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ASPARTATE-COMPLEXED MINERALS IN FEEDING BROILER CHICKENS.

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ABSTRACT

Scientifically proves and experimentally confirms high efficiency of a micro element complex (OMEC) on the basis of *L*-aspartic amino acid containing iron, zinc, copper, and manganese in organic form in Cobb500 broiler chickens diet and its impact on productivity, consumption, digestibility, and utilization of diet nutrients by broiler chickens. Nutritional intervention with *L*-aspartates of the trace minerals (OMEC) to the Cobb500 broiler chickens diet contributed to a significant increase of the digestibility of essential nutrients in the feed. The effect of the micronutrient complex on the trace mineral content in bones, pectorals, and droppings has been found out. The use of manganese, iron, copper, and zinc *L*-aspartates in feeding Cobb500 broiler chickens allows to reduce this micronutrients content in the premix due to its high bioavailability and provides the necessary deposition of the trace elements in the backbone of broilers. The efficiency of organic minerals in feeding Cobb500 broiler chickens has been proved, since they improve the assimilation of zinc, copper, iron, and manganese, normalize these trace elements more accurately, and maintain the health of animals, their productive and reproductive qualities. Furthermore, organic minerals can significantly reduce the environmental pollution due to the decrease of their concentration in the droppings.

Keywords: Poultry; Amino acids; Mineral; Feeding; Product quality

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INTRODUCTION

Organic trace minerals included as compounds of the complexes are known to improve integrity of bones, to reduce skeletal deformities, to improve the quality of the egg shell, to provide better immunity resistance, and to increase meat yield at a lower nutritional intervention that has a positive effect on reducing the excretion of trace minerals with droppings to the environment [1-5].

Nowadays mineral intervention to the broiler diet is claimed to be limited to reduce the contamination of soil because of transfer of additional trace minerals with droppings [6]. In the European Union (UA) acts of legislation about maximal admissible concentrations of copper, iron, zinc, cobalt, and manganese in the droppings were adopted in 2003. Thus, traditional approaches to the mineral nutrition of farm animals and birds need significant revising. Organic trace minerals are a natural solution of this problem, and today there is no alternative to it [7; 8].

Worldwide environmental contamination with heavy metals and their compounds is recognized as one of the important problems of ecology and public health. The main danger of the metal impact on the human body is not overt poisoning, but metals' ability to concentrate in the food chain gradually [9].

The biological role of essential trace minerals is now well known [10]. Despite the fact that all the organic trace elements are aimed at improving the bioavailability of minerals, their effectiveness is different yet [11].

The objectives of the research are:

- to study the mineral bioavailability of the OMEC premixes, containing zinc, manganese, iron, copper L-aspartates in the diets of Cobb500 broiler chickens;
- to define their degree of impact on the consumption, the digestibility, and the utilization of the diet nutrients by Cobb500 broiler chickens;
- to identify the influence of micronutrient complexes on the trace element content in bones, muscles, and droppings of chickens;
- to examine the content of heavy metals in muscles and droppings of Cobb500 broiler chickens.

MATERIALS AND METHODS

OMEC-Fe is a feed supplement that is intended to enrich and to balance the pigs and poultry diets with iron and contains iron aspartate and sodium sulphate in its structure. 1 kg of the feed supplement contains 108 g of iron. The feed supplement is a substitute of iron sulfate and has a high biological activity. Iron, a part of the respiratory pigments, cytochromes, hemoglobin, of many enzymes, is involved in the processes of binding and transport of oxygen to the tissues, stimulates the blood-forming organs.

OMEC-Zn is a feed supplement that is designed to enrich and to balance the diets of pigs and poultry with zinc and contains zinc aspartate and sodium sulphate in its composition. 1 kg of feed supplement contains 118 g of zinc. The feed supplement is a source of bioavailable zinc. Zinc is involved in nucleic acid metabolism and protein synthesis. As a part of hormones and enzymes it affects hematopoiesis, reproduction, growth, morphosis, carbohydrate, and energy metabolism. Zinc influences the formation of the skeleton, the reproduction (sperm production), the regulation of the essential nutrients metabolism.

