ACTA VET. BRNO 2008, 77: 533-538; doi:10.2754/avb200877040533

Milk Iodine Content in Slovakia

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Received December 20, 2007
Accepted July 7, 2008

Abstract

Paulíková I., H. Seidel, O. Nagy, G. Kováč: Milk Iodine Content in Slovakia. Acta Vet. Brno 2008, 77: 533-538.

The aim of this work was to map actual iodine status and its seasonal differences in raw milk of dairy cows, sheep, and goats in various regions of Slovakia. Iodine concentrations were determined in 457 samples of raw milk from dairy cows, 78 samples of sheep, and 16 samples of goat milk collected in various regions of Slovakia from 2002 to 2007. Among all the 457 samples of bovine milk, iodine content below 50 $\mu g \cdot l^{-1}$ was recorded in 114 samples (24.94%); 294 samples (64.33%) ranged between 50 and 200 $\mu g \cdot l^{-1}$; 19 samples (4.16%) from 200 to 500 $\mu g \cdot l^{-1}$; 17 samples (3.72%) between 500 and 1 000 $\mu g \cdot l^{-1}$, and 13 samples (2.85%) showed iodine concentrations over 1 000 $\mu g \cdot l^{-1}$. Regional concentrations showed the highest values in the Western, then Middle and Eastern Slovakia, and the lowest values in Northern Slovakia ($p < 0.05$, $p < 0.01$). In sheep and goat milk samples, we found iodine concentrations below 80 $\mu g \cdot l^{-1}$ in 49 sheep (62.8%) and in 6 goats below 60 $\mu g \cdot l^{-1}$ (37.5%), which are indicative of iodine deficiency. When comparing seasonal differences, sheep and goat milk had higher iodine content during the winter feeding period, however, in dairy cows we recorded the opposite ratio. Except for goat milk ($p < 0.01$) the seasonal differences were not significant.

Iodine, raw milk, cows, sheep, goats, season

Iodine as an essential element is incorporated into the chemical structure of thyroidal hormones. Iodine deficiency leads to serious health disorders both in humans and animals of all ages. However, iodopaenia is frequently only subclinical without clinical signs, thus affecting farm economy. Milk is one of the most important sources of iodine in human nutrition (Herzig and Suchý 1996; Borkovcová and Řehuřková 2001), with milk and its products representing over 50% of the total iodine intake (Park et al. 1981; Dellavalle and Barbano 1984). For example, Krajčovičová-Kudláčková et al. (2001) found in their experiment that the intake of purely plant foods induced signs of iodine deficiency in humans (urine iodine content below 100 $\mu g \cdot l^{-1}$).

As the milk iodine concentration changes readily in response to its dietary intake, it is a good indicator of momentary or recent iodine intake in the case of a relatively steady ration without goitrogens. Milk iodine concentrations depend on various factors, first of all on the dietary intake (Swanson et al. 1990; Kroupová et al. 2001), but also on the season (Binnerts 1979; Groppel and Anke 1991; Dahl et al. 2003; Trávníček et al. 2006), food processing (Herzig and Suchý 1996; Bobek 1998), environmental temperature (Lengemann 1979), and food harvesting time (Trávníček et al. 2004).

Iodine intake necessary to maintain its plasma levels over the critical threshold 10 µg per 100 ml (in which goitre development is probable), is 120 µg per day. As sufficient daily iodine intake in adults and adolescents, 150 µg are recommended (Wayne et al. 1964). Higher iodine intake is not desirable because it decreases its bioavailability and leads to goitre (Anke et al. 1998). In human medicine, iodine intake in the long term should not exceed 2 000 µg in adults and 1 000 µg in children (Wolff 1969). A long-term intake of iodides in amounts exceeding ten times the daily requirements for biosynthesis of thyroidal hormones may result in goitre or thyreotoxicosis (Wolff 1969; Braverman et al. 1971).

