Iodine content in raw milk

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ABSTRACT: The paper presents the latest information on iodine content in raw milk, in the Czech Republic. In 2005, iodine was determined using the Sandell-Kolthoff method in 169 milk samples, taken from transportation tanks (capacity 11 000–13 000 litres) of collecting milk for dairy processing, from 14 areas of South-western Bohemia. The average iodine content in milk samples was 442.5 ± 185.6 μg/l, minimum and maximum value were 68.6 and 1 000.6 μg/l respectively. 81.7% of the samples contained more than 250 μg/l. The average iodine content in milk from the collecting areas ranged from 230.2 ± 133.0 μg/l to 702.7 ± 166.2 μg/l ($P < 0.001$). In five collecting areas (i.e. 35.7%), means were higher than 500 μg/l. These values document the continuing trend of an increase in iodine content in raw cow's milk, as well as permanent local and regional differences. Higher mean values were determined in the period of winter feed rations (April 495.9 ± 50.8 and October 494.3 ± 176.4 μg/l), while lower values were measured during the period of summer feed rations (September 350.9 ± 178.4 μg I/l) ($P < 0.01$). If converted per dry matter, 1 kg of dry milk matter contained, on average, 3.428 ± 1.497 mg iodine, maximum and minimum values were 0.543 and 7.995 mg respectively.

Keywords: milk; dry milk matter; season; iodine surplus

The content of iodine in cow's milk is influenced by the animals' diet. The relationship between iodine content in feed ration and in milk is expressed by the correlation coefficient 0.66 (Maas et al., 1989). In connection with the application of mineral feed additives containing iodine at an amount of 20–150 mg/kg. Kroupova et al. (2001) reported an increase in iodine content in cow's milk to the values higher than 200 μg I/l, with the maximum value 596.2 μg I/l. After iodine (ethylenediamine dihydroiodide) supplementation on the level of 250% of the daily requirement, Trinacty et al. (2001) measured 594.8 ± 178.1 μg I/l in the milk of dairy cows. With the same supply of iodine and simultaneous intake of rapeseed meal, at an amount of 270 g/kg feed, the iodine concentration in milk decreased to 209.4 ± 145.3 μg I/l.

Dahl et al. (2003) investigated the influence of the season on iodine content in milk. In the winter season, they found a twofold difference in the amount of iodine in raw cow's milk from different areas of Norway, compared to the summer months (127 μg I/l against 60 μg I/l respectively). They also determined less iodine in low-fat milk in the summer season (63–122 μg I/l) than in winter (103– 272 μg I/l). Seasonal variations in iodine content in milk are explained by the lower iodine content in summer feed rations. Iodine content increases as a result of water loss during the preservation of plant biomass. Hay and ensiled fodders have a higher iodine content than green matter (Herzig and Suchy, 1996; Bobek, 1998). Iodine content in bulk feeds is also influenced by the time of harvest. From May to July the average iodine content in pasture forage

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in South-western Bohemia was 101.3 ± 73.6, from August to October 214.5 ± 107.3 μg I/l. The high variability of iodine content in bulk feeds is also affected by climatic factors that cause significant differences between years (Travnicek et al., 2004).

Curda and Rudolfova (2000) reported the effect of active iodine in a disinfectant "Betadine solution" used for the uterus lavage.

The supplementation of trace elements is primarily aimed at prevention of their deficiency, or at the functional improvement of metabolism in connection with high productivity (Herzig and Suchy, 1996; Kursa et al., 1997; Pavlata et al., 2005). The importance of supplementation in farm animals in relation to an increase in the nutritive value of foods from animal sources, was accentuated in the last years (Pavlata et al., 2004; Herzig et al., 2005).

The objective of this study was to evaluate the current content of iodine in milk in the Czech Republic, before its dairy processing and to evaluate the effect of the season on iodine variability in raw milk.

