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Selenium Status of Cattle in the Czech Republic

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Abstract

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Selenium status was assessed directly by determination of selenium concentration, or indirectly by measurement of glutathione peroxidase activity in whole blood samples collected from 879 cattle (733 cows, 63 calves, 42 heifers, 41 finishing bulls) reared on 93 farms in 12 of the 14 regions of the Czech Republic. Selenium deficiency or marginal values were found in 50 % of the tested animals and on 54 % of the farms. In terms of animal categories, deficient or marginal selenium status was found in 42 % of cows, 80 % of calves, 100 % of heifers, and 90 % of bulls. Selenium-deficient herds were detected in almost all regions of the Czech Republic. The lowest selenium concentrations (< 20 $\mu g \cdot l^{-1}$ whole blood) were found in western, northern, and north-eastern Bohemia and in northern Moravia. It is evident that selenium deficiency in cattle is a topical problem in the Czech Republic and that selenium status must be monitored within preventive diagnostics in all age groups of cattle to decide correctly on the most effective way of supplementation.

Glutathione peroxidase, preventive diagnostics, blood, dairy cows, heifers

Like with most minerals, satisfactory intake of selenium by ruminants depends on the presence of this element in soil and on the potential of plants to utilise it. The occurrence of selenium in soil varies considerably worldwide. Oldfield (2000) denoted as selenium deficient the west coastal and eastern areas of the United States and Canada, extensive areas in China and Australia, New Zealand, the Scandinavian countries (Finland, Sweden, Norway, Denmark), southern France, the Balkans, and northern England and Scotland.

The two principal methods for the assessment of selenium status include direct determination of its concentration in whole blood, blood plasma, or blood serum, and measurement of glutathione peroxidase (GSH-Px) activity in whole blood. Close correlation between the activity of GSH-Px and the selenium status has been demonstrated repeatedly (Erskine et al. 1987; Harapin et al. 2000; Pavlata et al. 2000a). Whole blood is used for the measurement, because up to 98% of the activity is bound to erythrocytes (Scholtz and Hutchinson 1979). Further methods used for the assessment of selenium status include determination of selenium concentrations in selected tissues, such as the liver, or muscles (Stowe and Herdt 1992; Venalainen et al. 1997; Pavlata et al. 2001a; Pavlata et al. 2001b), and in the hair (Kursa and Kroupová 1975), milk, or urine.

Although the first reports on the occurrence of diseases of young cattle associated with selenium deficiency were published here in the late sixties already (Kursa 1969; Kursa and Tesařík 1971), only few data on selenium status in animals living in the Czech Republic is available. Growing interest in this topic observed in the recent years has been encouraged, among other factors, by the development of advanced analytical methods. The activity of GSH-Px as a variable reflecting the selenium status in cattle was studied by Kursa et al. (1982) and Pavlata et al. (1998, 2000a). Koutník et al. (1996) assessed the

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selenium status in dairy cows in the South Moravian region by examination of milk samples. Other authors preferred the determination of selenium concentration in the blood or tissues (Pavlata et al. 1999; 2000a; 2000b; 2001b). The results of all these studies indicate that the current selenium status in cattle is unsatisfactory and that more data on the distribution of selenium deficiency in various regions of the Czech Republic is necessary.

Materials and Methods

Blood samples for this study were collected from 879 cattle in 1999 through 2001. The set of the animals consisted of 733 dairy cows, 63 calves, 42 heifers, and 41 finishing bulls. The sampling scheme covered 93 herds (67 cow houses, 9 calf houses, 8 heifer rearing facilities and 9 bull fattening facilities) located in 12 of the 14 regions and 34 of the 77 districts of the Czech Republic. The cows were examined within metabolic profile tests. The calf herds were identical with those in which investigations into causes of a high morbidity and mortality were running. The same applied to three heifer rearing facilities. The remaining heifers and bulls originated from randomly selected farms and were examined specifically for the assessment of the selenium status.

The selenium status was assessed by direct selenium determination in 494 animals and by measurement of catalytic GSH-Px activity in 385 animals. Blood samples were collected by puncture of *v. jugularis* into heparin-containing test tubes. The selenium concentration was determined in whole blood samples mineralised in the microwave oven MILESTONE MLS 1200 by the hydride AAS technique using the apparatus SOLAR 939 (UNICAM). The activity of GSH-Px was measured in whole blood by the UV-method of Paglia and Valentine (1967) in the COBAS MIRA apparatus using the set supplied by Randox.

The following blood selenium concentrations or GSH-Px activities were used as reference values (Pavlata et al. 2000a) for the assessment of the selenium status:

– $< 70\ \mu g \cdot l^{-1}$, or $< 472\ \mu kat \cdot l^{-1}$ – deficient
– 70 to 100 $\mu g \cdot l^{-1}$, or 472 to 665 $\mu kat \cdot l^{-1}$ – marginal
– $> l00\ \mu g \cdot l^{-1}$, or $> 665\ \mu kat \cdot l^{-1}$ – adequate.

Basic statistical characteristics for the set of the results were calculated using the Microsoft EXCEL 7.0 software.

