UDC 636.084/085:636.2

Accumulation of Pb and Cd in the muscle tissue and liver of calves during their feeding with different silages

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Goal. To assess the effect of feeding calves with silage from a 4-component mixture of spring legumes (oats + field peas + lupine + vetch) compared to silage from Echinochloa frumentacea on the level of Pb and Cd accumulation in their muscle tissue and liver. **Methods.** 2 groups of experimental calves were formed: Group I (control) — fed with leguminous silage; Group II (experimental) — received experimental silage from Echinochloa frumentacea. Preparation of samples of plant and animal origin for the establishment of heavy metals in their composition was carried out by the method of dry mineralization, analysis — on the atomic absorption spectrophotometer "Kvant-2A». **Results.** The concentration of heavy metals in the feeds of the diets of experimental animals was determined. It was found that the presence of Pb and Cd in feed led to their accumulation in the longest muscle of the back and liver of calves. Feeding young cattle with different silage affected the accumulation of heavy metals in the products. The concentration of Pb and Cd in the longest muscle of the back and liver of calves was found to be lower than the maximum allowable concentration. **Conclusions.** Replacement in the rations of multicomponent silage from legumes (oats + field peas + lupine + vetch) for silage from Echinochloa frumentacea for fattening calves in the III-rd zone of radioactive contamination hurt the environmental quality of products, increasing the content of heavy metals in a muscle on 5 4 – 33.3%. At the same time, the rate of transition of Cd to the longest back muscle was lower by 0.68% abs. in young animals of the II-nd (experimental) group in comparison with the control.

Key words: *animal organism, leguminous silage, Echinochloa frumentacea silage, products.*
DOI: https://doi.org/10.31073/agrovisnyk202105-05

The analysis of the ecological situation in Ukraine shows that the pollution of the environment with heavy metals has increased several times in recent decades and is projected to continue to grow [1-3]. Negative ecological changes in agroecosystems are exacerbated by violations of norms and rules of application of mineral fertilizers and pesticides. Anthropogenic impact on agroecosystems around industrial cities, including through the intensification of traditional agriculture, unfortunately, is increasing in different countries [4]. A great danger in the modern ecosystem is the contamination of soils by such elements as Pb, Cd, Cu, Zn [5-7].

The ingress of heavy metals into the soil can lead to the accumulation of undesirable concentrations for agricultural land, jeopardize fertility. The transfer of pollutants such as Pb and Cd from the soil to plants used for food animals and can be included in any diet that can complicate the production of quality livestock products, and hence raw materials for food production [8, 9]. Plants are able to accumulate heavy metals from the soil in large quantities [10].

Food contaminated with even a small concentration of heavy metals can cause subclinical poisoning of animals. It was proved that the content of Pb and Cd in the internal organs and muscles of animals when using feed from industrialized regions was several times higher than in animals from ecologically clean areas. According to the literature, it is known that feed is the main source of intake of heavy metals and can reach up to 99% of their total [11, 12]. Pollution of the atmosphere, hydrosphere and lithosphere with heavy metals has led to their migration and accumulation in food [7]. In particular, in the Polissya region in livestock products found a high content of Pb and Cd: in milk – 0,054-0,066 and 0,028-0,041 mg / kg, in beef – 0,485 and 0,093 mg / kg, pork – 0,032-0,082 and 0,0052- 0.0064 mg / kg, respectively [13].

Due to the wide range of biological and toxic effects of heavy metals on internal organs and systems of animals [14-16], it is necessary to improve the system of livestock and animal feeding in areas of high man-made load of agricultural production.

Therefore, research on the types of feeding and rations of animals in order to reduce the accumulation of heavy metals in livestock products during its production in the III zone of radioactive contamination due to the Chernobyl accident is quite relevant.

The aim of the research is to establish the accumulation of Pb and Cd in the longest muscle of the back and liver of bull-calves when they are fed silage from a 4-component mixture of spring cereals and legumes (oats + field pea + lupine + vetch) compared to silage from echinochloa frumentacea in conditions Polissya of Ukraine.

Materials and methods of research. The study was conducted in the physiological yard of the Institute of Agriculture of Polissya NAAS (Grozyne village, Korosten district, Zhytomyr region, III zone of radioactive contamination). For the research and production experiment, young cattle (bull-calves) of the Ukrainian black-and-white dairy breed were selected, 2 groups were formed by the method of balanced groups in accordance with the methodological provisions of Ibatullin I. I. and Zhukorsky O. M [17]. The scheme of research is shown in table 1.