OMEC-Mn is a feed supplement that is designed to enrich and to balance the diets of pigs and poultry with manganese and contains manganese aspartate and sodium sulphate in its structure. 1 kg of the feed supplement contains 105 g of manganese. The feed supplement is a source of bioavailable manganese. Manganese stimulates the cholesterol and fatty acids synthesis and has lipotropic effect. It promotes hematogenesis, strengthens the egg shells of birds, improves embryos, conduces to the better fat and protein absorption, produces bactericidal effect in the gastrointestinal tract, and contributes to the functioning of the endocrine glands. Manganese deficiency leads to a decrease of the islets of Langerhans number in the pancreas and to the decline of the glucose uptake.

OMEC-Cu is a feed supplement that is designed to enrich and to balance the diets of pigs and poultry with copper and contains copper aspartate and sodium sulphate in its structure. 1 kg of the feed supplement contains 115 g of copper. The feed supplement is a sulfate and copper carbonate substitute and has a high biological activity.

Copper is an important element of metalloproteins regulating the redox processes of the cellular respiration, photosynthesis, the assimilation of molecular nitrogen. Being present in hormones, copper affects growth and development, reproduction, metabolism in general, the hemoglobin formation processes, promotes the conversion of reticulocytes to normocytes. Copper is necessary for the melanin pigment formation, affects the growth of the bones, and increases the content of the vitamins B12 and C in the liver.

Closed Joint-Stock Company (CJSC) "Agrocomplex" in Krasnodar Territory has tested OMEC in breeding the broiler chickens. Three groups of day-old chicks were formed for the experiment (n = 100). Chickens in the control group had traditional complex of mineral salts in their diet composition; in the experimental group I, 5% of the complex mineral salts were replaced with aspartates; chickens in the experimental group II got 10% aspartates in the OMEC composition according to the feeding regulations.

The laboratory studies were performed in the certified laboratory of GC "Megamix" and in the complex laboratory of the company CJSC "Agrocomplex". The content of the trace elements and heavy metals was determined by stripping voltammetric titrations in accordance with government standards (GOST 8.563-96 and GOST R ISO 5725-2002) and with atomic absorption spectrometer Quantum-2A (GOST R ISO 5725-2002).

The data on different variables, obtained from the experiment, were statistically analyzed by Statistica 10 package (StatSoft Inc.). The significance of differences between the indices was determined using the criteria of nonparametric statistics for the linked populations [12]. The mean of a set of measurements was calculated according to the formula: $\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$, where $\bar{x}$ – a mean value; $\sum_{i=1}^{n} x_i$ – read this as "the sum of all x_i with i ranging from 1 to n"; n – number of measurements. The residual variation is expressed as a root mean square error (RMSE): $\sigma = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}$. The standard error (SE) was calculated by the formula: $SE = \frac{\sigma}{\sqrt{n}}$. The reliability of a sample difference (Student's t-distribution) was estimated by the test of the difference validity, which is the ratio between the sample difference to the non-sampling error. The test of the difference validity was determined by the formula:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{SE_1^2 + SE_2^2}} \geq t_{st}(d.f. = n_1 + n_2 - 2)$$

, where t – Student's t-distribution; ($\bar{x}_1 - \bar{x}_2$) – difference of the sample mean measurements; $\sqrt{SE_1^2 + SE_2^2}$ – sample difference error; SE_1, SE_2 – non-sampling error of the sample statistics compared; t_{st} – standard criterion according to the t-Table for the probability threshold preset depending on degrees of freedom ("probability": $^{a}P < 0.001$; $^{b}P < 0.01$; $^{c}P < 0.05$; not significant "ns"); n_1, n_2 – number of measurements in the samples compared; d.f. – degrees of freedom for difference of two mean measurements.

MS Office 2010 package was employed for graphical presentation of the data.

RESULTS

The study has found that by the end of breeding, the live weight of the broiler chickens in the experimental groups exceeded the results in the control group by 4.8% (P < 0.001) and 7.4% (P < 0.001), the average daily gain – by 4.9 (P < 0.001) and 7.6% (P < 0.001), respectively, the cost of feed per 1 kg of the gain decreased by 3.9 and 5.0% (Table 1).

