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SELENIUM CONCENTRATION IN DAIRY COWS AND ITS INFLUENCE ON PRODUCTION TRAITS

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Abstract. The aim of this study was to determine selenium concentration in the blood serum of dairy cows and to establish its influence on the level of production and reproduction traits. The study was performed on the farm located in Western Pomerania and involved 140 cows, which were selected using the analogue method on the basis of their physiological state, lactation number, milk yield, age and genotype. The following indices were analyzed in individual groups: milk yield (kg), milk fat yield (kg), milk fat content (%), milk protein yield (kg), milk protein content (%). Selenium concentration in the blood serum was determined with the spectrofluorometric method. The obtained results showed that 23.6% cows had selenium deficiency, 39.3% had threshold concentration and 37.1% had physiological concentration. The mean milk fat and protein contents were the highest in animals with the threshold concentration of selenium and differed statistically ($P \leq 0.01$) from those of the group with the deficiency or physiological concentration of this element. The study revealed that the problem of selenium deficiency is still present in some dairy cattle herds in Western Pomerania.

Keywords: dairy cattle, deficiency, reproduction indices, selenium, Western Pomerania

INTRODUCTION

New trends such as healthy food production and animal breeding on organic farms have resulted in the changes in cattle management systems.

High-yielding animals have very high dietary requirements. Reproduction indices of cows, especially high-yielding ones, depend on the appropriate meeting of requirements for micro-, macroelements and vitamins, which are not always sufficiently supplied from feed. Farm-made feeds satisfy only 30–50% mineral requirements. One of the basic microelements is selenium, whose significance as a bioelement essential for life was recognized in 1950s.

The content of this element in plants is evaluated, first of all, with regard to the dietary requirements of animals, since they determine the level of this microelement in an organism.

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In Poland, there are vast areas that are poor in selenium [Borowska and Koper 2007]. The content of this element in the soils of Poland was precisely analyzed and presented on a map [Dudka 1992]. According to this author, the content ranged from 0.070 to 0.410 mg · kg^{-1} depending on the type of soil. The comprehensive research on its level in soil profiles and in plants was performed in Western Pomerania by Zabłocki [1990]. He analyzed mean selenium concentrations in soils used for farming in this region. The indicator of this is its low concentration in plants (0.042 mg Se per 1 kg D.M. on average), which was reflected in white muscle disease in lambs [Uziębło 1974]. Considerable selenium deficiency was also shown in Bydgoszcz Province [Jaśkowski 1990]. The research conducted on arable soils located near Wrocław revealed a high content of this microelement ranging from 81 to 494 μg · kg^{-1} – 202 μg · kg^{-1} on average (Patorczyk-Pytlik and Kulczycki 2009]. The selenium level in feeds reflects the content of this element in soils and should range from 0.1 to 2 ppm per kg dry matter, whereas the concentration below 0.1 ppm is considered deficient. The average demand for selenium ranges between 0.10 and 0.15 mg · kg D.M. feed [Jamroz 2001]. At present, the law allows using selenium supplements of 0.3 mg · kg^{-1} D.M. of feed for farm animals [Dębski 2007, Kinal 2009].

It is accepted that the threshold (limiting) concentration is 0.5 ppm, below which the disorders caused by selenium deficiency may occur. In calves, the deficiency of this bioelement manifests itself as a white muscle disease. Selenium deficiency causes fertility disorders, which, according to Sablik [2002], are the main reason for culling cows and have influence on the profitability of dairy cows farming [Kruze et al. 2007]. The most frequent disorders include: ovarian dysfunction, fetal deaths and stillbirths, increased periparturient complications (metritis), decreased conception rate or impairment of reproductive performance [Hidiroglou 1982]. Fertility disorders associated with hyposelenosis also include retained placentae, which undergo putrefactive process and large difficulties are encountered at their manual separation. In bulls, selenium affects, among others, appropriate spermatozoal motility and facilitates their penetration into the ovum [Kossakowski and Kossakowska 1981, Ramisz et al. 1993, Jaśkowski 1990]. Selenium also plays an important role in spermatozoal metabolism. The examination of frozen semen showed that this element contributes to the increased spermatozoal liveability at 38ºC and the percentage of spermatozoa with an undamaged acrosome after adding 1 μ Se^{-1} to the extender [Udała et al. 2001].

