ACTA VET. BRNO 2001, 70: 35–42

IODINE CONCENTRATION IN MILK OF SHEEP AND GOATS FROM FARMS IN SOUTH BOHEMIA

J. TRÁVNÍČEK, J. KURSA

Faculty of Agriculture, South Bohemian University in České Budějovice, České Budějovice, Czech Republic

Received August 18, 2000
Accepted February 7, 2001

Abstract

Trávníček, J., J. Kursa: *Iodine Concentration in Milk Sheep and Goats from Farms in South Bohemia*. Acta Vet. Brno 2001, 70: 35-42.

Iodine concentration was determined in milk samples collected from 60 sheep on 10 farms and from 94 goats of 64 farmers. The animals were grazed in the summer and fed hay of local harvests in the winter. Pregnant and lactating sheep received daily 0.2 to 0.4 kg of cereal meal. The iodine concentration in the hay fed to the sheep and goats ranged from 20.5 to 162.4 µg per 1 kg dry matter. The mean iodine concentration in sheep milk was 105.5 $\mu g \cdot l^{-1}$. The corresponding value for the farms (n = 4) where the sheep had access to mineral licks (35 mg iodine per 1 kg) was 243.3 ± ± 87.2 $\mu g \cdot l^{-1}$ (ranged from 107.7 to 436.6) and for the rest of the farms (n = 6) 47.9 ± 27.8 $\mu g \cdot l^{-1}$. Mean iodine concentrations in goat milk (31.6 $\mu g \cdot l^{-1}$ in 1998 and 63.0 $\mu g \cdot l^{-1}$ in 1999) were indicative of iodine deficiency. The corresponding value for the goats (n = 17) receiving iodised salt was 142.1 ± 102.6 $\mu g \cdot l^{-1}$ (ranged from 51.8 to 393.6) and for the remaining goats 19.3 ± ± 13.2 $\mu g \cdot l^{-1}$. The mean iodine concentrations in goat milk on three farms on which neonatal goitre in kids was diagnosed ranged from 8.5 to 23.3 $\mu g \cdot l^{-1}$.

Kids, lambs, goitre, iodine deficiency, iodine supplementation.

Current methods for the assessment of the iodine status include the determination of concentrations of not only urinary, but also milk iodine (Grace 1995), because it has been found that iodine excretion in the milk varies significantly in dependence on its dietary intake. Miller et al. (1974) found that, under normal conditions and an adequate iodine supply, ruminants excrete 8% of ingested iodine in the milk. Determination of milk iodine for diagnostic and epidemiological purposes is often used in studies of the prevalence of juvenile goitre regarded as the most significant manifestation of iodine deficiency (Körber et al. 1985). Groppel (1991) pointed out that, at an equal dietary intake, the ovine and caprine colostrum and milk contain more iodine than milk of cows and that iodine concentrations of 79 $\mu g \cdot l^{-1}$ and 62 $\mu g \cdot l^{-1}$ in the sheep and goat milk, respectively, are indicative of iodine deficiency.

Azuolas and Caple (1984) used milk iodine concentration as a marker of the metabolic and iodine status of sheep in Australia. Mean concentrations found within an extensive monitoring in 59 sheep flocks in the state Victoria ranged from 79 to 1 831 $\mu g \cdot l^{-1}$. Two flocks in which goitre was diagnosed in lambs showed variations in the milk iodine concentration within the range of 45 to 98 $\mu g \cdot l^{-1}$. Milk of ewes receiving 30 µg of iodine per animal per day contained 45 $\mu g \cdot l^{-1}$ and 80% of their lambs developed neonatal goitre. On the other hand, daily intake of 80 to 100 µg I resulted in milk concentrations 95 to 131 $\mu g \cdot l^{-1}$ and lambs were free from goitre (Mason 1976). Similar experience was reported by Grace (1995).

