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ВЛИЯНИЕ ЭКОЛОГО-ГЕОГРАФИЧЕСКОГО ФАКТОРА НА СОДЕРЖАНИЕ ТЯЖЕЛЫХ МЕТАЛЛОВ В ЛЕГКИХ ГЕРЕФОРДСКОГО СКОТА

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Изучена проблема загрязнения пищи тяжелыми металлами из-за накопления их в биосистемах вследствие антропогенных воздействий. Представлены результаты исследования содержания кадмия, свинца, железа и марганца у крупного рогатого скота из Новосибирской области и Алтайского края. Цель исследования – оценить влияние эколого-географического фактора на содержание тяжелых металлов в легких бычков герефордской породы. Пробы легких взяты от 31 клинически здорового бычка герефордской породы в возрасте 16–18 мес. Пробоподготовка осуществлена в соответствии с ГОСТами 26929–94 и 30178–96. Определение химического состава проб проведено методом атомно-абсорбционной спектрометрии с пламенной и электротермической атомизацией. Медианные значения по содержанию кадмия, свинца, железа и марганца в легких бычков находились в диапазоне 0,01–0,12; 0,07–0,11; 70,9–89,1 и 0,3–0,4 мг/кг соответственно. Фенотипическая изменчивость уровня железа и марганца отмечена относительно низкой, свинца и кадмия – высокой. Дисперсии уровней свинца и кадмия в изученных группах животных зарегистрированы гомогенными, марганца и железа варианты были разнородными. Влияние эколого-географического фактора характерно только для уровня кадмия. Для марганца, железа, свинца и кадмия рассчитаны референтные интервалы: 0–1,12; 0–148,1 и 0–0,170 мг/кг соответственно. Они могут служить ориентировочной нормой для скота герефордской породы, разводимого на территориях Краснозерского, Новосибирского, Маслянинского районов Новосибирской области и Целинного района Алтайского края.

Ключевые слова: герефордская порода, легкие, тяжелые металлы, кадмий, свинец, экология

INFLUENCE OF ENVIRONMENTAL AND GEOGRAPHICAL FACTOR ON THE HEAVY METAL CONTENT IN THE LUNGS OF HEREFORD CATTLE

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The problem of food contamination by heavy metals due to their accumulation in biosystems as a result of anthropogenic influences has been studied. The results of cadmium, lead, iron and manganese in cattle from the Novosibirsk Region and the Altai Territory are presented. The purpose of the study was to assess the impact of the ecological and geographical factor on the heavy metal content in the lungs of Hereford bulls. Lung samples were taken from 31 clinically healthy Hereford bulls aged 16-18 months. Sample preparation was carried out in accordance with GOST 26929-94 and 30178-96. The chemical composition of the samples was determined by atomic absorption spectrometry with flame and electrothermal atomization. The median values of the content of cadmium, lead, iron and manganese in the lungs of bull-calf were in the range of 0,01-0,12; 0,07-0,11; 70,9-89,1 and 0,3-0,4 mg/kg. The phenotypic variability of the level of iron and manganese was relatively low, while that of lead and cadmium was high. The dispersions of lead and cadmium levels in the animal groups studied were homogeneous, manganese and iron variants were heterogeneous. The influence of the ecological and geographical factor is characteristic only for cadmium levels. For manganese, iron, lead and cadmium the calculated reference ranges

are: 0-1.12; 0-148.1 and 0-0.170 mg/kg respectively. They can serve as a guideline for Hereford cattle bred in the territories of Krasnozersky, Novosibirsky and Maslyaninsky districts of the Novosibirsk region and the Tselinny district of the Altai Territory.

Keywords: Hereford breed, lungs, heavy metals, cadmium, lead, ecology

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Conflict of interest
The author declares no conflict of interest.

INTRODUCTION

Livestock products are an important part of the human diet. In addition to their high protein and low carbohydrate content, meat products are rich in bioavailable essential micronutrients, amino acids and vitamins [1, 2]. Unlike other products, meat and by-products can accumulate large amounts of toxic elements [3-5]. The concentration of heavy metals in meat and by-products depends on the livestock production system [6]. In intensified livestock production, trace elements are supplied to the animals mainly in the form of premixes, which are added to concentrated feed. In addition, the mineral intake of livestock depends on the local environmental conditions [7-9]. Soil is an important source of trace elements, which are passed on to plants and through the food chain to animals and humans [10, 11]. Control of the concentration of toxic and essential trace elements in animal organs is necessary when raising livestock on large complexes [4, 12, 13]. This is necessary to ensure that heavy metals in food do not exceed the maximum levels established for human consumption. The results of the research are used to provide a balanced diet for animals in order to increase productivity and increase economically useful use [14]. Data on the content of heavy metals in animal organs and tissues provide important information on environmental pollution (natural or anthropogenic origin) and can be used to minimize the environmental impact of animal production [15, 16].

