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# Impact of the breeding region and the season on the content of the selected mineral elements in the hair of cows

# Wpływ regionu i sezonu na zawartość wybranych składników mineralnych w sierści krów

Dorota CYGAN-SZCZEGIELNIAK*, Magdalena STANEK, Emilia GIERNATOWSKA, Bogdan JANICKI, Karolina STASIAK and Aleksandra ROŚLEWSKA

Animal Biochemistry & Biotechnology Department; Chair of Biochemistry and Toxicology, University of Science and Technology, Mazowiecka Street 28, 85-084 Bydgoszcz, Poland
*correspondence: cygan@utp.edu.pl

## Abstract

The aim of the research was to analyze the effect of the season and the breeding region on the content of selected minerals (Ca, Mg, Na and K) in the hair of dairy cows. The research material was made up of 114 polish Holstein-Friesians breed cows from three breeding centres in Poland: Kombinat Rolny Sp. z o. o. - Kietrz (the opolskie province), Hodowla Zarodowa Zwierząt Sp. z o.o. - Knyszyn (the podlaskie province) and Ośrodek Hodowli Zarodowej Sp. z o.o. - Osięciny (the kujawsko-pomorskie province). The cows were kept in freestanding cowsheds with den boxes. The animal nutrition involved the use of the TMR system, considering the division into nutrition groups. The hair was sampled in summer and in the period of winter and spring from the side of the body, right behind the coastal arch. Determination of Ca, Mg, Na and K was performed by means of atomic absorption spectrophotometry (AAS). The study revealed seasonal variations in the content of mineral elements in the hair of dry cows and a region-dependent differentiation. The highest content of the quantity elements in question was found in the hair of the cows from Osięciny. The mean concentration of Ca, Mg, Na and K in the hair of cows from Osięciny was statistically significantly higher than in the hair collected in winter from the animals from Knyszyn and Kietrz. The lowest values of the determined elements were noted in the hair of cows bred in Knyszyn. The investigation of the correlation between the amounts of the elements, based on an analysis of all samples of hair, revealed a positive correlation between Na and K cations, as well as between Mg and Ca cations.

**Keywords:** cows, hair, makroelements, region

## Streszczenie

Celem pracy była analiza wpływu sezonu oraz regionu hodowli na zawartość wybranych składników mineralnych (Ca, Mg, Na i K) w sierści mlecznych krów. Materiał do badań pozyskano od 114 krów rasy Holsztyńsko-Fryzyjskiej hodowanych w trzech ośrodkach w Polsce: Kombinat Rolny Sp. z o.o. - Kietrz (województwo opolskie), Hodowla Zarodowa Zwierząt Sp. z o.o. - Knyszyn (województwo podlaskie) and Ośrodek Hodowli Zarodowej Sp. z o.o. - Osięciny (województwo kujawsko-pomorskie). Krowy utrzymywano w oborach wolnostanowiskowych z boksami legowiskowymi. W żywieniu zwierząt stosowano system TMR, z uwzględnieniem podziału na grupy żywieniowe. Sierść pobrano w okresie letnim i zimowo-wiosennym z boku ciała, tuż za łukiem żebrowym. Oznaczenie Ca, Mg, Na i K wykonano przy użyciu spektrofotometru absorpcji atomowej (AAS). Badania wykazały sezonowe różnice w zawartości składników mineralnych w sierści krów zasuszonych i zróżnicowanie zależne od regionu hodowli. Najwyższą zawartość badanych makroelementów stwierdzono w sierści krów z Osięcin. Średnia zawartość Ca, Mg, Na i K w sierści krów z Osięcin była statystycznie istotnie wyższa od ich zawartości w sierści krów pobranej zimą od zwierząt z Knyszyna i Kietrza. Najniższe ilości oznaczanych składników mineralnych stwierdzono w sierści krów pochodzących z hodowli w Knyszynie. Badania współzależności między ilością składników, oparte o analizę wszystkich próbek sierści, wykazały na istnienie dodatniej korelacji między kationami Na i K oraz Mg i Ca.

