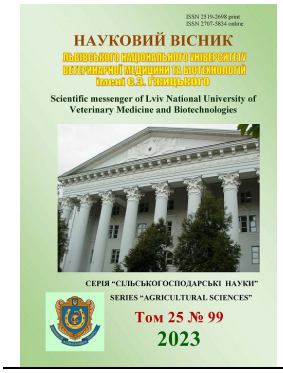

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System of antioxidant protection of young cattle under cadmium load

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It is known that free radical oxidation of lipids is an essential stage in the influence of heavy metals on the animal body. That is why the work aimed to investigate the indicators of the antioxidant system in young cattle under conditions of cadmium loading. For research, 15 clinically healthy six-month-old bulls of the black and spotted breed were selected, from which 3 groups of five animals were formed. The animals in the control group were on a regular diet. The animals of the experimental groups with compound feed were fed cadmium chloride in doses of 0.03 and 0.05 mg/kg of body weight. Feeding young cattle with cadmium chloride feed caused a decrease in the activity of the enzyme system of antioxidant protection of their body. These changes are confirmed by a decrease in their blood activity of superoxide dismutase by 31 %, catalase by 13.4 %, glutathione peroxidase by 23.2 %, glutathione reductase by 22.2 %, and glucose-6-phosphate dehydrogenase by 32.4 %, respectively. A decrease in the level of indicators of the non-enzymatic link of the system of antioxidant protection of the body of young cattle under cadmium load was also established, where, accordingly, a decrease in the content of reduced glutathione was established – by 10.4 %, selenium – by 14.8 %, vitamin A – by 31.3%, of vitamin E – by 30.8% in their blood compared to the control. It is worth noting that on the sixteenth and twenty-fourth days of the experiment, the lowest value of the enzymatic and non-enzymatic links of the antioxidant protection systems of young cattle under conditions of cadmium loading was observed. In the future, a practical scheme for preventing cadmium toxicosis in young cattle by studying indicators of the antioxidant system is planned.

Key words: *bulls, antioxidant system, cadmium, load, vitamins, selenium.*

Introduction

Protection of the environment from man-made pollution is one of the most important tasks of our time. Harmful emissions and waste from industrial enterprises, transport, etc., into the environment today have reached a significant scale, and in large industrial centers, the permissible sanitary standards are significantly exceeded; the problem of environmental pollution with heavy metals, the lion's share of which is cadmium, is particularly acute (Liao et al., 2011; Bahgaat et al., 2020; Bashchenko et al., 2020; Palamarchuk et al., 2022).

Cadmium is the second element in group II of the periodic system of chemical elements. It was first discovered in

zinc carbonate in 1817 by Stromer. Its atomic mass is 112.40. This element is widespread in the earth's crust, making up from 2 to 10 % of its mass. Cadmium most often accumulates in polymetallic ores. It is rarely found as an independent mineral – greenockite (CdS); even more rarely is cadmium carbonate, known as otavite ($CdCO_3$). The average metal content in non-volcanic soil varies from 0.01 to 1 mg/kg; in conditions of volcanic activity, this indicator can reach up to 4.5 mg/kg. However, the background concentration of this element usually does not exceed 0.5 mg/kg; a higher level indicates anthropogenic influence (Fregoneze et al., 1997; Zabarna & Jacenko, 2019; Lavryshyn & Gutyj, 2019; Slobodian et al., 2022).

Cadmium, entering the body through various routes, can be localized in the brain and bone marrow, lungs, heart, liver, kidneys, and spleen. Interaction with thiol groups of apoenzymes allows it to change the activity of antioxidant, microsomal, and other enzymatic systems, influencing the exchange of macro- and microelements, which can have a carcinogenic effect (Kalman et al., 2010; Fahmy et al., 2016; Gutyj et al., 2018, 2019, 2020, 2022, 2023).

Although there is a significant number of works in the literature devoted to the study of the mechanisms of adverse effects of cadmium on the body of animals and humans, the issue of functional changes and the state of the antioxidant system in the cells of various organs and tissues under the influence of cadmium for an extended period in young cattle is relevant (Lavryshyn et al., 2019, 2020; Ostapyuk & Gutyj, 2020).

