Effects of Lactation Stage, Breed, and Lineage on Selenium and Iodine Contents in Goat Milk

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Abstract

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Selenium and iodine contents were analysed in goat milk coming from three commercially oriented farms in east (farm A) and south (farms B, C) Bohemia. The average iodine level found in milk from farm A was 393.6 ± 111.2 µg/kg, from farm B 584.9 ± 186.9 µg/kg, and from farm C 397.6 ± 223.4 µg/kg. The average level of selenium found in milk from farm A was 9.19 ± 2.17 µg/kg, from farm B 6.20 ± 0.53 µg/kg, and from farm C 6.57 ± 2.29 µg/kg. The results showed significantly strong correlations between selenium and iodine contents in milk and in mineral supplement (r = 0.91 and 0.92, respectively). On average, 76.6% of the iodine in milk was transferred to the whey fraction. In the case of selenium, it was found out that 23.8% was transferred from milk to the whey fraction. As a consequence of the mineral licks used, the correlation between selenium and iodine contents in time was not proved (r = 0.06).

Keywords: caprine milk; caprine whey; lactation period; mineral supplement; brown short-haired goat; white short-haired goat

Breeding of goats in the Czech Republic used to be scarce but has recently become more widespread. Due to the increasing popularity of farmers' markets and interest in local groceries, the general availability of milk other than cow's has recently risen.

There is generally a deficit of selenium in European soils (Zimmerman & Köhrle 2002) as well as a difficult way of its utilisation by plants (Ellis & Salt 2003). Central European soils are also deficient in iodine (Anke *et al.* 1995). Silanikove (2010) reviewed that goat milk, in comparison with cow milk, is beneficial in view of the uptake and utilisation of certain minerals, including selenium. However, the intake of selenium and iodine from goat milk in human nutrition, when used as a substitute for cow milk, has not been well characterised yet. Groppel (1993) mentioned that goat and sheep milks when fed in the same way contain higher amounts of iodine than cow milk.

Some of the newer studies state that the contents of minerals in milk can be influenced by numerous factors, e.g. breed, lineage, system of feeding, milking, differences between individual animals, health status and age, seasonal changes, order and stage of lactation, life conditions and technology of keeping the animals, and processing the milk (Zeng & Escobar 1996; Meschy *et al.* 2000; Soryal *et al.* 2005; Morand-Fehr *et al.* 2007). Knowles *et al.* (1997) claims, that I and Se concentrations in cow milk can be quite easily manipulated by supplementation.

Most of the farms in the Czech Republic, regardless of the size, are nowadays using some kind of mineral supplement from the wide range available

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on the market. The majority of iodine in milk occurs in the form of iodide (Fernandez-Sanchez & Szpunar 1999) and is present in whey or bonded to casein (Flynn & Power 1985). Selenium in milk occurs mainly in the form of selenomethionin and the majority is bonded to protein fractions: 55–78% to casein and 17–38% to whey proteins (Knowles *et al*. 1999).

The question is how the situation looks like in real life, under many other influences, and if the goat milk from these farms can be considered good source of selenium and iodine. The aim of this study is to observe the occurrence of selenium and iodine in goat milk of the most commonly kept breeds and their lineages throughout the lactation phases.

MATERIAL AND METHODS

Collection of samples. Pooled samples were taken from three farms (A, B, C) located in east and south Czech Republic, each of the farms keeping about 400–600 goats. The samples were regularly taken all year round during a 2.5-year period. The fodder consisted of hay, straw, pasture and mineral lick with specified contents; Farm A: I = 110 mg/kg, Se = 45 mg/kg; Farm B: I = 135 mg/kg, Se = 15 mg/kg, Farm C: I = 120 mg/kg, Se = 30 mg/kg. No other mineral additives were used (e.g. iodine-based teat dips). The present breed involved the two most common in the Czech Republic: White and Brown Short-haired goat with 3 different lineages.

In this study, the goats were administered mineral supplements, iodine being provided in the form of potassium iodide and selenium in the form of sodium selenite. In the farms B and C, along with the milk, samples of whey were also collected. The samples were cooled and stored frozen (–20°C) until the analysis.

