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PREVENTION OF MINERAL METABOLISM DISORDERS IN FATTENING RABBITS

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Abstract. *The main reason for the weakening of the body of rabbits is a deficiency of nutrients and biologically active substances in their diet. The search for non-toxic and highly effective preventive drugs of complex action that have a positive effect on the metabolism of minerals in rabbits is of keen interest. Here we present the results of the study of morphological and biochemical parameters of the blood as well as the content of chemical elements in blood plasma in New Zealand White rabbits on the farm in Kyiv region. The paper presents the materials for determining the biochemical status of the body in fattening rabbits for the prevention of microelementoses using a new experimental environmentally friendly tool. The content of total protein, albumin, glucose, total calcium, inorganic phosphorus, total bilirubin, urea, creatinine, TBA-active products, Fe, Mn, Cu, Zn, Co and the activity of ALT, AST, LF, and HGT in the blood of New Zealand White rabbits in the first and 50th days of the experiment (before and after the use of biologically active additive "Huminorm plus") are presented here for the first time. The use of this additive had a positive effect on haematopoiesis, protein and mineral metabolism, and functional status of the liver, which indicates its high efficiency for the prevention of micronutrient deficiency. "Huminorm Plus" stimulates potential body growth in rabbits up to the age of 90 days.*

Keywords: *biochemical parameters, trace elements, TBA-active products, blood, biologically active additive, New Zealand White rabbits*

Introduction

Rabbit breeding is widespread throughout the world. Modern industrial rabbit breeding involves the slaughter of rabbits in an average of three months, by which time rabbits should gain about 2.5 kg of live weight. Although rabbits are usually considered as fast-growing animals, such results can only be achieved under the conditions of a complete and balanced diet including all the necessary components, in particular mineral complexes. The micronutrient deficiency caused by an impact of environmental changes and technogenic factors

*Scientific supervisor – D.Vet.Sci., associated professor N. G. Grushanska requires the development of complex biologically active additives for specific areas and provinces. The deficiency of mineral elements has a large economic loss due to mass diseases and death of animals arising from metabolic disorders, especially in late winter and early spring period of keeping. This is mostly due to the disproportion of basic nutrients and biologically active substances, in particular macro- and micronutrients, in the diet of rabbits (Fedak et al., 2012).

Analysis of recent researches and publications

Up to three months of age, rabbits need food additives comprising trace elements such as Calcium, Phosphorus, Ferrum, Zinc and Cuprum. This need for micronutrients is constantly increasing from birth with increasing of animal body size, lung and heart volume (Vorobiev & Ulihina, 2007).

Kuzmenko et al. (2019) found that the optimal dose of Cuprum in chelate form in the diet of juvenile rabbits is 3.91 g/t of feed; it covers the deficiency in this element by 50 %. Feeding of juvenile individuals with the compound feed containing Cu chelate increases their live weight by 8.7 % and reduces feed costs for growth by 2.9 % (Kuzmenko et al., 2019). Udris (1966), Nikolsky (1968) and Romanchuk & Annamuhamedova (2002) pointed out that Cu, Mn, Zn, Fe-comprising enzymes play an important role in immunogenesis of animal organism to infectious diseases.

The importance of Zinc for the growth and development of the animal body was proven for the first time by Todd (1934) on rats. The role of this element is determined by its participation in the functioning of the genetic apparatus and cell division processes through the synthesis of protein and nucleic acids. Zinc plays an important role in skeletal formation. Its deficiency causes an inhibition of alkaline phosphatase in chondrocytes of epiphyseal cartilage, which is a major biochemical defect in bone development according to Henning (1976). Zinc is also involved in processes of bone calcification (Lemesheva & Jurchenko, 2009).

Cobalt as a component of vitamin B_{12} impacts on haematopoiesis and digestion. The addition of 0.5 mg Co to the diet had a positive effect on the growth and development of juveniles and their slaughter qualities (Fedoruk & Lesyk, 2009).