Information on spontaneous occurrence of goitre in sheep and goats come from various parts of the world (De Vijdler et al. 1978; Alexander et al. 1990; Körber et al. 1985) and this country is no exception in this respect. Apart from reports from Slovakia (Vrzgula et al. 1971; Bíreš et al. 1993, 1996a, b), the problem here is revived by findings in several regions of the Czech Republic (Kursa et al. 1992), as well as by experience of veterinarians and farmers from

Address for correspondence:
Doc. Ing. Jan Trávníček, CSc.
Jihočeská univerzita v Č. Budějovicích
Zemědělská fakulta, Studentská 13
370 05 Č. Budějovice

Phone: +420 38 7772611
Fax: +420 38 7772621
E-mail: travnic@zf.jcu.cz
http://www.vfu.cz/acta-vet/actavet.htm

the districts of Domažlice, Klatovy, and Prachatice (South-west Bohemia). It is apparent that the occurrence of juvenile goitre in sheep, goats, other farm animal species (Čada 1988), and iodine deficiency affecting the human population in the areas under this study (Zamrazil et al. 1997) is mostly due to iodine deficiency associated with soil composition and geographic location (Oliveriusová 1997) responsible for low iodine content in feeds and drinking water. Also relevant may be further factors with thyreostatic effects which can modulate the epidemiological character and the general pattern of functional disorders of the thyroid gland. In addition to nitrates and nitrites (Prasad 1983; Písaříková et al.1996), goitrogenic effects of glucosinolates present in cabbage and particularly in rape and products thereof should be considered (Barry et al. 1983; Reid et al. 1994; Cox-Ganser et al. 1994).

The objective of our investigations was to obtain a survey on the occurrence and severity of iodine deficiency in sheep and goat flocks as manifested by iodine excretion in the milk. Our investigations concentrated on the South Bohemian region known for the occurrence of juvenile goitre in farm animals.

Materials and Methods

Our analyses were done in 60 sheep milk samples collected from 10 flocks in 1998 to 1999, and 61 goat milk samples collected on 49 small farms in 1998 and 33 goat milk samples collected from 33 flocks in 1999. All the flocks and farms were located in the South Bohemian region. The milk samples were obtained from sheep and goats of various ages and at various stages of lactation. Ten ml of milk was collected into glass or polyethylene vessels and the samples were stored at -20 °C until analysed. Milk iodine content was determined by the Sandell-Kolthoff

Table 1
Mean iodine concentration in sheep milk and iodine and nitrate concentrations in hay in South-Bohemian flocks in 1998 and 1999

District	Flock No.	Breed	Iodine supple-mentation	Nitrates hay	Iodine						
					Hay	Milk					
						n	$\mu g\ I \cdot l^{-1}$				
				$mg \cdot kg^{-1}$ dry matter	$\mu g \cdot kg^{-1}$ dry matter		$\bar{x}$	s	Min.	Max.	Median
České Budějovice	1	CH	+	417.3	95.0	5	216.6	88.8	115.4	285.8	273.6
Tábor	2	CH	+	398.2		3	436.6	145.1	269.0	520.4	520.4
Jindřichův Hradec	3	FM		508.3	162.4	5	92.9	25.2	61.6	123.5	96.6
Pelhřimov	4	FM		701.4	39.4	5	16.5	5.8	10.4	25.4	16.3
Prachatice	5	BFS	+	748.9	59.4	5	271.3	7.3	263.0	282.4	269.2
	6	ML	+	390.0	22.9	5	107.7	27.8	71.8	139.0	120.6
Strakonice	7	ML		1892.8	101.7	3	36.2	14.1	20.1	46.0	42.5
	8	ML		1045.6	45.6	5	33.8	11.5	16.5	47.9	35.4
	9	OD		424.8	31.7	5	26.6	3.9	22.3	31.3	27.1
Jindřichův Hradec	10	ML		130.4	62.9	19	55.4	22.0	27.3	93.0	49.2
Mean				520.4	55.7	60	105.4		10.4	250.4	55.7

*) CH = Charolais
FM = Feeder Merino
BFS = Bohemian Forest Sheep
ML = Merino Landschaf
OD = Oxford down

method as modified by Bednář et al. (1964). Detailed information on the sheep flocks and mean milk iodine concentrations are shown in Table 1 and the corresponding data for goats in Tables 2 and 3.

