Technology of predicting the productivity of the animals

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Abstract. The purpose of this study was to identify and evaluate cows with the “loaded metabolism” phenomenon. This study was performed on cows of black-and-white breed with a live weight of 620.3 ± 15.3 kg, aged 4–6 years. For the study, depending on the concentration of manganese in the fur, animals were divided into three groups: I – up to the 25th percentile, II – within the 25–75th centile interval, III – above the 75th percentile, calculated separately for each micropopulation. Cows showed an increase in chemical elements in the wool, depending on the percentile range of manganese concentration in the wool. Thus, with a high content of manganese, an increased content of macronutrients – calcium, sodium, and magnesium – was also observed. The results of an elemental analysis of the wool of black-and-white cows showed that the group of animals with a “loaded metabolism” also contains a higher content of almost all the elements studied.

1. Introduction

Present-day milk production is impossible without continuous monitoring of the health status of dairy cows [1, 2], including mineral metabolism. The importance of evaluating mineral metabolism is determined by the role of chemical elements in the work of enzymes [3], hormones [4, 5], as complexing agents or activators of metabolism [6], the functioning of the immune system [7–10], and the implementation of mechanisms of the antioxidant status of the body [11]. In this regard, the assessment of the elemental status of dairy cows according to the list of elements provides comprehensive information on the state of metabolism.

Manganese takes part in protein synthesis, metabolism in the body, the formation of connective tissue and the functioning of the immune system, affects the development and normal function of the genital organs, the fertility of animals and the viability of offspring [12]. In addition, it is present in many metal enzymes involved in the antioxidant process [13]. Thus, manganese is an essential nutrient for dairy cows, acting mainly as a coenzyme in biological processes [14]. However, on the other hand, manganese also has a toxic effect at high concentrations [15].

Despite the fact that the mechanism of interaction of trace elements has not yet been studied enough, it is still known that their exchange is closely related. An obvious deficiency or excess of any element entails changes in the exchange of other mineral substances due to the presence of synergism or antagonism between the elements. In this regard, there is a need for knowledge of the laws of metabolism and interaction of minerals in the body of animals.
2. Materials and methods
Experimental studies were conducted in the Vologda region on models of black-and-white cattle with a live weight of 620.3±15.3 kg, aged 4–6 years. Cows were in the same conditions of feeding and maintenance, which was carried out according to the accepted on the farm rations, compiled taking into account live weight and physiological condition [16]. The studies were carried out using methods regulated by order of the Ministry of Agriculture of Russia No. 25 of February 1, 2011. "Rules of keeping records in pedigree cattle breeding of dairy and dairy-meat directions of productivity" (http://www.rg.ru/2011/02/03/uchet-skotovod-site-dok.html), and regulatory documents (ICAR) (http://www.icar.org).

The study on animals of cattle was aimed at identifying and evaluating cows with the phenomenon of "loaded metabolism".

Wool sampling was carried out, followed by a study of the elemental composition. According to the research results, reference and centile ranges of concentrations of chemical elements in the wool of cows were established. Hair samples weighing at least 0.4 g were taken from the upper part of the withers of animals according to a previously developed technique [17]. For sampling, stainless steel scissors pretreated with ethyl alcohol were used.

The elemental composition of biosubstrates was studied by 25 indicators (Al, As, B, Ca, Cd, Co, Cr, Cu, Fe, Hg, I, K, Li, Mg, Mn, Na, Ni, P, Pb, Se, Si, Sn, Sr, V, Zn) using mass spectrometry (MS-ICP) and inductively coupled plasma atomic emission spectrometry (ICP-AES) and Optima 2000 DV and Nexion 300 D nuclear power plants (Perkin Elmer, USA).

VACUETTE tubes with a coagulation activator and gel for erythrocyte mass separation (Greiner Bio-One International AG, Austria) were used for blood sampling.

Cows were mechanically milked three times a day at 06.00, 14.00 and 22.00 hours. The milk produced was weighed individually from each cow daily for three consecutive days. Raw milk samples were taken individually from each cow three times a day at each milking and placed in sterile bottles, cooled (up to 5 °C) and sent to the laboratory for analysis. The fat and protein content in milk was evaluated using the FIL-IDF procedure on a MilkoScan™ FT1 instrument (Foss Electric, DK-3400, Hillerød, Denmark).

Depending on the concentration of manganese in the wool, the animals were divided into three groups: group I – up to the 25th percentile, II – within the limits of the 25–75th centile interval, III – above the 75th percentile, calculated separately for each micropopulation. The choice of centile intervals was based on previously performed work for humans [18] and cattle [19]. To exclude the influence of biogeochemical features of the territory of the location of farms and alimentary factors of keeping animals, the calculation of centile intervals was carried out separately for each farm. After dividing the animals into groups according to this principle, a comparison was made of the content of chemical elements in the wool of black-motley cows.

Processing of the obtained data was carried out using methods of variation statistics using the statistical package “StatSoft STATISTICA 10”. Storage of the research results and primary processing of the material was carried out in the original Microsoft Excel 2010 database. Verification of the compliance of the obtained data with the normal distribution law was carried out using the Kolmogorov consent criterion. The hypothesis that the data belong to the normal distribution was rejected in all cases with a probability of 95 %, which justified the use of nonparametric procedures for processing statistical aggregates (Mann-Whitney U-test). The data obtained are presented as the median (Me) and the 25–75th quartile (Q25–Q75).