Mangan actively involved in redox processes and tissue respiration in animals, bone formation and synthesis of cartilage, affects the growth of juveniles, regulates endocrine function, enhances the action of vitamins being included into enzymes as their activator. Mangan stimulates protein synthesis in muscles and glycogen in the liver, promotes the Mg-ATPase activity which increases live weight (Pedan, 2013).

Insufficient Mn intake causes anaemia and rickets (Pedan, 2013). Mangan together with Ferrum, Cuprum and Cobalt stimulate haematopoiesis (Pedan, 2013).

Ahmadi et al. (2007) studied the impact of toxic doses of Ferrum (Fe^{2+}) on mineral status of the blood serum of rabbits. The results showed that the intra-peritoneal introduction of 10 mg/kg Fe^{2+} leads to increased levels of K, Mg, Fe and Ca, and also reduces the concentration of Na and Cl in the blood serum of rabbits with a balanced diet (Ahmadi et al., 2019). Fe in biotic doses accelerates the animal growth, tissue healing, and enhances liver regeneration (Bogoslovskaja et al., 2007). Fe, Cu, Zn, Mn and Co belong to essential micronutrients, and their absence or insufficient dose in the diet caused a slowdown in animal body growth (Pedan, 2013).

Humic acids are widely used in animal husbandry, poultry and fish farming. New research on the effectiveness of their use and dosage in rabbit breeding is recently relevant. Willis (2015) found the effectiveness of using humic acids for better absorption of minerals in the intestines of mice. Salama et al. (2019) in their studies with the addition of 0.2 % humic acid to the diet of rabbits found an improvement in feed intake and final body weight, as well as a reduction in the mortality rate of animals. In addition, humic acid in the presence of ochratoxin-A (OTA) improves the function of liver and kidneys, reducing pathological changes in these organs and restoring the antioxidant status of the body (Salama et al., 2019).

Minerals with the adsorbent properties within complex substances and dietary additives are widely used in animal husbandry and veterinary medicine (Willis, 2015; Filipova et al., 2019). It is showed a positive sorbent effect of glauconite accumulating in the gastrointestinal tract of animals for 3–4 days. This mineral promotes better Cu absorption and does not cause calcium loss (Filipova et al., 2019).

Succinic acid is an important component in the products of cellulose fermentation. Its addition to the diet of rabbits has a positive effect on feed digestibility (Hall, 1952). Zadnipriany et al. (2019) found that succinic acid in combination with inosine acting as high-energy phosphate supply by maintaining adenosine triphosphate at levels sufficient for supporting the contractile function of the myocardium. Raafat (2011) showed the efficiency of di-mercapto-succinic acid (DMSA) to reduce the concentration of Pb ions in the blood, liver, kidneys and brain in the case of lead toxicity of the body of rabbits. The use of complex drugs for the prevention of mineral disorders in rabbits is the most effective. Mista et al. (2012) studied the effect of humic-fatty acids (HFA) on production parameters and quality of rabbit meat. The HFA consists of 80 % humic-mineral components (Si, Al, Fe, Ca, Na, Mg, P, Mn, Zn, Cu, K, Co, Se) and 20 % vegetable oil (oleic, linoleic, linolenic, palmitic acids). The results of studies indicate a tendency to increase body weight, improve the quality of rabbit meat and increase the content of Fe (Mista et al., 2012).

Fedorchenko (2016) reported positive changes in the antioxidant system of rabbits after adding of mineral additive including K, P, Na, Ca, Cu, Zn, Mn, Fe, I, Co, Se, and vitamins A, D_3, E, K_3, B_1, B_2, B_3, B_4, B_5, B_6, B_{12} to their diet.

Thus, the use of dietary additives including glauconite, humic acid salts, succinic acid and trace elements is a promising research area.

The aim of the study is to determine the impact of complex biologically active additive on organism of fattering rabbits for the prevention of microelementoses.

Materials and methods of research

Research was conducted at the company "Antonov-agro" (Kyiv region). The diet of rabbits for fattening is balanced according to the main indicators, water supply is centralized, watering from automatic drinking bowls.