Analytical methods. The samples of milk for the iodine determination were dried and prepared using alkalic ashing, in the presence of potassium hydroxide and zinc sulphate, in accordance with the method by Fiedlerová (1998). The supernatants were filtered and iodine was analysed in the form of iodide (iodine content is transposed into iodide form by mineralisation) using ion-pair high performance liquid chromatography with electrochemical detection (HPLC-ED; Waters, Milford, USA) on reversed phase column NOVA-PAK C-18 (Hejtmánková *et al*. 2005), following a modified procedure in accordance with Technical standard IDF 167:1994, which describes direct determination of iodine content in fresh or dried refreshed milk. The same method for determining the iodine content in cow milk was used by Hejtmánková *et al*. (2006).

The milk samples for the determination of selenium were exposed, after lyophilisation, to the acid treatment by concentrated nitric acid (2 ml) and hydrogen peroxide 30% (3 ml) overnight, after which they were wet ashed in a microwave mineraliser MW-3+ (Speedwave, Berghof, Germany). The analysis was performed by atomic absorption spectrometry (Varian, Palo Alto, USA) with hydrides generator (GH-AAS). Selenium was determined in the form of selenium dioxide, as described by Muniz *et al*. (2005).

Statistical evaluation. All the samples were measured in triplicates. The results were processed in Microsoft Excel and statistically evaluated in R. The differences were analysed using One-way and Two level nested design ANOVA with Tukey HSD test as a post-hoc test. The correlations were tested with Pearson's product-moment correlation, with previous testing of normal distribution using scatterplot. For examining the relationships between the elements, the Standard linear regression was used.

RESULTS AND DISCUSSION

Total concentrations of Se and I

The measured levels of selenium in goat milk were 7.32 ± 1.62 µg/kg on average (Table 1). The results are lower than those published by Rodriguez (2002), Ayar *et al*. (2009) or Petrera *et al*. (2009). The highest average content of selenium in milk was found in the farm using the mineral supplement richer in selenium than in the others.

The average contents of iodine in goat milk taken from different farms are shown in Table 1. Total average content of iodine was at all farms 458.7 ± 109.3 µg/kg. According to Groppel (1993), the levels of iodine in goat milk below 62 µg/l are deficient, however, the levels of iodine in milks from this study were far above this amount. Schöne and Rajkumar Rajendram (2009) published that iodine content in goat milk higher than 500 µg/l is already undesirable. A result above this limit was found in farm B. The mineral lick at this farm, accordingly, contained the highest amount of iodine

Table 1. Total amounts of selenium and iodine (μg/kg) in goat milk from different farms

Farm	Mean	SD	*CV*%	Min	Max	*n*
Selenium						
A	9.19	2.17	23.7	6.20	14.9	24
B	6.20	0.53	8.62	5.62	7.06	8
C	6.58	1.91	29.1	4.05	10.1	13
Iodine						
A	393	111	28.2	217	606	24
B	584	186	31.9	329	940	11
C	397	223	56.1	120	838	13

SD – standard deviation; *CV*% – correlation variance; *n* – number of sample

of them all. The correlation coefficient between selenium and iodine was –0.12, indicating no significant association.

Influence of supplementation

Different mineral licks were available for animals at each farm. The differences between the farms in selenium content were found to be statistically significant ($P < 0.001$). Milk from farm A contained a higher amount of selenium in comparison to both farm B and C ($P < 0.01$). The differences between the farms in iodine content were also confirmed ($P < 0.01$), but in this case milk from farm B had a higher content of iodine ($P < 0.05$) than the other two farms.

The results show a strong relationship between the selenium content in milk and that in the mineral supplement, which corresponds with the study by Knowles *et al.* (1999). The regression coefficient was 0.112 ($P < 0.001$, $r^2 = 0.31$).

Between the iodine content measured in milk and that in the supplement a significant relationship was also found. The regression coefficient was 7.363 ($P < 0.01$, $r^2 = 0.16$).

In the farm B, the values of iodine were the highest, which corresponds to its highest content in the mineral supplement (135 mg/kg of iodine). The chemical analyses of milk imply that the higher contents of iodine in mineral licks can cause an increase of iodine in milk above the desired levels. The supplement should always be selected for the real needs of the animals based on chemical analysis of milk. In the farm A, the goats had an access to a lick containing an increased amount of selenium (45 mg/kg). In their milk, accordingly, the highest levels of selenium were found.