MATERIAL AND METHOD

Iodine content was determined in milk samples taken from milk transportation tanks (tank volume 11–13 000 litres) of collecting milk from regular collecting areas for dairy processing. Fourteen collecting areas from the region of Ssouth-western Bohemia were included in the investigation (districts: Cesky Krumlov – area 1, 3, 6; Ceske Budejovice – area 2, 4, 7, 8, 10, 11, 13; Jindrichuv Hradec – 4, 9, 12, 14). The particular collecting areas represented 4 to 20 milk producers with different volumes of daily supply of milk (from 200 to 6 200 litres of milk). Milk samples were taken in weekly intervals, during the months April to May, and September to October. The samples were taken by the same method as for determination of quality traits by qualified employees of the dairy. The samples were frozen in standard sampling bottles on the day of sampling and kept at −15°C for 4 to 6 weeks before their analysis. In total, 169 milk samples from transportation tanks were examined. Iodine in milk was determined on the basis of alkaline ashing by a spectrophotometric method according to Sandell-Kolthoff (Bednar et al., 1964). The principle behind determination is the reduction of Ce^{4+} to Ce^{3+}, in the presence of As^{3+} due to the catalytic effect of iodine. Dry mineralisation takes place in the alkaline environment at 600°C. The above described method was used to determine total iodine (inorganically and organically bound iodine to proteins).

Iodine content was also expressed per 1 kg dry matter of milk on the basis of conversion according to the actual dry matter of milk. Statistical processing of data included the calculation of average values ($\bar{x}$), standard deviations (SD), coefficient of variation (*V*%), minimum and maximum values, median and statistical significance, and was determined by the ANOVA – Tukey test.

RESULTS AND DISCUSSION

The iodine concentration in 169 milk samples collected from transportation tanks in 2005 ranged from 68.6 to 1 006.6 μg/l, the mean value was 442.5 ± 185.6 μg/l and the median value 413.5 μg/l. The minimum and maximum concentration, and the value of the coefficient of variation (41.9%) document marked variability in the set of analysed samples (Table 1). Compared to the average iodine content (310.4 μg/l) that was determined in milk samples taken from 226 farms of the Czech Republic in 2003–2004 by Kursa et al. (2005), the average iodine concentration found in milk, shows an increase by 42.6%.

Table 1. Average iodine content in milk from transportation tanks (μg/l)

Number of analysed tanks	$\bar{x}$	SD	*V*%	Min.	Max.	Median
169	442.5	185.6	41.9	68.6	1 006.6	413.5

Table 2. Relative representation of iodine concentrations in milk samples from transportation tanks

Iodine content in milk (μg/l)	20.1–80.0	80.1–250.0	250.1–500.0	500.1–1 000.0	>1 000.0
Relative proportions (%)	0.6	17.7	43.8	37.3	0.6