Selenium is a microelement of great physiological significance. In organisms, it most often occurs in connection with amino acids, mainly in the form of selenocystein of an enzyme included in glutathione peroxidase (GSH-Px). A decrease in the activity of this enzyme increases susceptibility to infectious and invasive diseases through reduced cellular immunity, mainly phagocytosis [Bronicki and Dembiński 1991]. T lymphocytes are especially sensitive to Se deficiency. Their cell membrane contains lipids that are more easily oxidized. The lymphocytes of animals suffering from selenium deficiency produce lower amount of factors inhibiting migration of leukocytes and macrophages, which contributes to the cell infiltration in an inflammatory condition [Zagrodzki 2004].

Selenium is well assimilated both from organic and inorganic sources. It is considered that the administration of preparations of organic origin, e.g. in the form of selenium yeast, is safer, since they bind this element to tissue proteins more effectively [Jacquse 2001].

Prophylactically, cows before calving can be intramuscularly administered 50 mg Se together with vitamin E 2–4 weeks before parturition and directly before grazing season [Dębski 2007].

The aim of this study was to determine selenium concentration in the blood serum of dairy cows and to establish its effect on the level of production and reproduction traits in these animals.

MATERIAL AND METHODS

The study was conducted on a farm located in Western Pomerania and involved 140 cows, which were selected by the analogue method on the basis of physiological state, lactation number, milk yield, age and genotype. The feeding of animals was based on farm-made feeds. The herd was divided into three groups according to the selenium concentration in blood serum using biochemical standards [Grace 1997]:

– deficient – selenium concentration below 0.041 μg · ml,
– with threshold concentration – 0.042–0.079 μg · ml,
– with physiological concentration – above 0.080 μg · ml.

The following indices were analyzed in each group: milk yield (kg), milk fat yield (kg), milk fat content (%), milk protein yield (kg) and milk protein content (%).

Se level in blood serum was determined with Watkinson's method [1966], modified by Grzebuła and Witkowski [1979], using Shimadzu spectrofluorometer.

The data were verified statistically by means of Statistica®7.1 PL software. The mean values (), standard deviations (S) and coefficients of variation (V) were calculated.

RESULTS AND DISCUSSION

Cattle are to a large extent at risk of the deficiency of minerals, including selenium. The appropriate concentration of this bioelement affects both normal health state and normal functioning of animals.

Insufficient supply of this element to an organism results in a decrease in its content in all organs, which can indirectly lead to decreased productivity and cause many enzootic diseases [Bik 2003].

The studies on the selenium concentration in cattle have a character of analyses associated mainly with disorders caused by decreased fertility of animals and their prevention. The application of selenium supplements in the form of premixes resulted in an improved fertility index, decreased frequency of periparturient disorders and mastitis [Pinkiewicz et al. 1986, Żarski and Dębski 1996, Pilarczyk et al. 2004].

The results of the studies on the selenium level in blood serum of dairy cows kept in Western Pomerania in connection with mean milk yields (kg) are summarized in Table 1. The obtained results show that 23.6% cows had selenium deficiency, 39.3% had threshold concentration and 37.1% had physiological concentration. The mean selenium con-

centration on the studied farm was 0.066 µg·ml. The levels of milk yield for physiological and deficient concentrations were similar. The lowest milk yield was characteristic of cows, in which selenium concentration had the threshold value. However, these differences were not statistically significant.