The sheep flocks under study were grazed in the summer period and fed hay in the winter period. Haylage or silage was offered rather exceptionally. Concentrates (grain meal or pressed grain) at a dose of 0.2 to 0.4 kg per animal per day were fed mostly to pregnant or lactating ewes. All the feeds were of local origin. Licks containing 35 mg of iodine per 1 kg were at disposal in some of the flocks only. Goitre in newborn and adolescent animals had been observed in previous years.

The goats were grazed and fed hay of local harvests. The feed was supplemented with iodized salt in 17 flocks. White Shorthaired goats prevailed in the set of various breeds. Iodine content in hay as the basic component of rations for sheep and goats was determined by the Sandell-Kolthoff method after drying at 60 °C and expressed as mg per 1 kg dry matter. The hazard of goitrogenic factors was evident from the nitrate content in hay determined with a selective electrode.

The results were processed by Student's *t*-test using the STATplus software (Matoušková et al. 1992).

Results

Mean iodine concentration in sheep milk calculated from results of 60 samples collected from 10 flocks was 105.5 $\mu g \cdot l^{-1}$, median 55.7 $\mu g \cdot l^{-1}$ (Table 1). The highest (436.6 ± 145.1 $\mu g \cdot l^{-1}$) and the lowest (16.5 ± 5.8 $\mu g \cdot l^{-1}$) mean concentrations were found in the flocks No. 2 (district of Tábor) and 4 (district of Pelhřimov), respectively. Mean concentrations lower than 50 $\mu g \cdot l^{-1}$ were found in three flocks (No. 7, 8, 9) in the district of Strakonice. A great variability within the set is evident from the difference between the highest and the lowest individual concentration (520.4 vs. 10.4 $\mu g \cdot l^{-1}$). The iodine concentration in hay fed at the time of milk sampling ranged from 22.9 to 162.4 $\mu g \cdot kg^{-1}$ dry matter (Table 1). Concentrations lower than 100 $\mu g \cdot kg^{-1}$ were found in 77% of the samples. Mean milk iodine concentration in the four flocks in which mineral licks were at disposal was 243.3 ± 87.2 $\mu g \cdot l^{-1}$. Mean concentration for the remaining six flocks was 47.9 ± 27.8 $\mu g \cdot l^{-1}$. The difference between the two subsets was highly significant ($P < 0.01$).

Table 2
Comparison of mean iodine concentrations in goat milk in South-Bohemian flocks in 1998

District	Number of tested flocks	Number of tested milk samples	Milk iodine concentration ($\mu g \cdot l^{-1}$)			
			$\bar{x}$	Median	Min.	Max.
České Budějovice	11	16	20.9	15.9	9.5	63.5
Strakonice	6	10	23.6	11.3	10.0	96.4
Jindřichův Hradec	6	6	94.3	22.1	11.9	393.6
Český Krumlov	5	5	15.7	17.7	9.5	20.6
Prachatice	6	8	20.8	16.6	8.5	49.1
Tábor	2	2	52.9	52.9	13.1	92.5
Pelhřimov	3	3	32.6	35.7	26.0	36.1
Písek	10	11	31.3	20.4	10.0	75.5
Mean	49	61	31.6	18.6	8.5	393.6

Table 3
Comparison of mean iodine concentrations in goat milk in South-Bohemian flocks in 1998

District	Number of tested flocks	Number of tested milk samples	Milk iodine concentration ($\mu g \cdot l^{-1}$)			
			$\bar{x}$	Median	Min.	Max.
České Budějovice	14	14	60.9	17.1	4.3	244.8
Strakonice	7	7	103.0	16.5	9.6	347.1
Jindřichův Hradec	4	4	20.7	19.2	10.5	33.6
Český Krumlov	6	6	64.6	39.0	16.5	148.9
Prachatice	1	1	13.9	–	–	–
Tábor	1	1	18.9	–	–	–
Mean	33	33	63.0	18.9	4.3	347.1

