Iodine content in bulk feeds in western and southern Bohemia

J. Trávníček, V. Kroupová, M. Šoch

Agricultural Faculty, University of South Bohemia in České Budějovice, České Budějovice, Czech Republic

ABSTRACT: In 1997–2001 a total of 304 samples of bulk feeds were analysed. Iodine was determined spectrophotometrically by Sandell and Kolthoff's method (Bednář *et al*., 1964). The highest content of iodine was determined in grass silage (213.3 ± 169.3 μg/kg DM). The lowest concentration was measured in maize silage (110.0 ± 97.2) and hay (112.1 ± 93.9). Pasture herbage contained on average 148.9 ± 105.1. Feeds originating from foothill areas of western Bohemia (geological bedrock built of crystalline schists and igneous intrusions of earlier granite) contained a higher amount of iodine than feeds from foothill areas of southern Bohemia (geological bedrock in which crystalline schists prevail). The largest difference in iodine content in relation to feed origin was found out in hay: western Bohemia 168.0, southern Bohemia 78.0 ($P < 0.01$). From May to July pasture herbage contained 101.3 ± 73.6 and from August to October 214.5 ± 107.3 μg/kg DM ($P < 0.01$).

Keywords: pasture herbage; hay; grass silage; maize silage

Iodine content in feeds from plant sources is highly variable, mostly depending on its amount in soil and water that is influenced by the geological genesis of soils, their distance from the ocean, soil exploitation and fertiliser applications.

McDowell (1992) stated that important sources of iodine for plants were soils formed from alluvial deposits, clay soils and diluvial sands in which leaching in the glacial epoch caused an iodine loss in Central Europe. Podzols and sandy soils have lower contents of iodine than Chernozems. Soils with intensive cultivation and rich in humus contain a higher amount of iodine (Anke *et al*., 1995). Concentrations lower than 4 mg I/kg are considered as deficient (McGrath *et al*., 1990). Bíreš *et al*. (1996) reported congenital goitres in kids coming from areas with the iodine content of soil 14.6 mg/kg.

Experiments aimed to determine correlations between iodine contents in soil and in plants were only partly successful, probably due to different chemical forms of iodine presence in soil and different bioavailability to plants (Underwood, 1981). Low pH values and high content of chlorides in soil reduce its resorption (McGrath *et al*., 1990).

Iodine is accumulated in plants in the process of leaf area enlargement. Its content changes if biomass is processed by preservation. Hay and ensiled feeds usually have a higher iodine content than herbage (Herzig and Suchý, 1996), which is probably connected with its dehydration (Bobek, 1998). It also explains higher concentrations of iodine in milk in the winter season (Phillips, 1997) when preserved feeds are used.

In conditions of the Czech Republic the composition of parental rocks determines the primary iodine content in the environment. From this aspect the CR territory is built of three geological groups: crystalline rocks (mainly granite, gneiss and granodiorites) with almost zero content of iodine; volcanic rocks in western Bohemia with higher content of iodine;

Supported by the National Agency for Agricultural Research of the Ministry of Agriculture of the Czech Republic (Grant No. 44013/2004) and by the Ministry of Education, Youth and Sports of the Czech Republic (Project No. MSM 122200002).

Quaternary sediments in southern Moravia comprising Pannonian clays with the relatively highest content of iodine. None of the rock species the territory of the Czech Republic is built of comprises such an amount of iodine that would ensure its sufficient input into the food chain (Oliveriusová, 1997).

Sommer *et al*. (1994) reported these iodine contents in μg per kg of dry matter: 90–400 for clover-grass silage, 270 for silage from meadow herbage, 160–260 for maize silage (190 at higher altitudes), 230–260 for pasture herbage, 410–1 100 for meadow herbage and 90–400 μg I/kg dry matter for clover-grass hay. McDowell (1992) gave the range of 300–1 500 μg I/kg dry matter for pasture herbage, while the iodine content in grasses is usually 14 times lower than in dicotyledonous plants.

The objective of the paper was to review iodine content in bulk feeds in the area of western and southern Bohemia, where the risk of low iodine content in cow's milk exists. By 1996 51.7% of dairy cow herds in this area had an iodine content below 20 μg/l, in 1997–1999 it was still 26.7% (Kroupová *et al*., 2001).

MATERIAL AND METHODS

A total of 304 bulk feed samples were analysed in 1997–2001: 93 samples of pasture herbage, 118 samples of hay, 67 samples of grass silage and 26 samples of maize silage.