Table 1. Se level in the blood serum of cows from the area of Western Pomerania, depending on milk yield, kg

Tabela 1. Poziom Se w surowicy krwi krów z terenu Pomorza Zachodniego w zależności od wydajności mlecznej, kg

Clasification cows for grups Grupy krów	Number Liczebność		Se level, µg·ml Poziom Se, µg·ml			Average milk productivity, kg Średnia wydajność mleka, kg		
	N	%	$\overline{X}$	S	V%	$\overline{X}$	S	V%
Deficiency Se Niedobór Se (<0.041 µg · ml)	33	23.6	0.028^{AB}	0.008	29.71	5856.9	1117.35	19.08
Border concentration Se Stężenie graniczne Se (0.041–0.079 µg · ml)	55	39.3	0.0657^{AC}	0.010	15.27	5424.2	1310.48	24.16
Phisiological concentration Se Stężenie fizjologiczne Se (>0.079 µg · ml)	52	37.1	0.089^{BC}	0.007	8.05	5948.6	1212.11	20.38
Total Suma	140	100.0	0.066	0.025	37.62	5721.0	1245.91	21.78

A, B, C – the same letters denote statistically significant differences at P≤0.01.
A, B, C – te same litery oznaczają statystycznie istotne różnice dla P≤0,01.

McIntosh and Royle [2002], using selenium yeast as a feed supplement at the doses of 2 and 6 mg Se per day, did not find any significant effect of this element on an increase in milk yield. However, they observed a decreased occurrence of mammary gland infections and mastitis. Kruze et al. [2007] considered a low concentration of this element in an organism as one of the reasons for fertility disorders and mastitis.

Gabryszuk et al. [2010] conducted large-scale research on the content of minerals, including selenium, in milk and hair of cows from organic farms. Analyzing the interdependency between bioelements, he found, among others, a high and positive correlation between the content of potassium, magnesium and selenium. However, these results were not statistically significant. Dobrzański et al. [2005] showed an increase in selenium level in the blood and milk of cows, which were administered selenium preparations. The Se molar level ranged between 0.09 µg · L and 0.52 µg · L depending on the form of administration, dosage and season. This discrepancy is explained by the absence of significant correlation between Se in milk and blood.

The levels of biochemical parameters in milk depending on selenium concentration are presented in Tables 2 and 3.

Table 2. Average fat efficiency of (kg) fat content (%) in the milk of cows, depending on the concentration of selenium

Tabela 2. Średnia wydajność tłuszczu (kg), zawartość tłuszczu (%) w mleku krów w zależności od stężenia selenu

Group Grupa	N	Fat productivity, kg Wydajność tłuszczu, kg			Content of fat, % Zawartość łuszczu, %		
		$\overline{X}$	S	V	$\overline{X}$	S	V
Deficiency Se Niedobór Se (<0.041 µg · ml)	33	236.58	56.43	23.85	4.01^{A}	0.32	7.97
Border concentration Se Stężenie graniczne Se (0.041–0.079 µg · ml)	55	231.31	53.15	22.98	4.31^{Aa}	0.53	12.31
Phisiological concentration Se Stężenie fizjologiczne Se (>0.79 µg · ml)	52	241.48	48.59	20.12	4.09^{a}	0.39	9.51
Total Suma	140	236.33	52.12	22.06	4.16	0.45	10.86

A – the same letters denote statistically significant differences at P≤0.01.
a – the same letters denote statistically significant differences at P≤0.05.
A – te same litery oznaczają statystycznie istotne różnice dla P≤0,01.
a – te same litery oznaczają statystycznie istotne różnice dla P≤0,05.

Table 3. Average efficiency of protein (kg) protein content (%) in the milk of cows, depending on the concentration of selenium

Tabela 3. Średnia wydajność białka (kg), zawartość białka (%) w mleku krów w zależności od stężenia selenu

Group Grupa	N	Proteins productivity, kg Wydajność białka, kg			Content of proteins, % Zawartość białka, %		
		$\overline{X}$	S	V	$\overline{X}$	S	V
Deficiency Se Niedobór Se (<0.041 µg · ml)	33	192.33	37.09	19.29	3.30^{A}	0.29	8.65
Border concentration Se Stężenie graniczne Se (0.041–0.079 µg · ml)	55	176.07^{a}	52.70	29.93	3.49^{Aa}	0.26	7.57
Phisiological concentration Se Stężenie fizjologiczne Se (>0.79 µg · ml)	52	197.90^{a}	35.54	17.96	3.36^{a}	0.24	7.25
Total Suma	140	188.01	44.23	23.53	3.40	0.27	7.99

A – the same letters denote statistically significant differences at P≤0.01.
a – the same letters denote statistically significant differences at P≤0.05.
A – te same litery oznaczają statystycznie istotne różnice dla P≤0,01.
a – te same litery oznaczają statystycznie istotne różnice dla P≤0,05.