Iodine content in goat milk ranged from 8.5 to 393.4 μg · l^{-1} in 1998 and from 4.3 to 347.1 μg · l^{-1} in 1999 (Tables 2 and 3). Mean iodine content increased from 31.3 μg · l^{-1} in 1998 to 63.0 μg · l^{-1} in 1999 (Tables 2 and 3) without any significant change in median values (18.2 vs. 18.9 μg · l^{-1}). The iodine content was higher than 50 μg · l^{-1} in only 12.2% of the samples in 1998 and in 33.3% of the samples in 1999. Irregular supplementation of the ration with iodized salt, practised by 17 farmers (20.7 %), resulted in an increase in mean milk iodine concentration to 142.4 ± 102.6 μg · l^{-1} whereas the mean for the remaining farms (79.3%) was 19.3 ± 13.2 μg · l^{-1} (Table 4).

Table 4
Effect of supplementation on iodine concentration in goat milk in South-Bohemian flocks in 1998–1999

District	Number of tested flocks	Number of tested milk samples	Milk iodine concentration (μg · l^{-1})				
			$\bar{x}$	s	Median	Min.	Max.
No supplementation	65	77	19,3	13,2	4,3	76,2	16,5
Iodine supplementation	17	17	142,1	102,6	51,8	393,6	96,4

Iodine content in samples of hay fed to goats on small farms (n = 17) was 69.1 ± ± 21.1 μg · kg^{-1} dry matter, from 20.5 to 119 μg · kg^{-1} (values not shown). The correlation between iodine concentrations in hay and milk (r = 0.39) was non-significant, however. In 1998, iodine content was significantly lower in goat milk than in sheep milk ($P < 0.01$) (Tables 1 and 2).

Iodine deficiency demonstrated by our analyses was manifested by the development of clinical neonatal goitre (Plate V, Fig. 1) diagnosed in kids on three farms in the districts of Prachatice and Strakonice. The milk iodine content on the affected farms ranged from 8.5 to 26.6 μg · l^{-1}. In the past, neonatal goitre was observed in sheep flocks No. 1 (district of České Budějovice) and 6 (district of Prachatice), Considering this experience, iodine-containing mineral licks were given at disposal to ewes in the two flocks. The milk iodine concentration rose subsequently to 216.6 ± 88.8 in flock No. 1 and to 107.7 ± 27.8 μg · l^{-1} in the herd No. 6 and neonatal goitre was not observed any more.

Discussion

Data obtained in several surveys done in dairy cow flocks (Philips 1977; Bobek 1998; Pennington 1990) as well as results tests of iodine utilisation in various supplementation methods encouraged us to the assessment of the current state in sheep and goats. The results of our investigations done in the South Bohemian region are indicative of considerable among-flock differences both in sheep and goats and that most of them, in particular goat flocks, suffered from iodine deficiency. Mean iodine concentration in sheep milk in five districts under study was 70 μg · l^{-1}, which, according to Mason (1976), is the limit for iodine deficiency.

The prevalence of low iodine concentrations in goat milk was even more marked and indicated an evident deficiency. We assume that this marked iodine deficiency results from local conditions in Southwest Bohemia, a region which had been known for frequent occurrence of human goitre and cretenism before salt iodinisation was started (Hníková 1995; Stárka 1995).

Considering these facts, we can state that our findings of low iodine content in sheep and goat milk closely approach results of analyses of bovine milk done in the same or adjacent areas within recent investigations of spontaneous hypothyroidism in calves (Kroupová and Brožová 1986; Kursa et al. 1997).

Insufficient iodine intake results from nutritional practices. Animals of small farmers, who do not practice iodine supplementation, are fully dependent on the natural local iodine sources. Hence, the results obtained in animals fed roughage of local harvests can be regarded as another valuable information on the iodine status in the given area. Up to a point, they correspond to data published by Kursa et al. (1997) who, in the same area, found that roughage met only 9.8% and 13.9% of the requirement for iodine in lactating and dry cows, respectively. The results of milk analyses are also supported by the finding of low iodine concentrations in sample of hay fed to goats.