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The primary aim of this work was to determine the iodine content in raw milk of dairy cows, sheep, and goats regardless of breed, production, and reproduction cycle. The second goal was to compare milk iodine levels in various regions of Slovakia, as well milk iodine concentrations during winter and summer feeding periods.

Materials and Methods

Milk iodine concentrations were determined in 457 samples of raw milk from dairy cows, 79 samples of sheep, and 17 samples of goat milk collected in various regions of Slovakia from 2002 to 2007. The samples were taken manually after washing of quarters and halves, respectively, without the use of iodine disinfectant. Animals from 32 farms (dairy cows - 23, sheep - 7, goats - 2) were divided into four groups according to the regions - Western (162 cows), Middle (24 cows, 6 goats) Eastern (241 cows, 60 ewes, 10 goats) and Northern (30 cows, 18 ewes) Slovakia. We compared also milk iodine concentrations recorded during the summer (1 May - 31 October; 169 cows, 6 ewes, 6 goats) and winter (1 November - 30 April; 288 cows, 72 ewes, 10 goats) feeding periods. The milk iodine concentrations were determined by photometric method for the analysis of trace iodine based on catalytic reaction NO_2^-/SCN^- (Tušl 1983). As reference values for the iodine content in milk of cows, sheep, and goats we used data published by various authors (Groppel 1993; Anke et al. 1998; Mee and Rogers 1996). The results were summarised, expressed in percentage, means (x), standard deviations (SD), median, minimum, and maximum values; in sum and on corresponding farms. Statistical evaluation of differences was done by one-way ANOVA analysis with subsequent non-paired Student's *t*-test (MS Office Excel 2007).

Results and Discussion

Milk iodine concentrations in dairy cows found in our survey are presented in Tables 1–5.

Table 1. Milk iodine concentrations in dairy cows ($\mu g \cdot l^{-1}$) from various West-Slovakia farms (x ± SD)

Farm	1	2	3	4	5	6	7	8
x	44.1	56.3	119.9	54.6	60.3	109.4	221.6	1110.4
SD	32.5	7.8	86.3	2.5	5.0	56.2	126.3	393.2
median	29.4	55.6	82.5	54.3	60.1	102.9	193.3	953.5
min.	9.2	40.6	51.6	52.0	51.9	56.7	70.2	650.0
max.	92.7	84.9	337.3	59.2	68.6	273.3	497.8	1790.6
n	27	54	14	11	12	14	18	12

min. – minimum individual value
max. – maximum individual value
n – number of samples

Table 2. Milk iodine concentrations in dairy cows ($\mu g \cdot l^{-1}$) from various Middle-Slovakia farms (x ± SD)

Farm	9	10
x	259.2	48.1
SD	401.7	1.9
median	98.1	48.6
min.	47.9	43.7
max.	1182.1	50.4
n	12	12

The iodine content in the milk of dairy cows, as published by various authors, varies within a wide range of 10 to 2000 $\mu g \cdot l^{-1}$or more, the most frequent concentration being found within 100–300 $\mu g \cdot l^{-1}$ (Hemken 1979; Park et al. 1981; Šucman et al. 1984; Herzig et al. 1999; Trávníček et al. 2006). Park et al. (1981) analysed ca 2 500 US dairy farms and found 62% of farms with a milk iodine content below 200 $\mu g \cdot l^{-1}$, 28% between 200 and 500 $\mu g \cdot l^{-1}$, and 7% from 500 to 1 000 $\mu g \cdot l^{-1}$. Almost 3% of farms had a milk iodine content over 1 000 $\mu g \cdot l^{-1}$. Trávníček et al. (2006) presented iodine concentrations in raw bovine milk in the Czech Republic in 2005. In 169 tank samples from 14 areas of South-western Bohemia they found the average concentration of 442.5 ± 185.6 $\mu g \cdot l^{-1}$ (68.6–1 000.6), when in five regions they recorded a milk iodine content higher than 500 $\mu g \cdot l^{-1}$. Milk iodine concentrations are also influenced by goitrogens present in the diet. Třináctý et al. (2001) determined 594.8 ± 178.1 $\mu g \cdot l^{-1}$ in the milk of dairy cows. With the same supply of iodine and simultaneous feeding rapeseed meal (270 $g \cdot kg^{-1}$ food) the iodine content in milk decreased to