The purpose of the study was to assess the influence of the ecological and geographical factor on the content of heavy metals and to determine the reference intervals in the lungs of Hereford breed steers.

MATERIAL AND METHODS

Lung samples were taken from 31 Hereford steers aged 16-18 months bred in the Novosibirsk Region and the Altai Territory. The animals were bred in four districts: Krasnozersky (n = 4), Novosibirsky (n = 6), Maslyaninsky (n = 17) and Tselinniy (n = 4). The animals had no history of disease and were clinically healthy at the time of slaughter. Sampling was carried out after slaughter, followed by freezing and storage at -24°C until analysis.

The chemical composition of lung tissues was determined by atomic absorption spectrometry with flame (Mn, Fe) and electrothermal (Cd, Pb) atomization on a Shimadzu AA-7000 spectrometer in the biochemical laboratory of the Siberian Research Institute of Animal Husbandry of the Siberian Federal Scientific Center of AgroBioTechnologies of the Russian Academy of Sciences. Sample preparation was carried out in accordance with GOST 26929-94 and 30178-96.

Due to the small sample size in the groups, we calculated robust measures of descriptive statistics: median (Me), first and third quartiles (Q1, Q3), interquartile range (IQR), minimum and maximum values of the variable (Min, Max). Homogeneity of variance was assessed

using the Fliegner-Keelin test. To identify differences between districts in the concentration of heavy metals in the lungs of bulls, the Kraskell-Wallisle test was applied [17]. A posteriori analysis was performed using Dunn's test [18] with Hill's correction [19]. Reference intervals were calculated on the basis of the American Veterinary Clinical Society's Quality Assurance and Laboratory Standards Manual [20], taking into account the Clinical and Laboratory Standards Institute (CLSI) expert protocols[1]. Statistical processing of raw data was performed using the statistical programming language R and the data analysis environment RStudio, version 1.2.5033.

RESULTS AND DISCUSSION

Descriptive statistics on the content of heavy metals in the lungs of Hereford cattle, taking into account the breeding area, are shown in Table 1. Significant variability in iron and manganese levels was observed in cattle in the Maslyaninsky district. Intergroup phenotypic variability in cadmium levels was recorded as relatively low and in lead levels as high. Cadmium and lead concentrations in lung tissue of animals were generally comparable.

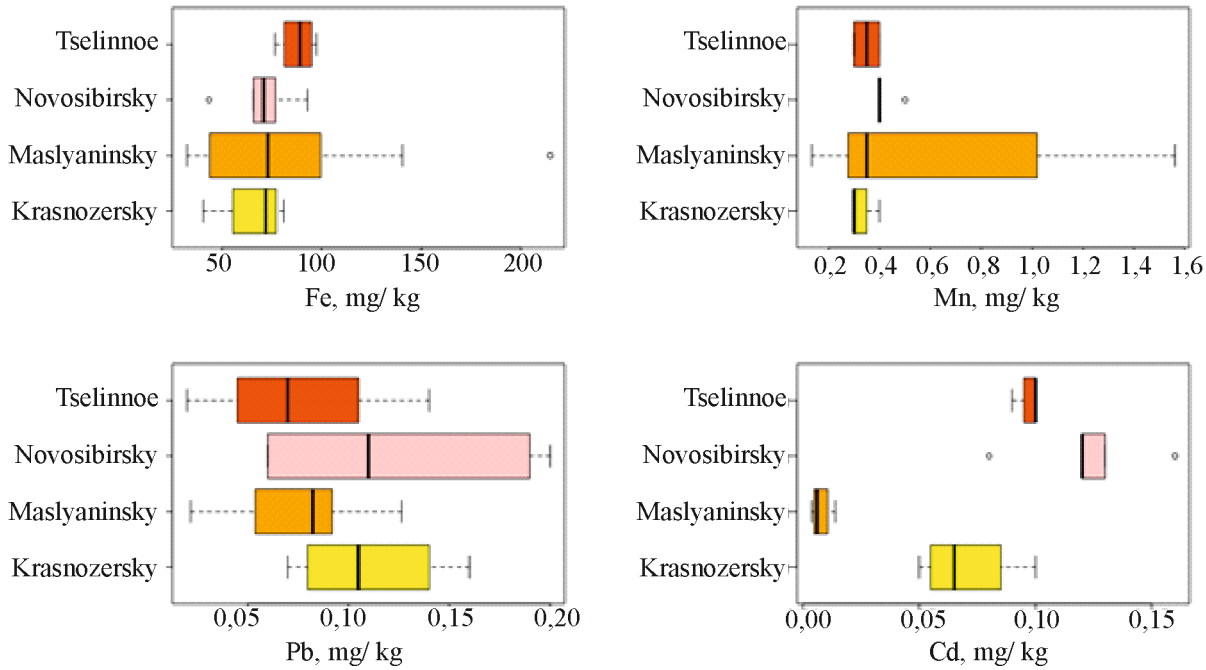
Concentrations of heavy metals were recorded fairly uniform across the studied areas (see the figure). Only cadmium level had rather high inter-group variability. Thus, cadmium level in Maslyaninsky district was more than 10 times lower relative to other districts. Concentration of heavy metals in cattle lungs is currently understudied. This is probably due to the fact that the levels of many trace elements are not normalized in the lungs. In addition, the lungs are not a widely consumed organ. Nevertheless, there are papers that have studied the accumulation of heavy metals in the lungs of animals.

