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Micro Mineral Concentrations of Dairy Cows in Selected Areas from Slovak Republic

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Abstract

The aim of study was evaluation of the quality of feeds for dairy cattle on the content of copper and zinc from two agro-ecological zones (western Slovakia and eastern Slovakia). Feed samples-corn silage (n=70), lucerne silage (n=32), grass silage (n=25), and total mixed ration for dairy cows-TMR (n=66) came from livestock farms. The Cu and Zn contents were assessed in samples using atomic absorption spectrophotometer (AAS). Higher average values of zinc were found in lucerne silage from eastern Slovakia (75.04 mg/kg), in other silage were the concentration of zinc in range from 51.77 to 58.13 mg/kg. The lowest average values were found of copper in silages-corn, lucerne and grass (9.80; 9.67 and 8.10 mg/kg), respectively. In the TMR was detected the higher average content of Zn in production phases, before calving 100.43 mg/kg, after calving 109.35 mg/kg and on the top of lactation 105.29 mg/kg. A total of 396 blood serum samples were collected from 22 farms of cattle. In western Slovakia, the percentage of animals deficient in serum Zn and Cu were observed in all production phases. The levels of Zn in serum were lower than the critical level 45.07% before calving and 38.03% after calving. The serum concentration of Cu were higher at after calving 33.8% and at top lactation 33.33% of the total number of analyzed samples. In eastern Slovakia, the levels of Zn and Cu in serum samples were lower. Of the total number of samples, the amounts of Cu in serum were reduced in all production phases (before calving 14.20%, after calving 7.81% and top of lactation 16.33%. Similarly, the amount of Zn in serum was reduced (10.65%, 19.17% and 12.78%, respectively).

Keywords: Blood serum; Silage; Total mixed ration (TMR) for dairy cows; Zinc; Copper; Atomic absorption spectrophotometer (AAS)

Introduction

The quality of feed is a complex of several interrelated factors evaluated in several ways. An important indicator is the mineral content. Monitoring the mineral content is important in terms of the ecosystem (cycle minerals) but also in terms of quality feed [1]. Khan et al. [2] reported that mineral contents in forages depend on soil, drainage and pH, forage species and varieties, forage maturity, pasture management, forage yield and climate. A natural source of minerals in the diet of farm animals is feed. Utilization minerals from food can be changed to different combinations of feed and representation grasses, legumes and herbs [3,4]. Forages species vary widely in the range and quantity of trace elements. Fertilizer application may also affect trace elements concentration. On the 16 trace elements currently recognized as being essential for farm livestock, only eight of them have practical significance.

Minerals have a special role in ensuring efficient growth [5], production [6] and immunocompetence in animals [7]. The transitional period (defined as the period from 3 weeks before to 3 weeks after calving) is extremely challenging for the dairy cow [8]. It has been reported that the concentration of some trace minerals are affected during the transitional period, especially around the time of parturition [9,10].

Trace mineral status, especially selenium (Se) and zinc (Zn), affects neutrophil function in postpartum cows [11]. Mineral deficiency remains the top issue in countries with dairy farming.

Furthermore, evidence suggests that herds have increased risks of metritis, mastitis locomotion problems or diarrhea in calves when zinc (Zn) or copper (Cu) status are either marginal or deficient [5]. Dairy cow feeds typically a range of different compounds that possess anti-oxidant activities, many of which are minerals or are mineral-dependent. The key trace elements involved in animal feed are zinc, copper, iron and manganese [7].

Supplementation of zinc in the deficient animals has caused a significant improvement in hormone levels like thyroxin, triiodothyronine, oestrogen, and progesterone [12]. It was observed that marginal or low zinc and copper contents in pasture, soil or animal feed may be responsible for the delayed age of puberty [13]. Inadequate intakes of Cu, Zn, and Fe might produce oxidative stress, growth retardation in young animals, anemia, decrease in follicular growth and fertility, increase in abortion, disturbance in anti-oxidant/free radical balance, decrease immune system function and enhance the virulence of the infectious agent [14-16].