Table 3. Milk iodine concentrations in dairy cows (μg·l^{-1}) from various Northern-Slovakia farms (x ± SD)

Farm	11	12
x	45.97	54.52
SD	1.64	10.12
median	45.4	50.0
min.	44.32	44.69
max.	50.55	82.91
n	12	18

209.4 ± 145.3 μg·l^{-1}. Similarly, Hermansen et al. (1995) reported a decrease in the milk iodine content in dairy cows fed over 4.4 kg rapeseed per day.

Concerning dairy cow saturation with iodine, Mee and Rogers (1996) suggested the following milk iodine concentrations: very low - below 25 μg·l^{-1}; low - 25–38 μg·l^{-1}; marginal - 39–50 μg·l^{-1}; normal 51–300 μg·l^{-1}; and high - over 300 μg·l^{-1}. According to Anke et al. (1998) milk iodine concentration of 50 μg·l^{-1} is considered to be normal. On the other hand, dairy industry accepts a maximum milk iodine concentration of 500 μg·l^{-1} (Hemling 2001). In this connection, the Food Code of the Slovak Republic does not state the milk iodine content (www.svssr.sk/sk/legislativa/kodex/2_07_05.pdf).

Table 4. Milk iodine concentrations in dairy cows (μg·l^{-1}) from various Eastern-Slovakia farms (x ± SD)

Farm	13	14	15	16	17	18	19	20	21	22	23
x	56.3	87.1	839.3	52.9	57.8	55.4	67.4	345.2	64.1	62.5	46.5
SD	2.5	5.9	307.0	4.6	18.5	1.9	15.7	426.7	17.3	15.6	90.2
median	56.5	87.4	846.9	52.4	50.5	55.5	65.7	155.2	58.0	55.8	9.1
min.	53.3	76.1	206.9	42.9	44.6	52.8	44.0	61.9	37.0	41.7	8.1
max.	60.6	95.1	1355.0	63.9	135.8	169.2	97.2	3065.0	103.2	91.1	230.6
n	12	12	17	18	87	12	24	12	16	25	6

Table 5. Milk iodine concentrations in dairy cows (μg·l^{-1}) from various regions of Slovakia (x ± SD)

Region	West	Middle	East	North	Total
x	161.0^{a,c}	153.6^{b}	75.9^{b,c}	51.1^{a}	136.9
SD	298.0	298.0	116.4	8.9	258.2
median	60.7	50.2	54.7	47.4	56.8
min.	9.2	43.7	8.1	44.3	8.1
max.	1790.6	1182.1	1501.9	82.9	1790.6
n	162	24	241	30	457

Numbers with the same superscipts differ at ^{a,b} $p < 0.05$ and ^{c} $p < 0.01$, respectively

In Slovakia, milk iodine concentrations determined in 1970s ranged between 21 and 103 μg·l^{-1} (Görner et al. 1979). The average milk iodine concentration in the non-endemic area was 89.24 μg·l^{-1}, in the low-land endemic area 52.57 μg·l^{-1}, and in the mountain endemic area 31.02 μg·l^{-1}.

In our observation, in all the 457 examined samples of bovine milk, an iodine content below 50 μg·l^{-1} was recorded in 114 samples (24.94%); 294 samples (64.33%) ranged between 50 and 200 μg·l^{-1}; 19 samples (4.16%) from 200 to 500 μg·l^{-1}; 17 samples (3.72%) between 500 and 1000 μg·l^{-1}, and 13 samples (2.85%) showed a milk iodine content over 1000 μg·l^{-1}. Concentrations in the Slovak regions showed the highest values in the Western, then Middle, Eastern, and the lowest values in Northern Slovakia ($p < 0.05$, $p < 0.01$; Table 5). The aforementioned iodine concentrations are substantially higher than those described by Görner et al. (1979). Similar increase in milk iodine concentrations (compared to past) was also recorded by Trávníček et al. (2006). However, the results showed large variability within both regions and farms.