Lead figures in similar studies [21-23] were 2-8 times higher than in our work. The minimum level of lead (0.004 mg/kg) was found in lung samples from calves reared on farms in Italy. Such a significant difference between our studies and those cited can only be explained by the early age of the animals from which the samples were taken [24]. Apparently, lead accumulates significantly with age and the difference between young and mature animals may

Табл. 1. Содержание ТМ в легких быков герефордской породы, мг/кг
Table 1. The content of heavy metals in the lungs of Hereford bulls, mg/kg

Factor	District	Me	Min	Max	Q_1	Q_3	IQR
Fe	Krasnozersky	71,9	40,6	81	53	77,9	24,9
Fe	Maslyaninsky	73	32,4	214,7	42,2	104	61,8
Fe	Novosibirsky	70,9	43,6	93,1	64	78,3	14,4
Fe	Tselinny	89,1	76,7	97,4	80,5	95,3	14,7
Mn	Krasnozersky	0,3	0,3	0,4	0,3	0,36	0,06
Mn	Maslyaninsky	0,35	0,13	1,56	0,27	1,03	0,76
Mn	Novosibirsky	0,4	0,4	0,5	0,4	0,41	0,01
Mn	Tselinny	0,35	0,3	0,4	0,3	0,4	0,1
Pb	Krasnozersky	0,11	0,07	0,16	0,08	0,14	0,07
Pb	Maslyaninsky	0,08	0,02	0,13	0,05	0,09	0,04
Pb	Novosibirsky	0,11	0,06	0,2	0,06	0,19	0,13
Pb	Tselinny	0,07	0,02	0,14	0,04	0,11	0,07
Cd	Krasnozersky	0,07	0,05	0,1	0,05	0,09	0,03
Cd	Maslyaninsky	0,01	0,004	0,014	0,005	0,01	0,005
Cd	Novosibirsky	0,12	0,08	0,16	0,11	0,14	0,03
Cd	Tselinny	0,1	0,09	0,1	0,09	0,1	0,01

[1]Defining, establishing, and verifying reference intervals in the clinical laboratory – 3th ed. CLSI Document C28-A3c. Approved guideline – Wayne, Pa, USA: CLSI, 2010. 59 p.



Содержание тяжелых металлов в легких герефордского скота по районам разведения
The content of heavy metals in the lungs of Hereford cattle by breeding area

be significant. Cadmium levels in our work are comparable with those of previously studied cattle lung samples [22]. A.A. Farmer and A.M. Farmer [23] showed that the concentration of this element in cattle lungs can vary in a wide range from 0.02 to 0.33 mg/kg depending on the breeding area. In our work, cadmium also showed the highest intergroup variability depending on breeding area. A single-factor analysis of variance had to be performed to identify the influence of the ecological and geographical factor. The raw data were checked to ensure that the conditions of the analysis were fulfilled. The null hypothesis of homoscedasticity of variance for manganese and iron concentrations can be rejected from the Fliegner-Keelin test (see Table 2). The intergroup variances of cadmium and lead pollutants were homogeneous. It is not possible to assess the distribution of traits for a Gaussian fit due to the small number of some groups. Therefore, it was decided to use the Kruskal-Wallis test. As a result, only in cadmium levels in the lungs of steers was a significant influence of the factor studied, in all other cases the differences were random (see Table 3).