Copper is a component of a several range of physiologically important metalloenzymes, lipid metabolism, anti-oxidant defense as an integral part of the essential enzyme superoxide dismutase (SOD), immune function and carbohydrate metabolism. Zinc is the second most abundant trace element in mammals and birds, and forms a structural component of over 300 enzymes, where it may also be key to catalytic and regulatory activity. It play and important role in anti-oxidant defense as an integral part of SOD. These elements have each other both negative and positive relationship within intermediary metabolism [7]. Positive chemical bonds (Mn–Zn) are less than the antagonistic bonds (Cu-Zn). Absorption of Zn and Mn is inhibited also by Ca [2,17,18]. Occurrence of secondary Zn deficiency in animals with excessive content of Ca, P and phytic acid in feed rations are frequent.

In the present study, we intended to monitor the serum concentration of Cu and Zn in dairy cows in different production phases (pre-calving, calving and at the top of lactation) in relation of mineral content in feed.

Materials and Methods

The study was carried out in two regions of Slovakia, Western and Eastern Slovakia. The monitoring was conducted in two phases; the first phase was the collection of feeds and biological samples – blood serum and the second phase was laboratory analysis of the collected samples. The farms were not in the industrial area. The climate of the locality is the mild climate zone characterized for Central Europe.

Ten dairy cattle farms were located in Western Slovakia and twelve farms in Eastern Slovakia. In each farm, sample was collected from eighteen healthy dairy cows (3-6 years old). A total of 396 blood serum samples were collected from 22 farms of cattle. Feed samples–corn silage (n=70), lucerne silage (n=32), grass silage (n=25) and TMR–total mixed ration (n=66) were used.

Blood samples were collected in the morning via the jugular vein. After proper clotting, the blood samples were centrifuged at 3500 rpm for 15 minutes and the serum samples were stored at -20°C until analyses. Before measuring, serum samples were deproteinized by supplementing trichloracetic acid at a 1:1 ratio. After centrifugation, the content of Zn and Cu in the supernatant was measured directly by using the flame method of an atomic absorption spectrometer (Unicam Solar, 939, Great Britain).

Feed samples were processed by digestion in the microwave oven (MLS-1200 Mega, Milestone) by using 5 mL HNO_3 and 1 mL HCl per 1 g of sample. The program of digestion was as follow: 1st step-250 W, 2 minutes; 2nd step-0W, 2 minutes; 3rd step-250W, 5 minutes; 4th step-400 W, 5 minutes; 5th step-500 W, 5 minutes; and 6th step-600W, 2 minutes. The digested samples of feeders were analyzed for the presence of Cu and Zn by using the flame method of an atomic absorption spectrometer (Unicam Solar, 939, Great Britain). The flame conditions were those recommended by the instrument manufacturer for Cu and Zn (wavelength 324.8 and 213.9, respectively, band pass 0.5 nm). The content of Cu and Zn in forage and blood were determined according to the methodology used by the Official lists methods and laboratory diagnosis of food and feed [19].

Results and Discussion

Zinc and copper in blood serum

In the western Slovakia, the mean level of serum Cu was: in production phases (16.80 µmol/L) before calving, after calving (17.07 µmol/L) and in the top of lactation (16.96 µmol/L). The mean zinc content obtained in these phases was: 29.25 µmol/L; 26.90 and 26.55 µmol/L, respectively. The maximum increase of serum concentrations of Zn were found in the period before calving 45.07% and after calving 38.03%. Zn concentration in the serum fluctuates with age, stress, and the reduction of feed.

In the eastern Slovakia, the average concentration of Cu in production phases-before calving, after calving and in the top of lactation, were 17.11 µmol/L; 16.75 µmol/L and 17.69 µmol/L. The zinc in serum in these phases was 25.64 µmol/L; 26.59 µmol/L and 24.10 µmol/L, respectively. These results of zinc concentration in serum were a comparable with serum zinc content from dairy cows in western Slovakia.

