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THE MINERAL ELEMENTS CONTENT IN HAIR OF COWS FROM CONVENTIONAL AND ORGANIC FARMS

Summary

The objective of this study was to determine the effect of different production systems on contents of 29 major and trace elements in cow's hair. The experimental material consisted of 30 cows of Polish Holstein-Friesian (HF) breed, from one dairy organic farm (15 cows) and one dairy conventional farm (15 cows). All the farms were located in one climatic zone and under similar soil conditions. In conventional farm cows were kept in a cubicle barn and cows were fed with total mixed ration (TMR) from a feeding around the year. In organic farms cows were kept in traditional tied-up barns. Feeding was traditional, with ration components offered separately. Cows were grazed from May to October. Depending on pasture yield and availability of other feeds, feeding ration was supplemented by hay, straw, silage and cereals. Samples of hair for analyses of minerals were collected in October, i.e. after pasture feeding. The hair was taken from poll. The concentration of Ca, K, Mg, Na, P, S, B, Ba, Co, Cr, Cu, Fe, Ge, I, Li, Mn, Mo, Ni, Se, Si, Sn, Sr, V, Zn, Al, As, Cd, Hg, Pb was determined. The content of Ca, K, Na, P and S in hair of cows from conventional farm were the similar like in the organic cows. The content of Mg was significantly higher in cows from intensive production system compared to cows from ecological farm with pasture feeding. The significantly lower contents of B, Ba, Cr, Cu, Ge, I, Li, Mn, Mo, Ni, Se, Si, Sn, Sr, V, Zn were shown in organic farm. The content of Al, As in cow's hair were significantly lower, but content of Cd significantly higher in cows from conventional dairy farm compared to ecological farm. There was no difference in Hg and Pb content. It seems that the wider investigations of mineral composition of cow's hair could be useful for settlement of reference value for some elements and would make a contribution to better animals' welfare.
***Key words**: cows, hair, mineral elements, organic farm*

ZAWARTOŚĆ SKŁADNIKÓW MINERALNYCH WE WŁOSACH KRÓW Z GOSPODARSTWA EKOLOGICZNEGO I KONWENCJONALNEGO

Streszczenie

Celem badań było oszacowanie wpływu systemu utrzymania krów mlecznych (konwencjonalnego i ekologicznego) na zawartość 29 makro- i mikroelementów we włosach krów. Do badań wybrano 30 krów rasy polskiej holsztyńsko-fryzyjskiej (hf). Z gospodarstwa konwencjonalnego i ekologicznego wybrano po 15 krów mlecznych. Gospodarstwa były położone w tej samej strefie klimatycznej i miały podobne warunki glebowe. W systemie konwencjonalnym krowy były utrzymywane w oborze legowiskowej i żywione pełnoporcjową mieszanką treściwą (TMR) przez cały rok. W gospodarstwie ekologicznym krowy były utrzymywane w tradycyjnej oborze uwięziowej. Krowy korzystały z pastwiska od maja do października. W zależności od wydajności pastwiska i potrzeb krów dawka pokarmowa była uzupełniana o siano, słomę, kiszonkę i zboża. Próbki włosów do oznaczenia składników mineralnych pobrano w październiku, po zakończeniu żywienia pastwiskowego. Włosy pobrano z wału międzyrożnego. We włosach oznaczono zawartość Ca, K, Mg, Na, P, S, B, Ba, Co, Cr, Cu, Fe, Ge, I, Li, Mn, Mo, Ni, Se, Si, Sn, Sr, V, Zn, Al, As, Cd, Hg i Pb. Zawartość Ca, K, Na, P i S we włosach krów z gospodarstwa konwencjonalnego była podobna jak u krów z gospodarstwa ekologicznego. Zawartość Mg była istotnie większa u krów z gospodarstwa o intensywnym sposobie produkcji w porównaniu do krów z gospodarstw ekologicznych z dostępem do pastwisk. Istotnie niższa zawartość B, Ba, Cr, Cu, Ge, I, Li, Mn, Mo, Ni, Se, Si, Sn, Sr, V, Zn była u krów z gospodarstwa ekologicznego. Zawartość Al i As we włosach krów była istotnie niższa, a zawartość Cd istotnie wyższa u krów z gospodarstwa konwencjonalnego w porównaniu do krów z gospodarstwa ekologicznego. Nie było istotnych różnic w zawartość Hg i Pb. Wydaje się, że dalsze badania składu mineralnego włosów u krów mogą być przydatne do oszacowania w przyszłości wartości referencyjnych dla niektórych pierwiastków i mogą się przyczynić do lepszego dobrostanu zwierząt.
***Słowa kluczowe**: krowy, włosy, składniki mineralne, gospodarstwo ekologiczne*

1. Introduction

The progress in analytical methods has led to elucidation the biological role of many elements occurring in plant, animal and human organisms. Mineral distribution within the body's tissues is not uniform, since some tissues selectively concentrate specific elements. There is no disagreement concerning the essential nature of major and trace elements for livestock [7]. Monitoring of trace element status of cattle is strongly required for prevention of diseases and high performance. Chemical analysis of soil and feed does not always indicate the real intake of trace elements in animals due to the presence of insoluble complexes or antagonists that depress mineral bioavailability [5].