While the activation of free radical processes is a universal mechanism in the development of cadmium toxicosis, cell damage by radical metabolites occurs due to their ability to initiate lipid peroxidation, interaction with biomacromolecules, and generation of reactive oxygen species (ROS), which are highly toxic and can initiate new chains of free radical reactions. The level of damage is determined by the intensity of their formation and the rate of neutralization by the antioxidant system. Therefore, our work aimed to develop a practical scheme for the prevention of cadmium toxicosis for young cattle. These studies were crucial in such a context (Ostapyuk & Gutyj, 2019; Ostapyuk et al., 2021).

The patterns of changes in the antioxidant status of young cattle under cadmium intoxication have not yet been sufficiently covered in the literature. Studying these processes will allow us to reveal hitherto unknown features of metabolic processes in young animals under the conditions of development of chronic cadmium toxicosis. Conducting research in this aspect is relevant.

Aim of the research

The work aimed to study the state of the antioxidant protection system of young cattle under cadmium load.

To achieve the set goal in experiments on young cattle under cadmium load, the following tasks had to be solved:

- to study the effect of cadmium on the activity of the enzyme link of the antioxidant antioxidant system of the body of young cattle;
- to study the influence of cadmium on the level of the non-enzymatic link of the antioxidant system of young cattle.

Materials and Methods

The studies aimed to study the activity of the system of antioxidant protection of the body of bulls under conditions of cadmium load. When conducting the research, the rules mandatory for performing zootechnical experiments regarding the selection and maintenance of analogous animals in groups, harvesting technology, use, and accounting of consumed feed were followed. The animals' diet was balanced regarding nutrients and minerals, ensuring their need for essential nutrients.

For the experiments, 15 clinically healthy six-month-old bulls of the black-spotted breed were selected, from which three groups were formed, five animals in each:

1st group – control (C), steers were on a regular diet;

2nd group – experimental 1 (R1), steers were fed with compound feed containing cadmium chloride at a dose of 0.03 mg/kg of body weight;

In the 3rd group (experimental 2 (R2), steers were fed with cadmium chloride compound feed at 0.05 mg/kg of body weight. Blood for biochemical studies was taken from animals – from the jugular vein. Blood was stabilized with heparin. Blood serum was separated from the shaped elements by centrifugation for 5–8 min at 3000 rpm.

The activity of glutathione peroxidase (GP) (K.F.1.11.1.9.) and glutathione reductase (GR) (K.F.1.6.4.2.) was studied in blood serum – according to the method of V. V. Lemeshko et al. (1985); catalase activity (K.F. 1.11.1.6) – according to the method of M. A. Korolyuk (1988), the activity of superoxide dismutase – according to the method of E. E. Dybinina (Vlizlo et al., 2012).

High-performance liquid chromatography determined Vitamins A and E in blood plasma; reduced glutathione content was determined according to O. V. Travina's method (1955). Selenium content was determined according to the method of I. I. Nazarenko et al. (1982) (Vlizlo et al., 2012).

All experimental interventions were carried out in compliance with the requirements of the "European Convention for the Protection of Vertebrate Animals Used for Experimental and Scientific Purposes" (Strasbourg, 1985) and the resolutions of the First National Congress on Bioethics (Kyiv, 2001).

The research results were analyzed using the Statistica 7.0 software package. Students' t-tests assessed the probability of differences. The results of average values were considered statistically significant at * – $P < 0.05$, ** – $P < 0.01$, *** – $P < 0.001$ (ANOVA).

Results and discussion

The enzyme superoxide dismutase regulates the initial stages of free radical oxidation, contributing to the neutralization of superoxide radicals and reducing the toxic effect of reactive oxygen species. Table 1 shows the superoxide dismutase activity in the blood of bulls treated with cadmium chloride in doses of 0.03 and 0.05 mg per kilogram of animal body weight.