3. Results
The manganese content in the coat of animals of group I was 2 mg/kg, which was 1.8 times less than group II and 8.5 times less than group III (Figure 1). The range of Mn concentrations in the wool of group I cows was from 1.4 to 2.3 mg/kg, II from 3.1 to 4 mg/kg, and group III from 15.2 to 20.6 mg/kg.
Figure 1. Relative values of the content of chemical elements in the wool of black-and-white cows of the Vologda depending on the percentile range of Mn concentration in wool: X axis (0) – level of elements in group II. The significance of differences in indicators with group II: * – (p <0.05); ** – (p <0.01)

In group I with the lowest manganese content, a significantly lower content of a number of elements was observed relative to group II: Pb by 42 % (p <0.01), Al by 47 % (p <0.01), Ca by 40 % (p < 0.05), Fe by 68 % (p <0.01), Hg by 18 % (p <0.01), I by 24 % (p <0.05), Mg by 42 % (p <0.05), Ni by 38 % (p <0.05), P by 14 % (p <0.05), Sr by 54 % (p <0.05) and V by 50 % (p <0.05). In group III with the highest manganese content in the wool, a significantly higher content of the following elements was revealed: Al by 654 % (p <0.01), Ca by 199 % (p <0.05), Co by 175 % (p <0.05), Li by 39 % (p <0.05), Mg by 206 % (p <0.01), Na by 35 % (p <0.05), Ni by 309 % (p <0.01), Sr by 338 % (p <0.05) and V by 124 % (p <0.05).

There are also differences in the content of chemical elements in the blood serum of black-and-white cows, depending on the percentile range of Mn concentration in wool. In group I with the lowest manganese content in the coat, a lower content of a number of other elements in the blood was also noted relative to group II: Ca by 3.6 % (p <0.05), K by 10.3 % (p <0.05) Mg by 7.4 % (p <0.05), I by 27.8 % (p <0.05), Si by 13.7 % (p <0.05), Sr by 8.4 % (p <0.05). In group III with the highest manganese content in wool, a significantly lower Mg content was noted at 14.8 % (p <0.05), Se at 37.5 % (p <0.05), V at 11.6 % (p <0.05), Sr by 21 % (p <0.05) in blood serum relative to group II.

Table 1. Indicators of the quantity and quality of milk depending on the percentile interval of Mn concentration in the hair from the withers of cows of the black-and-white breed "Vologda", Me(Q25–Q75)

| Indicator              | Group (range of Mn concentration in wool, mg/kg) | Group I 2 (1.4–2.3) | Group II 3.7 (3.1–4) | Group III 17 (15.2–20.6) |
|-----------------------|--------------------------------------------------|---------------------|----------------------|--------------------------|
| Milk yield for the last month, L | 1174 (1113.7–1335.7) | 1148 (1054–1250) | 993.5 (980.2–1006.7) |
| Average-per-day, L    | 39.1 (37.1–44.5) | 38.3 (35.1–41.6) | 33.1 (32.6–33.5) |
| Fat, %                | 3.52 (3.49–3.71) | 3.57 (3.45–3.64) | 3.5 (3.47–3.57) |
| Protein, %            | 3.3 (3.28–3.34) | 3.37 (3.31–3.43) | 3.3 (3.2–3.34) |
| Fat, kg               | 4.2 (4.1–4.6) | 4.13 (3.59–4.49) | 3.5 (3.4–3.6) |
| Protein, kg           | 3.8 (3.6–4.47) | 3.9 (3.43–4.17) | 3.3 (3.2–3.33) |

Note: the reliability of differences between indicators with group II: * – (p <0.05); ** – (p <0.01); *** – (p <0.001)
In terms of the milk productivity of cows, depending on the percentile interval of the concentration of manganese in the wool in all experimental groups, no differences were found between the content of fat and protein in milk in the groups differing in the amount of manganese in the wool (table 1).

There was a decrease in average daily milk yield in group III by 6 l or 15.3 % relative to group I and by 5.2 l or 13 % relative to group II. However, this trend is not reliable.

4. Discussion
Wool is increasingly being considered among biosubstrates, being readily available biological material; its selection is simple, painless, it can be stored for a long time and is suitable for mass screening examinations. The advantage of wool research is also determined by the close relationship between the concentration of trace elements in wool and blood of dairy cows [19–21] and the information content of cow wool as a long-term parameter for assessing the state of mineral metabolism. The diagnostic significance of a blood test as a biosubstrate is much lower, but a comparative analysis of the microelement composition of wool and blood adequately reflects the physiological state of the body and is in correct agreement with each other [22].

The different levels of manganese in cattle wool, as an assessment of elemental status, reliably reflects the biochemical processes taking place in the body. Thus, the manganese content in the hair of the test animals indicates a sufficient supply of chemical elements to their body, namely, in the group with a high content of manganese in the wool, an increased content of macroelements such as calcium, sodium and magnesium was also observed.

Previous studies have shown the possibility of using indicators of the content of toxic chemical elements in cattle wool as an indicator of monitoring the health of highly productive cattle against the background of the absence of pronounced toxic effects, which is confirmed by our study, namely, there is a direct correlation between the increase in the chemical elements of animal hair depending from the percentile interval of the concentration of manganese in wool [23]. The use of elemental analysis of hair to interpret the obtained data is possible only after comparing them with the reference values of the content of chemical elements in human hair [24, 25].

In experimental studies, it was found that high consumption of manganese (200 ppm) caused a relatively small number of changes in lipids in tissues, while very high consumption (1000 ppm) significantly increased the classes of plasma lipids and, apparently, interfered with the metabolism of major fatty acids in the liver, which in turn affected the indicators of milk productivity [26].

5. Conclusion
Summing up the results of the elemental analysis of the wool of black-and-white cows, we can conclude that the group of animals with the maximum content of manganese in the wool contains a higher content of almost all the studied elements.

Acknowledgments
The studies were carried out in accordance with the research plan for 2019-2020 of the Federal Research Center of Biological Systems and Agrotechnologies RAS No. 0526-2019-0001.

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