation period

Ruminant milk and milk products have formed an inseparable element of human diet since the earliest domestication of livestock. Although the milk dominating in the dairy industry in many countries is cow milk, other farm animals such as sheep and goats are used for milk production increasingly. Goat and sheep milk products have interesting properties (Casper *et al*. 1999), including hypoallergenicity, compared to those made of cow milk (El-Agamy 2007). The goat milk is much easier to digest than the cow milk as the protein composition is different. Better digestibility of goat milk ensures that the fat it contains is dispersed in the smaller fat beads (Jandal 1996). Due to the better digestibility of milk proteins the goat milk is an important part of the diet of people suffering from allergies (Høst 2002, Viñas *et al*. 2012). In addition, the breeding of sheep and goats in the public eye is associated with a friendlier attitude towards animals and nature, so that their milk is considered as organic and ecological. With the increasingly growing network of farmers markets it is much easier to get these products and for these both reasons the consumption of sheep and goat milk constantly grows. Goat milk is consumed in its raw liquid form and in the form of dairy products, while sheep milk is mainly used to make cheese.

Milk contains relatively low amounts of vitamins A and E. However, due to its frequent consumption in

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various forms, it represents an important dietary source of these vitamins. Vitamin A plays a substantial role in the biochemical processes related to visual perception, it is important for bone development, affects the growth, differentiation, and maturation of gametes and is also important for foetal development (Debier *et al.* 2005). Vitamin A is also an effective antioxidant. It plays a role in the synthesis of proteins, nucleic acids, and lipoproteins. Vitamin A deficiency is associated with vision disturbances (night blindness), inhibition of growth and deformities of bones and reproductive organs. High doses of vitamin A result in increased hepatic reserve (Haenlein 1996; Miller *et al.* 1998). The recommended daily dose for adults ranges from 0.8 mg to 1 mg (2600–3300 IU) and for children from 0.4 mg to 0.6 mg (1300–2000 IU) (Capita & Calleja 2006).

Vitamin E is a very important antioxidant, it has an irreplaceable function in protecting the body against free oxygen radicals which can lead to DNA damage, and inhibits mutagens in the gastrointestinal tract. It is also a factor that slows down the aging of the body and plays a role in the prevention of cardiovascular diseases and cancer (Eitenmiller & Junsoo 2004). The recommended daily dose of vitamin E is from 10 mg to 15 mg for adults and from 5 mg to 8 mg for children (Monsen 2000).

Vitamin E deficiency is often associated with disorders of fat absorption or distribution or cystic fibrosis (Pekmezci 2011).

The content of the vitamins in raw milk is influenced by many factors. These include species of animal, breed, stage of lactation, and the individual health status. According to Morand-Fehr *et al.* (2007) and Zervas and Tsilapkou (2011) the nutrition of the animal and specific character of the farming (e.g. indoor vs. pasture farming system) are other important aspects. The content of these vitamins is also influenced by technological processing and heat treatment of milk.

There are not many studies focused on how other factors influence the vitamin content in sheep and goat milk, especially in real life. Raynal-Ljutovac *et al.* (2008) indicated the content of vitamin A in goat and sheep milk 0.4 and 0.8 mg/kg, respectively. For vitamin E these values are 0.4 and 1.1 mg/kg, respectively. An extensive monograph devoted to sheep and goats (Park *et al.* 2007) specified a value for vitamin A (185 IU for goat milk, 146 IU for sheep milk) but not for vitamin E. These studies also do not distinguish between different breeds.

The aim of this study was to determine and compare the content of fat-soluble vitamins A and E in sheep and goat milk from private farms in the Czech Republic and to assess the effect of heat treatment and storage in a freezing box on the content of these vitamins.

MATERIAL AND METHODS

Experimental material. Levels of vitamins A and E were determined in goat and sheep pool samples taken from 9 different farms (F1–F9) of central, southern and eastern Bohemia. Samples had been collected repeatedly once a month during the period of lactation from April to September (6 times a year) in the years 2012–2013. Samples were collected to the clean plastic sampling flasks of 100 ml volume, cooled to 4–6°C, and transferred in thermo boxes to the laboratory. To ensure the homogeneity of the sample the sampling flasks were thoroughly shaken for 2 min prior to the measurement.