Table 1
The activity of superoxide dismutase in the blood of young cattle under cadmium stress (M ± m, n = 5)

Blood test time (days)	Superoxide dismutase (m.units/mg protein)		
	Group of animals		
	Control	Experimental 1	Experimental 2
At the beginning of the experiment	0.58 ± 0.012	0.59 ± 0.012	0.61 ± 0.011
The first day	0.59 ± 0.010	0.64 ± 0.013*	0.68 ± 0.012**
The eighth day	0.62 ± 0.013	0.56 ± 0.011**	0.52 ± 0.013**
The sixteenth day	0.61 ± 0.012	0.48 ± 0.010**	0.44 ± 0.011**
Twenty-fourth day	0.60 ± 0.011	0.47 ± 0.012**	0.40 ± 0.012**
Thirtieth day	0.61 ± 0.010	0.50 ± 0.013**	0.46 ± 0.015**

Note: the degree of probability is compared with the data of the control group – P < 0.05 – *, P < 0.001 – **

The activity of this enzyme at the beginning of the experiment in the blood of all experimental animals was within the range of 0.59 ± 0.012 – 0.61 ± 0.011 um. units/mg of protein. After introducing the specified toxic compound, the activity of superoxide dismutase in the blood of both groups of animals on the first day of the experiment increased by 8.5 % and 11.5 % compared to the control group. Subsequently, a gradual decrease in the activity of this enzyme was detected. On the eighth day of the experiment, the values were 0.56 ± 0.011 and 0.52 ± 0.013 mcg/mg of protein, respectively. On the twenty-fourth day, superoxide dismutase activity was the lowest, decreasing by 21.7 % and 31 %, respectively, compared to the control group of animals. On the thirtieth day, the enzyme activity increased slightly but remained low.

It is important to note that the activity of superoxide dismutase is closely related to the work of catalase, which protects the body from highly toxic oxygen radicals. It should be noted that a sudden and significant increase in SOD activity without a corresponding increase in catalase activity can independently cause cytotoxic consequences. Catalase decomposes hydrogen peroxide to form water and oxygen. Table 2 shows changes in catalase activity in steers after the development of chronic cadmium toxicosis.

After determining the activity of catalase in the blood of bulls, it was found that under the influence of cadmium chloride at a dose of 0.03 mg/kg of animal body weight, a decrease in the activity of this enzyme was observed compared to the initial data. For example, on the first day, the decrease was 1.4 %; on the eighth day, it was 4.1 %; and on the sixteenth day, it was 9.7 %. The minimum activity of the enzyme was reached on the twenty-fourth day of the study when, in the first experimental group, this value was 5.93 ± 0.12 units. Later, catalase activity gradually increased to initial values and, on the thirtieth day of the study was 6.01 ± 0.12 units.

After feeding cadmium chloride at a dose of 0.05 mg/kg body weight of animals, the same changes as in the first group were found. Still, catalase activity significantly decreased, reaching 5.63 ± 0.12 units on the twenty-fourth day of the study. Compared to the initial level, catalase activity was 2, 5.1, 12.6, and 8.3 % lower on the 1st, 8th, 16th, and 30th days after cadmium administration.

Table 2
Catalase activity in blood serum of young cattle under cadmium stress (M ± m, n = 5)

Blood test time (days)	Catalase (units)		
	Group of animals		
	Control	Experimental 1	Experimental 2
At the beginning of the experiment	6.48 ± 0.13	6.51 ± 0.10	6.52 ± 0.13
The first day	6.56 ± 0.12	6.47 ± 0.12	6.43 ± 0.12
The eighth day	6.53 ± 0.14	6.26 ± 0.15	6.20 ± 0.16
The sixteenth day	6.57 ± 0.12	5.93 ± 0.12*	5.74 ± 0.13*
Twenty-fourth day	6.50 ± 0.15	5.84 ± 0.13*	5.63 ± 0.12**
Thirtieth day	6.51 ± 0.15	6.01 ± 0.12*	5.97 ± 0.13*

Note: the degree of probability is compared with the data of the control group – P < 0.05 – *, P < 0.001 – **

After conducting research, it was established that before feeding cadmium chloride, the activity of glutathione reductase and glutathione peroxidase in the blood of experimental animals was within the physiological norm. After using cadmium chloride in doses of 0.03 and 0.05 mg/kg of the animal's body weight, the activity of glutathione peroxidase on the first day of the experiment increased by 4.4 and 5.5 %, respectively (Table 3). During the further experiment, the activity of this enzyme gradually decreased. On the eighth day of the study, it was 32.5 ± 1.15 nmol NADPH/min per 1 mg of protein in group R1 and 31.2 ± 1.14 nmol NADPH/min per 1 mg in group R2, respectively.