A posteriori analysis showed that animals bred in Maslyaninsky district differed significantly in cadmium levels in lungs from cattle from other districts of the Novosibirsk Region and the Altai Territory (see Table 4). It is possible that these differences are caused by significant variability of cadmium, which is typical for homogeneous populations of cattle[2] and limited sampling from districts. It is necessary to continue monitoring cadmium levels in cattle and to identify individual factors that influence its variability.

Табл. 2. Оценка гомоскедастичности дисперсий тяжелых металлов в легких скота методом Флигнера-Килина

Table 2. Evaluation of the homoscedasticity of dispersions of heavy metals in cattle lungs by the Fligner-Kilin method

HM	χ^2	*df*	*p*
Cadmium	6,9092	3	0,07485
Lead	4,1719	3	0,2435
Iron	9,0672	3	0,02841
Manganese	12,429	3	0,00605

As a result of the experiment, the concentration of lead, iron and manganese was found to be homogeneous in the populations of cattle in the areas studied. Consequently, it is possible to combine the animals into one group and calculate the reference intervals. Data on the reference intervals for heavy metal concentrations in the lungs of Hereford cattle are presented in Table 5.

The reference values for lead levels were lower by a factor of 3 in the lower interval than those suggested by R. Puls [25]. Such differences may indicate a high variability of lead in different cattle populations, moreover, in the study of R. Puls [25] did not specify the breeding location, breed, age and sex of the cattle. These factors should be taken into account when developing regional standards for the content of heavy metals in animal organs and tissues.

Табл. 3. Влияние фактора районирования на уровень тяжелых металлов в легких животных герефордской породы

Table 3. The influence of the zoning factor on the level of heavy metals in the lungs of Hereford breed animals

Variables	*H*	*df*	*p*
Cadmium-District	21,513	3	0,0001
Lead- District	4,6744	3	0,1972
Iron- District	2,2547	3	0,5213
Manganese-District	3,3696	3	0,3381

CONCLUSION

In the course of the study a significant influence of the ecological and geographical factor on the cadmium content in the lungs of Hereford cattle has been established. In Maslyaninsky district the level of cadmium in Hereford cattle is 7-12 times lower than in Novosibirsk, Krasnozersky and Tselinnoe districts. No differences were found between the indicators of iron, manganese and lead content in the lungs of animals of the studied districts. Phenotypic variability of cadmium level in lungs is much higher than that of other heavy metals. The obtained reference values of iron, manganese and lead content in lungs can serve as a conventional norm for Hereford cattle bred in the territories of Krasnozersky, Novosibirsky, Maslyaninsky districts of the Novosibirsk region and Tselinnoe district of the Altai territory.

Табл. 4. Межгрупповое сравнение районов по содержанию кадмия в легких герефордского скота

Table 4. Intergroup comparison of areas by the content of cadmium in the lungs of Hereford cattle

District	Factor	Krasnozersky	Maslyaninsky	Novosibirsky
Maslyaninsky	Z p	2,379008 0,0347	–	–
Novosibirsky	Z p	–1,042339 0,4459	–3,973060 0,0002	–
Tselinny	Z p	–0,474417 0,6352	–2,689774 0,0179	0,461292 0,3223

Note. Z - criterion; p - level of significance including Holm correction.

Табл. 5. Референтные интервалы с 90%-ми доверительными интервалами (ДИ) для содержания тяжелых металлов в легких герефодского скота, мг/кг

Table 5. Reference intervals with 90% confidence intervals (CI) for the content of heavy metals in the lungs of Herefod cattle, mg/kg

Factor	Reference interval	Lower limit 90% CI	Top limit 90% CI
Mn	0–1,12	0–0	0,879–1,421
Fe	0–148,1	0–18,59	124,0–190,8
Pb	0–0,170	0–0,009	0,145–0,204

[2]Petukhov V.L., Syso A.I., Narozhnykh K.N., Konovalova T.V., Korotkevich O.S., Sebezhko O.I., Kamaldinov E.V., Osadchuk L.V., Soloshenko V.A., Myadelets M.A., Titova T.V., Tsygankova A.R., Saprykin A.I. Cadmium level in soil, coarse fodder, organs and tissue of cattle West Siberia // 18th International Conference on Heavy Metals in the Environment: Proceeding of Abstract, 12-15 September 2016. Ghent, Belgium, 2016. S10-P07.

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