Farm characteristics

Farm F1: family farm, herd of 100 heads, White shorthaired goat; feeding: full-day pasture, hay, silage, pressed barley, BIOSAXON mineral licks.

Farm F2: small family farm, herd of 50 heads, Brown shorthaired goat; feeding: full-day pasture, hay, silage, pressed barley, branches of pine, oak, beech, birch, pine branches dominance, ALMAGEROL mineral licks and salt licks.

Farm F3: small family farm, herd of 40 heads, Anglo-Nubian goat; feeding: full-day pasture, hay, silage, pressed barley, oats, MILLAPHOS Z-V mineral licks.

Farm F4: small family farm, flock of 65 heads, Lacaune sheep; feeding: full-day pasture, hay, silage, pressed grains, molasses, SANO mineral licks.

Farm F5: big commercial farm, flock of 380 heads of East Friesian sheep, 330 heads of White shorthaired goat, and 120 heads of Brown shorthaired goat; feeding: full-day pasture, hay, silage, pressed grains, maize, mineral licks: RUMIHERB, NATURMIX.

Farm F6: big family farm, flock of 130 heads, Romanov sheep; feeding: full-day pasture, hay, lucerne silage, scrap lupine, pressed grains, mineral licks: MILLAPHOS and BIOSAXON.

Farm F7: small family farm, herd of 18 heads, Brown shorthaired goat; feeding: full-day pasture, hay, silage, oats, mineral licks SCHAUMANN LECKSTEIN.

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Farm F8: family farm, herd of 85 heads, Lacaune sheep; feeding: full-day pasture, hay, silage, pressed barley, maize, wheat, SANO mineral licks.

Farm F9: small family farm, herd of 30 heads,East Friesian sheep; feeding: full-day pasture, hay, silage, pressed barley, mineral licks RUMIHERB, NATURMIX.

Chemicals. For the preparation of analytical samples the following standards and chemicals were used: retinol, > 99% (Sigma-Aldrich, Darmstadt, Germany), tocol and tocopherol set DL-α-tocopherol 98.2% (both Calbiochem, Canada), pyrocatechol, > 99.5% (Sigma-Aldrich, Darmstadt, Germany), potassium hydroxide, p.a. (Lachema, Brno, Czech Republic), methanol, p.a. (Lach-Ner, Neratovice, Czech Republic), hexane p.a. (Penta, Prague, Czech Republic), methanol, super gradient, content min. 99.9% (Lach-Ner, Neratovice, Czech Republic), treated distilled water (Milipore, Molsheim, France).

Measurement of vitamins A and E content in milk samples. The content of both vitamins was extracted by the method of Sánchez-Machado *et al.* (2006) with minor modifications. Approx. 1 g of homogenised sample was weighed in a plastic tube with a lid. 200 µl of methanolic pyrocatechol (0.2 g/ml) and 5 ml 1 M KOH were added to the sample. The mixture was vortexed for 20 s, saponified for 10 min in the presence of ultrasound and vortexed again for 20 seconds. Then 5 ml of hexane and 1 ml of distilled water were added to the mixture and it was again vortexed for 1 minute. Subsequently 3 ml from the upper hexane layer were taken and evaporated until dry using a Büchi rotovapor R-215 rotary evaporator (Büchi Labortechnik GmbH, Essen, Germany). The residue was dissolved in 0.5 ml of methanol and an aliquot was transferred through a nylon filter into 1 ml Eppendorf tube, which was placed in the freezer (–20°C) for 30 minutes. The sample was centrifuged for 2 min (Eppendorf miniSpin plus microcentrifuge, by 14.4 rpm) and drained off into a dark vial. The analysis was carried out using an Ultimate 3000 High Performance Liquid Chromatograph (Thermo Fisher Scientific, Dionex, Sunnyvale, USA) with a quaternary pump, refrigerated autosampler, column heater and FLD and DAD detectors. Tocols and tocopherols in the sample were determined by HPLC-FLD under the following conditions: analytical column Develosil 5 µm RP AQUEOUS (250 × 4.6 mm) (Phenomenex, Torrance, USA); precolumn Develosil 5 µm C30 UG-100A (10 × 4 mm) (Phenomenex, Torrance, USA); mobile phase methanol : deionised water (93 : 3, v/v), HPLC super gradient methanol (Lach-Ner, Neratovice, Czech Republic) and Milli-Q water, isocratic elution; flow rate 1 ml/min; injection 10 µl, column temperature 30°C; detection FLD (excitation 292 nm, emission 330 nm). Retinol was determined under the same chromatographic conditions using DAD detector (λ = 325 nm). The detection limits for tocopherol (T), tocotrienol (TKT), and vitamin A, expressed as a ratio of three times the value of the signal-to-noise ratio, were as follows: δ-TKT and δ-T 0.01µg/ml β-TKT, TKT γ-T, β-T, and γ-T 0.025 µg/ml, α-TKT and α-T 0.05 µg/ml, vitamin A 0.025 µg/ml. All results were expressed in mg/kg of milk as the mean value of three replications.