Results and Discussion

Mean selenium concentration in whole blood samples collected from the 494 animals was $89.57 \pm 52.51\ \mu g \cdot l^{-1}$ (range $4.06 – 212.4\ \mu g \cdot l^{-1}$). Mean GSH-Px activity in whole blood samples collected from the 385 animals was $676.85 \pm 285.06\ \mu kat \cdot l^{-1}$ (range $22.48 – 1557\ \mu kat \cdot l^{-1}$). The results arranged by age categories and data on the assessment of the selenium status in the individual herds are shown in Tables 1 to 3.

Table 1
Blood selenium concentrations ($\mu g \cdot l^{-1}$) or activities of GSH-Px ($\mu kat \cdot l^{-1}$) in tested animals (x - mean; S.D. - standard deviation; n - number of animals; v_x - variation coefficient)

	Cows		Calves		Heifers		Bulls	
	Se	GSH-Px	Se	GSH-Px	Se	GSH-Px	Se	GSH-Px
x	94.89	729.61	43.32	490.64	44.92	244.78	38.18	40.36
S. D.	50.40	246.92	23.53	314.99	22.51	182.01	38.32	16.69
v_x (%)	53.11	33.84	54.32	64.20	50.11	74.36	100.37	41.35
min.	4.06	22.48	13.16	134.52	18.35	63.60	5.15	28.55
max.	212.40	1557.00	90.03	1110.00	89.66	585.48	145.90	52.15
n	412	321	24	39	19	23	39	2

The results show considerable among-herd and only small within-herd differences. Adequate selenium status was found in only 46 % of the 93 tested herds. Selenium deficiency was observed more frequently in young animals. The selenium status was satisfactory in only one of the nine tested bull finishing facilities and in none of the eight heifer herds. These

Table 2
Assessment of selenium status in animal categories on the basis of results obtained in individual animals
(n - number of animals)

Se status	Cows		Calves		Heifers		Bulls		Total	
	n	%	n	%	n	%	n	%	n	%
Deficient	188	26	47	75	35	83	33	80	303	34
Marginal	124	17	3	5	7	17	4	10	138	16
Adequate	421	57	13	20	0	0	4	10	438	50
Total	733		63		42		41		879	

Table 3
Assessment of selenium status in animal categories on the basis of means obtained in individual herds
(n - number of herds)

Se status	Cows		Calves		Heifers		Bulls		Total	
	n	%	n	%	n	%	n	%	n	%
Deficient	16	24	6	67	7	88	7	78	36	39
Marginal	11	16	1	11	1	12	1	11	14	15
Adequate	40	60	2	222	0	0	1	11	43	46
Total	67		9		8		9		93	

findings were probably due to a lower mineral intake by young animals than by dairy cows in which selenium is a usual component of mineral supplements included into concentrates. Moreover, dairy cows receive larger amounts of concentrates with a higher natural content of readily utilizable organic selenium. The results obtained in younger animals, particularly heifers, are warning. Selenium deficiency can result in debilitation of natural resistance, increased morbidity, and infertility and thus affect the performance and herd economy.

Although the selenium status was somewhat better in dairy cows the danger of deficiency should not be neglected. Very low concentrations (around 10 $\mu g \cdot l^{-1}$), found in some herds, can result in clinically apparent muscular dystrophy and eventually in the downer cow syndrome and even sudden death (Pavlata et al. 2001c; Illek et al. 2000).

Selenium is known to pass the placental and mammary gland barriers readily (Shamberger 1983; Enjalbert et al. 1999). Therefore, the selenium status of calves depends largely on the status of dams. All the calves tested within this study were born in herds with above-average morbidity (nonspecific diarrhoea, respiratory diseases, locomotor and growth disorders) and mortality rates. The assessment of the selenium status in this age group was done within the investigations into causes of such heath disorders. The results of this study indicated that selenium deficiency affected approximately 80% of calves. Considering the good passage of selenium through the placenta and its excretion in milk, we can conclude that the occurrence of selenium deficiency in calves approximately parallels the situation observed in cows, or is more serious, because it will be found frequently in calves born by first-calvers affected by the deficiency more often. The higher percentage of selenium-deficient calves can also result from changing mineral intake by the dam in the course of the reproductive cycle. Late-pregnant cows were found to suffer from selenium deficiency more frequently than lactating cows (Illek et al. 1999).

Our finding of a generally high occurrence of selenium deficiency in cattle in the Czech Republic is consistent with the data on the selenium status of the human population which indicate that the Czech Republic ranks with countries with a very low selenium intake and blood selenium concentrations below the European mean (Korunová et al. 1993; Kvíčala et al. 1994; Kvíčala et al. 1995a; Kvíčala et al. 1995b; Kučera et al. 1995; Kvíčala et al. 1999).

Table 4
Assessment of selenium status of cattle in various districts and regions of the Czech Republic
(^{a} - selenium deficiency; ^{b} - selenium concentration in the marginal zone; ^{x} - satisfactory selenium status; C - cows; B - bulls; H - heifers; c - calves).