1. The scheme of the experiment

Groups	Number of animals in the group, h.	Experimental periods	
		comparative (45 days)	pilot (187 days)
I – control	8	BR - basic ration (clover hay, oat straw, grain mixture, table salt) + cereal-bean silage	BR + cereal-bean silage
II – research	8	BR + cereal-bean silage	BR + silage from echinochloa frumentacea

According to the scheme of the experiment, bull-calves of the I (control) group received a basic ration, which consisted of 4-component cereal-bean silage, clover hay, oat straw, grain mixture and table salt. Animals of the II (experimental) group, in addition to feed of the main diet, were fed silage from echinochloa frumentacea.

The rations of animals according to the composition of basic feeds differed between groups, at the same time they were balanced by basic nutrients, they were adjusted monthly according to live weight and average daily gain according to modern detailed feeding norms and taking into account the actual chemical composition and nutritional value of feeds [18]. Type of animal feeding – silage-concentrate. In the structure of the feed ration of bull-calves in terms of energy nutrition, concentrated feed was 34,6-35,4%, roughage – 18,7-19,2 and succulent feed – 45,4-46,7%.

Preparation of samples of plant and animal origin for the determination of heavy metals was carried out by dry mineralization according to GOST 26929 - 94, analysis by atomic absorption spectrophotometry (spectrophotometer «Kvant-2A») according to GOST 30178.

The transfer factor (TF) of heavy metals (Pb and Cd) in the chain "diet - products (muscle tissue and liver)" were determined by the formula: $TF = C_{hmp}/C_{hmd} \times 100$, where TF is the transition factor; C_{hmp} – content of heavy metals in animal products, mg/kg; C_{hmd} – content of heavy metals in the daily diet, mg. This coefficient is a relative integrated indicator that reflects the migration of heavy metals from the diet to the product (in %) and allows a comparative assessment of the transition of pollutants for different types of feeding bull-calves.

All animal manipulations were performed in accordance with the European Convention for the Protection of Vertebrate Animals Used for Experimental and Scientific Purposes (Strasbourg, 1986).

Results. Toxic chemical elements entering the human and animal body (with food, feed) are excreted from it slowly. Heavy metals accumulate in the body by individual organs and tissues. Therefore, the products of plant origin and feeds, which are grown even on relatively clean or slightly contaminated soils, can be a source of heavy metals in the body in excessive amounts and adversely affect metabolism [19].

Studies have shown that in the feed used for fattening bulls during the experiment, the content of heavy metals (Pb and Cd) did not exceed the maximum allowable concentration (MPC). At the same time, the highest concentration of Pb was in clover hay (2,105 mg/kg) and legume silage (1,337 mg/kg), and Cd – in paise silage (0,041 mg/kg) and 4-component silage (0,032 mg/kg). These indicators relative to the MPC were 42,1 and 26,7% and 13,7 and 10,7%, respectively (Table 2). Oat straw and grain mixture have the lowest content of heavy metals from the studied feeds.

The mineral composition of the animal body largely depends on the chemical elements contained in the environment and come with food. Based on the concentration of heavy metals in the feed consumed by the experimental young cattle, the average daily intake of bull-calves for fattening was determined. The daily intake of Pb was 29,58 mg in the body of animals in the control group, which is 6,1% more than in the experimental group. At the same time, the body of bull-calves of group II received on average more Cd per day by 22,8% compared to analogues of group I.

2. Concentration of heavy metals in feed, mg/kg of natural feed

Feed	Heavy metals	
	Pb	Cd
Silage from echinochloa frumentacea	1,250	0,041
Silage from a 4-component mixture	1,337	0,032
Clover hay	2,105	0,026
Oat straw	0,053	0,028
Grain mixture	0,112	0,031
MPC	5,0	0,3

The content of Pb i Cd in meat is one of the important indicators of its quality in conditions of anthropogenic contamination of agricultural land and feed with heavy metals. According to the current medical, biochemical and sanitary requirements for food raw materials and food products, the content of Pb and Cd in meat should not exceed the MPC (0,5 and 0,05 mg/kg, respectively). Beef in which the concentration of heavy metals is higher than these indicators, without additional processing can't be used for its intended purpose.

The addition of different silos to the main diet of experimental animals was accompanied by a redistribution of levels of heavy metals in their products. This is especially true of Pb, which is a cumulative poison and one of the most toxic and dangerous heavy metals.