In western Bohemia samples of all bulk feeds were collected in localities of the foothill and mountain areas of the Šumava Mts. involving the district Klatovy with the geological bedrock in which crystalline schists and igneous intrusions of older granite prevailed. In southern Bohemia a majority of hay samples ($n = 66$) was taken in localities with the geological bedrock mostly built of crystalline schists (districts Prachatice, Český Krumlov and Strakonice – areas of the Šumava Mts.) and 13 samples were collected in localities with the bedrock of sweet-water sedimentary deposits (districts Jindřichův Hradec and České Budějovice. Samples of the other feeds (pasture herbage, grass silage, maize silage) were taken in southern Bohemia in the district Prachatice only.

Iodine content in bulk feeds was determined spectrophotometrically after alkaline ashing by Sandell and Kolthoff's method, which was modified by Bednář *et al*. (1964). Feed samples were taken from storage facilities, silage pits or directly on pasture. Iodine concentration in feed was expressed in μg per 1 kg of 100% dry matter (DM).

The results of analyses were statistically processed by the statistical software STAT plus (Matoušková *et al*., 1992).

RESULTS

The highest content of iodine expressed by the average value (213.3 ± 169.3 μg/kg DM), median (148.0 μg/kg DM) and the highest relative frequency of samples with iodine content above 300 μg/kg dry matter (28.3%) was determined in grass silage (Table 1). The lowest concentration of iodine was measured in maize silage (110.0 ± 97.2 μg/kg DM, median 78.7 μg/kg DM) and hay (112.1 ± 93.9, median 78.0). Pasture herbage contained on average 148.9 ± 105.1 μg/kg DM and its median was 118.7 μg I/kg DM (Table 1). The highest proportion of samples with the lowest iodine content (below 100 μg I/kg DM) is related with the low average content of iodine in maize silage and hay: 68.0% of maize silage samples and almost 61.9% of hay samples.

Although there were differences in average values (Table 1) for the particular feed types, their minimum values did not differ substantially, ranging from 22.8 (hay) to 34.5 μg I/kg DM (maize silage). The range of maximum concentrations was 463.3 (maize silage) – 947.5 (grass silage).

Tables 2, 3 and 4 document the effect of the area of feed origin on iodine content in feed.

Bulk feeds originating from foothill areas of the Šumava Mts. of western Bohemia (district Klatovy) had higher iodine contents than feeds from mountain and foothill areas of the Šumava Mts. of southern Bohemia (districts Prachatice, Český Krumlov and Strakonice); this finding was also true of hay from the area of southern Bohemia (districts České Budějovice and Jindřichův Hradec) on the bedrock of sweet-water sedimentary deposits (Table 3). The largest difference according to feed origin was in iodine content in hay: the average concentration of iodine in hay from the area of western Bohemia 168.0 ± 121.5 μg/kg DM amounted to 215% of iodine content in hay from southern Bohemia (districts Prachatice, Český Krumlov and Strakonice, the average concentration 78.0 ± 58.5 μg/kg DM, $P < 0.01$).

A statistically significant difference ($P < 0.01$) was proved in the iodine content of pasture herbage in

Table 1. Iodine content in bulk feeds (μg/kg dry matter)

Feed type	*n*	$\bar{x}$	SD	Min.	Max.	Median	Relative frequency (%)			
							< 100	101–200	201–300	> 300
Pasture herbage	93	148.9[1,2]	105.1	26.6	555.0	118.7	39.8	33.3	19.4	7.5
Hay	118	112.1[1,3]	93.9	22.8	523.4	78.0	61.9	23.7	8.5	5.9
Grass silage	67	213.3[2,3,4]	169.3	25.3	947.5	148.0	29.9	29.9	11.9	28.3
Maize silage	26	110.0[4]	97.2	34.5	463.3	78.7	68.0	24.0	8.0	0.0

[1,2,3,4] *t*-test $P < 0.01$

Table 2. Iodine content in pasture herbage according to the areas (μg/kg dry matter)

Area	n	$\bar{x}$	SD	Min.	Max.	Median	Relative frequency (%)			
							< 100	101–200	201–300	> 300
Western Bohemia*	44	159.5	125.3	26.6	555.0	123.6	38.6	34.1	13.6	13.7
Southern Bohemia**	49	139.3	83.2	34.7	399.8	113.2	40.8	32.7	24.5	2.0

