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Selenium status of beef cattle in the Czech Republic

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Abstract

The aim of the study was to determine the prevalence of selenium (Se) deficiency in Angus Aberdeen (AA) cows and calves during the grazing season on several farms in different geographical locations of the Czech Republic. Selenium deficiency was diagnosed by measuring Se concentrations in whole blood. A total of 78 cows and 78 calves aged 3 to 6 months were examined in eight herds. The reference range of blood Se in cows and calves is 80 to 120 ug/l. Lower values are indicative of deficiency. Overall, Se deficiency was observed in 39.75% cows and 80.76% calves. Suboptimal Se status was mainly a consequence of low Se concentration in pasture vegetation. The Se concentration in plants ranged from 0.032 to 0.086 mg/kg on dry matter basis. Selenium deficiency adversely affected fertility and natality in cattle. In the herd with the highest prevalence of Se deficiency (Herd 2), the number of calves reared till 6 months of age per 100 cows (natality) was as low as 80. The findings show that the grazing cattle suffered from major Se deficiency. The results of the study highlight the importance of implementing early diagnosis, effective prevention, and use of appropriate mineral supplements.

Selenium (Se) is an essential trace element that performs various functions in the body. Its biological effect is mediated by a number of substances, mainly enzymes and selenoproteins such as glutathione peroxidase, thioreductase, deiodinase, selenomethionine, selenocysteine, and others. Through these substances, Se influences the entire metabolism (Zarczynska et al. 2013; Suttle 2021). The essential function of Se lies in its antioxidant activity. Together with other antioxidants such as vitamins C and A, beta carotene and glutathione, it neutralizes reactive oxygen species or significantly reduces their activity, thus protecting cell membranes, mitochondria, nucleic acids and whole cells (Žust et al. 1996).

Selenium plays an important role in thyroid metabolism, allowing the conversion of T4 into active T3 (Rowentree et al. 2004). Selenium compounds also perform important functions in immunity (Swecker et al. 1989). Selenium supports macrophage activity and differentiation and lymphocyte proliferation (Salles et al. 2014). It also has a favourable effect on immunoglobulin production and colostrum quality (Salman et al. 2013; Illek et al. 2019).

Selenium plays an important role in the metabolism of smooth and skeletal muscle. Food-producing animals quite often suffer from nutritional myodystrophy as a consequence of prolonged severe Se deficiency. The clinical form of the disease occurs in calves, lambs, kids, young cattle, and poultry (Pavlata et al. 2002). Dystrophic changes of muscle have been observed in calves and small ruminants. Intercostal muscle dystrophy adversely affects respiration; tongue muscle dystrophy hampers suckling and leads to reduced colostrum

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intake, inadequate colostral immunity and development of diseases (diarrhoea, respiratory diseases) (Illek et al. 2002). Later on, dystrophy of the limb muscles may develop. The affected calves and lambs are not able to stand and eventually die.

In cows, Se deficiency adversely affects fertility (Vaswani and Kumar 2023), causes embryonic mortality, birth of calves with low viability, retained placenta, metritis and endometritis, and significant prolongation of puerperium. The immune suppression results in poor colostrum quality and predisposes to mastitis (Sordillo 2013). Severe Se deficiency in the mother may lead to damaged myocardium in the calf. Calves with congenital cardiomyopathy die at an early age (Illek et al. 1999; 2000; 2002). Moderate cardiomyopathies have also been diagnosed in calves during rearing and in lactating cows.

In the Czech Republic, Kursa (1969) was the first to diagnose Se deficiency in the South Bohemia Region. However, the author based his diagnosis on postmortem findings only. An accurate diagnosis of subclinical Se deficiency was enabled only by laboratory diagnostics based on the measurement of Se concentrations in blood and tissues. Selenium deficiency had been diagnosed mainly in calves. Gradually, the diagnosis of trace element deficiencies was extended to dairy sheep, goats, and pigs. Beef cattle received attention only after 1992 when beef farming started expanding.

Beef cattle are mainly reared in foothill and mountain areas where hard-to-reach locations are used for extensive agricultural production. Cattle is grazed from April to October. The Se concentration in pasture vegetation is determined by its concentration in the soil and the ability of plants to absorb Se from various chemical compounds. The Se concentration in pasture vegetation on the farms under study ranged from 0.032 to 0.086 mg/kg dry matter. Malyugina et al. (2021) measured Se in the pasture plants in the Rapotín area (Šumperk District, Czech Republic), obtaining values within the range of 0.036 to 0.038 mg/kg dry matter. The low Se content in plants and the low ability of some plants to absorb Se pose a significant risk of Se deficiency in the food chain of grazing ruminants for which plants are the main source of Se and other trace elements (Száková et al. 2015; Malyugina et al. 2021). As reported by Poláková (2010), soils in the Czech Republic have a low Se content of 0.3–0.4 ppm/kg. Soils in other European countries are also poor in Se (Scandinavia) and there are also Se deficient sites in the USA, Canada, China and other countries. The monitoring carried out mainly in dairy cattle in the 1990s showed a high prevalence of Se deficiency (Illek et al. 1999; 2000; 2002; Pavlata et al. 2001; 2002).