New Zealand White rabbits aged 60 days, weighing 1.341 ± 0.084 kg were divided into two groups: 10 individuals in the experimental group and seven individuals – in the control one. These groups were kept in two separate cages.

Animals from the control group received pellet feed of 0.155 kg per animal per day up to 90 days of age and 0.175 kg per animal per day from the 91th day until the end of the study, with free access to drinking water. The feed mixture included (g/kg): lucerne hay 265, wheat 140, sunflower meal 110, barley 309, oats 100, soybean meal 58, Lumantse C 1, chalk 4, premix "FYS" 4.5 (650 g calcium carbonate, 100 g saraponin, 250 g oligosaccharide in 1 kg of the premix), Clinofid 2 (neutralizer of mycotoxins based on clinoptilol and heulandite), tricalcium phosphate 4, salt 1.5, lysine 1. In the experimental group, rabbits were given in addition to the basic ration biologically active additive "Huminorm plus" – 4 g per 1 kg of feed daily, during 50 days. This additive included glauconite, succinic acid, sodium salts of humic and fulvic acids, as well as Zn, Mn, Cu, Co and Fe lactates. The daily dose of trace elements in this additive per one animal was the following (up to 90 days of age and from the 91th day, respectively): Zn – 28.7 and 32.4 mg, Mn – 5.7 and 6.5 mg, Cu – 5.7 and 6.5 mg, Co – 0.12 and 0.13 mg, Fe – 28.7 and 32.4 mg.

Blood in fattening rabbits was sampled from the marginal ear vein in a disposable test tubes after preliminary clinical examination of animals, early in the morning before feed. Heparin-stabilized blood was transported and stored at 4 °C. Morphological and biochemical studies, antioxidant status and element composition of blood samples were carried on the first and fiftieth day. Control weighing of animals was performed in the morning before feed on the first, fourteenth, thirtieth, fortieth and fiftieth day to determine the weight gain.

All manipulations with animals were carried out in accordance with the European Convention for the protection and vertebrate animals used for experimental and scientific purposes (2006) and General ethical principles of animal experiments adopted by the First National Congress on Bioethics (Kyiv, Ukraine, 2001).

The clinical analysis of blood included the counting of the number of erythrocytes and leucocytes in the chamber with Goriaev's grid under the MicroMed XS 3320 microscope, determination of haemoglobin content (haemoglobin cyanide method with acetone cyanohydrin) and the average content of haemoglobin in erythrocytes; derivation of the leukogram by the calculation method according to Filipchenko. Blood smears were stained with a set of Leykodif 200 (LDF 200).

The concentration of total protein, albumin, glucose, total calcium and inorganic phosphorus was determined by colorimetry, while the activity of alkaline phosphatase (ALP), aspartate aminotransferase (AST), alanine aminotransferase (ALT) and gamma-glutamiltransferase (g-GT) was estimated by the kinetic method. The study was performed on a semi-automatic biochemical analyser "Labline – 010".

TBA-active products in red blood cells were determined by the Jagi's method modified by Ishihara & Goncharenko (1985), catalase activity in blood serum was estimated using the SF-26 spectrophotometer according to Koroliuk (1988).

The content of chemical elements in blood plasma was determined by the method of atomic emission spectrometry with inductively coupled plasma on the device Optima 2100 DV Perkin Elmer. All digital data obtained during the study were processed statistically using Microsoft EXCEL. Student's criterion was used to determine the probability of differences between mean values.

Results of the research and their discussion

Clinical parameters of rabbits during the fattening were within the range of physiological fluctuations. The morphological composition of the blood of animals of both groups on the first day of the experiment did not exceed physiological limits, however the haemoglobin content, the number of erythrocytes and the average hemoglobin content in erythrocytes approached the lower physiological limit (Table 1). A reliable increase of haemoglobin content (in 1.1 times) and a tendency to increase the number of erythrocytes and average haemoglobin content was observed after the use of biologically active additive "Huminorm plus" (50th day) in the blood of animals from the experimental group compared with rabbits in the control group (Table 1). Other morphological parameters of the blood of rabbits also do not go beyond the physiological limits.