Geological bedrock:
*crystalline schists, igneous intrusions of older granite (district Klatovy)
**crystalline schists (district Prachatice)
t-test statistically insignificant

Table 3. Iodine content in hay according to the areas (μg/kg dry matter)

Area	*n*	$\bar{x}$	SD	Min.	Max.	Median	Relative frequency (%)			
							< 100	101–200	201–300	> 300
Western Bohemia*	39	168.0[1]	121.5	28.0	523.4	120.6	30.8	46.2	7.7	15.3
Southern Bohemia**	66	78.0[1,2]	58.5	22.8	387.4	63.8	81.8	10.6	6.1	1.5
Southern Bohemia***	13	117.4[2]	63.9	56.9	219.6	84.9	53.8	23.1	23.1	0.0

Geological bedrock:
*crystalline schists, igneous intrusions of older granite (district Klatovy)
**crystalline schists (districts Prachatice, Český Krumlov, Strakonice)
***sweet-water sedimentary deposits (districts Jindřichův Hradec, České Budějovice)
[1,2]*t*-test $P < 0.01$

Table 4. Iodine content in grass silage according to the areas (μg/kg dry matter)

Area	*n*	$\bar{x}$	SD	Min.	Max.	Median	Relative frequency (%)			
							< 100	101–200	201–300	> 300
Western Bohemia*	36	260.2[1]	195.9	41.8	947.0	183.0	16.7	36.1	16.7	30.5
Southern Bohemia**	31	158.7[1]	112.0	25.3	339.7	114.3	45.2	22.6	6.5	25.7

Geological bedrock:
*crystalline schists, igneous intrusions of older granite (district Klatovy)
**crystalline schists (district Prachatice)
[1]*t*-test $P < 0.05$

Table 5. Iodine content in pasture herbage according to the grazing season (μg/kg dry matter)

Grazing season (months)	n	$\bar{x}$	SD	Min.	Max.	Median	Relative frequency (%)			
							< 100	101–200	201–300	> 300
May–July	51	101.3[1]	73.6	26.6	375.6	78.3	62.8	23.5	11.8	1.9
August–October	39	214.5[1]	107.3	85.3	550.0	181.2	10.3	41.0	33.3	15.4

[1]t-test $P < 0.01$

relation to the season (month) of grazing (Table 5). Pasture herbage grazed in the months of May to July contained only 47.2% of iodine compared to the months of August to October (101.3 ± 73.6 vs. 214.5 ± 107.3 μg/kg DM).

Significant differences in iodine content in feed dry matter were determined between the years of observation (Figures 1, 2 and 3). For example the iodine content in hay measured in 1998 (74.6 ± 43.0 μg/kg DM) was 2.6 times lower than in 1997 (192.4 ± 120.0, $P < 0.05$) and 2.4 times lower than in 2000 (175.2 ± 118.3 μg/kg DM, $P < 0.01$). Similarly, pasture herbage contained almost a twice lower amount of iodine in 1998 compared to 1999 (90.0 ± 31.6 vs. 177.7 ± 120.0 μg/kg DM, $P < 0.05$).