Statistical analysis was done in the Statistica Version 9 programme (2009). The measured values were processed by the analysis of variance (ANOVA), using post-hoc Tukey's test, two-side *t*-test and correlation and regression for more detailed evaluation.

Measurement of fat content. The milk samples were heated to 40°C and measured by using a MilcoScan FT1 milk analyser (FOSS Analytical A/S, Hillerød, Denmark).

Pasteurisation. The milk samples were treated by heating by the method of short-time pasteurisation (HTST), i.e. to 72–74°C for 15–40 s, then cooled to 4–6°C (done on the farms) and transported to the laboratory.

RESULTS AND DISCUSSION

Monitoring of vitamin A and vitamin E content in sheep and goat milk. Only the content of α-tocopherol out of the eight forms of vitamin E was above the limit of detection. The higher content of vitamin E compared to vitamin A was observed in most samples of sheep and goat milk. The measured mean levels of vitamins A and E in sheep milk were 0.93 ± 0.07 and 2.93 ± 0.87 mg/kg, respectively, and in goat milk 0.79 ± 0.08 and 1.29 ± 0.35 mg/kg, respectively (Table 1). These results with the exception of vitamin A in goat milk are higher than those published by Raynal-Ljutovac *et al.* (2008), levels of vitamin E are consistent with the values reported by this author. A consistent value was also reported by Kondyli *et al.* (2012). Average values measured in goat and sheep milk were higher than the values determined by Park *et al*. (2007) but lower than the values by Morand-Fehr *et al.* (2007). These authors reported very high values of both vitamins (up to 11 mg/kg of vitamin E and up to 6 mg/kg of vitamin A) depending on the farming and

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Table 1. Total amounts of vitamin A and vitamin E (mg/kg) in sheep and goat milk from monitored farms (n = 18)