The value of the so far applied routine analyses of whole blood, serum and urine for bioelements are limited. Blood mineral level often does not correspond to their contents in the whole body, because the composition of plasma results from supplementation of deficiencies by different homeostatic mechanisms. Moreover, the blood bioelements concentration is relatively low and depends on the current diet, thus the diagnostic value of the analytical results may be fairly small. Studies have shown that the analysis of hair and nails are an appropriate alternative for the analysis of blood and urine, and for biopsy. The diagnostic value of hair analysis is confirmed by many authors who have demonstrated the presence of correlation between the levels of principal elements in hair and their contents in the body, both in the case of physiological equilib-

rium and during pathological disturbances [8]. Research confirms that the hair can be useful for the evaluation of the mineral profile of the cow body, the level of environmental pollution as well as for determining the reference values of some elements [1]. Other authors suggested that body hair (mule deer) may serve as a supplementary sample to measure selenium, but for other trace minerals, the concentrations between concentrations in hair and other samples types were not strong enough to conclude that hair can be used as a reliable supplementary sample to evaluate the true trace elements status of free-ranging deer, but limited sample size may have influenced the results [14]. Chemization in agriculture, animal production and food processing introduces a lot of food contaminants into the food chain. Organic methods in agriculture are safer and therefore very important. Nutrition based on the organically produced foods and anthroposophic lifestyle can play an important role in health prophylactic [12]. Gabryszuk et al. [4] suggested that the mineral composition of milk and hair depended on production system (conventional *vs.* organic system). It seems that the wider investigations of mineral composition of cow's hair could be useful for settlement of reference value for some elements.

The objective of this study was to determine the effect of different production systems on contents of 29 major and trace elements in cow's hair.

2. Material and methods

The experimental material consisted of 30 cows of Polish Holstein-Friesian (HF) breed, from one dairy organic farm (15 cows) and one dairy conventional farm (15 cows). All the farms were located in one climatic zone and under similar soil conditions. In conventional farm cows were kept in a cubicle barn and cows were fed with total mixed ration (TMR) from a feeding around the year. In organic farms cows were kept in traditional tied-up barns. Feeding was traditional, with ration components offered separately. Cows were grazed from May to October. Depending on pasture yield and availability of other feeds, feeding ration was supplemented by hay, straw, silage and cereals. All of the herds were under official milk recording system, provided by the Polish Society of Cattle Breeders and Dairy Farmers.

Samples of hair for analyses of minerals were collected in October, *i.e.* after pasture feeding. The hair was taken from poll. Hair was washed with acetone pure for analysis and 3 times rinsed with deionized water. The concentration of Ca, K, Mg, Na, P, S, B, Ba, Co, Cr, Cu, Fe, Ge, I, Li, Mn, Mo, Ni, Se, Si, Sn, Sr, V, Zn, Al, As, Cd, Hg, Pb was determined. Samples of hair (0.3 g) and milk (1 ml) were mineralised in a mixture of 4 ml HNO_3 and 1 ml H_2O_2 in hermetic high-pressure vessels by heating in a microwave oven. Mineral elements contents were estimated by inductively coupled plasma optical emission spectroscopy (ICP-OES).

The statistical analyses were performed using Statistica 6.0 for Windows (StatSoft, USA). The average values were tested by Tukey's method, were the significance level was $p \leq 0.05$.

3. Results and discussion

The mean contents and their standard deviations (SD) for macro- and microelements in hair of cows are shown in Tables 1 and 2. The content of Ca, K, Na, P and S in hair of cows from conventional and organic farm was similar. The content of Mg was significantly higher in cows from intensive production system compared to cows from ecological farm with pasture feeding. Polish soils are considered to be low or very low in Mg. Soils with low and medium concentration of Mg represent 64% of total soils in Poland [6].

Table 1. Means and their standard deviations for macroelements content of cows' hair (mg kg^{-1})
Tab. 1. Średnie i odchylenia standardowe dla zawartości makroelementów we włosach krów (mg kg^{-1})

Element	Conventional		Organic	
	mean	SD	mean	SD
Ca	555.9	129.1	572.4	221.0
K	1361	189.3	1298	594.3
Mg	68.08[a]	13.68	54.36[b]	16.41
Na	376.0	109.5	369.5	158.8
P	41.11	29.41	39.22	30.14
S	39.90	20.91	38.54	21.25

a, b - significant at $P \leq 0.05$

Source: own work / Źródło: opracowanie własne

Table 2. Means and their standard deviations for trace elements content of cows' hair (μg kg^{-1})
Tab. 2. Średnie i odchylenia standartowe dla zawartości mikroelementów we włosach krów (mg kg^{-1})