As a result of the conducted researches it was established that in the products of slaughter of bull-calves of both experimental groups the accumulation of Pb was much less than the MPC (0,50-0,60 mg/kg) (Table 3). At the same time, the concentration of this heavy metal in the longest back muscle of young animals of the experimental group compared to control analogues increased by 0,09 mg/kg, or 33,3% with a significant difference (P<0,05).

3. The concentration of Pb in the diets and products of slaughter of bull-calves

Groups of bull-calves	The concentration of Pb			
	average daily diet, mg	products, mg/kg	± to the control group	
			mg/kg	%
The longest back muscle				
I – control	29,58	0,27 ± 0,01	-	-
II – research	27,88	0,36 ± 0,03	+0,09	+33,3
MPC	-	0,50	-	-
Liver				
I – control	29,58	0,41 ± 0,06	-	-
II – research	27,88	0,36 ± 0,03	-0,05	-12,2
MPC	-	0,60	-	-

The opposite pattern is observed for the accumulation of Pb in the liver. Thus, in this animal body the element contained in the range of 0,36-0,41 mg/kg, which does not exceed the regulatory requirements (0,60 mg/kg). However, when pea silage (group II) was used in the diets of bull-calves, the Pb concentration decreased by 0,05 mg/kg, or by 12,2% compared to feeding young animals with cereal and legume silage.

The transfer factor of Pb from diets to the longest back muscle and liver ranged from 0,91-1,29% and 1,29-1,39%, respectively (Figura 1). Pb accumulation in muscle tissue was 0,38% higher. and less in the liver by absolute 0,10% in bull-calves of the experimental group compared with the control.

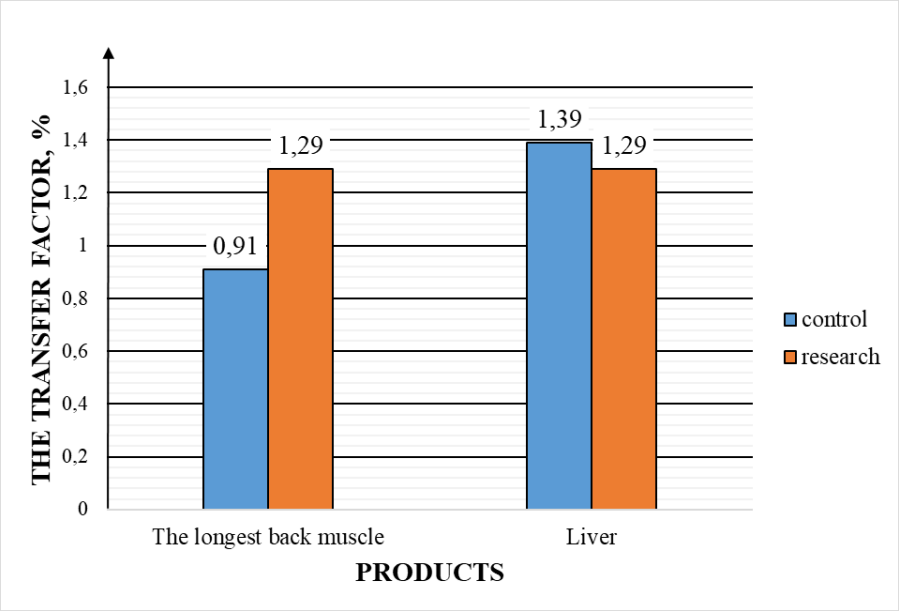

Fig. 1. The transfer factor of Pb into bull-calves products

The concentration of Cd entering the body of young cattle was significantly less than Pb and was 0,773-0,949 mg per day (Table 4).

4. The content of Cd in the diets and products of slaughter of bull-calves

Groups of bull-calves	The concentration of Pb			
	average daily diet, mg	products, mg/kg	average daily diet, mg	
			mg/kg	%
The longest back muscle				
I – control	0,773	0,037±0,002	-	-
II – research	0,949	0,039±0,002	+0,002	+5,4
MPC	-	0,05	-	-
Liver				
I – control	0,773	0,065±0,009	-	-
II – research	0,949	0,062±0,002	-0,003	-4,6
MPC	-	0,3	-	-

According to the results of research, it can be stated that the concentration of Cd in the products of slaughter of animals for fattening was significantly lower than the MPC (0,05 and 0,3 mg/kg, respectively). However, when fed to bull-calves in the diet of silage from echinochloa frumentacea compared with the use of 4-component cereal-bean silage (oats + field pea + lupine + vicia), the accumulation of Cd in the longest back muscle was greater by 0,002 mg/kg (5,4%), and in the liver less by 0,003 mg/kg (4,6%) with insignificant intergroup difference.