Region	District	Number of tested herds	
		total	in terms of animal categories
Plzeňský	Tachov	1	B^a
	Klatovy	3	$1B^a$; $1H^a$; $1C^a$
Ústecký	Litoměřice	9	$4C^a$;$3c^a$; $1H^a$;$1B^a$
	Louny	1	C^a
Liberecký	Semily	3	$2C^a$;$1c^a$
Středočeský	Mělník	1	C^x
Královehradecký	Hradec Králové	1	C^b
	Jičín	1	H^a
	Náchod	1	C^a
	Rychnov nad Kněžnou	2	$1C^b$; $1H^a$
Pardubický	Ústí nad Orlicí	3	$2C^a$; $1C^b$
	Svitavy	4	$2C^x$; $1C^a$; $1c^a$
	Pardubice	1	C^x
Jihočeský	Jindřichův Hradec	1	C^x
Vysočina	Jihlava	3	$1C^x$; $1C^b$; $1B^a$
	Třebíč	5	$1C^x$; $1C^b$; $2c^x$; $1H^b$
	Havlíčkův Brod	5	$1C^a$;$1C^b$; $1C^x$; $1c^b$;$1H^a$
Jihomoravský	Brno venkov	7	$4C^x$; $1C^b$; $1H^a$; $1B^x$
	Brno	5	C^x
	Blansko	3	$2C^x$; $1C^b$
	Znojmo	4	C^x
	Hodonín	1	C^x
	Břeclav	3	$2C^x$;$1C^b$
	Vyškov	3	$2C^x$; $1H^a$
Zlínský	Uherské Hradiště	3	$2C^x$; $1C^b$
	Vsetín	1	C^x
Olomoucký	Šumperk	1	C^a
	Olomouc	1	C^x
	Přerov	2	C^x
	Prostějov	2	$1C^x$; $1C^b$
Moravskoslezský	Frýdek – Místek	6	$1C^x$; $1C^a$; $1c^a$; $3B^a$
	Karviná	1	B^b
	Nový Jičín	3	C^x
	Opava	2	$1C^x$; $1C^a$

The data obtained within the surveys carried out in the human population emphasize the necessity of monitoring of selenium status in cattle herds as a basis for decisions on effective supplementation. Such supplementation is important not only for health and performance promotion in the animals, but also as a means for increasing the selenium intake in the human population via milk and beef.

Table 4, presenting the geographic distribution of selenium deficiency in the Czech Republic, shows that it was diagnosed in most of the tested regions. High occurrences were found in western, northern, and north-eastern Bohemia and in northern Moravia. The lowest blood selenium concentrations were found in finishing bulls in the districts of Tachov (5.15 $\mu g \cdot l^{-1}$) and Frýdek-Místek (12.6 $\mu g \cdot l^{-1}$), in cows and calves in the districts of Semily and Litoměřice (20 $\mu g \cdot l^{-1}$), and in heifers in the district of Jičín (around 20 $\mu g \cdot l^{-1}$).

It can be concluded from our results that the selenium status of cattle depends largely on the supplementation of rations and that natural intake of selenium in cattle via feed stuffs is insufficient, because most of the regions of the Czech Republic are selenium-deficient. Therefore, monitoring of selenium status should become a part of preventive diagnostics to provide data necessary for decisions on supplementation when necessary. The same care must be provided to range-kept beef cattle, which are fully dependent of selenium content in forages an in which the development of selenium deficiency is highly probable.

Vyhodnocení stavu zásobení selenem u skotu v České republice

V rámci zjišťování stavu zásobení skotu v České republice selenem bylo provedeno vyhodnocení výsledků jeho stanovení u 879 kusů skotu (733 krav, 63 telat, 42 jalovic, 41 vykrmovaných býků) z 93 chovů různých oblastí celé České republiky. Stav zásobení selenem byl hodnocen na základě přímého stanovení koncentrace selenu v plné krvi nebo nepřímým stanovením prostřednictvím měření aktivity glutathionperoxidázy (GSH-Px) v plné krvi. Jako deficitně nebo marginálně zásobených selenem bylo vyhodnoceno celkem 50 % vyšetřených zvířat, resp. 54 % chovů. Při vyhodnocování stavu zásobení selenem u jednotlivých kategorií skotu byl deficitní nebo marginální stav selenu zjištěn u 43 % vyšetřených krav, 80 % vyšetřených telat, 100 % vyšetřených jalovic a 90 % vyšetřených býků. Chovy s nedostatečným zásobením selenem byly zjištěny téměř ve všech oblastech republiky. Nejnižší hodnoty (pod 20 µg·l-1 plné krve) byly zjišťovány v chovech z oblasti západních, severních a severovýchodních Čech a na severní Moravě. Lze tedy konstatovat, že problematika karence selenu u skotu je v České republice aktuálním problémem a že posuzování stavu zásobení selenem je nutno věnovat pozornost již v rámci preventivní diagnostiky u všech chovaných kategorií skotu, aby bylo možné určit správný způsob jeho případné suplementace.

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