1. Morphological parameters and haemoglobin content in the blood of New Zealand White rabbits with prevented microelementosis during fattening, *M ± m, n = 5*

Parameter	Reference interval [*]	Duration of the study, day			
		1		50	
Group of animals		control	experimental	control	experimental
RBCs, $\times 10^6/\mu L$ (T/L)	5.30 – 6.24	5.47 ± 0.09	5.83 ± 0.15	5.76 ± 0.14	6.04 ± 0,06
Lim $_{min-max}$		5.34 – 5.62	5.58 – 6.18	5.43 – 6.18	5.88 – 6,20
Hb, g/L	112 – 134	111 ± 3	115 ± 4	112 ± 4	128 ± 2**
Lim $_{min-max}$		105 – 115	108 – 123	106 – 123	124 – 134
MCH, pg	21.0 – 21.5	20.3 ± 0.9	19.8 ± 1.1	19.4 ± 0.6	21.2 ± 0.1
Lim $_{min-max}$		18.7 – 21.1	18.0 – 20.8	17.5 – 20.8	20.9 – 21.6
WBCs, $\times 10^3/\mu L$ (G/L)	7.7 – 9.1	8.01 ± 0.20	8.0 ± 0.1	7.2 ± 0.7	8.3 ± 0.4
Lim $_{min-max}$		7.7 – 8.4	7.8 – 8.2	5.7 – 9.2	6.9 – 8.9
Basophils, %	0.8 – 3.1	1.3 ± 0.4	1.7 ± 0.4	0.8 ± 0.2	1.2 ± 0.2
Lim $_{min-max}$		1 – 2	1 – 2	0 – 1	1 – 2
Eosinophils, %	0.9 – 1.6	1.3 ± 0.4	1.7 ± 0.4	1.4 ± 0.3	1.2 ± 0.2
Lim $_{min-max}$		1 – 2	1 – 2	1 – 2	1 – 2
Neutrophils (Heterophils), %	25.0 – 35.9	32.7 ± 1.0	30.3 ± 2.5	32.8 ± 0.9	28.4 ± 2.1
Lim $_{min-max}$		31 – 34	26 – 33	30 – 35	24 – 34
Lymphocytes, %	60.0 – 67.5	61.7 ± 1.4	63.0 ± 1.7	63.2 ± 1.0	65.8 ± 1.7
Lim $_{min-max}$		60 – 64	61 – 66	62 – 67	61 – 69
Monocytes, %	1.4 – 5.6	3.0 ± 0.6	3.3 ± 0.9	3.8 ± 0.5	3.4 ± 0.6
Lim $_{min-max}$		2 – 5	2 – 5	2 – 5	2 – 5

Note: * Jain, (1986). *Schalm's veterinary haematology*. Lea & Febiger, Philadelphia, p. 1221; Sanderson & Phillips, (1981). *An Atlas of Laboratory Animal Haematology*. Oxford University Press, Oxford, p. 473; ** P < 0.01 as compared with animals of the control group.

Values in the leucogram of rabbits of both groups during the fattening do not go beyond the physiological limits (Table 1). On the 50th day of the experiment, the percentage of neutrophils in the leucogram of rabbits in the experimental group slightly decreased due to an increase in the percentage of lymphocytes compared to the corresponding values on the first day. Hematopoietic processes are positively influenced by such trace elements as Co, Cu, Mn, Fe (Fedoruk & Lesyk, 2009; Pedan, 2013). According to Kowalska (1959), anaemia caused by the deficiency of these elements, manifested in the decrease of total protein, reserve alkalinity, the number of erythrocytes and haemoglobin (Romanchuk & Annamuhamedova, 2002). Therefore, the use of the biologically active additive "Huminorm plus" had a positive effect on the haematopoiesis of experimental animals.