Apart from one sample (farm No. 3, district of Jindřichův Hradec; 162.4 μg I per kg dry matter, Table 1), roughage fed to sheep did not differ in iodine content from those fed to goats. The content found on the farm No. 3 approaches the requirement of growing animals as set by Groppel (1987), but does not meet the requirement of adult lactating animals (200 to 300 μg per 1 kg dry matter). The optimal iodine concentration in sow's milk that meets the requirement of sucking piglets is 100 $\mu g \cdot l^{-1}$. To reach it, Schöne et al. (1997a) recommended to supplement conventional daily rations for lactating sows (grain and soy meals) with 460 μg of iodine per 1 kg. This recommendation, derived from results of exact experiments and field studies in large breeding operations, is consistent with British data (400 $\mu g \cdot kg^{-1}$, Schöne et al. 1997b) and approaches the German recommendation (500 to 600 $\mu g \cdot kg^{-1}$, Schöne et al. 1997a).

The requirement for iodine given above is higher if feeds contain thyreostatic agents (Schöne et al. 1997b; Cox-Gancer et al. 1994). In the conditions of our investigations, this applied to sporadic presence of goitrogenic feed components (cabbage, kale) and a solitary finding of higher nitrate content in hay. The effect of nitrates on the iodine status was apparent in the herd No. 7 (district of Strakonice) fed hay with a relatively high iodine content and showing a lower-than-standard milk iodine concentration. Experience gained in South Bohemian dairy cattle flocks indicate possible goitrogenic effects of a high nitrate content in drinking water (Písaříková et al. 1996). Goitre was induced in lambs experimentally in an earlier study (Kursa et al. 2000) as a result of combined thyreostatic action of nitrates and glucosinolates present in extracted rapeseed meal. The thyreostatic effect, which was also apparent from a significant decrease in iodine concentration in the colostrum and milk of ewes could be blocked by supplementation of iodine and selenium which increased iodine excretion in the colostrum and milk.

The results of our investigations indicate that farmers in the area under study cannot rely on locally produced feeds, which make up the bulk of rations for sheep and goats, as the only source of iodine. Insufficient iodine intake by the dam, leading to depletion of iodine reserves in the thyroid gland, affects the development of fetuses which react by compensatory thyroid hyperplasia, as well as the transport of iodine from the thyroid gland and possibly other stores in the maternal organism to the secretory parenchyma of the mammary gland. Inadequate iodine supply results in births of kids and lambs affected by neonatal goitre and in low iodine content in the milk affecting its wholesomeness for human consumption and nutrition of sucking animals. In this context, the general lack of knowledge on the effects of iodine deficiency on the health of goats and vitality of kids cannot be disregarded. Lack of information is surprising particularly in farmers who have already experienced neonatal goitre in kids which was lethal in some cases. Knowledge is somewhat better in owners of larger sheep flocks who are informed of the role of iodine and include iodine-containing mineral products into rations for pregnant and lactating dams.

Low milk iodine content demonstrated in our investigations was manifested by neonatal goitre diagnosed by veterinary practitioners in kids on three farms (districts of Strakonice and Prachatice). Iodine content in milk samples collected on the affected farms ranged between 8.5 and 23.3 $\mu g \cdot l^{-1}$. In previous years, neonatal goitre had also been recorded in lambs of the sheep flocks Nos. 1 (district of České Budějovice) and 6 (district of Prachatice).

In view of this experience, the farmers exposed iodine-containing mineral licks. This measure increased milk iodine concentrations to 216.6 ± 88.8 μg · l^{-1} (herd No. 1) and 107.7 ± 27.9 μg · l^{-1} (flock No. 6) and eliminated health problems in newborn lambs.

The high mean iodine concentration in sheep milk in the flocks Nos. 2 and 5 (Table l) and the highest individual contents in goat milk (436.6 vs. 393.6 μg · l^{-1}, Tables 2 and 3) are already results of superfluous iodine intake in form of mineral licks or iodides salt.

The successful prophylaxis of primary and secondary iodine deficiency in small ruminants in the districts of South Bohemian requires systematic bat with respect to nutrition conditions different iodine suplementation.

Koncentrace jódu v mléce ovcí a koz v jihočeských chovech

Cílem práce bylo určit stupeň krytí potřeby jódu ovcí a koz v oblasti jižných Čech na základě vylučování jódu mlékem.