**Słowa kluczowe:** krowy, makroelementy, region, sierść

## Streszczenie szczegółowe

Celem pracy była analiza wpływu sezonu oraz regionu hodowli na zawartość wybranych składników mineralnych (Ca, Mg, Na i K) w sierści mlecznych krów. Materiał do badań pozyskano od 114 krów rasy Holsztyńsko-Fryzyjskiej hodowanych w trzech ośrodkach w Polsce: Kombinat Rolny Sp. z o. o. - Kietrz (województwo opolskie), Hodowla Zarodowa Zwierząt Sp. z o.o. - Knyszyn (województwo podlaskie) and Ośrodek Hodowli Zarodowej Sp. z o.o. - Osięciny (województwo kujawsko-pomorskie). Kombinat Rolny w Kietrzu znajduje się w województwie opolskim, które pod względem zanieczyszczenia powietrza pyłem zajmuje 12 miejsce w Polsce. Ośrodek Hodowli w Knyszynie znajduje się w województwie podlaskim, w regionie rolniczym z niewielkim przemysłem, na terenie którego znajdują się cztery parki narodowe i trzy parki krajobrazowe. Ośrodek Hodowli Zarodowej w Osięcinach znajduje się w średnio uprzemysłowionym województwie kujawsko-pomorskim, w na terenie którego funkcjonuje przemysł chemiczny, elektromechaniczny, spożywczy, celulozowy. Krowy utrzymywano w oborach wolnostanowiskowych z boksami legowiskowymi. W żywieniu zwierząt stosowano system TMR, z uwzględnieniem podziału na grupy żywieniowe. Ośrodki wyposażono w systemy sterowania ilością zadawanej paszy. Zwierzęta pozostawały pod stałą opieką lekarza weterynarii i w

okresie 4 tygodni poprzedzających pobranie próbek nie wykazywały żadnych objawów chorobowych. Sierść pobrano w dwóch terminach: letnim (od 05 lipca 2005 do 06 września 2005) i zimowo-wiosennym (od 04 stycznia do 09 marca 2006) z boku ciała, tuż za łukiem żebrowym, za pomocą specjalistycznych nożyczek. Próbki wycinano tuż przy skórze z obszaru o wielkości 10 × 10 cm. Do czasu dalszej analizy próbki przechowywano w szczelnie zamkniętych woreczkach polietylenowych w suchym i zacienionym miejscu. Oznaczenie Ca, Mg, Na i K wykonano przy użyciu spektrofotometru absorpcji atomowej (AAS). Badania wykazały sezonowe różnice w zawartości składników mineralnych w sierści krów zasuszonych i zróżnicowanie zależne od regionu hodowli. Najwyższą zawartość badanych makroelementów stwierdzono w sierści krów z Osięcin. Średnia zawartość Ca, Mg, Na i K w sierści krów z Osięcin była statystycznie istotnie wyższa od ich zawartości w sierści krów pobranej zimą od zwierząt z Knyszyna i Kietrza. Badania współzależności między ilością składników, oparte o analizę wszystkich próbek sierści, wykazały na istnienie dodatniej korelacji między kationami Na i K oraz Mg i Ca.