According to Groppel (1993), at an equal dietary intake, the ovine and caprine colostrums and milk contain more iodine than the milk of dairy cows, and that iodine concentrations of 79 μg·l^{-1} and 62 μg·l^{-1} in the sheep and goat milk, respectively, are indicative of iodine deficiency. Ferri et al. (2003) reported the milk iodine content in sheep milk 675 ± 154 μg·l^{-1}. Azuolas and Caple (1984) investigated 54 sheep flocks and average milk iodine concentrations ranged between 79 and 1 831 μg·l^{-1}. Two flocks with the occurrence of goitre in lambs showed variations in the milk iodine content within 45–98 μg·l^{-1}. Similarly, Trávníček and Kursa (2001) investigated the milk iodine content in 10 sheep flocks and in 94 goats from 64 farms. An average iodine concentration in sheep milk was 105.5 μg·l^{-1}. The corresponding value for four farms where sheep had access to mineral licks (35 mg iodine per 1 kg) was 243 ± 87.2 μg·l^{-1} (107.7–436.6) and for the rest of the farms 47.9 ± 27.8 μg·l^{-1}. Mean iodine concentrations in goat milk (31.6 μg·l^{-1} and 63.0 μg·l^{-1} in two consecutive years) were indicative of iodine deficiency. In goats receiving iodised salt, the average milk iodine concentration was 142.1 ± 102.6 μg·l^{-1} (51.8–39.6) and for the remaining goats 19.3 ± 13.2 μg·l^{-1}. Average iodine concentration in goat milk on three farms with neonatal goitre occurrence ranged between 8.5 and 23.3 μg·l^{-1}.

Average iodine concentrations of iodine in sheep and goat milk recorded in our observation are presented in Table 6.

Table 6. Milk iodine concentrations in sheep and goats (μg·l^{-1}) from various regions of Slovakia (x ± SD)

	Sheep								Goats		
	East					North		Total	Middle	East	Total
x	106.1	57.0	668.2	62.4	254.3	55.9	116.0	186.7	48.0	89.2	73.7
SD	109.5	7.6	432.4	2.9	296.8	7.2	441.1	287.6	2.4	25.6	28.6
median	74.2	53.5	556.4	62.2	121.8	53.8	52.7	66.0	47.7	85.1	66.4
min.	59.1	50.2	207.1	59.1	60.2	49.5	47.8	47.8	45.4	62.7	45.4
max.	524.5	72.3	1613.2	67.0	1050.0	70.0	816.3	1613.2	51.9	146.0	146.0
n	18	10	10	10	12	6	12	78	6	10	16

Regarding limits indicating iodine deficiency (Groppel 1993), we found milk iodine concentrations below 80 μg·l^{-1} in 49 sheep (62%) and in 6 goats (37.5%) below 60 μg·l^{-1}.

Milk iodine concentrations recorded in summer and winter feeding periods are presented in Table 7. When comparing seasonal differences, sheep and goat milk was higher in the iodine content during the winter feeding period, however, in dairy cows we recorded the opposite ratio. Except for goat milk ($p < 0.01$) the seasonal differences were not significant.

Table 7. Milk iodine concentrations in dairy cows, sheep, and goats (μg·l^{-1}) during summer and winter feeding periods (x ± SD)

	Summer feeding period			Winter feeding period		
	Cows	Sheep	Goats	Cows	Sheep	Goats
x	154.6	56.0	48.0^{a}	126.6	197.6	89.2^{a}
SD	309.2	7.2	2.4	223.3	296.8	25.6
median	57.0	53.8	47.7	56.6	67.9	85.1
min.	8.1	49.5	45.4	9.2	47.8	62.7
max.	1790.6	70.0	51.9	1501.9	1613.2	146.0
n	169	6	6	288	72	10