Koncentrace jódu byla stanovena v mléce 60 ovcí z deseti lokalit 7 jihočeských okresů a 94 koz 64 různých majitelů z 8 jihočeských okresů. Výživa ovcí a koz zahrnovala v létě pastvu, v zimním období seno místního původu. Gravidní a kojící bahnice přijímaly denně 0,2 - 0,4 kg obilních šrotů. Ve 4 chovech měly ovce k dispozici minerální liz s obsahem jódu 35 mg · kg^{-1}. Obsah jódu v seně zkrmovaném ovcím a kozám se pohyboval v rozmezí 20,5 - 162,4 μg · kg^{-1} sušiny. 77 % vzorků vykázalo hodnoty nižší než 100 μg · kg^{-1}. V 17 chovech koz byl zvýšený příjem jódu zajištěn kuchyňskou solí.

Průměrný obsah jódu v mléce ovcí dosáhl 105,5 μg · l^{-1}. Ve 4 chovech, ve kterých byla prováděna suplementace jódem ve formě minerálních lizů byla průměrná hodnota 243,3 ± ± 87,2 μg · l^{-1} jódu v mléce ovcí, v rozmezí od 107,7 do 436,6 μg · l^{-1}. V ostatních chovech bez suplementace (n = 6) obsahovalo mléko 47,9 ± 27,8 μg · l^{-1}. Rozdíly mezi průměry jsou vysoce statisticky průkazné ($P < 0{,}01$).

Průměrný obsah jódu v mléce koz 31,6 (rok 1998) a 63,0 μg · l^{-1} (rok 1999) poukazuje na deficitní příjem jódu. Podávání jódované jedlé soli zvyšovalo příjem jódu u koz a bylo provázeno průměrnou hodnotou 142,1 ± 102,6 μg · l^{-1} v mléce, v rozmezí od 51,8 do 393,6 μg · l^{-1}. Mléko koz bez této formy suplementace obsahovalo 19,3 ± 13,2 μg · l^{-1} jódu. Rozdíly průměrů jsou statisticky významné ($P < 0{,}01$).

Ve třech lokalitách s výskytem neonatální strumy u kůzlat se obsah jódu v mléce koz pohyboval v rozmezí od 8,5 do 23,3 μg · l^{-1}.

Výsledky informují o nízkém obsahu jódu v prostředí jihočeských okresů, kladou důraz na systematické obohacování krmných dávek ovcí a koz jódem a indikují další výzkum.

Acknowledgements

Supported by Grant Agency of the Czech Republic (Project No. 524/97/0654) and Ministry of Agricultureof the Czech Republic (Project NAZV No. EP9269/99), and by Ministry of Education of the Czech Republic (Project CEZ No. J 06/122200002/7).

The authors express their thanks for excellent and competent assistance to Ing. G. Rovenská, Ms. D. Randáková and Ing. R. Thér.

References

ALEXANDER, G., STEVENS, D., BRADLEY, L. R. 1990: Intensive observation during lambing goitre-affected flock, with special reference to behaviour of lambs. Aust. J. of Exp. Agric. (Anim.husb.) **30**: 749-757

AZUOLAS, J. K., CAPLE, I. W. 1984: The iodine status of grazing sheep as monitored by concentration of iodine in milk. Aust. Vet. J. **61**: 223-227

BARRY, T. N., DUNCAN, W. A., SADLER, K. R., TILLAR, A. D. 1983: Iodine metabolism and thyroid hormone relationships in growing sheep fed on kale (*Brassica oleracea*) and ryegrass (*Lolium perenne*) – Clover (*Trifolium repens*) fresh forage diets. Brit. J. Nutr. **49**: 241-253

BEDNÁŘ, J., RÖHLING, S., VOHNOUT, S. 1964: Příspěvek k stanovení proteinového jódu v séru. Československ. Farm. **13**: 203-209

BÍREŠ, J., BARTKO, P., PAUER, T. 1993: Jodopénia u plemenných baranov – klinika, patologicko-anatomický nález a laboratórny nález (Iodopoenia in breeding rams – clinics, pathological and anatomical findings). Veterinářství **43**: 6-8