## Introduction

The research performed over the recent years showed that the best method of the body mineral state evaluation is the analysis of minerals in the animal hair (Gabryszuk et al., 2008; Piątkowska-Sokoła et al., 2009). It is a method fully alternative to the blood and urine tests due to the regular accumulation of bioelements in the hair which is excluded from the metabolic processes in the body (Budzyńska et al., 2006). The level of minerals in body fluids is relatively low and it depends considerably on various homeostasis mechanisms as well as on the diet applied (Blad, 1984). Keratin external hair coat ensures the permanence of the chemical composition by preventing from the loss of internal nutrients as well as external pollutions penetrating inside (Dunnett and Lees, 2003; Gratacós-Cubarsí et al., 2006). Bioelements are built into the hair structure during its growth, thanks to the presence of sulfhydryl group -SH of cysteine capable of elements chelatation (Patra et al., 2007). Thanks to it, the concentration of minerals in the hair is higher than in the blood and urine and provides information on their content in the whole body over a longer period (Budzyńska et al., 2006; Patra et al., 2007). Besides, the animal hair gets easily and non-invasively sampled, without hurting, causing pain, transporting and storage (Dunnett and Lees, 2003; Gratacós-Cubarsí et al., 2006). Over the recent years few research were made on the level of minerals in the hair of animals, only getting limited to the assays in milk, meat and internal organs (Cygan-Szczegielniak et al., 2012a; Cygan-Szczegielniak et al., 2012b; Gabryszuk et al., 2008; Szkoda and Żmudzki, 2001). However, the analysis of minerals in the cow hair can facilitate the evaluation of reference values for some minerals and can help ensuring a better animal welfare (Gabryszuk et al., 2008, 2010). The hair of animals can be a good bioindicator of nutrition mistakes being a consequence of inadequate meeting of the mineral requirements of animals as well as soil, water and air pollution (Piątkowska-Sokoła et al., 2009; Szkoda and Żmudzki, 2001; Tymczyna et al., 2000).

The aim of the research was the assessment of the impact of the breeding region as well as the season on the content of the selected elements in the hair of 3-year-old dry cows.

## Materials and methods

The research material involved 114 cows of polish Holstein-Friesians breed during drying-off. The cows were derived from 3 breeding centres in Poland: Kombinat Rolny Sp. z o.o. - Kietrz the opolskie province, Hodowla Zarodowa Zwierząt Sp. z o.o. - Knyszyn the podlaskie province as well as Ośrodek Hodowli Zarodowej Sp. z o.o. - Osięciny the kujawsko-pomorskie province. The animals from all the three breeding centres were kept in freestanding cowsheds with den boxes. The animal nutrition involved the use of the TMR system, considering the division into nutrition groups. The centers were equipped with systems which controlled the amount of feed administered to the animals. The cows remained under a constant supervision of a veterinarian and within the 4 weeks prior to the collection of the samples they showed no signs of any disease.

The Breeding Centre in Kietrz is located in the opolskie province which, in terms of dust air pollutions comes 12$^{th}$ and in terms of gas pollutions – it comes 7$^{th}$ in Poland. The content of toxic metals in soil does not exceed the admissible values Report WIOS, 2007-2010. The Breeding Centre in Knyszyn is located in the podlaskie province; in the agricultural region with little industry. The podlaskie province is one of the least polluted in the country and it offers four national parks and three landscape parks. The land protected by law account for 32% of the area of the province Report WIOS, 2004-2006. Over 2000-2007 the concentration of gas pollutions in those areas remained at low level, not exceeding admissible norms. The Breeding Centre in Osięciny is located in average-industrialised kujawsko-pomorskie province, with chemical, electromechanical, foodstuffs, cellulose and printing industries. The analysis of the air over 2000-2007 demonstrated a decreasing tendency in the concentration of $SO_2$, $NO_2$ and particulates in the province Report WIOS, 2000-2007.

The hair was sampled over two periods: summer from July 5, 2005 to September 6, 2005 and winter-spring covering the period from January 4 to March 9, 2006 from the side of the body, right behind the coastal arch, with specialist scissors. The hair sample was cut out just next to the skin from the area about 10×10 cm in size. Until further analysis the sample was stored in a hermetically closed polyethylene bag in a dry and shaded place. To remove the pollutions and to defatten, the hair samples were accurately washed in acetone and additionally placed in the ultrasound bath for 15 minutes. Then the samples were stored for 12 hours. Having removed acetone through decantation, the hair was rinsed twice with distilled water and dried in the lab drier at the temperature not exceeding 50°C.