Different forms of Se supplementation have been studied such as inorganic and organic Se feed supplements (Kumprechtová et al. 2008; Illek et al. 2021). The effects of Se supplementation on the quality of colostrum, colostral immunity, and health status of calves and cows have been studied. The introduction of dietary supplementation with an organic form of Se (selenium yeast) significantly reduced the incidence of Se deficiency in dairy cattle. Currently, Se deficiency in dairy cows is rare. However, Se deficiency prevalence in beef cattle is still high and causes large economic losses for farmers. Calves are born with reduced live weight and longevity, unable to take in a sufficient amount of colostrum, some may suffer of congenital cardiomyopathy. This leads to high morbidity and mortality of calves. On some farms, the morbidity rate is up to 70% and the mortality rate up to 30% (Illek 2008; 2021).

The aim of this study was to determine the prevalence of Se deficiency in selected beef cattle herds.

Materials and Methods

The monitoring was carried out in 8 AA herds in different locations of the Czech Republic, during the season of May to September 2022. Cows and calves had access to pasture, drinking water and mineral licks all day. Selenium concentration in mineral licks was 20 mg/kg, and 30 mg/kg. The reproduction and the number of calves reared up to 6 months of age per 100 cows were evaluated for each herd. Selenium deficiency was diagnosed by measuring blood Se levels. A total of 78 cows and 78 randomly chosen calves aged 3 to 6 months were examined in the herds under study. Blood was collected from the tail vein into the Hemos sampling kits containing heparin as anticoagulant. Pasture vegetation samples were taken each time the blood samples were collected.

Selenium concentrations were measured in whole blood samples after mineralization with nitric acid and hydrogen peroxide in a closed system in a MILEOSTON MLS 1200 (Milestone, Italy) microwave oven using the AAS hydride technique on a SOLAR 939 (Unicam, UK) instrument. The Se concentrations in the pasture plant samples (on dry matter basis) were also measured.

Results

Table 1. Blood selenium concentrations in beef cattle (Herds 1–8).

Herd	Cows			Calves		
	Mean	SD	n	Mean	SD	n
1	81.88	18.46	8	52.15	14.23	8
2	57.01	22.04	10	47.9	11.78	10
3	75.07	21.28	10	49.18	12.28	10
4	66.54	16.96	10	52.03	4.31	10
5	86.39	11.33	10	61.38	3.71	10
6	98.63	5.78	12	79.64	11.38	12
7	86.17	7.59	10	83.88	11.12	10
8	87.71	7.84	8	69.66	9.92	8

SD - standard deviation

Selenium levels in cows and calves in different herds under study are given in Table 1. The mean Se values varied among the herds. There was also considerable variability in animals within each herd.

As shown in Table 2, the optimum blood Se concentrations were found in 60.25% of cows and only in 19.24% of calves. The reference values for blood Se in cows and calves are 80 to 120 ug/l (Illek 2002). Significantly low Se concentrations (less than 60 ug/l) were found in 15.40% and 47.43% of cows and calves, respectively. Blood Se concentrations ranging from 60 to 80 ug/l (moderate deficiency) occurred in 24.35% and 33.33% of cows and calves, respectively. In general, suboptimal blood Se values were observed in 39.75% and 80.76% of cows and calves, respectively.

Table 2. Prevalence of selenium (Se) deficiency in cows and calves in 8 herds (%).

	Cows (n = 78)	Calves (n = 78)
Severe deficiency (blood Se < 60 ug/l)	15.40	47.43
Moderate deficiency (whole blood Se 60–80 ug/l)	24.35	33.33
Suboptimal Se status	39.75	80.76
Optimal Se status (blood Se 80–120 ug/l)	60.25	19.24

The lowest blood Se concentrations were obtained from the cows located in the Jihlava and Havlíčkův Brod districts (Table 3). The calves in these herds showed even lower blood Se concentrations than the cows and this was also the case in the herd located in the Žďár nad Sázavou district. In general, calves always showed lower blood Se concentrations compared to cows, which indicates a reduced Se intake. Cows and calves were grazed together and the significantly lower blood Se concentrations in growing calves reflect a lower Se intake and probably

Table 3. Reproduction and birth rate.