Numbers with the same superscript differ at $p < 0.01$

Several authors reported higher milk iodine concentrations during the winter feeding period (Binnerts 1979; Groppel and Anke 1991; Dahl et al. 2003; Trávníček et al. 2006). Seasonal differences are explained by the lower iodine content in summer food rations. Iodine content increases due to water loss during plant biomass preservation. Hay and ensiled fodders have higher iodine content than green matter (Herzig and Suchý 1996; Bobek 1998). However, loss of iodine may occur during the drying and storing of foods (Kroupová et al. 2001). Opposite findings were reported by Azuolas and Caple (1984), who reported the highest milk iodine concentrations in late summer, decreasing during autumn to the lowest concentrations in spring. Similarly, Graham (1991) reported higher thyroid iodine content in summer and autumn than that in winter and spring. Seasonal differences in the milk iodine content may be related also to environmental temperature. According to Lengemann (1979), six times more iodine appeared in goat milk at environmental temperatures of 33 °C than at 5 °C. The author suggested that at 33 °C less iodine is used for thyroxin production while the iodine concentrating mechanism continues in the mammary gland. High temperatures made more iodine available, made the mammary gland more efficient in clearing blood of iodine, and influenced the size of body iodine pool.

Regarding seasonal differences recorded in our study, the opposite summer-winter ratio of milk iodine content found in dairy cows (compared with sheep and goats) could be related to cattle feeding, which is not so strictly bound to summer and feeding periods as in small ruminants.

The bovine, ovine, and caprine milk iodine concentrations recorded in our study correspond to data published by various authors. When comparing various Slovak regions, we found the highest values in the Western, then Middle, Eastern, and the lowest values in the Northern Slovakia. Comparing seasonal differences, sheep and goat milk had higher iodine content during the winter feeding period; however, in dairy cows we recorded the opposite ratio. Yet, the results showed large variability within both regions and farms.

Obsah jódu v mlieku na Slovensku

Cieľom práce bolo zmapovať aktuálne koncentrácie jódu v surovom mlieku dojníc, oviec a kôz a ich sezónne rozdiely v rôznych regiónoch Slovenska. Koncentrácia jódu bola stanovená v 457 vzorkách surového kravského mlieka, 78 vzorkách ovčieho a 16 vzorkách kozieho mlieka odobraného v rokoch 2002 až 2007 v rôznych regiónoch Slovenska. Spomedzi 457 vzoriek kravského mlieka bol obsah jódu pod 50 $\mu g \cdot l^{-1}$ zaznamenaný v 114 vzorkách (24,94 %); 294 vzoriek (64,33 %) vykazovalo koncentrácie od 50 do 200 $\mu g \cdot l^{-1}$; 19 vzoriek (4,16 %) od 200 do 500 $\mu g \cdot l^{-1}$; 17 vzoriek (3,72 %) medzi 500 a 1000 $\mu g \cdot l^{-1}$ a v 13 vzorkách (2,85 %) boli zaznamenané koncetrácie jódu nad 1000 $\mu g \cdot l^{-1}$. Pri porovnaní rôznych regiónoch boli najvyššie koncetrácie jódu v mlieku zaznamenané na západnom, potom strednom a východnom Slovensku, najnižšie koncentrácie boli zistené na severnom Slovensku ($p < 0,05$, $p < 0,01$) Vo vzorkách ovčieho a kozieho mlieka sme zistili koncentrácie jódu pod 80 $\mu g \cdot l^{-1}$ u 49 oviec (62,8 %) a u 6 kôz pod 60 $\mu g \cdot l^{-1}$ (37,5 %), pričom tieto hodnoty poukazujú na deficit jódu. Porovnanie sezónnych rozdielov koncentrácie jódu v mlieku oviec a kôz ukázalo vyššie koncentrácie počas zimného kŕmneho obdobia, avšak u dojníc sme zaznamenali opačnú tendenciu. S výnimkou kozieho mlieka ($p < 0,01$) sezónne rozdiely neboli významné.

Acknowledgement

This work was supported by the Slovak Research and Development Agency under the contract No APVV 20-027905.

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