The hair prepared that way was wet-mineralized using the microwave Ethos Plus mineralizer Milestone according to Polish Norm PN-EN 13805. To do so, weighed amount of 0.20 g was made and treated with 6.25 cm$^3$ of the mixture of $HNO_3$ 65% and $H_2O_2$ 30% at the volumetric ratio 4:1 v:v. The time of mineralization was 20 minutes. For the first 10 min. temperature was increasing up to 190°C, and then it was kept at the level of 190±5°C. The mineralized samples were transferred quantitatively into volumetric flasks 25 cm$^3$ in volume and filled up with distilled water. The content of minerals in the hair was expressed in g*kg$^{-1}$ and mg*kg$^{-1}$ of dry matter.

Determination of Ca, Mg, Na and K was performed by means of atomic absorption spectrophotometry (AAS) with the use of capillaries 25 cm long and inner diameter of 0.5 cm. The assays were made in the certified laboratory compliant with the methods provided by Chatt & Katz 1979 as well as with Polish Norm PN-EN-13805.

The results of the measurements of some parameters did not meet the assumption of the distribution normality which was shown using the Shapiro-Wilk test and the assumption of homogeneity of variance required when applying parametric statistical tests; and so to investigate significant differences across the groups, non-parametric Kruskal-Wallis test non-parametric ANOVA was used. For the parameters meeting the assumptions of the normality of distribution and the assumption of homogeneity of variance, parametric analysis of variance ANOVA was used. The results were statistically verified using the Statistica 2008 software.

## Results

The Tables 1-3 present the results obtained from the analyses of the content of quantity elements in the hair of cows. The samples were collected in summer and winter from the breeding centers in Kietrz (Table 1.), Knyszyn (Table 2.) and Osięciny (Table 3.). The analyses revealed that in the case of the cows from Knyszyn and Kietrz in the hair which were collected in summer the content of the quantity elements was higher than in the samples that were collected during winter but the differences were not statistically significant for most elements. Statistically important differences between the samples that were collected in summer and in winter occurred in the case of the mean content of sodium in the cows from Knyszyn. As for the hair of the animals from Osięciny, a higher content of the quantity elements was noted in the winter samples, however, the differences were not statistically important.

Table 4. compiles the results of the analyses of the content of quantity elements in the hair collected during summer from the cows in the three breeding centers. The highest mean content of Ca, Na and K was found in the hair of the cows from Osięciny. The lowest concentration of the above elements was marked in the hair of the cows from Kietrz. However, statistically important differences between the content of the quantity elements in the samples from the three breeding centers were noted only in the case of Na.

Table 5. presents the values obtained from the analyses of the mean content of mineral elements in the winter samples from Kietrz, Knyszyn and Osięciny. The concentration of all the marked elements was highest in the cows from Osięciny. The calculations showed that the mean content of Mg, Na and K in the samples from Osięciny was significantly different from the content in the samples from Kietrz and Knyszyn. The lowest concentration of the above elements was found in the case of hair from the cows from Knyszyn. The analysis of correlation proved a positive and statistically important relationships between Mg and Ca ($r_{xy}$ = 0.40, P≤0.05) and between K and Na ($r_{xy}$ = 0.38, P≤0.05) (Table 6.). In Tables 1-5 the mean concentrations of the selected quantity elements (Ca, Mg, Na and K) are presented. In most cases, except for Mg, the highest content of the elements was noted in the hair of the cows from Osięciny.

Table 1. The mean content of macroelements (g*kg$^{-1}$) in the cow hair sampled in summer and winter from the Kietrz breeding centre

Tabela 1. Średnia zawartość makroelementów (g*kg$^{-1}$) w sierści krów pobranej latem i zimą z ośrodka hodowlanego w Kietrzu

| Season | | Macroelements (g* kg$^{-1}$) | | | |
|---|---|---|---|---|---|
| | | Ca | Mg | Na | K |
| Summer | | 2.600 | 0.497 | 1.545 | 3.388 |
| | s | 0.936 | 0.170 | 0.649 | 0.882 |
| Winter | | 2.502 | 0.497 | 1.394 | 3.090 |
| | s | 1.289 | 0.125 | 0.286 | 1.134 |

a, b - means marked with different letters in the same column differ significantly P≤0.05