The lowest activity of glutathione peroxidase in the blood serum of experimental animals was observed on the sixteenth and twenty-fourth day of the experiment. In particular, in the group of animals injected with cadmium chloride at a dose of 0.03 mg/kg of body weight, enzyme activity decreased by 15.7 % and 21 %, respectively, during these periods. In the animals injected with cadmium chloride at 0.05 mg/kg of body weight, enzyme activity decreased by 19.8 % and 23.2 %, respectively.

Table 3
The activity of glutathione peroxidase in blood serum of young cattle under cadmium load (M ± m, n = 5)

Blood test time (days)	Glutathione peroxidase (nmol of NADPH/min per 1 mg of protein)		
	Group of animals		
	Control	Experimental 1	Experimental 2
At the beginning of the experiment	36.1 ± 1.25	36.3 ± 1.26	36.2 ± 1.27
The first day	36.2 ± 1.19	37.8 ± 1.22	38.2 ± 1.25
The eighth day	36.4 ± 1.19	32.5 ± 1.15*	31.2 ± 1.14*
The sixteenth day	36.3 ± 1.24	30.6 ± 1.14*	29.1 ± 1.18*
Twenty-fourth day	36.2 ± 1.20	28.6 ± 1.21*	27.8 ± 1.26*
Thirtieth day	36.4 ± 1.22	32.2 ± 1.18*	31.6 ± 1.21*

Note: the degree of probability is compared with the data of the control group – P < 0.05 – *, P < 0.001 – **

On the thirtieth day of the experiment, a specific increase in the activity of glutathione peroxidase is observed, but compared to the control group, it remains at a low level.

The activity of glutathione reductase in the blood serum of young cattle under conditions of cadmium loading is shown in Table 4. This enzyme reduces fatty peroxides and converts hydrogen peroxide into water, which is essential for protecting the body from oxidative damage and further development of oxidative stress.

At the beginning of the experiment, glutathione reductase activity was within physiological values. After introducing cadmium chloride to the animals, enzyme activity was observed on the first day in both the first and second experimental groups by 6.7 % and 8.6 %, respectively. However, on the eighth day of the experiment, the activity of the enzyme began to decrease, reaching values of 1.39 ± 0.059 nmol NADPH/min per 1 mg of protein for the second group and 1.32 ± 0.048 nmol NADPH/min per 1 mg of protein for the second group, respectively, on the sixteenth day.

Table 4
Glutathione reductase activity in blood serum of young cattle under cadmium stress (M±m, n = 5)

Blood test time (days)	Glutathione reductase (nmol of NADPH/min per 1 mg of protein)		
	Group of animals		
	Control	Experimental 1	Experimental 2
At the beginning of the experiment	1.61 ± 0.037	1.63 ± 0.035	1.60 ± 0.039
The first day	1.63 ± 0.042	1.74 ± 0.045*	1.77 ± 0.032*
The eighth day	1.61 ± 0.041	1.54 ± 0.055	1.51 ± 0.044
The sixteenth day	1.60 ± 0.039	1.39 ± 0.059*	1.32 ± 0.048*
Twenty-fourth day	1.62 ± 0.038	1.32 ± 0.035**	1.26 ± 0.035**
Thirtieth day	1.63 ± 0.031	1.38 ± 0.038*	1.33 ± 0.037**

Note: the degree of probability is compared with the data of the control group – P < 0.05 – *, P < 0.001 – **

On the twenty-fourth day of the experiment, the activity of this enzyme continued to decrease: in animals given cadmium chloride at a dose of 0.03 mg/kg of body weight, it was 1.32 ± 0.035 nmol NADPH/min per 1 mg of protein, and in animals that received cadmium chloride at a dose of 0.05 mg/kg of body weight, the activity of the enzyme was 1.26 ± 0.035 nmol NADPH/min per 1 mg of protein. This means a decrease of 18.5 % and 22.2 %, respectively, compared to the indicators of the control group of animals. On the thirtieth day of the experiment, a slight increase in the activity of glutathione reductase was noted. However, compared to the control group, the enzyme activity remained low.

The activity of glucose-6-phosphate dehydrogenase in the blood of experimental bulls is presented in Table 5. It follows from these data that at the beginning of the study, the activity of this enzyme in animals was within physiological values.