DISCUSSION

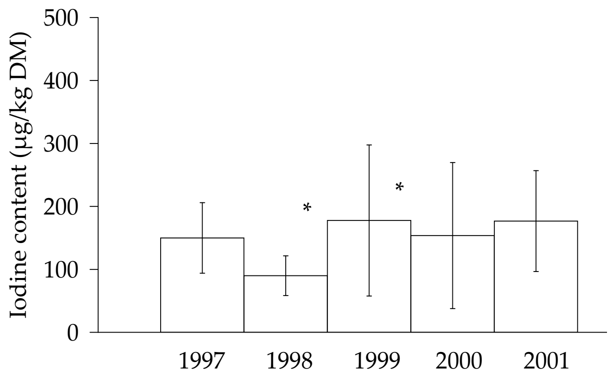

Figure 1. Iodine content in pasture herbage in 1997–2001

*t-test, $P < 0.05$

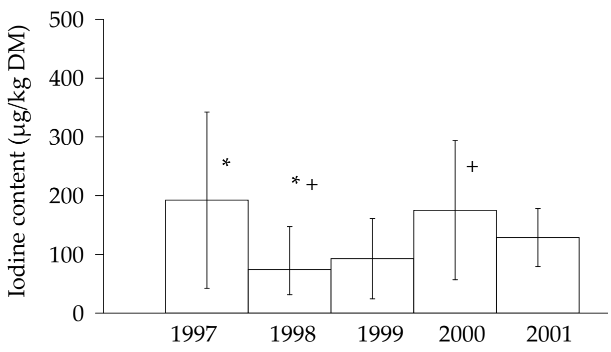

Figure 2. Iodine content in hay in 1997–2001

*t-test, $P < 0.05$; + t-test, $P < 0.01$

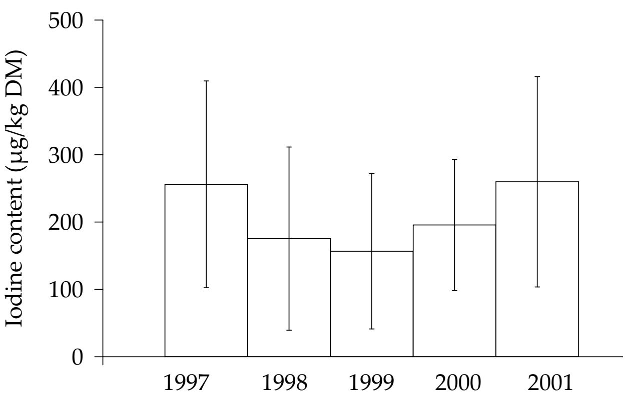

Figure 3. Iodine content in grass silage in 1997–2001

As a follow-up of the long-term investigations into iodine saturation of cattle (Kroupová *et al*., 2001) and small ruminants (Trávníček and Kursa, 2001) our research on iodine content in bulk feeds was conducted in south-western Bohemia, in the area with the occurrence of low iodine content in milk and with the increased prevalence of goitres in new-born calves in the past (Kursa *et al*., 1997).

In comparison with iodine contents indicated in the tables of nutritive values of feeds for ruminants (Sommer *et al*., 1994) average iodine content (Table 1) in the analysed samples of maize silage produced in foothill areas amounted to 58% only, of grass silage to 79%, and of pasture herbage to 60%. The average content of iodine in meadow hay approximately corresponded to the values given for clover-grass hay of average quality (Sommer *et al*., 1994).

Besides the low average values and medians, high variability and high frequency of very low values should be accentuated. The minima were on the level of 20–30 μg/kg DM in all feeds, and more than 73% of pasture herbage samples, 62% of hay samples and almost 60% of grass silage did not match the tabular values (Sommer *et al*., 1994). The lower iodine content in hay compared to grass silage and green matter – pasture herbage (Table 1) does not agree with data on a general increase in iodine content in preserved feeds (Herzig and Suchý, 1996) as a consequence of water loss during their preservation (Bobek, 1998). It is to suppose that the manipulation of biomass in the course of its drying, or hay storage, can cause that a part of plant leaves with higher iodine content is rubbed off.

Tables 2–5 show the influence of geological bedrock, soil type and soil exploitation (Anke *et al*., 1995; Oliveriusová, 1997), and of the season of harvest and/or grazing of pasture herbage on iodine content in feed dry matter and its variability. Yearly differences in iodine content (Figures 1, 2 and 3) suggest climatic and other influences that contribute to the high variability of iodine in bulk feeds. For example the soil has been depleted by a long-term rainfall low in iodine content. Hay that has been exposed to rain and sun can have deficient iodine levels for good animal nutrition (McDowell, 1992).

Although cattle and sheep saturation with iodine has been increasing gradually since 1997 thanks to a higher supply of mineral feed additives and licks with higher iodine content (15–150 mg iodine per kg) (Kroupová *et al*., 2001), there still exist categories of cattle (heifers, dry cows, grazed cattle) in which the administration of mineral feed additives is not paid enough attention and whose intake of iodine is dependent on its amount in bulk feeds of local origin. If confronted with the requirements for iodine content in feed dry matter 0.8–1 mg I/kg for lactating and pregnant cows (Blood and Radostis, 1989; Sommer *et al*., 1994), the amount of iodine in feeds from plant sources is insufficient in the given area of south-western Bohemia. Targeted supplementation of iodine should respect the local, seasonal and yearly variability of iodine content in bulk feeds while requirements for iodine deposition in animal products should be taken into account.

REFERENCES

Anke M., Groppel B., Müller M., Scholz E., Kramer K. (1995): The iodine supply of humans depending on site, food offer and water supply. Fresenius Journal of Analytical Chemistry, *352*, 97–101.

Bednář J., Röhling S., Vohnout S. (1964): Příspěvek k stanovení proteinového jodu v séru. Českoslov. Farm., *13*, 203–209.