Table 2. The mean content of macroelements (g* kg$^{-1}$) in the cow hair sampled in summer and winter from the Knyszyn breeding centre

Tabela 2. Średnia zawartość makroelementów (g*kg$^{-1}$) w sierści krów pobranej latem i zimą z ośrodka hodowlanego w Knyszynie

| Season | | Macroelements (g* kg$^{-1}$) | | | |
|---|---|---|---|---|---|
| | | Ca | Mg | Na | K |
| Summer | | 2.944 | 0.483 | 2.703$^{a}$ | 3.478 |
| | s | 1.082 | 0.116 | 0.995 | 1.035 |
| Winter | | 2.656 | 0.483 | 1.233$^{b}$ | 3.025 |
| | s | 0.864 | 0.122 | 0.229 | 1.006 |

a, b - means marked with different letters in the same column differ significantly P≤0.05

Table 3. The mean content of macroelements (g* kg$^{-1}$) in the cow hair sampled in summer and winter from the Osięciny breeding centre

Tabela 3. Średnia zawartość makroelementów (g* kg$^{-1}$) w sierści krów pobranej latem i zimą z ośrodka hodowlanego w Osięcinach

| Season | | Macroelements (g* kg$^{-1}$) | | | |
|---|---|---|---|---|---|
| | | Ca | Mg | Na | K |
| Summer | | 3.677 | 0.421 | 2.754 | 3.732 |
| | s | 1.179 | 0.119 | 0.627 | 0.789 |
| Winter | | 3.763 | 0.523 | 2.972 | 3.098 |
| | s | 1.759 | 0.119 | 1.133 | 1.115 |

a, b - means marked with different letters in the same column differ significantly P≤0.05

Table 4. The mean content of macroelements (g* kg$^{-1}$) in the cow hair sampled in summer from three breeding centres

Tabela 4. Średnia zawartość makroelementów (g* kg$^{-1}$) w sierści krów pobranej latem z trzech ośrodków hodowlanych

| Macroelements (g* kg$^{-1}$) | | Breeding centres | | |
|---|---|---|---|---|
| | | Kietrz | Knyszyn | Osięciny |
| Ca | | 2.600$^{a}$ | 2.944$^{a}$ | 3.677$^{b}$ |
| | s | 0.936 | 1.082 | 1.179 |
| Mg | | 0.497 | 0.483 | 0.421 |
| | s | 0.170 | 0.116 | 0.119 |
| Na | | 1.545$^{a}$ | 2.703$^{b}$ | 2.745$^{b}$ |
| | s | 0.650 | 0.995 | 0.627 |
| K | | 3.388 | 3.478 | 3.732 |
| | s | 0.882 | 1.035 | 0.789 |

a, b - means marked with different letters in the same column differ significantly P≤0.05

Table 5. The mean content of macroelements (g*kg$^{-1}$) in the cow hair sampled in winter from three breeding centres

Tabela 5. Średnia zawartość makroelementów (g*kg$^{-1}$) w sierści krów pobranej zimą z trzech ośrodków hodowlanych

| Macroelements (g* kg$^{-1}$) | | Breeding centres | | |
|---|---|---|---|---|
| | | Kietrz | Knyszyn | Osięciny |
| Ca | | 2.502$^{a}$ | 2.656$^{a}$ | 3.763$^{b}$ |
| | s | 1.289 | 0.864 | 1.759 |
| Mg | | 0.497$^{a}$ | 0.483$^{a}$ | 0.523$^{b}$ |
| | s | 0.125 | 0.122 | 0.119 |
| Na | | 1.394$^{a}$ | 1.233$^{a}$ | 2.972$^{b}$ |
| | s | 0.285 | 0.229 | 1.133 |
| K | | 3.090 | 3.025 | 3.098 |
| | s | 1.134 | 1.006 | 1.115 |

a, b - means marked with different letters in the same column differ significantly P≤0.05

Table 6. Values of Spearman's rank correlation coefficient for selected mineral elements assayed in the cow hair collected from Kietrz, Knyszyn and Osięciny breeding centres