After the introduction of cadmium chloride at a dose of 0.03 mg/kg of body weight in the blood of experimental animals, the activity of glucose-6-phosphate dehydrogenase on the first day of the experiment increased to 0.78 ± 0.027 nmol of NADPH/min per 1 mg of protein. During the entire experiment, a decrease in the activity of this enzyme was observed: on the eighth day, it was 13.7 %, and on the sixteenth day, it was 18 %. From the twenty-fourth day, the activity of the enzyme began to increase slowly, and on the thirtieth day of the experiment, it was 0.62 ± 0.024 nmol of NADPH/min per 1 mg of protein.

After administration of cadmium chloride through feed at a dose of 0.05 mg/kg of body weight in the animals of the second research group, enzyme activity on the first day of the experiment increased by 15.7 % compared to the control. On the eighth day of the experiment, the activity of glucose-6-phosphate dehydrogenase decreased by 20.5 %. The enzyme activity was the lowest on the sixteenth day compared to the control and the first experimental groups. It amounted to 0.50 ± 0.025 nmol of NADPH/min per 1 mg of protein, respectively. Starting from the experiment's twenty-fourth day, the enzyme's activity began to increase.

Table 5
Glucose-6-phosphate dehydrogenase activity in blood serum of young cattle under cadmium stress (M ± m, n = 5)

Blood test time (days)	Glucose-6-phosphate dehydrogenase (nmol NADPH/min per 1 mg of protein)		
	Group of animals		
	Control	Experimental 1	Experimental 2
At the beginning of the experiment	0.72 ± 0.023	0.70 ± 0.020	0.73 ± 0.024
The first day	0.70 ± 0.028	0.78 ± 0.027	0.81 ± 0.026*
The eighth day	0.73 ± 0.027	0.63 ± 0.024*	0.58 ± 0.026*
The sixteenth day	0.74 ± 0.022	0.56 ± 0.021**	0.50 ± 0.025**
Twenty-fourth day	0.71 ± 0.020	0.59 ± 0.023**	0.51 ± 0.021**
Thirtieth day	0.73 ± 0.024	0.62 ± 0.024	0.59 ± 0.023*

Note: the degree of probability is compared with the data of the control group – P < 0.05 – *, P < 0.001 – **

Therefore, the development of chronic cadmium toxicosis in young cattle is accompanied by a decrease in the activity of enzymes in the glutathione system of antioxidant protection.

One of the essential antioxidants in the glutathione system, glutathione, performs important functions in the animal body, including protection against free radicals, membrane support, participation in the metabolism of xenobiotics, and influence on enzyme activity. Glutathione plays a direct role as an antioxidant. After reduction, glutathione becomes an electron donor to eliminate reactive oxygen species.

The level of reduced glutathione in the blood of bulls under chronic cadmium toxicosis is shown in Table 6. At the beginning of the experiment, the level of reduced glutathione in animals given cadmium chloride at a dose of 0.03 mg/kg of body weight was 34.21 ± 0.57 mg%, 6.5 % more than in the control group of animals. On the eighth day of the experiment, this indicator began to decrease by 2.4 % compared to the control. On the sixteenth day, the level of reduced glutathione continued to decrease and amounted to 30.19 ± 0.55 mg%. On the twenty-fourth day of the experiment, this indicator was lower by 9.9 % compared to the control group of animals. On the thirtieth day of the experiment, an increase in the level of reduced glutathione was noted in the first experimental group of animals.

After introducing cadmium chloride at a dose of 0.05 mg/kg of body weight, the level of reduced glutathione was observed at the beginning of the experiment in the second experimental group. But starting from the experiment's eighth day, this indicator's decrease was recorded to 29.85 ± 0.66 mg% on the sixteenth day. On the twenty-fourth day, the level of reduced glutathione fluctuated within the same limits as in the previous case. On the thirtieth day of the experiment, the glutathione level began to increase, but compared to the control group of animals, it was lower by 6.3 %.

The increase in the level of reduced glutathione on the first day of the experiment is probably caused by the arrival of toxic elements that provoked the reactions of the formation of free radicals and activated the lipid oxidation processes. The depletion of the glutathione system can explain a further decrease in the level of reduced glutathione due to the formation of a significant amount of free radicals and lipid oxidation products.