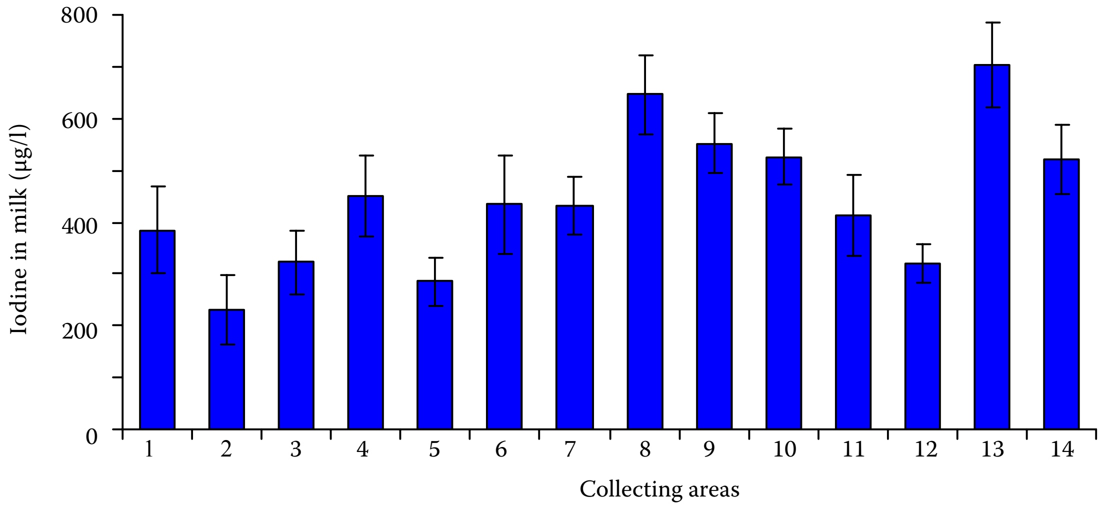

Figure 1. Average iodine content in milk according to the collecting areas

The number of samples with iodine content between 80 and 250 μg/l, which is considered an optimum iodine saturation for dairy cows (Kursa et al., 2005), accounted for only 17.7% of the 169 analysed samples. A higher content was found in 81.7% of samples (Table 2).

The average content of iodine in milk from the particular collecting areas ranged from 230.2 ± 133.0 μg/l (collecting area No. 2) to 702.7 ± 166.2 μg per litre (collecting area No. 13), (Figure 1). A difference between the means is statistically highly significant ($P < 0.001$, Table 3). The means in 5 collecting areas (i.e. 35.7%) amounted to 500 μg and above iodine per litre of milk. These values document the continuing trend of an increase in iodine content in raw cow's milk and permanent local and regional differences (Kursa et al., 2005).

Table 4 shows the average content of iodine in milk, according to the period of milk collection for dairy processing. The lowest average con-

Table 3. Statistical significance differences of iodine content in raw milk of collecting areas (CA)

CA	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	–							**					**	
2		–		**		*	*	***	***	***			***	***
3			–					*					**	
4				–				*					*	
5					–			***	***	**			***	**
6						–		**					**	
7							–	**					**	
8								–			**	***		
9									–			**		
10										–		*		
11											–		**	
12												–	***	*
13													–	
14														–

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

Table 4. Seasonal iodine content in milk (μg/l)

Date	11.4.	18.4.	25.4.	2.5.	9.5.	12.9.	19.9.	26.9.	30.9.	10.10.	17.10.	24.10.	31.10.
Samples of tanks (*n*)	14	14	14	14	14	13	13	13	12	12	12	12	12
Average	540.5^{1}	528.6^{2}	440.2	475.5	405.6^{3}	$290.1^{1,2}$	466.1	346.6^{4}	307.2	$539.9^{3,4}$	504.8	415.6	517.0
SD	141.7	126.9	175.2	151.6	238.6	147.4	221.2	179.9	116.6	155.9	170.2	156.9	194.0
V%	26.2	24.0	39.8	31.9	58.8	50.8	47.5	51.9	37.9	28.9	33.7	37.8	37.5
Min.	240.2	318.0	183.6	194.7	161.4	68.6	136.4	101.7	109.2	271.6	237.3	168.3	164.0
Max.	737.6	715.7	698.9	710.8	1 006.6	558.4	829.1	678.3	454.7	727.7	733.2	612.0	896.8
Median	543.9	559.1	416.9	498.3	344.9	274.0	398.2	321.6	329.3	612.9	489.6	437.0	480.5

$^{1,2\ 3,4}P < 0.05$

centrations were more frequent in the month of September (290.1 and 307.2 μg/l). Higher average concentrations were determined in April (528.6; 540.5 μg/l) and October (539.9 μg/l). A difference between average iodine content in milk from all collecting areas in September (350.9 ± 178.4) and April (495.9 ± 150.8) and/or October (494.3 ± 176.4 μg/l) was statistically significant ($P < 0.01$), (Table 5). Seasonal differences in milk iodine content can be explained by a higher proportion of preserved fodders in winter types of feed rations that contain more iodine (Herzig and Suchy, 1996; Dahl et al., 2003) and by variations in iodine content in grass and pasture stands in relation to the growing season (Travnicek et al., 2004). Marked differences in iodine content between winter (430 μg/l) and summer (200 μg/l) seasons have also been reported in the United Kingdom (MAFF, 2000).