Biochemical parameters do not go beyond the physiological limits in blood serum of rabbits of both groups on the first day of experiment, but the content of total protein and albumin approached the lower physiological limits (Table 2). The concentration of the total protein, albumin, total calcium, urea and creatinine is reliably higher in blood serum of rabbits from the experimental group after the use of "Huminorm plus" (50th day) 1.1, 1.1, 1.2, 1.7, and 1.3 times, respectively. At the same time, concentrations of inorganic phosphorus and g-GT were lower (1.2 and 1.8 times, respectively) compared with those in animals of the control group.

The formation of urea and creatinine in the body increases with increasing of protein catabolism, and its decrease – with insufficient intake with the food. Increasing concentrations of urea and creatinine may also indicate kidney disease and urinary system pathology, when their values go beyond physiological limits. So, such an increase in the blood serum of rabbits of the experimental group can be explained by the presence humic substances in the composition of dietary additives. These substances are a mixture of natural organic macromolecular compounds (biochemical transformation of organic products into humus). An increase of urea and creatinine in the blood serum of could be due to the high degree of assimilation of humic acids.

An increase of total calcium content and the decrease of inorganic phosphorus allow us assuming the processes stimulating calcium metabolism and more intensive assimilation of phosphorus. It is manifested in growth acceleration and weight gain.

Increased total protein and albumin in the blood of rabbits of the experimental group indicates stimulation of protein metabolism in their body. The decrease of g-GT activity in the blood of these animals confirms the absence of harmful effects of biologically active additives on liver cells, and conversely, the physiological state of the liver has improved with the use of dietary additives.

Alkaline phosphatase activity did not change significantly during the experiment. The total activity of alkaline phosphatase in the blood of healthy animals consists of the activity of bone, liver and intestinal isoenzymes. It is insufficient to diagnose liver pathology by changes in alkaline phosphatase activity; it is also necessary to take into account the activity of g-GT, AST, and ALT as well as the concentration of total bilirubin. In growing animals, alkaline phosphatase activity may be increased, which will not be a sign of a pathological condition. Therefore, the use of the biologically active additive "Huminorm plus" has a positive effect on the metabolism of protein, calcium, phosphorus and the liver function.

2. Biochemical parameters of the blood serum of New Zealand White rabbits, *M ± m, n = 5*

Parameter	Reference interval [*]	Duration of the study, days			
		1		50	
Group of animals		control	experimental	control	experimental
Protein total, g/L	54 – 75	55.7 ± 0.8	55.9 ± 2.2	54.9 ± 1.1	62.5 ± 1.6**
Lim $_{min-max}$		54.3 – 57.0	49.4 – 60.4	53.1 – 56.7	58.9 – 66.3
Albumin, g/L	25 – 50	25.9 ± 0.6	26.4 ± 0.4	25.8 ± 0.9	28.1 ± 0.5**
Lim $_{min-max}$		25.1 – 26.9	24.9 – 27.2	24.3 – 26.9	26.2 – 29.1
Glucose, mmol/L	4.16 – 8.33	5.20 ± 0.17	5.32 ± 0.10	4.41 ± 0.41	5.62 ± 0.17
Lim $_{min-max}$		4.90 – 5.40	5.03 – 5.72	4.00 – 5.12	5.00 – 5.95
Calcium, mmol/L	2.00 – 3.70	2.56 ± 0.15	2.62 ± 0.16	2.58 ± 0.18	3.20 ± 0.13**
Lim $_{min-max}$		2.31 – 2.80	2.1 – 2.9	2.35 – 2.89	2.9 – 3.5
Phosphorus, mmol/L	0.74 – 2.23	2.07 ± 0.12	2.09 ± 0.08	2.08 ± 0.09	1.76 ± 0.11**
Lim $_{min-max}$		1.86 – 2.20	1.90 – 2.25	1.92 – 2.20	1.37 – 2.01
Urea, mmol/L	2.50 – 8.33	2.67 ± 0.10	2.82 ± 0.39	3.33 ± 0.21	5.50 ± 0.83**
Lim $_{min-max}$		2.50 – 2.80	2.1 – 4.0	3.10 – 3.70	3.0 – 7.1
Creatinine, µmol/L	44.20 – 229.84	149.93 ± 10.76	142.96 ± 11.82	151.97 ± 7.80	199.64 ± 19.33**
Lim $_{min-max}$		131.4 – 160.1	119.7 – 181.8	139.3 – 165.4	160.8 – 238.3
ALP, IU	4 – 70	35.8 ± 3.2	36.6 ± 3,3	34.8 ± 5.5	37.8 ± 4.2
Lim $_{min-max}$		30.3 – 40.1	26.0 – 43.34	29.22 – 44.30	27.1 – 48.5
AST, IU	14 – 113	18.1 ± 1.3	20.8 ± 3.5	19.8 ± 4.3	19.6 ± 2.7
Lim $_{min-max}$		15.9 – 20.1	14.5 – 32.3	12.4 – 27.0	13.5 – 26.1
ALT, IU	14 – 80	38.0 ± 2.9	35.2 ± 7.1	35.0 ± 5.4	25.9 ± 5.2
Lim $_{min-max}$		35.0 – 43.0	14.4 – 52.3	28.6 – 44.3	14.9 – 38.7
g-GT, IU	0 – 7	6.1 ± 0.6	5.9 ± 0.6	6.7 ± 0.5	3.8 ± 0.6**
Lim $_{min-max}$		5.1 – 7.2	3.8 – 7.2	5.9 – 7.1	2.1 – 5.7
Bilirubin total, µmol/L	0 – 12.83	6.87 ± 0.99	7.12 ± 0.59	7.20 ± 1.45	6.36 ± 0.65
Lim $_{min-max}$		5.17 – 8.13	5.8 – 8.3	4.70 – 9.10	5.1 – 8.0