BÍREŠ, J., BARTKO, T., WEISSOVÁ, T., MICHNA, A., MATIŠÁK, T. 1996a: Goat iodopenia as a cause of congenital struma in kids. Vet. Med.– Czech **41**:133-138

BÍREŠ, J., BARTKO, T., WEISSOVÁ, T., MATIŠÁK, T., MICHNA, A., BÍREŠOVÁ, M. 1996b: Clinical and metabolic response of goats suffering from iodopenia to potassium iodine application. Vet. Med.– Czech **41**: 177-182

BOBEK, S. 1998: Profilaktyka jodowa u zwierzat. Medycyna Wet. 54: 80-86

COX-GANSER, J. M., JUNG, G. A., PUSHKIN, R. T., REID, R. L. 1994: Evaluation of Brassicas in grazing systems for sheep: II. Blood composition and Nutrient status. J. Anim. Sci. **72**: 1832-1841

ČADA, F. 1988: Patomorfologické sledování štítné žlázy telat v raném postnatálním období v nasávací oblasti SVÚ Plzeň (Pathomorphological investigation of thyroid gland of calves in early postnatal period in inlet region of SVI Plzeň). Vet. Med. (Praha) **33**: 69-80

DE VIJDLER, J. J. M., VAN VOORTHUIZEN, W. F., VAN DIJK, J. E., RIJNBERK, A., TEGELAERS, W. H. H. 1978: Hereditary congenital goitre with thyroglobulin deficiency in a breed of goats. Endocrinology **102**:1214-1222

GRACE, N. D. 1995: Use of biochemical criteria to diagnose trace element deficiencies in sheep and cattle. Proceedings (IXth International Conference on Production diseases in farm animals 1995, September 11-14), Free University of Berlin, pp. 40-42.

GROPPEL B., ANKE M., JAHREIS G., KÖHLER B., SCHOLTZ E. (1987): Jodversorgung und Jodstatus des Wiederkäuers 7. Mitteilung: Einfluss des Wiederkäuers 7. Mitteilung: Einflur B., Scholtz E. (1987): Jodversorgung bei Lämmern und Kälbern. In: Anke M. et al. : Mengen- und Spurenelemente. Leipzig, 381 – 390

GROPPEL, B. 1991: Jodmangel beim Tier. In: Anke M., Gürtler M.: Mineralstoffe und Spurenelemente in der Ernährung. Gersdorf, Verlag Media Touristik, 127 - 156

HERZIG, I., PÍSAŘÍKOVÁ, B., KURSA, J., ŘÍHA, J. 1999: Defined iodine intake and changes of its concentration in urine and milk of dairy cows. (Definovaný příjem jódu a změny jeho koncentrace v moči a mléce dojnic). Vet. Med.– Czech. **44**: 35 - 40

HNÍKOVÁ, O. 1995: Iodine deficiency in children and adolescents. (Jodový deficit u dětí a dospívajících). Vesmír 74: 196-197

KAUFMANN, S., KURSA, J., KROUPOVÁ, V., RAMBECK, W. A. 1998: Iodine in milk by supplementing feed: An additional strategy to erase iodine deficiency Vet. Med.-Czech. **6**: 173-179

KÖRBER, R., ROSSOW, N., OTTA, J. 1985: Beitrag zum Jodmangelsyndrom der landwirtschaftlichen Nutztiere Rind, Schaf und Schwein. Mh. Vet.-Med. **40**: 220-224

KROUPOVÁ, V., BROŽOVÁ, V. 1986: Jód v mléce dojnic v jihozápadních Čechách (Iodine in milk of dairy cows in South-western Bohemia). Sborník VŠZ AF Č. Budějovice, Řada zootechn. **3**: 57-67

KURSA, J., HERZIG, I., KROUPOVÁ, V., KRATOCHVÍL, P., TRÁVNÍČEK, J. 1997: Consequences of iodine deficiency in cattle in some regions of the Czech Republic. Sci. Agric. Bohem. **28**: 105-117