Table 6
The level of reduced glutathione in the blood of young cattle under cadmium load (M ± m, n = 5)

Blood test time (days)	Reduced glutathione (mg%)		
	Group of animals		
	Control	Experimental 1	Experimental 2
At the beginning of the experiment	31.78 ± 0.52	32.05 ± 0.50	31.92 ± 0.52
The first day	32.12 ± 0.51	34.21 ± 0.57*	34.28 ± 0.60*
The eighth day	31.92 ± 0.49	31.16 ± 0.60	30.94 ± 0.62
The sixteenth day	32.10 ± 0.47	30.19 ± 0.55*	29.85 ± 0.66*
Twenty-fourth day	32.88 ± 0.55	29.61 ± 0.62*	29.45 ± 0.52*
Thirtieth day	32.16 ± 0.60	30.72 ± 0.59	30.15 ± 0.62*

Note: the degree of probability is compared with the data of the control group – P < 0.05 – *, P < 0.001 – **

The level of formation of free radicals in animals depends on the oxygen concentration in tissues and the activity of enzymatic and non-enzymatic systems. Vitamins A and E are essential antioxidants related to non-enzymatic defense systems. The protective reaction of these compounds consists of reducing free oxygen in cells and increasing the activity of oxidation and phosphorylation processes.

The content of vitamin A in the blood of bulls during cadmium loading is shown in Table 7. At the beginning of the experiment, the vitamin A content in the blood of bulls in all experimental groups was in the range of 0.80 ± 0.024 to 0.82 ± 0.026 micromoles per liter.

After introducing the specified toxin, the level of vitamin A in the blood of experimental bulls began to decrease. On the eighth day of the experiment, it fell by 11 % and 14.6 %, respectively, in the first and second experimental groups. On the sixteenth day, the content of vitamin A in the blood of the first group decreased by 16 %, and in the second group - by 19.8 %. On the experiment's twenty-fourth day, the vitamin A content in all experi-

mental groups ranged from 0.62 ± 0.028 to 0.57 ± 0.020 micromoles per liter.

Table 8 shows changes in vitamin E content in the blood of young cattle with chronic cadmium toxicosis. This vitamin belongs to endogenous antioxidants that protect cell membranes from the effects of free radicals.

After the development of chronic cadmium toxicosis in steers, the vitamin E content in the blood decreases throughout the experiment. The decrease in the content of this vitamin was noticeable from the eighth day of the experiment. For example, in animals that were given cadmium chloride at a dose of 0.03 mg/kg of body weight, the vitamin content was 3.5 ± 0.11 micromol/l. In animals that were given cadmium chloride at a dose of 0.05 mg/kg body weight, the content was 3.3 ± 0.15 micromol/l. On the sixteenth day, the vitamin E content in the experimental groups' blood decreased by 17.5 % and 25 % compared to the control group. On the twenty-fourth day, the vitamin E content in the blood of animals of both groups was the lowest and amounted to 3.0 ± 0.13 and 2.7 ± 0.12 micromol/l, respectively.

Therefore, the development of chronic cadmium toxicosis in young cattle was accompanied by a decrease in vitamins A and E in their blood, which in turn leads to a disturbance in the balance between the activity of the antioxidant defense system and lipid peroxidation processes.

Selenium is a crucial element in the antioxidant defense system in animals. Its antioxidant property consists of fighting the most dangerous aggressive free radicals.

Table 9 shows the level of selenium in the blood of bulls under conditions of chronic cadmium toxicosis.

Table 7

The content of vitamin A in the blood of young cattle under cadmium load (M ± m, n = 5)

Blood test time (days)	Vitamin A (μmol/l)		
	Group of animals		
	Control	Experimental 1	Experimental 2
At the beginning of the experiment	0.81 ± 0.022	0.80 ± 0.024	0.82 ± 0.026
The first day	0.83 ± 0.024	0.78 ± 0.020	0.77 ± 0.015
The eighth day	0.82 ± 0.023	0.73 ± 0.021*	0.70 ± 0.020*
The sixteenth day	0.81 ± 0.019	0.68 ± 0.018*	0.65 ± 0.017**
Twenty-fourth day	0.83 ± 0.022	0.62 ± 0.028**	0.57 ± 0.020**
Thirtieth day	0.82 ± 0.025	0.67 ± 0.023*	0.62 ± 0.019**