Tabela 6. Wartości współczynnika korelacji Spearmana dla wybranych składników mineralnych oznaczonych w sierści krów pobranej z ośrodka hodowlanego w Kietrzu, Knyszynie i Osięcinach

| | Ca | Mg | Na |
|---|---|---|---|
| Mg | 0.3999* | | |
| Na | 0.2327 | -0.0100 | |
| K | 0.2014 | 0.2029 | 0.3784* |

Correlations marked with (*) are significant at P≤0.05

## Discussion

The content of Ca in the hair of cows ranged from 2.6 to 3.7 g · $kg^{-1}$, depending on the season and the breeding center (Tables 1.-5.).

In the own research the noted concentration of Ca was higher by half from the one reported by Budzyńska et al. (2006) and Krupa and Budzyńska (2011), also obtained from the hair of cows. A 5-fold lower content of Ca (2.36-3.22 g*$kg^{-1}$), depending on the season and breeding region, was observed in the hair of heifers (Cygan-Szczegielniak et al., 2012a). The concentration of this element in the body is mainly affected by its content in food. The evidence for this can be found in the study on the effect of a mineral and herb dietary mix on the content of quantity elements, including calcium, in the hair of goats of white ennobled race from the south-eastern region of Poland. As it can be concluded from this research, adding such mix to the animals' feed results in a considerable increase in the level of this element in the animal body. In the control animals the average concentration of 1.42 g*$kg^{-1}$ of calcium was noted, while after 10 weeks of supplementing the diet of the experimental individuals with the mineral and vitamin mix, the content of calcium in the animals' hair rose to 1.57 g*$kg^{-1}$ (Bis – Wencel, 2003) and the difference was statistically significant.

The content of Mg in the hair of cows ranged from 4.2 to 5.2 g*$kg^{-1}$, depending on the season and the breeding center (Tables 1.-5.). In the research by Cygan-Szczegielniak et al. (2012a) a similar content of Mg was marked in the hair of heifers, depending on the breeding region and season. For contrast, in the hair of bison the content of Mg was 50-times lower comparing to the own results, i.e. 0.097 g*$kg^{-1}$ (Kośla et al., 2011). Other authors investigating the concentration of Mg in the hair of cows also obtained values which were significantly lower, even 30-fold, i.e. 0.015 g*$kg^{-1}$ to 0.063 g*$kg^{-1}$ (Saba et al., 1992; Budzyńska et al., 2006; Gabryszuk et al., 2010; Krupa and Budzyńska, 2011). The study by Wolańczyk-Rutkowiak (1977) indicates that the season, (and in effect – the kind of feed and the supplementations to it) affects the distribution of this element in the organism. In the own research the level of Mg was found slightly higher in winter. It can be justified by the different diet depending on the season. Summer high-protein and low in raw fiber diet can result in some disorders to the absorption of Mg in cows (Wolańczyk-Rutkowiak, 1977), which may explain such tendency.

Another important quantity element under the presented research was Na, and its content in the hair of cows ranged from 1.2 to 2.9 g*$kg^{-1}$, depending on the season and the region of breeding (Tables 1-5). Similar concentration of this element was found in the hair of heifers, i.e. from 0.99 g*$kg^{-1}$ to 3.37 g*$kg^{-1}$ (Cygan-Szczegielniak, et al., 2012a). In the research by other authors the content of Na in the hair of cows ranged from 0.37 g*$kg^{-1}$ to 2.57 g*$kg^{-1}$ (Budzyńska et al., 2006; Gabryszuk et al., 2010; Krupa and Budzyńska, 2011). The concentration of Na in animal hair within the species is usually comparable. It is well illustrated by the results of the studies on the pure blood Arabian mares, with consideration of genealogical lines (Krupa et al., 2006). Both in the individuals descending from the male and female lines the mean content of sodium in the hair was 0.22 g*$kg^{-1}$. For comparison, in a gelding from the stud farm in Janowo Podlaskie the obtained mean value was slightly lower than in the own research, i.e. 0.89 g*$kg^{-}$1 (Budzyński and Truchliński, 2004).