Note: * Carpenter, (2018). Exotic Animal Formulary; ** P < 0.05 as compared with animals of the control group.

Similar results were obtained by Chiericato et al (2000) during the study of metabolic, enzymatic and mineral profile of rabbits aged from 36 to 119 days. It was showed that glucose level did not change with the age; total proteins, albumins and globulins, urea and creatinine increased; AST, ALT, LF enzymes do not change, and g-GT decreased; Ca level increased, while P decreased, and the levels of Mn, Na, K and Cl remained unchanged during the experimental period (Chiericato et al., 2000).

The concentration of elements in blood plasma of rabbits from both groups on the first day of the experiment was in the range of physiological indicators (Table 3).

3. The content of chemical elements in blood plasma of New Zealand White rabbits, *M* ± *m*, *n* = 5

Parameter	Duration of the study, days			
	1		50	
Group of animals	control	experimental	control	experimental
Calcium R	95.0 ± 3.89	96.45 ± 6.18	112.39 ± 6.32	268.75 ± 50.85*
Lim $_{min-max}$	88.30 – 99.60	87.26 – 107.09	101.52 – 120.14	164.08 – 408.24
Manganese	0.0054 ± 0.0001	0.0055 ± 0.0004	0.021 ± 0.006	0.032 ± 0.002*
Lim $_{min-max}$	0.0052 – 0.0056	0.0048 – 0.0062	0.01 – 0.03	0.025 – 0.038
Zinc	4.18 ± 0.33	4.18 ± 0.46	4.24 ± 0.36	6.94 ± 0.56**
Lim $_{min-max}$	3.76 – 4.76	3.44 – 4.92	3.63 – 4.84	5.3 – 8,78
Iron	1.43 ± 0.25	1.48 ± 0.32	1.84 ± 0.12	2.60 ± 0.23*
Lim $_{min-max}$	1.03 – 1.86	0.96 – 1.99	1.68 – 2.04	1.68 – 3.05
Cobalt	0.005 ± 0.001	0.005 ± 0.001	0.010 ± 0.001	0.020 ± 0.005
Lim $_{min-max}$	0.004 – 0.007	0,0024 – 0.0072	0.008 – 0.012	0.0073 – 0.027
Cuprum	1.12 ± 0.05	1.12 ± 0.05	1.16 ± 0.19	1.85 ± 0.24*
Lim $_{min-max}$	1.03 – 1.19	1.03 – 1.20	0.83 – 1.46	1.18 – 2.55

Note: * $P < 0.05$; ** $P < 0.01$, as compared with animals of the control group.