Table 1: Live weight change (mean ± se)

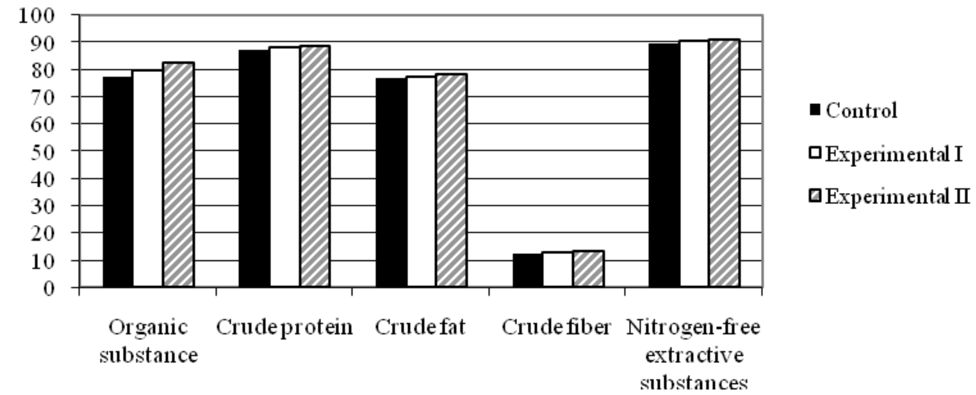
Indicators*	Groups		
	Control (n = 100)	Experimental I (n = 100)	Experimental II (n = 100)
Live weight change, g 24 hrs	40.0 ± 0.2	40.2 ± 0.1 ns	40.1 ± 0.2 ns
7 days	159.3 ± 2.8	163.7 ± 3.3 ns	169.9 ± 3.1 c
21 days	725.5 ± 8.9	749.1 ± 7.7 c	767.8 ± 9.2 b
28 days	1230.4 ± 14.8	1298.5 ± 14.6 b	1364.2 ± 15.2 a
39 days	2085.8 ± 18.9	2185.3 ± 19.4 a	2240.7 ± 19.8 a
Average daily gain, g	52.4 ± 0.2	55.0 ± 0.3 a	56.4 ± 0.2 a
The cost of feed per 1 kg of the gain, kg	1.80	1.73	1.71

* – compared with data on the control group;
a – P < 0.001; b – P < 0.01; c – P < 0.05; ns – not significant

Performance efficiency of the new feed in the animal diets is associated with digestibility and utilization of diet nutrients by the chicken body.

The digestibility coefficient of the organic substance in the test groups increased as compared to the control group by 2.3 ($P < 0.01$) and 5.4% ($P < 0.001$); of the crude protein – by 1.1 ($P < 0.05$) and 1.7% ($P < 0.01$); of the crude fat – by 0.4 (ns) and 1.4% ($P < 0.05$); of the crude fiber – by 0.6 ($P < 0.001$) and 1.3% ($P < 0.001$); of the nitrogen-free extractive substances – by 0.6 (ns) and 1.4% ($P < 0.05$) (Fig. 1).

Figure 1: Digestibility coefficient, %



In course of the studies a positive effect of the new supplements on the processes of the protein digestion of the feed has been found.

The nitrogen balance in the body of broiler chickens in all experimental groups was positive and its uptake was high. Higher nitrogen intake was observed in the experimental groups I and II by 0.12 g and 0.16 g or 2.8 ($P < 0.05$) and 3.8% ($P < 0.01$) compared to the control group (Table 2). The loss of nitrogen in the indigestible nutrients proved to be lower in the experimental groups. So, the nitrogen excretion with droppings by the chickens in the experimental group I was 2.33 g (53.7% of the taken dose), in the experimental group II – 2.30 g (52.5% of the taken dose), and in the control group – 2.38 g (56.4% of the taken dose). As a consequence, the most significant amount of the taken nitrogen was digested by the broilers of the experimental groups.