Farm	Breed	Year	Range	Average	Median	St. dev.	Fat (%)
Vitamin A							
F1	White short haired goat	2012	0.45–0.75	0.60^{a}	0.58	0.10	3.28
		2013	0.30–0.71	0.56^{a}	0.63	0.14	3.24
F2	Brown short haired goat	2012	0.47–0.85	0.70^{ab}	0.75	0.13	3.95
F3	Anglonubian goat	2012	0.49–1.55	1.09^{d}	1.13	0.37	5.31
		2013	0.75–1.36	1.18^{d}	1.24	0.18	5.06
F4	Lacaune sheep	2012	0.52–0.96	0.77^{b}	0.78	0.12	8.11
F5	East Friesian sheep	2012	0.44–1.10	0.67^{b}	0.64	0.20	6.39
		2013	0.74–1.20	0.96^{b}	0.93	0.13	6.62
	Brown short haired goat	2013	0.45–1.02	0.68^{b}	0.68	0.18	3.46
	White short haired goat	2013	0.41–1.00	0.75^{b}	0.78	0.22	2.98
F6	Romanov sheep	2012	0.60–1.32	0.98^{cd}	1.03	0.22	8.29
		2013	0.55–1.80	1.13^{cd}	1.18	0.36	7.69
F7	Brown short haired goat	2013	0.62–1.04	0.75^{b}	0.73	0.15	3.31
F8	Lacaune sheep	2013	0.64–1.34	0.99^{cd}	1.06	0.21	7.81
F9	East Friesian sheep	2013	0.75–1.33	1.00^{c}	0.93	0.18	5.85
Vitamin B							
F1	White short haired goat	2012	0.33–1.96	1.13^{a}	1.18	0.46	3.28
		2013	0.45–1.15	0.88^{a}	1.03	0.25	3.24
F2	Brown short haired goat	2012	0.79–2.56	2.05^{bc}	2.29	0.55	3.95
F3	Anglonubian goat	2012	0.61–2.39	1.55^{ab}	1.74	0.63	5.31
		2013	0.96–2.34	1.37^{ab}	1.22	0.43	5.06
F4	Lacaune sheep	2012	0.92–3.73	2.29^{c}	2.25	0.80	8.11
F5	East Friesian sheep	2012	1.82–3.49	2.44^{bc}	2.45	0.48	6.39
		2013	1.47–3.52	2.57^{bc}	2.66	0.64	6.62
	Brown short haired goat	2013	0.55–1.45	0.96^{bc}	0.91	0.27	3.46
	White short haired goat	2013	0.63–1.75	1.04^{bc}	1.03	0.36	2.98
F6	Romanov sheep	2012	0.93–7.16	4.22^{e}	4.59	1.75	8.29
		2013	1.07–9.61	3.93^{e}	3.53	2.61	7.69
F7	Brown short haired goat	2013	0.50–2.04	1.30^{ab}	1.40	0.53	3.31
F8	Lacaune sheep	2013	0.45–3.19	1.62^{abc}	1.55	0.73	7.81
F9	East Friesian sheep	2013	2.64–6.57	3.45^{d}	2.64	1.50	5.85

$^{a–d}$ values in the same line marked with different letters differ significantly ($P \leq 0.05$); Fat (%) – average fat content for the entire lactation period

feeding system. Determined levels of vitamins A and E in sheep milk varied from 0.44 mg/kg to 1.80 mg/kg and from 0.45 mg/kg to 9.61 mg/kg, respectively. The content of both vitamins in goat milk ranged from 0.30 mg/kg to 1.36 mg/kg and from 0.33 mg/kg to 2.56 mg/kg, respectively. Variability of the content of vitamin E in the milk of small ruminants from all the farms included in the study was 52.9%, which was more than twice higher than the variability in the content of vitamin A (23.6%).

The highest average content of vitamin A was found in milk from farm F3 (1.18 ± 0.18 mg/kg – Anglo-Nubian goat) and in milk from farm F6 (1.13 ± 0.36 mg/kg – Romanov sheep). The highest content of vitamin E was found in milk from farm F6 (4.22 ± 1.75 mg/kg – Romanov sheep), followed by the value in milk from farm F9 (3.45 ± 1.50 mg/kg – East Friesian sheep). No statistical difference in the content of vitamin A in milk between the particular farms was determined, but the difference was found in the

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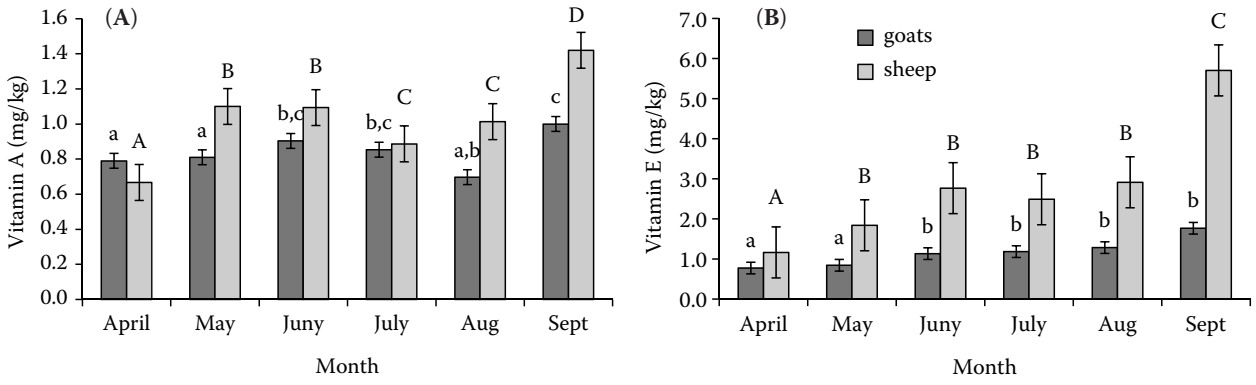