Element	Conventional		Organic	
	mean	SD	mean	SD
Al	7361[a]	1137	14224[b]	3492
As	17.82[a]	4.15	31.56[b]	6.83
B	1341[a]	327.1	720.8[b]	202.3
Ba	767.7[a]	189.2	286.4[b]	161.3
Cd	5.81[a]	1.02	2.63[b]	0.95
Co	38.62	36.41	46.28	41.28
Cr	157.4[a]	98.72	74.16[b]	41.37
Cu	1248[a]	394.3	2292[b]	642.1
Fe	17036	1056	15989	11698
Ge	64.41[a]	17.32	40.15[b]	11.37
Hg	81.62	41.89	83.64	59.24
I	4561[a]	2293	9872[b]	4124
Li	21.69[a]	9.43	11.63[b]	7.38
Mn	4528[a]	1790	3427[b]	933
Mo	476.6[a]	121.8	202.8[b]	106.1
Ni	138.9[a]	24.9	69.12[b]	10.8
Pb	43.92	21.8	38.54	18.1
Se	1426[a]	137.1	824.5[a]	159.4
Si	7500[a]	1120	5021[a]	1096
Sn	318.0[a]	29.82	130.7[b]	27.61
Sr	391.5[a]	140.1	596.3[b]	202.8
V	21.41[a]	15.58	39.95[b]	19.63
Zn	47713[a]	14410	29542	11411[b]

a, b - significant at $P \leq 0.05$

Source: own work / Źródło: opracowanie własne

It can explain the fact that grazed cows showed significantly lower concentration of Mg in hair and milk compared with TMR-fed cows [4]. Disorders of calcium, phosphorus and magnesium homeostasis in ruminants provide natural models for the study of the physiology and pathophysiology of these minerals. The knowledge that can be acquired with a better understanding of the pathogenesis of these diseases could give useful clues in puzzle of human osteoporosis [13].

The contents of trace elements in hair are shown in Table 2. The levels of trace elements were within published

ranges. The significant differences for B, Ba, Cr, Cu, Ge, I, Li, Mn, Mo, Ni, Se, Si, Sn, Sr, V, Zn were identified between farms. The lower contents of trace elements were shown in organic farm. Differences in the concentrations of major and trace elements in hair of cows depended on nutrition, breed, colour of hair, age, dairy period and performance, geographical location, place of experiment, occupation, production system, mineral status of cows and animal welfare. Szigeti et al. [15] reported that breed differences exist in Ca, Mg, and Cu of hair mineral content even in case of similar nutrition ($P<0.05$). This may reflects metabolic differences. Sampling site of short haired body parts has no influence on hair mineral content [15].

The reference minerals concentrations in cow's hair dry matter are for example 0.1-2.5% for Ca, 130-455 ppm for Mg, 0.2 ppm for Cr, 6.7-32 ppm for Cu, 59-200 ppm for Fe, 0.5-1.32 ppm for Mn, 0.5-1.32 ppm for Se and 100-150 ppm for Zn [11]. According to this author determination of certain elements in hair may be useful for long term monitoring of mineral status of animals [11]. Also the mineral element status in the sheep's flock determined by wool analysis can be a good method. The content of mineral elements in the wool showed statistically significant differences between Booroola and Polish Merino ewes. The results of concentration of the same minerals in the blood plasma of the same ewes were within the reference value, and no significant differences were observed between breeds [2]. The mineral contents of wool depended also on physiological status (parturition, gestation, mating) of sheep [3]. Main problem in pasture feeding is that composition and digestibility of nutrients, also contents of mineral elements, are highly affected by the stage of plant growth and can vary significantly in relatively short periods. Eventually, it is difficult to maintain constantly high milk production based on pasture feeding, even when quality of grass is high and soil and water conditions are suitable for grass production.

The contents of toxic elements in hair were low. The content of Al and As in cows' hair was significantly lower, but content of Cd significantly higher in cows from conventional dairy farm compared to ecological farm. There was no difference in Hg and Pb content. The lead and cadmium accumulation in hair were associated with higher blood lead concentration and hair lead influenced the hair cadmium accumulation [9]. The higher blood lead concentrations in cattle irrespective of locality/industrial operations areas affected trace elements profile in blood and hair [10]. The content of heavy metals in hair depends on feed, content of these metals in soil, environment contamination as well as the antagonistic bioelements x heavy metals interaction, which influence their absorption and metabolism. For these reasons the contents of toxic elements of hair from ecological farms were not found lower than of hair from conventional herds.

4. Conclusion

This study demonstrated that the lower contents of mineral elements of cow hair under extensive farming system (ecological) could reflect their deficiency in soil and in green forage. The content of heavy metals in hair of cows from ecological farm were not found lower than those from conventional herd. The content of toxic elements in hair depends on feed, their content in soil, environment contamination, interaction between bioelements and heavy metals, affecting their absorption and metabolism. The determination of macro- and microelements in hair can be useful for long term monitoring of mineral status of cows. It seems that the wider investigations of mineral composition of cow's hair could be useful for settlement of reference value for some elements and would make a contribution to better animals' welfare.

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