The results of study were summarized in Tables 1 and 2. The average serum concentration of trace elements between western and eastern Slovakia did not show any statistical significance. The monitored amounts of zinc and copper serum, in all productions phases of dairy cows, were within the physiological range (Zn-12.2-30.0 µmol/L; Cu-12.6-18.9 µmol/L, respectively). The balanced total mixed ration for dairy cows ensures the supply of nutrients in all phases of lactation and does not occur of some minerals. Although there is no deficiency of micro nutrient in this study, several samples of plants and blood serum have shown deficiency of minerals. The relationship of plant–animal is a complex chain of biochemical events.

Element		Before calving	Before calving	Top of lactation
		n=60	n=60	n=60
Cu	Mean	16.80	17.07	16.96
	SD	3.22	4.64	2.80
Zn	Mean	29.25	26.90	26.55
	SD	10.65	9.44	9.40

Table 1: The concentration of Cu and Zn in blood serum (µmol/L) of dairy cows from western Slovakia.

Element		Before calving	Before calving	Top of lactation
		n=72	n=72	n=72
Cu	Mean	17.11	16.75	17.69
	SD	4.80	2.27	2.13
Zn	Mean	225.64	26.59	24.10
	SD	8.14	7.28	7.60

Table 2: The concentration of Cu and Zn in blood serum (µmol/L) of dairy cows from eastern Slovakia.

Singh et al. [20] reported the lower concentration in blood serum of Cu and Zn from grazing cows in India in compared with results in this study. The average of serum Zn in grazing cows was in range from 0.81 to 1.03 ppm and the concentration of serum Cu was from 0.64 to 0.69 ppm. Deficiency up to 50% has been reported by Ramana et al. [21], similarly, Kawitkar [22] reported lower serum Zn values in lactating animals than pregnant and heifers. Mishra [23] also observed low serum Zn content in 46% of anestrus cows in India. The reason might be the effect of season physiological state of the animals and availability of feeds. The Cu deficiency observed in some grazing ruminants, this could be due to poor biological availability of Cu, which was mostly due to increased lignification's in fodders and the susceptibility of Cu to form biologically unavailable complexes (Cu-Fe, Cu-Zn) which is also responsible for high incidence of Cu deficiency syndrome, particularly in grazing ruminants [20]. Trace minerals bound to organic compounds are more readily adsorbent from the digestive tract, and maybe more biologically compared with the inorganic salts to these minerals. Results from study of Hackbart et al. [24] and other studies indicate that trace mineral source can have a positive effect on milk production. Adding inorganic Zn, Mn, Cu, Co with organic forms would increase milk production. Noaman et al. [25] have concluded that Holstein dairy cattle reared under semi-industrial dairy farming were deficient in serum Cu concentrations, especially in summer.

Zinc and copper in feed

The quality of roughage is dependent on weather conditions, soil potential and the stage of maturity of the plant species. TMR (total mixed ration for dairy cows) provides a balance of nutrients for dairy mixing fodder and grain, minerals and vitamins. The analytical characteristic of the nutritional value of TMR is the presence of minerals. The contents of Cu and Zn in the TMR for the dairy cow are listed in Tables 3 and 4.

Element		Before calving	Before calving	Top of lactation
		n=10	n=10	n=10
Cu	Mean	18.02	22.68	22.49
	SD	11.91	17.56	17.93
Zn	Mean	70.93	95.10	95.24
	SD	27.45	18.01	23.05

Table 3: The contents of trace elements (mg/kg) in the TMR for dairy cows from western Slovakia.

Element		Before calving	Before calving	Top of lactation
		n=12	n=12	n=12
Cu	Mean	20.12	19.95	19.80
	SD	10.95	10.60	5.14
Zn	Mean	100.43	109.35	105.29
	SD	55.56	47.89	38.92

Table 4: The contents of trace elements (mg/kg) in the TMR for dairy cows from eastern Slovakia.

The content of Cu in TMR for dairy cows before calving was found 18.02 mg/kg and 20.12 mg/kg, after calving 22.68 and 19.95 mg/kg, and on the top of lactation 22.49 and 19.80 mg/kg, respectively. In TMR from eastern Slovakia, the content of Zn (100.43 mg/kg) was found higher, for cows before calving, in comparison with feed from western Slovakia (70.93 and 84.81 mg/kg, respectively). The slight increase of Zn content (95.10 and 109.35 mg/kg) weas found in TMR, phase after calving, in compared with tolerance specified by the NRC [26].