Maus et al. [1980] described the linear relationship between Se content in feeds as well as blood serum and milk of cattle. Especially high-yielding cows during lactation are at risk of deficiency of this microelement, which is secreted with milk [Żarski and Dębski 1996, Pilarczyk et al. 2008]. Also, a significant correlation was observed between selenium concentration in blood serum and milk of cows [Dębski 1992] as well as decrease in the level of this bioelement in blood serum of cows during lactation, which results from its secretion with milk [Bombik et al. 2010].

The mean milk fat and protein content was the highest in animals with a threshold selenium concentration and differed statistically ($P \leq 0.01$) from that of the group with a deficient and physiological selenium concentration (Table 3). Abd El-Ghani [2004], using yeast-like preparations containing, among others, selenium in ruminants feeding, found that they increased milk yield, content of energy, protein, dry matter and solid non-fat compared with control group. The research on the use of biopreparations containing selenium, which were given to dairy cows, showed a higher concentration of macroelements, vitamins and higher level of biochemical indices (glucose, protein) in their blood serum [Dobrzański et al. 2006]. Similar indices (increase in the content of minerals in milk and blood serum) in cattle were obtained after administering preparations containing yeast [Korniewicz et al. 2005].

In Western Pomerania, which is an area with selenium deficiency, research on its level in farm animals, including cattle, has been conducted for many years [Ramisz et al. 2001]. A 10.1% higher milk yield was found in the group of cows, which were administered selenium preparations. The studies on the relationship between selenium concentration in blood serum and biochemical parameters as well as production traits are a valuable supplement of the research conducted in this area.

CONCLUSIONS

The obtained results show that 23.6% cows had selenium deficiency, 39.3% had threshold concentration and 37.1% had physiological concentration. The mean milk fat and protein content was the highest in animals with a threshold selenium concentration and differed statistically ($P \leq 0.01$) from that of the group with deficiency or physiological selenium concentration. The research showed that the problem of selenium deficiency is still present in some dairy cattle herds in Western Pomerania.

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STĘŻENIE SELEN U KRÓW MLECZNYCH ORAZ USTALENIE JEGO WPŁYWU NA KSZTAŁTOWANIE SIĘ CECH UŻYTKOWYCH

Streszczenie. Celem pracy było określenie stężenia selenu w surowicy krów mlecznych oraz ustalenie wpływu na kształtowanie się cech użytkowych i reprodukcyjnych. Badania przeprowadzono w gospodarstwie położonym na terenie Pomorza Zachodniego. Ogółem objęto badaniami 140 krów, które zostały dobrane metodą analogów, uwzględniającą stan fizjologiczny, kolejność laktacji, wydajność mleczną, wiek oraz genotyp. W poszczególnych grupach przeanalizowano następujące wskaźniki: wydajność mleczną (kg), wydajność tłuszczu (kg), zawartość tłuszczu w mleku (%), wydajność białka w mleku (kg), zawartość białka w mleku (%). Zawartość Se w surowicy oznaczono metodą spektofluorymetryczną. Z uzyskanych wyników badań wynika, że u 23,6% krów stwierdzono niedobór selenu, stężenie graniczne występowało u 39,3%, a stężenie fizjologiczne u 37,1% zwierząt. Średnia zawartość tłuszczu i białka w mleku krów była największa u zwierząt z granicznym stężeniem selenu i różniła się statystycznie ($P \leq 0,01$) w stosunku do grupy z niedoborem i fizjologicznym stężeniem selenu. Badania wykazały, że problem niedoboru selenu nadal istnieje w niektórych stadach bydła mlecznego na Pomorzu Zachodnim.

Słowa kluczowe: bydło mleczne, deficyt, Pomorze Zachodnie, selen, wskaźniki reprodukcyjne

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