Figure 1. Average content of (**A**) vitamin A and (**B**) vitamin E in sheep and goat milk during lactation

The values marked with different letters (a-b for goat) and (A-C for sheep) differ significantly ($P \leq 0.05$)

content of vitamin E in milk. It was not possible to divide the farms strictly according to the content of vitamins in milk into two groups, namely into sheep and goat farms. However, a correlation was observed between the monitored vitamins and fat content. The correlation coefficient $R^2 = 0.57$ corresponds to the medium strong relationship between the content of vitamin A in milk and the percentage of milk fat. In addition, the strong relationship ($R^2 = 0.75$) was found between the content of vitamin E in milk and the percentage of milk fat. It seems that the percentage of milk fat is a significant factor influencing the content of vitamin A and especially the content of vitamin E in milk.

To determine the influence of breed on the content of vitamins A and E in milk of small ruminants, the milk of White shorthaired goat, Brown shorthaired goat and East Friesian sheep coming from the same farm (F5) in the year 2013 was used (Table 1). No statistical difference ($P < 0.05$) between the two goat breeds was found. The statistically significant higher content of both vitamins was found in the milk of East Friesian sheep. The detected statistical difference between goat breeds and sheep breed was apparently associated with a higher fat content in sheep milk. It is in good accordance with an assumption of the mutual relationship between the content of fat and the contents of both lipophilic vitamins in milk. Kondyli *et al.* (2012) showed a difference between two sheep breeds and one goat breed. According to this author the mean content of vitamin A was significantly higher in sheep milk of Boutsiko than in Karamaniko breed, while no significant differences were found in vitamin E content between milks of the two sheep breeds. Goat milk had a lower content of vitamins A and E than sheep milk of both breeds.

To monitor the effect of a specific character of individual farms, sheep and goat milk of the same breed from different farms was used, specifically White shorthaired goat (farms F1, F5), Brown shorthaired goat (farms F7, F5) and East Friesian sheep (farms F5, F9) (Table 1). A statistically significant difference ($P < 0.05$) in the content of both vitamins was recorded between sheep farms F5 and F9. On the farms where goats were kept, a statistically significant difference ($P < 0.05$) in the content of vitamin A and E was found between farms F1 and F5 (White shorthaired goat) but not between F5 and F7 (Brown shorthaired goat). Thus, the vitamin content reflected the specifics of breeding.

The milk samples from two goat breeds, namely Anglo-Nubian goat (farm F6) and White shorthaired goat (farm F1), and two sheep breeds, namely East Friesian sheep (farm F5) and Romanov sheep (farm F6), were collected in 2012 and 2013 to determine the influence of the year. The year was found to have no statistically significant influence ($P < 0.05$) on the content of vitamins A and E in either sheep or goat milk.

Changes during lactation period. The influence of the lactation phase on vitamin A and E content in sheep and goat milk was also monitored. The samples of milk were taken once a month during lactation from April to September on all farms. The results are expressed as averages of the vitamin contents in milk from all sheep breeds and from all goat breeds in each month. It was found that the content of both vitamins in sheep and goat milk at the beginning of lactation period was statistically significantly different ($P < 0.05$) from the content at the end of this period (Figure 1). The contents of vitamins in the mid-lactation period were not statistically significantly different but there were some nuances between them. The differences in the content of

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vitamin E in the milk at the beginning and at the end of lactation period were significantly larger, especially in the sheep milk, than the differences in the content of vitamin A. The milk yield during the lactation period may change, especially of sheep milk. At the end of lactation period the milk yield was reduced 4 times compared with the beginning of lactation, which led to an increase in the percentage of the main milk compounds including fat. The content of lipophilic vitamins related to 1 kg of milk was increased as well. Related to the total amount of milk produced the content of vitamin A slightly decreased while the content of vitamin E slightly increased. The increase in the content of vitamins in milk at the end of lactation period corresponds very well with a higher percentage of fat in milk that occurs right at the end of lactation period (Zeng & Escobar 1996; Prasad & Sengar 2002; Kuchtík & Sedláčková 2003; Kuchtík *et al.* 2008).