KURSA, J., KROUPOVÁ, V., KRATOCHVÍL, P. 1992: Nutritional factors in iodine deficiency diseases in cattle. In: Proc. Eighth International Conference on Production Diseases in Farm Animals, University of Bern, Switzerland, August 25-27, 23

KURSA, J., TRÁVNÍČEK, J., RAMBECK, W. A., KROUPOVÁ, V., VÍTOVEC, J. 2000: Goitrogenic effects of extracted rapeseed meal and nitrates in sheep and their progeny. Vet. Med.- Czech **45**: 129-140

MASON, R. W. 1976: Milk iodine content as an estimate of the dietary iodine status od sheep. Brit. Vet. J. **132**: 374-379

MATOUŠKOVÁ, O., CHALUPA, J., CÍGLER, M., HRUŠKA, K. 1992: Statistický systém STAT plus, verze 1,01, uživatelská příručka, Výzkumný ústav veterinárního lékařství, Brno, 1992, 168 p.

MILLER, J. K., SWANSON, E. W., SPADLING, G. E. 1974: Iodine absorption, excretion, recycling, and tissue distribution in the dairy cow. J. Dairy Sci. **58**: 1578-1593

OLIVERIUSOVÁ, L. 1997: Obsah jodu v prostředí v ČR. Sborník: Jak řešit nedostatek jodu v naší výživě. Státní zdravotní ústav Praha, 8 p.

PENINNGTON, J. A. T. 1990: Iodine concentrations in US milk: variation due to time, season, and region. J. Dairy Sci. 73: 3421-3427

PHILLIPS, D. I. W. 1997: Iodine, milk, and the elimination of endemic goitre in Britain: the story of an accidental public health triumph. J. Epidemiol. Community Health **51**: 391-393

PÍSAŘÍKOVÁ, B., HERZIG, I., ŘÍHA J. 1996: Inorganic anions with potential strumigenic effects in potable water for humans and animals. (Anorganické anionty s možným strumigenním vlivem v pitných a napájecích vodách).Vet. Med.- Czech **41**: 33-39

PRASAD, J. 1986: Effect of high nitrate diet on thyroid glands in goats. Indian Vet. J. **53**: 791-794

REID, R. L., PUOLI, J. R., JUNG, G. A., COX-GANSER, J. M., MCCOY, A. 1994: Evaluation of Brassicas in grazing systems for sheep: I. Quality of forage and animal performance. J. Anim. Sci. **72**: 1832-1841

SCHÖNE, F., LEITERER, M., FRANKE, K., KINAST, C., LÖSER, P., LAMPE, V., NESTLER, E. 1997a: Zum Jod- und Schilddrüsenhormonstatus von Mutterschweinen und ihren Nachkommen. Dtsch. Tierärztl. Wschr. **104**: 490-492

SCHÖNE, F., RUDOLPH, B., KIRCHHEIM, U., KNAPP, G. 1997b: Counteracting the negative effects of rapeseed and rapeseed press cake in pig diets. Brit. J. Nutr. **78**: 947-962

STÁRKA, L. 1995: Cretenism in Bohemia 102 years ago. (Kreténismus v Čechách před 102 lety) Vesmír: **74**, 197

SWANSON, E. W., MILLER, J. K., MUELLER, F. J., PATTON, C. S., BACON, J. A., RAMSEY, N. 1990: Iodine in milk and meat of dairy cows fed different amounts of potassium iodide or ethylenediamine dihydroiodide. J. Dairy Sci. **73**: 398-405

VRZGULA, L., BARTKO, P., MAJSTRIK, M., PÍCHOVÁ, D., MIKULŠIČÁK, R., CHYLA, M., LEHOTSKÝ, J., KONRÁD, V., SOKOL, J. 1971: Hromadný výskyt strumy u plemenných baranov (Mass occurrence of goitre in breeding rams). Veterinářství, **21,** 152-156

ZAMRAZIL, V., ČEŘOVSKÁ, J., ŠIMEČKOVÁ, A., BÍLEK, R., DVOŘÁKOVÁ, M., KANTOROVÁ, I., KVÍČALA, J. 1997: Iodine supply and thyroid in district in South Bohemia. Trace elements, 21-24.