A higher content of Ca (2.4 times), Mn (1.5 times), Zn (1.6 times), Fe (1.4 times) and Cu (1.6 times) was recorded on the 50th day of the experiment in the blood of rabbits of the experimental group compared with those of the control group. A slight increase in the concentration of all studied chemical elements was observed in the blood plasma of rabbits of the control group on the 50th day of the experiment. Thus, the use of "Huminorm Plus" had a positive effect on the metabolism of Calcium, Manganese, Zinc, Ferrum and Copper in rabbits.

Catalase activity in the erythrocytes of rabbits of the experimental group at fattening on the 50th day was 1.6 times lower (Table 4) compared with that of the control group. Catalase lowering the concentration of cytotoxic hydroxyl radicals by the reduction of H_2O_2. The increase of catalase activity in eryth-

4. The indicators of antioxidant defence system of New Zealand White rabbits, *M* ± *m*, *n* = 5

Parameter	Duration of the study, days			
	1		50	
Group of animals	control	experimental	control	experimental
TBA-active products, mmol/L	56.55 ± 6.72	59.62 ± 3.69	49.48 ± 1.04	50.64 ± 3.69
Lim $_{min-max}$	44.98 – 66.38	44.87 – 67.31	48.07 – 51.28	38.46 – 60.90
Catalase, mkat/L	7.47 ± 1.08	7.30 ± 0.86	11.33 ± 0.07	7.20 ± 1.46*
Lim $_{min-max}$	5.60 – 9.00	5.33 – 9.10	11.21 – 11.43	5.38 – 10.21

rocytes of rabbits of the control group may indicate the peroxide oxidation of lipids (Brechka et al., 2019).

The content of TBA-active products allowing to estimate the state of lipid peroxidation in the body does not significantly changed in the blood serum of rabbits from both groups during the experimental period.

Body weight gain for the first 14 days of the experiment amounted to 28 % in rabbits of the control group, and 36 % – in the individuals of the experimental group (Table 5). Over the next 16 days, an increase of body weight in rabbits of the control and experimental group was equal to 16 % and 37 %, respectively. Weight gain in rabbits of both groups during the next few decades is presented in Table 5.

High weight gain in rabbits of the experimental group was observed up to 90 days, and after there was a significant decrease in growth rate. Rabbits are usually kept up to 90 days, and then transferred for slaughter; therefore, the weight gain of these animals from 60 to 90 days is rather important in terms of industrial husbandry. During this period, the increase in body weight of rabbits of the control group was 45%, while it reached 73 % in individuals of the experimental group. Over the entire period of the experiment, the percentage of body weight gain in rabbits of the control and experimental groups was 87 % and 98%, respectively. The use of "Huminorm Plus" stimulates potential body growth in rabbits up to the age of 90 days.

Summarizing, the use of "Huminorm plus" for rabbits had a positive effect on haematopoiesis, protein and mineral metabolism, and functional status of the liver, which indicates its high efficiency for the prevention of micronutrient deficiency.

Conclusions and future perspectives of the study

Morphological and biochemical parameters of the blood of rabbits from the control and experimental groups before the use of biologically active additive "Huminorm plus" (first day) do not go beyond the physiological limits.

An increase of haemoglobin content (1.1 times) was recorded in the blood of rabbits of the experimental group after the use of "Huminorm plus" (50^{th} day).

After the use of "Huminorm plus" (50^{th} day), a higher concentration of the total protein and albumin (1.1 times), total calcium (1.2 times), urea (1.7 times), creatinine (1.3 times) was observed together with the lower concentration of inorganic phosphorus (1.2 times) and g-GT (1.8 times) in the blood serum of rabbits of the experimental group compared to those in the control group.