Bíreš J., Bartko P., Weissová T., Michna A., Matišák T. (1996): Goat iodopenia as a cause of congenital struma in kids (in Slovak). Veterinarni Medicina, *41*, 133–138.

Blood D.C., Radostis O.M. (1989): Veterinary Medicine: A text-book of the diseases of cattle, sheep, pigs, goats and horses. ELBS Bailiere Tindall, U.K., 7th ed., 1176 pp.

Bobek S. (1998): Profilaktyka jodowa u zwierzat. Medycyna Wet., *54*, 80–86.

Herzig I., Suchý P. (1996): Actual experience of importance iodine for animals (in Czech). Veterinarni Medicina, *41*, 379–386.

Kroupová V., Herzig I., Kursa J., Trávníček J., Thér R. (2001): Saturace krav jodem v České republice. Veterinářství, *51*, 155–158.

Kursa J., Herzig I., Kroupová V., Kratochvíl P., Trávníček J. (1997): Consequences of iodine deficiency in cattle in some regions of the Czech Republic. Scientia Agriculturae Bohemica, *28*, 115–127.

Matoušková O., Chalupa J., Cígler M., Hruška K. (1992): Statistický systém STAT plus, verze 1.01. Uživatelská příručka, Výzkumný ústav veterinárního lékařství, Brno, 168 s.

McDowell L.R. (1992): Minerals in Animal and Human Nutrition. Academic Press Inc., New York. 225–245.

McGrath D., Poole D.B.R., Fleming G.A. (1990): Health implications of soil iodine content. Farm and Food Research, *21*, 20–21.

Oliveriusová L. (1997): Obsah jodu v prostředí v ČR. In:

Jak řešit nedostatek jodu v naší výživě. Sborník, Státní zdravotní ústav, Praha. 8 s.

Phillips D.I.W. (1997): Iodine, milk, and the elimination of endemic goiter in Britain: the story of an accidental public health triumph. J. Epidemiol. Community Health, *51*, 391–393.

Sommer A., Čerešňáková Z., Frydrych Z., Králík O., Králíková Z., Krása A., Pajtáš M., Petrikovič P., Pozdíšek J., Šimek M., Třináctý J., Vencl B., Zeman L. (1994): Potřeba živin a tabulky výživné hodnoty krmiv pro přežvýkavce. ČAZV, VÚVZ Pohořelice. 196 s.

Trávníček J., Kursa J. (2001): Iodine concentration in milk of sheep and goats from farms in South Bohemia. Acta Vet. Brno, *70*, 35–42.

Underwood E.J. (1981): The Mineral Nutrition of Livestock. Commonwealth Agricultural Bureau, England. 77–90.

Received: 03–10–30
Accepted after corrections: 04–09–30

ABSTRAKT

Obsah jodu v objemných krmivech v západních a jižních Čechách

V průběhu let 1997–2001 bylo analyzováno 304 vzorků objemných krmiv. Jod byl stanoven spektrofotometricky podle Sandella a Kolthoffa (Bednář *et al*., 1964). Nejvyšší obsah jodu byl zjištěn v travních silážích (213,3 ± 169,3 μg/kg sušiny), nejnižší v kukuřičné siláži (110,0 ± 97,2) a v seně (112,1 ± 93,9). Pastevní porost obsahoval v průměru 148,9 ± 105,1 μg/kg sušiny. Krmiva původem z podhorských oblastí západních Čech (geologické podloží krystalické břidlice a vyvřeliny starší žuly) obsahovala více jodu než krmiva z podhorských oblastí jižních Čech (geologické podloží v převaze krystalické břidlice). Největší rozdíl v obsahu jodu v závislosti na původu krmiva byl u sena: západní Čechy 168,0, jižní Čechy 78,0 μg/kg sušiny ($P < 0,01$). Obsah jodu v pastevním porostu byl ovlivněn sezonou. V období od května do července obsahoval pastevní porost 101,3 ± 73,6 ug/kg sušiny a v období srpna až října 214,5 ±107,3 μg/kg sušiny ($P < 0,01$).

Klíčová slova: pastevní porost; seno; travní siláž; kukuřičná siláž

Corresponding Author

Doc. Ing. Jan Trávníček, CSc., Jihočeská univerzita, Zemědělská fakulta, Studentská 13, 370 05 České Budějovice, Česká republika
Tel. +420 387 772 611, fax +420 387 772 621, e-mail: travnic@zf.jcu.cz