Effect of pasteurisation on the content of vitamins in milk. It is generally known that the content of vitamins decreases during processing and technological processes. To determine a difference between the levels of the observed vitamins in raw and pasteurised milk, the milk of Anglo-Nubian goats and East Friesian sheep was used. The decrease of both vitamins in sheep and goat milk treated with the most frequently used high-temperature short-time (HTST) pasteurisation varied to a large extent. The decrease of vitamin A content ranged from 4% to 27% in goat milk and from 1% to 57% in sheep milk, an average loss of vitamin A was 13% and 14%, respectively (Table 2). The decrease of vitamin E in pasteurised milk varied from 1% to 70% in sheep milk and from 6% to 31% in goat milk, an average loss of vitamin E was 23 and 14%, respectively (Table 2). Almost 50% of the observed decline was an order of magnitude higher than the decline of both vitamins during pasteurisation described in the literature. Holt (1995) reported the vitamin A decrease of about 6% during pasteurisation. According to Pol and Groot (1990) pasteurisation had even no effect on the content of vitamin A. Öste *et al*. (1997) reported the vitamin E loss of 5% due to pasteurisation. However, this study showed that in the second half of lactation period the losses of both vitamins were significantly reduced and those in sheep milk were even lower than described by Holt (1995) and Öste *et al*. (1997). These high losses could be caused by the fact that in farm conditions the procedure of milk pasteurisation was not always exactly adhered to the standard procedure applied in a big dairy (e.g. milk after pasteurisation is not cooled quickly enough, the heating was done at a higher temperature or for a longer period of time). Even a relatively frequent rotation of labourers on the farms could probably play the role because they need some time to get experience and working habits. In conclusion it could be stated that if all the steps were exactly adhered to the default technological process of pasteurisation, the loss of the contents of both vitamins was in accordance with literature references.

Table 2. Content of vitamins A and E in raw and pasteurised sheep and goat milk

	Content of vitamin (mg/kg)					
	April	May	Juny	July	August	September
Vitamin A						
Goat raw milk	1.35	1.24	1.28	1.14	0.84	1.23
Goat pasteurised milk	0.99	1.16	0.99	1.00	0.81	1.11
Sheep raw milk	0.77	0.91	1.1	0.89	0.99	1.17
Sheep pasteurised milk	0.68	0.39	1.06	0.88	0.95	1.16
Decrease of vitamin content in goat milk (%)	27	7	23	13	4	10
Decrease of vitamin content in sheep milk (%)	12	57	4	2	4	1
Vitamin E						
Goat raw milk	0.97	1.15	1.38	1.24	1.22	2.26
Goat pasteurised milk	0.67	1.05	1.06	1.17	1.12	2.12
Sheep raw milk	1.93	1.56	3.05	2.63	2.78	3.59
Sheep pasteurised milk	1.65	0.47	1.72	2,54	2.75	3.47
Decrease of vitamin content in goat milk (%)	31	9	23	6	8	6
Decrease of vitamin content in sheep milk (%)	15	70	44	3	1	3

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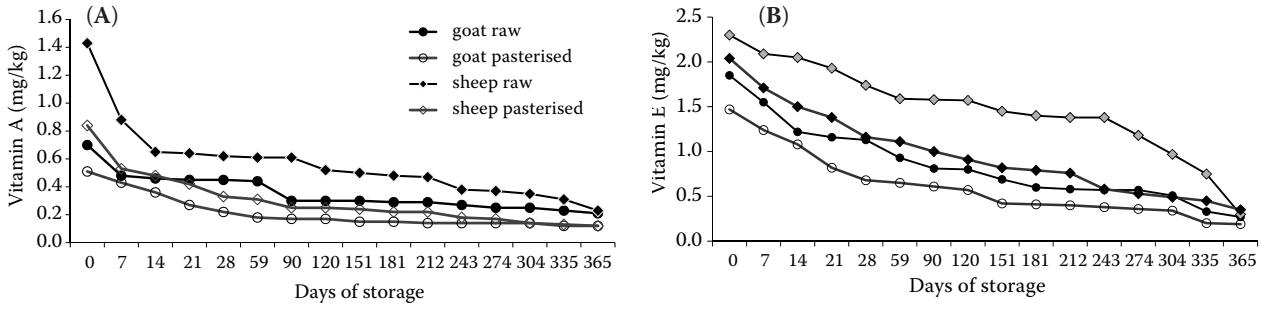