Herd	Location (district)	Non-pregnant cows (%)	Number of calves reared per 100 cows
1	Žďár nad Sázavou	5	83
2	Jihlava	6	80
3	Jihlava	4	82
4	Havlíčkův Brod	6	84
5	Náchod	4	88
6	Ústí nad Orlicí	3	96
7	Klatovy	4	92
8	Domažlice	3	86

higher Se requirements. Selenium intake from mineral licks also played a role. Calves were less interested in freely accessible mineral licks than cows. The Se intake from cow's milk and by grazing was insufficient. Calves up to 10 to 12 weeks of age had free access to starter feed with Se content of 2.5–3 mg/kg dry matter. In the herds under study, older calves did not receive starter feed.

Reproduction evaluation by pregnancy diagnosis at the end of the grazing period (Table 3) revealed the highest number of non-pregnant cows in the Jihlava and Havlíčkův Brod districts (Herds 2 and 4). The proportion of cows that failed to conceive from natural mating was up to 6%. The non-pregnant cows were removed from the herds. Interesting results were also found in the number of calves reared per 100 cows. The lowest number was observed in the two herds of the Jihlava district (80 and 82). In contrast, the highest number of reared calves was found in the herds with cow's blood Se concentrations over 86 ug/l, where the calves also had high blood Se concentrations (Herds 5, 6, 7, 8). The average blood Se values in calves in Herds 5–8 were fairly high, ranging from 61.38 ± 3.71 to 83.88 ± 11.12 ug/l (Table 1).

Discussion

Pavlata et al. (2002) studied blood Se levels in dairy cattle from 1999 to 2001. They found Se deficiency in 43% cows and 80% of calves under study. Slavík et al. (2008; 2009) also observed Se deficiency in both dairy and beef cattle. Profound Se deficiency in Holstein cows was also observed by Kumprechtova et al. (2008), and they also showed a highly positive effect of organic Se supplementation on Se status, increasing Se concentration in blood, colostrum and milk of dairy cows.

Major Se deficiency in cows and calves of meat breeds in the Šumava region was pointed out by Slavík et al. 2007. They found blood Se concentrations as low as 26.58 ± 8.01 ug/l in cows and 30.41 ± 12.0 ug/l in calves aged 1 to 3 weeks. Also, Zarczynska et al. (2020; 2021) highlighted the issue of Se deficiency in cattle and demonstrated a positive effect of parenteral Se administration in both cows and calves. Vasiľ et al. (2022) drew attention to the increased susceptibility to mastitis in Se deficient cows.

Our results demonstrate an important incidence of Se deficiency in both cows and calves. In all the herds under study, the Se concentrations observed in calves aged 3 to 6 months were lower than those in cows. This fact is probably related to the increased Se requirements during intensive muscle growth and to insufficient intake of minerals from the available mineral licks. Increased Se requirements in rapidly growing calves have also been pointed out by Gerloff (1992). Illek et al. (2002) demonstrated higher Se concentrations in the blood of newborn calves compared to their mothers. Similar results were also reported by Van Saun et al. (1989) and Pavlata et al. (2003).

A noteworthy finding in our observation is that the herds with very low blood Se concentrations had poor conception rates. Natural mating was used and a higher percentage of non-pregnant cows was found in the herds with suboptimal Se status (Table 3). Although other factors also play a role in this regard, the effect of Se deficiency on fertility cannot be overlooked. As stated by Zarczynska et. al (2013), oocyte damage and early embryonic mortality occur with Se deficiency.

Selenium also plays an important role in the immune system (Swecker et al. 1989). It positively affects macrophage activity and differentiation, and lymphocyte proliferation (Salles et al. 2014). Selenium has a positive effect on immunoglobulin production and colostrum quality (Salman et al. 2013; Illek et al. 2019). Poor natality in herds with suboptimal Se status is associated with increased calf morbidity in the early postnatal period due to immunosuppression induced by Se deficiency (Swecker et al. 1989). In cows with Se deficiency, Illek et al. (2019) reported impaired colostrum quality with significantly lower concentration of immunoglobulins as well as significantly lower Se concentrations in colostrum and milk. Although Se is easily transferred via placenta into the foetus, colostrum and subsequently milk are important Se sources. The lower natality in the herds we studied may be related to Se deficiency, although it is not the only factor.

Although the incidence of mastitis in beef cows is not well understood, Se deficiency predisposes to subclinical and clinical mastitis. Vasiľ et al. (2022) considered Se deficiency as an important predisposing factor to mastitis. Cows with mastitis do not provide optimal nutrition and pose a risk for the calf health.

Based on our study, we can state that the issue of Se supply in beef cattle is still relevant in the Czech Republic. Low values of Se supply were observed mainly in calves, even when they and their mothers had mineral licks containing Se available. With regard to the mentioned diseases that Se deficiency can cause, it is advisable to pay more attention to the diagnosis of its deficiency and, when necessary, to supplement it.

Conflict of Interest

The authors claim no conflict of interest.

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