Na and K are elements which are closely connected with each other in the bodies of living organisms. Their proper ratio is essential for sustaining the acid-base balance and water-electrolyte homeostasis in the organism (Hatta et al., 2002). The content of K in the hair of cows stayed within the range of 3.0 to 3.7 $g*kg^{-1}$, depending on the season and the breeding center (Tables 1.-5.). In the gelding from the stud farm in Janowo Podlaskie the content of K potassium in the hair was 0.75 $g*kg^{-1}$ (Budzyński and Truchliński, 2004). The content of K in the body can be influenced by the concentration of Ca. Basing on the results presented by Krupa et al. (2006) some tendency can be observed, i.e. along with the lowering content of Ca calcium in the hair of mares, the concentration of potassium also decreased and its mean value was 0.09 $g*kg^{-1}$. Analogous dependence was noted in the own research as well. Similar concentration of K was noted in the hair of heifers (Cygan-Szczegielniak et al., 2012a). The research by Anke and Risch (1979) demonstrated that the content of K in the hair can also be associated with their color. In the black hair the content of K was 1.35 $g*kg^{-1}$, while in the red ones it was half as high (0.78 $g*kg^{-1}$). The studies conducted by other authors (Budzyńska et al., 2006; Gabryszuk et al., 2010; Krupa and Budzyńska, 2011) show that the concentration of K in the hair of cows ranges from 0.75 $g*kg^{-1}$ to 1.30 $g*kg^{-1}$.

The analyses of the content of mineral elements in the hair of heifer from Kietrz, Knyszyn and Osięciny (Cygan-Szczegielniak et al. 2012a) showed numerous positive and statistically significant correlations between them. The highest correlation coefficients ($r_{xy}$) were obtained for Na-K ($r_{xy}$=0.59), Ca-Mg ($r_{xy}$=0.56) and Mg-Mn ($r_{xy}$=0.53). Similar relationships between the elements in the hair of dairy cows are reported by Budzyńska et al. (2006). In the own research also a positive, but not statistically important correlation coefficient was found between Na and K ($r_{xy}$=0.39). As it was already mentioned, Na and K are tightly connected with each other and together they play vital roles in the bodies of living organisms (Hatta, 2002). Chłopicka (2003) in her research on human hair noted a positive and statistically significant correlation between the content of Ca and Mg ($r_{xy}$ = 0.50, P≤0.0001). Morita, et al. (1986) presented similar correlation coefficient for the content of Ca and Mg in human hair ($r_{xy}$ = 0.85, P≤0.001). In living organisms these two elements act antagonistically to each other. A deficit of Mg stimulates secretion of parathyroid hormone, and in effect, it launches the release of Ca from the bones so that its level in blood rises. Ca and Mg are mostly stored in the deposit tissues, i.e. bones and teeth. Their strong correlation in the hair or fur may reflect the homeostasis they maintain in the individual. On the other hand, this correlation may also stem from the chemical alikeness of those two elements, which belong to the same group within the periodic table.

In the analysis of the hair of cows from Knyszyn, Kietrz and Osięciny positive correlation coefficients were found for the relationships between Ca and Mg and between Na and K (Table 6.). The research by Budzyńska et al. (2006) did not confirm the above correlations. In their experiments a negative correlation between the ions of K and Ca was found ($r_{xy}$ = -0.471, P≤0.01) and no statistically significant correlations between the ions of Na and Ca were observed.

## Conclusion

In conclusion, the time and range of the inclusion of mineral elements to the metabolic pool is varied in the living organisms. It is dependant on the level of pollution of environment they live in and the kind of diet. Thereby, it should be emphasized that there is a clear variation in the content of mineral elements in the hair of the animals under the investigation, which can be a result of a higher concentration of these elements in the environment. The above research confirms the thesis that hair can serve as a useful tool for assessment of the mineral profile in cows and determining the reference values of the selected elements.

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