Note: the degree of probability is compared with the data of the control group – P < 0.05 – *, P < 0.001 – **

Table 8

The content of vitamin E in the blood of young cattle under cadmium load (M ± m, n = 5)

Blood test time (days)	Vitamin E (μmol/l)		
	Group of animals		
	Control	Experimental 1	Experimental 2
At the beginning of the experiment	4.0 ± 0.11	4.1 ± 0.10	4.2 ± 0.14
The first day	4.1 ± 0.13	3.9 ± 0.14	3.8 ± 0.17
The eighth day	4.2 ± 0.12	3.5 ± 0.11*	3.3 ± 0.15**
The sixteenth day	4.0 ± 0.12	3.3 ± 0.12*	3.0 ± 0.12**
Twenty-fourth day	3.9 ± 0.10	3.0 ± 0.13**	2.7 ± 0.12**
Thirtieth day	4.0 ± 0.12	3.3 ± 0.13*	3.0 ± 0.14*

Note: the degree of probability is compared with the data of the control group – P < 0.05 – *, P < 0.001 – **

Table 9

Selenium content in the blood of young cattle under cadmium load (M ± m, n = 5)

Blood test time (days)	Selenium (mcg/l)		
	Group of animals		
	Control	Experimental 1	Experimental 2
At the beginning of the experiment	46.4 ± 0.85	47.0 ± 0.82	47.4 ± 0.74
The first day	47.1 ± 0.80	45.4 ± 0.81*	45.1 ± 0.91*
The eighth day	47.5 ± 0.91	44.2 ± 0.85*	43.1 ± 0.92*
The sixteenth day	46.8 ± 0.79	43.4 ± 0.90*	42.2 ± 0.80*
Twenty-fourth day	47.2 ± 0.80	41.2 ± 0.78**	40.2 ± 0.92**
Thirtieth day	47.0 ± 0.65	44.4 ± 0.87	42.3 ± 0.90**

Note: the degree of probability is compared with the data of the control group – P < 0.05 – *, P < 0.001 – **

At the beginning of the experiment, the selenium content in the blood of both groups of steers ranged from 46.4 ± 0.85 to 47.4 ± 0.74 μg/l. Starting from the experiment's first day, the selenium level gradually decreased in both groups. On the eighth day of the experiment, the selenium content in the blood of animals from the experimental groups decreased by 6.9 % and 9.3 % compared to the control group. On the sixteenth day, a further decline in the selenium level in the blood of animals treated with cadmium chloride was observed. In animals administered

cadmium chloride at a dose of 0.03 mg/kg of body weight, the level was 43.4 ± 0.90 µg/l, and when a dose of 0.05 mg/kg of body weight was administered, it was 42.2 ± 0.80 µg/l.

On the twenty-fourth day of the experiment, it was found that the level of selenium in the blood of young cattle in the experimental groups was the lowest, where it was 41.2 ± 0.78 and 40.2 ± 0.92 µg/l, respectively. On the thirtieth day of the experiment, the selenium level increased, but compared to the control group, it was lower by 5.5 % in the bulls of the first experimental group and by 10 % in the second.

A decrease in the selenium content in the bodies of animals under conditions of chronic cadmium toxicosis indicates the suppression of the antioxidant system in the bodies of animals.

The decrease in the protective activity of the antioxidant system in conditions of cadmium exposure is explained by the fact that cadmium contributes to the increase in the formation of free radicals and reactive oxygen species, which destroys the balance between oxidation products and antioxidants.

Conclusions

Feeding young cattle with cadmium chloride feed caused a decrease in the level of the non-enzymatic and enzymatic system of antioxidant protection of the bulls' body. This is confirmed by a decrease in the activity of superoxide dismutase, catalase, glutathione peroxidase, glutathione reductase, and glucose-6-phosphate dehydrogenase, as well as a decrease in the content of reduced glutathione, selenium, and vitamins A and E in their blood.

On the sixteenth and twenty-fourth days of the experiment, the lowest value of the enzymatic and non-enzymatic systems of antioxidant protection of the body of young cattle under cadmium load was observed.

Conflict of interest

The authors declare that there is no conflict of interest.

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