The Zn content in measured samples was in the tolerance values according to NRC [26] in the TMR intended for dairy cows at top lactation. Skalická et al. [27] found almost the same amounts of Cu in the analyzed TMR in production stages, but found higher zinc content (117.59 mg/kg before calving; after calving 134.79 mg/kg and 132.49 mg/kg at top lactation) compared to western and eastern Slovakia. In other hand, Noaman et al. [25] found low content of Cu (13.00 mg/kg) and Zn (47.30 mg/kg) in total diet for cows in in comparison with the results of our study.

Tables 5 and 6 shows the average mineral content of the silage. The analyzed levels of minerals finding from western Slovakia in corn silage were for Cu 9.80 mg/kg and Zn 55.99 mg/kg, respectively. In eastern Slovakia, were found the slightly higher contents only in case of Cu (11.02 mg/kg). The monitored average contents of Cu and Zn were higher compared to limits specified by the NRC [26], in corn silage (Cu 6 mg/kg, Zn 24 mg/kg). By contrast in Ireland, Rogers et al. [28] found lower amounts of Cu (5.11 mg/kg) and Zn (26.61 mg/kg) in corn silage. In eastern Slovakia, were found the higher contents of Cu in corn silage, lucerne silage and grass silage compared from western Slovakia. The content of Zn in Lucerne silage from eastern Slovakia was higher (75.04 mg/kg), in other silage were the concentration of zinc in range from 51.77 to 58.13 mg/kg.

Silage		Corn	lucerne	Grass
Element		n=30	n=11	n=10
Cu	Mean	9.80	9.67	8.10
	SD	4.70	4.39	4.83
Zn	Mean	55.99	57.52	53.60
	SD	34.61	27.51	30.10

Table 5: The content of Cu and Zn (mg/kg) in feed from western Slovakia.

Silage		Corn	lucerne	Grass
Element		n=30	n=11	n=10
Cu	Mean	11.02	13.78	13.02
	SD	6.07	6.16	6.88
Zn	Mean	21.77	75.04	58.13
	SD	41.91	49.30	31.68

Table 6: The content of Cu and Zn (mg/kg) in feed from eastern Slovakia.

Corn silage is one easily digestible carbohydrate food for dairy cows. Lucerne is widely grown throughout the world as forage for cattle, and is most often harvested as hay, but can also be made into silage and grazed. In terms of the ratio of nutrients is one of the protein feed. Lucerne silage is a major source of Ca compared with maize silage. The content of trace elements in the feed is governed by the nature of geochemical soil and plant species. Several authors [1,17,29,30] have dealt with the occurrence of trace elements in feed and blood serum of cattle from various weather conditions who similarly found a low Cu content in grass and grass hay.

The micro mineral content of feeds from various climatic conditions was presented by Shahjalal et al. [17]. The mean values obtained in this study were low for Cu (6.12 mg/kg), and higher for (Zn 291.3 mg/kg). The results of Zn were considerable higher than those indicated in our study (Tables 5 and 6). Nearly the same values of micro elements were found in grass by Ramana et al. [30] in India (Cu 27.9 mg/kg and Zn 31.00 mg/kg). In the observed period, we found higher levels of Zn in silage–corn, lucerne and grass. The average detected levels of Cu, Zn in the TMR were in range of tolerance values [26].

Raising cattle is influenced by the quality of feed. Correctly aligned phase nutrition program minimizes metabolic problems of dairy cows. Because of the antagonistic relationship and high body burden of high production dairy cows should be in the diet of dairy production, dosage minerals. In the present study, concerning the serum Cu and Zn concentrations was no statistically significant between monitored farms. The serum concentrations were within the recommended range. It is essential to consider all the dietary nutrient sources including forages, concentrate mineral supplements when evaluating mineral interaction.

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