The content of Ca, Mn, Zn, Fe and Cu in the blood plasma of rabbits of the

5. The indicators of productivity in fattening New Zealand White rabbits, *M ± m, kg*

Group of animals	Age of animals, days					Average weight gain per day	Weight gain over the studied period (50 days)
	60	74	90	100	110		
Control, n=7	1.34 ± 0,06	1.72 ± 0,09	1.94 ± 0,11	2.15 ± 0,07	2.51 ± 0,08	0.023 ± 0.001	1.17 ± 0.04
Experimental, n=10	1.34 ± 0,06	1.82 ± 0,08	2.32 ± 0,12	2.44 ± 0,08	2.66 ± 0,08	0.026 ± 0.001	1.316 ± 0.072

experimental group has become higher (2.4, 1.5, 1.6, 1.4 and 1.6 times, respectively) as compared to those in individuals of the control group.

On the 50th day of the experiment, catalase activity in the erythrocytes of rabbits of the experimental group was 1.6 times lower than that of the control group.

The use of biologically active additive "Huminorm Plus" for rabbits in the age of 60 days over 50 days increased body weight by 12 % compared with that in the control group. The most appropriate is the use of this additive during 30 days.

It is promising to study the effect of complex biologically active additives which include glauconite, salts of humic and fulvic acids, succinic acid and organic compounds of Mn, Zn, Cu, Co and Fe used in different ways (internally and parenterally) and compare them with each other in the effectiveness of the application and impact on the body of New Zealand White rabbits.

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Анотація. *Основною причиною ослаблення організму кролів є дефіцит поживних (якісного протеїну) і біологічно активних речовин у раціоні. Це завдає великих економічних збитків господарствам через масові захворювання і падіж тварин, які виникають внаслідок* *порушення обміну речовин, зокрема макро- і мікроелементів. Актуальним на сьогодні є пошук нетоксичних і високоефективних профілактичних препаратів комплексної дії, що позитивно впливають на метаболізм мінеральних речовин в організмі тварин.*

Дослідження проводили у господарстві Київської області. Морфологічні показники крові визначали стандартними методами. Біохімічні показники крові досліджували наборами реактивів на напівавтоматичному аналізаторі. Вміст хімічних елементів у плазмі крові досліджували методом атомно-емісійної спектрометрії з індуктивно-зв'язаною плазмою на приладі Optima 2100 DV. У роботі викладені матеріали щодо визначення біохімічного статусу організму кролів на відгодівлі за профілактики мікроелементозів із використанням нового експериментального екологічно чистого засобу.

Досліджено вміст загального білка, альбумінів, глюкози, Кальцію загального, Фосфору неорганічного, білірубіну загального, сечовини, креатиніну, ТБК-активних продуктів, Феруму, Мангану, Купруму, Цинку, Кобальту та активність АЛТ, АСТ, ЛФ, ГГТ і каталази в крові кролів, на першу та 50-у добу застосування біологічно активної добавки «Гумінорм плюс». У крові кролів за застосування засобу «Гумінорм плюс» на 50 добу досліду встановлено вірогідно вищий уміст гемоглобіну в 1,1 раза, загального білку і альбумінів – в 1,1 раза, Кальцію загального – в 1,2 раза, сечовини – в 1,7 раза, креатиніну – в 1,3 раза, Мангану – в 1,5 раза, Цинку – в 1,6 раза, Феруму – в 1,4 раза, Купруму – в 1,6 раза, нижчу концентрацію фосфору неорганічного в 1,2 раза та ГГТ – в 1,8 раза порівняно з відповідними показниками тварин контрольної групи. Встановлено позитивний вплив профілактичного засобу на показники гемопоезу, метаболізм білків, мінеральних речовин і функціональний стан печінки у кролів на відгодівлі.

Розробка і застосування нетоксичних засобів для профілактики порушень обміну мінеральних речовин у кролів є перспективним напрямом досліджень.

Ключові слова: *біохімічні показники, мікроелементи, ТБК-активні продукти, кров, БАД, кролі новозеландської білої породи*

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