Figure 2. Changes in (**A**) vitamin A and (**B**) vitamin B content in raw and pasteurised sheep and goat milk during 12-month storage in a freezing box

Changes during storage in freezing box. The observed variations in the content of vitamins also occurred during the storage of milk**.** The influence of annual storage in a freezing box at the temperature of –20°C on levels of vitamins A and E in raw and pasteurised (HTST) sheep and goat milk was also monitored. Milk of East Friesian sheep and Anglo-Nubian goats was analysed. Initial levels of both vitamins in pasteurised sheep and goat milk were always lower in comparison with raw milk.

The content of vitamin A in raw milk decreased sharply during the first fourteen days (about 34%), then it stabilised until the 59th day and then it dropped again. After three months the decline became linear. The content of vitamin A in pasteurised milk declined almost linearly throughout the observation period. In sheep pasteurised milk the decrease was intensive during the first seven days (about 38%). At the end of the reporting period, the level of this vitamin in raw and pasteurised milk was relatively stable. After a year of milk storage in the freezer, the content of vitamin A reached approximately 30 and 24% of the original value in raw and pasteurised goat milk, respectively, and approximately 16 and 14% of the original content in raw and pasteurised sheep milk, respectively (Figure 2).

The downward trend of the vitamin E level in goat milk was similar to a decline of vitamin A, only the absolute initial levels of vitamin E were higher (Figure 2). The most significant decrease in raw milk was recorded during 14-day storage in a freezing box (about 34%). In pasteurised goat milk an almost linear decrease was found out as well as in raw and pasteurised sheep milk. However, in raw sheep milk after 243 days of storage the sharp decrease (about 78%) was observed. At the end of the entire storage period the content of vitamin E as well as vitamin A in measured milk stopped at almost the same value (18%) of the original content in raw and pasteurised milk.

CONCLUSIONS

Compared with the most frequently consumed cow milk, goat milk, and sheep milk are comparable or even better sources of vitamins A and E in human nutrition. No statistical difference in the content of vitamin A was established between the farms, while it was found in the content of vitamin E. It is not possible to distinguish strictly between goat and sheep milk according to the content of vitamin E, however, a correlation between the monitored vitamins and fat content was observed. For these reasons a higher content of both vitamins can be expected in sheep milk and milk of Anglo-Nubian goat, which have a higher fat content.

In general, a higher content of vitamin E in milk was detected when compared with the content of vitamin A. A statistically significant difference in vitamin E content was found in milk of the same goat and sheep breed kept on different farms. Except Brown shorthaired goats (F5 and F7) the content of both monitored vitamins on sheep and also on goat farms was statistically different. The content was apparently influenced by specific conditions of breeding. The year had no statistically significant influence on the content of vitamins A and E in milk of these small ruminants. The levels of vitamins A and E were significantly lower in the early phase and significantly higher in the late phase of lactation. When the pasteurisation procedure was performed, an average loss of vitamin A and vitamin E in sheep and goat milk was 13 and 14%, respectively, and 23 and 14%, respectively. The content of vitamins A and E dropped also during the storage of milk in a freezing box. A sharp decrease was observed during the first two weeks of storage. After a year of milk storage in the freezer (at –20°C) the content of vitamin E as well as vitamin A in measured milk stopped at almost the same average value of 18% of the original content in raw and pasteurised milk.

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References

Capita R., Caleja C.A. (2006): Evaluation of vitamin and mineral intakes and impact of snack foods on Spanish adults. Nutrition Research, 26: 255–265.

Casper J.l., Wendorff W.L, Thomas D.L. (1999): Functional properties of whey protein concentrates from caprine and ovine specialty cheese wheys. Journal of Dairy Science, 82: 265–271.

Debier C., Pottier J., Gofee Ch., Larondelle Y. (2005): Present knowledge and unexpected behaviours of vitamins A and E in colostrum and milk. Livestock Production Science, 98: 135–147.