Similarly, iodine content converted per 1 kg dry matter (Table 6), showed the highest concentrations during the months of October and April, and the lowest in September (Figure 2). The average content of iodine in 1 kg of dry milk matter contained on average 3.428 ± 1.497 mg I/kg, minimum value was 0.543 mg, maximum value 7.995 mg and the median was 3.152 mg I/kg dry matter.

The highest iodine content in samples from transportation tanks (Table 4), as well as the means during the months of April and October (Table 5) approach the values (500 μg/l) that milk processers e.g. in the USA and Australia consider as undesirable (Berg et al., 1988). The extreme concentration 1 006.6 mg I/kg determined in May 2005 (Table 4) is identical to the maximum tolerated daily intake of iodine for humans, according to WHO (Braverman, 1994). However, the total

Table 5. Average iodine content in milk according to the months (μg/l)

Month	*n*	$\bar{x}$	SD	Min.	Max.	Median
April	42	495.9^{2}	150.8	183.6	737.6	506.1
May	28	440.5	195.7	161.4	1 006.6	391.6
September	51	$350.9^{1,2}$	178.4	68.6	829.6	321.6
October	48	494.3^{1}	176.4	164.0	896.8	507.6

$^{1,2}P < 0.01$

Table 6. Average iodine content in milk from transportation tanks (mg/kg dry matter)

Number of analysed tanks	$\bar{x}$	SD	*V*%	Min.	Max.	Median
169	3.428	1.497	43.7	0.543	7.995	3.152

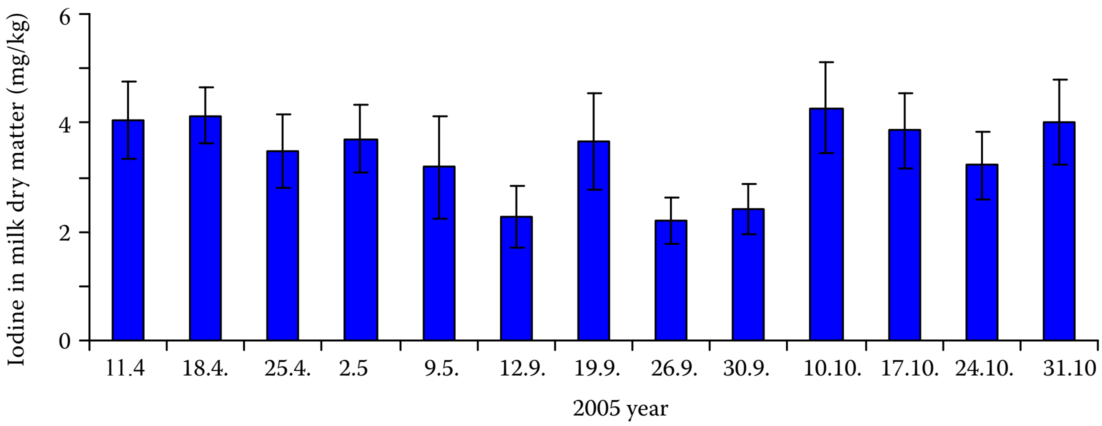

Figure 2. Seasonal variations of iodine in raw milk dry matter (mg /kg)

balance of iodine intake in humans must accept a similar increase in iodine content in other foods from animal sources, particularly in eggs (Travnicek et al., 2006).

Our results, documenting a marked increase in the content of iodine in cow's milk in connection with the increased dietary intake, correspond to data reported by Launer and Richter (2005), who recorded an iodine increase from the mean value 70 μg/l in 1996 to 210 μg/l in Saxony in 2001, or to changes in iodine content in consumer milk in the United Kingdom, where from 1991 to 2000 iodine in milk in the winter season increased from 210 to 430 μg/l (MAFF, 2000).

Differing content of iodine in milk from large-capacity tanks, i.e. in milk volumes of 11 000–13 000 litres, existing at the beginning of dairy processing of raw milk, influence the final iodine content in consumer milk.

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