The transfer factor of Cd from rations to beef ranged from 4,11 to 4,79%, to the liver from 6,53 to 8,41% and were lower in group II (experimental) than in group I (Figura 2).

Comparing the total amounts of heavy metals that come with diet food, with their content in the longest muscle of the back and liver of experimental animals, their accumulation certain patterns. First, there is a selective assimilation of certain metals in animals. Secondly, the main number of elements is not retained in organs and tissues. According to our data, the transfer factor of individual metals, %:

- in the longest back muscle: Pb – 0,91-1,29; Cd – 4,11-4,79;
- in the liver: Pb – 1,29-1,39; Cd – 6,53-8,41.

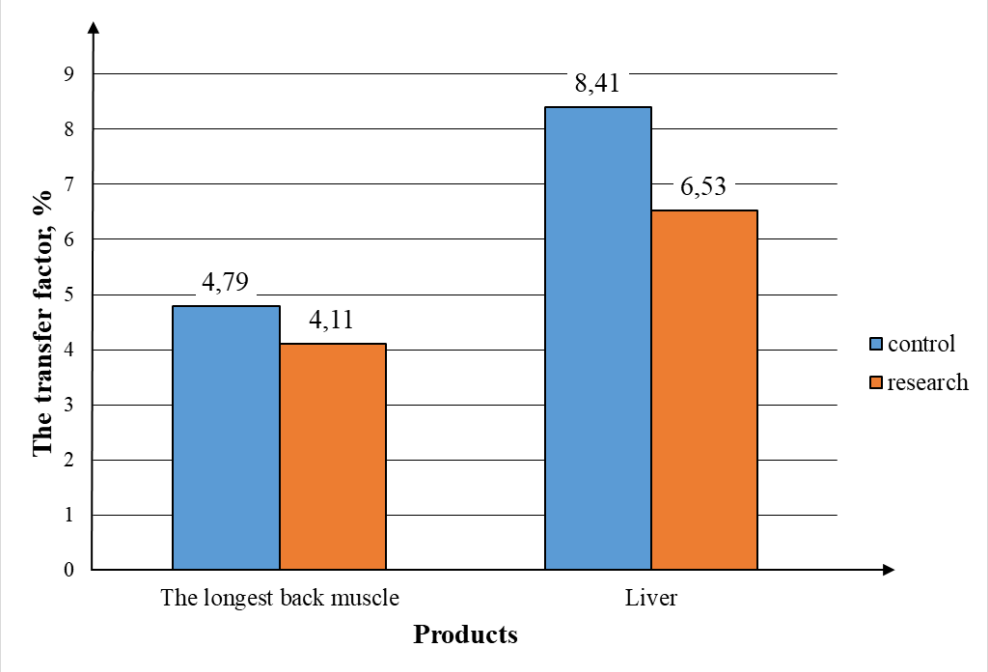

Fig. 2. The transfer factor of Cd into bull-calves products

This suggests that among the studied toxic metals, Cd is characterized by significant accumulation properties in muscle tissue and liver. Its transition coefficient was higher than Pb by 3,2-5,3 times and 4.7-6,5 times, respectively.

A similar pattern was obtained in the studies of Rasputnii O. I. [20]. According to him, the main concentration of metals retained in the body accumulates in the carcasses of animals. In addition, organs and tissues that act as accumulators of certain heavy metals were found. The coefficients of transition of Cd into the body of young animals were 14,0%, Pb – 3,1%, which is consistent with the results of our studies.

Conclusions

The accumulation of Pb and Cd in the longest back muscle and liver of experimental bulls during their feeding with different silos in Polissya Ukraine (III zone of radioactive contamination due to the Chernobyl accident) was lower than the MPC and ranged from 0,27-0,36 and 0,36-0,41 mg/kg and 0,03-0,039 and 0,062-0,065 mg/kg respectively. The use of experimental silage from echinochloa frumentacea for fattening bull-calves compared to cereal and leguminous silage of spring forage crops (oats + field pea + lupine + vicia) have negatively affected the quality of beef, increasing the content of heavy metals (Pb i Cd) in muscle tissue by 5,4-33,3%. At the same time, the rate of transition of Cd to the longest back muscle was lower by 0,68% abs. in young animals of the II (experimental) group compared with the control.

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