Eitenmiller R., Junsoo L. (2004): Vitamin E – Food Chemistry, Composition and Analysis. Food Science and Technology. New York, Marcel Dekker,.

El-Agamy E.I. (2007): The challenge of cow milk protein allergy. Small Ruminant Research, 68: 64–72.

Haenlein G.F.W. (1996): Nutritional value of dairy products of ewe and goat milk. In: Anifantakis E.M. (ed.): Proceedings of the IDF/CIRVAL Seminar Production and Utilization of Ewe and Goat Milk, SI 9603: 159–178.

Holt C. (1995): Effect of heating and cooling on the milk salts and their interaction with casein. In: Fox P.F. (ed.): Heat Induced Changes in Milk.2nd Ed. Brussels, International Dairy Federation: 159–178 .

Høst A. (2002): Frequency of cow's milk allergy in childhood. Allergy, Asthma and Immunology, 89: 33–37.

Jandal J.P. (1996): Comparative aspects of goat and sheep milk. Small Ruminant Research, 22: 177–185.

Kondyli E., Svarnas C., Samelis J., Katsiari M.C. (2012): Chemical composition and microbiological quality of eve and goat milk of native Greek breeds, Small Ruminant Research, 103: 194–199.

Kuchtík J., Sedláčková H. (2003): Composition and properties of milk in White Short-haired goats on the third lactation. Czech Journal of Animal Science, 48: 540–550.

Kuchtík J., Šustová K., Urban T., Zapletal D. (2008): Effect of the stage of lactation on milk composition, its properties and the quality of rennet curling in East Friesian ewes, Czech Journal of Animal Science, 53: 55–63.

Miller R.K., Hendrikx A.G., Mills J.L., Hummler H., Wiegand U.W. (1998): Perinconceptional vitamin A use: How much is teratogenic? Reproductive Toxicology, 12: 75–88.

Monsen E.R. (2000): Dietary reference intakes for the antioxidant nutrients: vitamin c, vitamin e, selenium, and carotenoids. Journal of the American Dietetic Association, 6: 637–640.

Morand-Fehr P., Fedele V., Decandia M., Le Frileux Y. (2007): Influence of farming and feeding system on composition and quality of goat and sheep milk. Small Ruminant Research, 68: 20–34.

Öste R., Jägerstad M., Anderson I. (1997): Vitamins in milk and milk products, in: Fox P.F. (ed.): Advanced Dairy Chemistry. Vol. 3. Lactose, Water, Aalts and Vitamins. 2nd Ed. London, Chapman & Hall.

Park Y.W., Juáres M., Ramos M., Haenlein G.F.V. (2007): Physico-chemical characteristics of goat and sheep milk. Small Ruminant Research, 68: 88-113.

Pekmezci D. (2011): Vitamin E & immunity. Vitamins and Hormones, 86: 179–215.

Pol G., Groot E.H. (1990): Effect of processing on the nutritive value of milk. Nederlandssh Melk- en Zuiveltijdschrift, 14: 158–175.

Prasad H., Sengar O.P.S. (2002): Milk yield and composition of the Barbari goat breed and its crosses with Jamunapari, Beetal and Black Bengal. Small Ruminant Research, 45: 79–83

Raynal-Ljutovac K., Lagriffoul G., Paccard P., Guillet I., Chilliard Y. (2008): Composition of goat and sheep milk products: an update. Small Ruminant Research, 79: 57–72.

Sánchez-Machado D.I, López-Cervantes J., Ríos Vázques N.J. (2006): High-performance liquid chromatography method to measure α- and γ-tocopherol in leaves, flowers and fresh beans from *Moringa oleifera*. Journal of Chromatography A, 1105: 111–114.

Viñas M., Carnés J., López-Matas M.A., Hernández N., Castillo M.J., Ibero M. (2012): Allergy to goat and sheep cheese with tolerance to cow's milk and its derivatives. Allergologia et Immunophologia, 42: 186–190.

Zeng S.S., Escobar E.N. (1996): Effect of breed and milking method on somatic cell count, standard place count and composition of goat milk, Small Ruminant Research, 19: 169–175.

Zervas G., Tsiplakou E. (2011): The effect of feeding system on the characteristic of product from small ruminants. Small Ruminant Research, 101: 140–149.

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