Changes during lactation period

As another factor, the influence of the lactation phase on selenium and iodine contents in goat milk was monitored. Three sets of samples were taken from farm A: in April (about 6 weeks on average after the birth of kids), in July (about 18 weeks of lactation), and in September (about 28 weeks of lactation). Selenium concentration in milk slightly increased in the course of the lactation period from 7.44 μg/kg to 11.10 μg/kg, while with iodine a small maximum was visible in the middle of the lactation period, but it was not statistically significant.

The levels of selenium during the phases of lactation showed a significant difference between them ($P < 0.001$). In the late phase of lactation period, the levels of selenium were significantly higher ($P < 0.001$). The values of iodine content fluctuated (Figure 1) and no differences in the means were found ($P < 0.26$).

Influence of breed and lineage

Samples of goat milk coming from different breeds and lineages were taken from farm A. The feeding ratio and condition of breeding were the same. The samples of milk were taken from breeds white and brown short-hair goats. The white breed consisted of lineages Emil, Mohykan, and Ferda, and the brown breed of Jested, Othello, and Hansi.

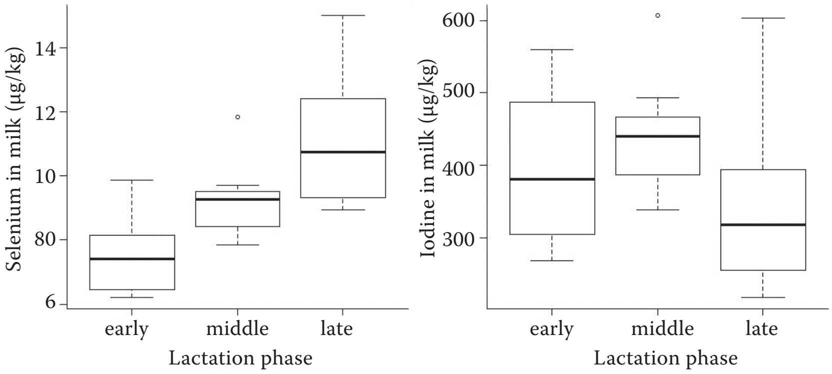

Figure 1. Comparison of means of selenium and iodine in goat milk (µg/kg) during the lactation period

The average content of selenium in milk from the white breed was 9.31 ± 2.45 µg/kg and from the brown breed 9.07 ± 1.97 µg/kg. The average content of iodine in milk from the white breed was 367.1 ± 102.0 µg/kg and from the brown breed 408.0 ± 111.1 µg/kg.

No significant differences were found in selenium and iodine levels neither between the white and brown breeds their three lineages.

Transfer of I and Se to the whey fraction

The major part of goat milk in dairy farms is processed to milk products, and thus we monitored the transfer of iodine from milk to whey (distribution of iodine between the casein fraction and whey fractions). To compare the occurrence of elements in goat milk and whey, the samples from farms B and C were used. As for farm B, the whey fraction retained 79.9% of the iodine present in whole milk, and in milk from farm C it was 73.3%. These results are lower than those published by Fernandez-Sanchez and Szpunar (1999), who found 95% of iodine in the whey fraction. Isaac-Olive *et al.* (2008) reported that in bovine whey 89–96% of iodine is in the form of iodide, and the rest is in the form of iodate and whey protein-bound iodine.

The samples were also analysed for selenium content. Contrary to iodine (a non-metal), the majority of selenium (a metalloid) remains bonded with the casein fraction and is not transferred to the whey. It was found that 23.6% (farm B) and 23.9% (farm C) of selenium is transfered from whole milk to the whey fraction after casein coagulation. This does not fully correspond with the study of Muniz *et al.* (2005), who determined 56.6% of selenium transferred from whole milk to milk whey.

CONCLUSION

The total average content of selenium in milks from all farms was 7.32 ± 1.62 µg/kg, and that of iodine 458.7 ± 109.3 µg/kg. The differences between the farms in selenium and iodine contents were found to be statistically significant. The results showed a strong relationship between selenium content in milk and in the mineral supplement. It was observed that the levels of selenium are significantly higher in the late phase of lactation. No significant differences were found in selenium or iodine levels between white and brown breeds or in their three lineages. Approximately 77% of iodine and 23.8% of selenium are transfered from milk to the whey fraction.

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