Table 2: The nitrogen balance in the body of broiler chickens (mean ± se)

Indicators*	Groups		
	Control (n = 100)	Experimental I (n = 100)	Experimental II (n = 100)
Nitrogen taken with feed, g	4.22 ± 0.04	4.34 ± 0.04 [c]	4.38 ± 0.03 [b]
Excretion with droppings, g	2.38 ± 0.02	2.33 ± 0.01 [c]	2.30 ± 0.02 [b]
Assimilated, g	1.84 ± 0.04	2.01 ± 0.02 [a]	2.08 ± 0.03 [a]
Assimilated, %	43.6	46.3	47.5

* – compared with data on the control group;
a – P < 0.001; b – P < 0.01; c – P < 0.05; ns – not significant

The chickens in the experimental group I digested more nitrogen by 0.17 g (9.2%, P < 0.001), in the experimental group II – by 0.24 g (13.0%, P < 0.001) compared to the chickens in the control group. The utilization coefficient of the digested nitrogen was higher in broiler chickens of the experimental groups by 2.7 and 3.9% in comparison with control.

In life of an organism minerals have important and various functions. They are parts of the organs and tissues and have a significant impact on the energy, protein and lipid metabolism, as well as of the synthesis of vitamins, enzymes and hormones.

Therefore, we studied the calcium and phosphorus metabolism in the body of the broilers (Table 3).

Table 3: The calcium and phosphorus balance in the body of broiler chickens (mean ± se)

Indicators*	Groups		
	Control (n = 100)	Experimental I (n = 100)	Experimental II (n = 100)
Calcium			
Taken with feed, g	1.37 ± 0.02	1.41 ± 0.01 [ns]	1.43 ± 0.01 [b]
Excretion with droppings, g	0.64 ± 0.01	0.65 ± 0.02 [ns]	0.64 ± 0.02 [ns]
Assimilated, g	0.73 ± 0.01	0.76 ± 0.01 [c]	0.79 ± 0.02 [b]
Assimilated, %	53.3	53.9	55.2
Phosphorus			
Taken with feed, g	1.06 ± 0.02	1.08 ± 0.02 [ns]	1.10 ± 0.02 [ns]
Excretion with droppings, g	0.61 ± 0.01	0.62 ± 0.01 [ns]	0.61 ± 0.02 [ns]
Assimilated, g	0.45 ± 0.01	0.46 ± 0.01 [ns]	0.49 ± 0.01 [b]
Assimilated, %	42.5	42.6	44.5

* – compared with data on the control group;
a – P < 0.001; b – P < 0.01; c – P < 0.05; ns – not significant

In course of the study, the calcium and phosphorus balance has been found to be positive in the bodies of the experimental broilers. The utilization of calcium taken with food was higher with the chickens in the experimental groups by 4.1 (P < 0.05) and 8.2% (P < 0.01); of phosphorus – by 2.2 (ns) and 8.9% (P < 0.01) compared to the chickens in the control group.

Thus, the use of the studied supplements in broiler chickens diets of the experimental groups had a positive impact on both the protein and mineral metabolism.

The research has found that the use of L-aspartate micronutrients in broiler chickens diets had a positive impact on their deposition in the bones (Table 4).

Table 4: Chemical composition of femurs of broiler chickens (mean ± se)

Indicators*	Groups		
	Control	Experimental I	Experimental II

	(n = 100)	(n = 100)	(n = 100)
Crude ash, g/kg	491.2 ± 5.2	502.1 ± 5.4 [ns]	506.4 ± 4.9 [c]
Calcium, g/kg	160.7 ± 4.8	175.9 ± 5.2 [c]	179.1 ± 5.2 [b]
Phosphorus, g/kg	76.9 ± 2.3	80.7 ±2.7 [ns]	86.4 ± 2.8 [b]
Zinc, mg/kg	18.78 ± 0.31	22.19 ± 0.29 [a]	22.45 ± 0.39 [a]
Ferrum, mg/kg	19.90 ± 0.27	24.82 ± 0.34 [a]	29.64 ± 0.31 [a]
Manganese, mg/kg	3.10 ± 0.14	3.75 ± 0.15 [b]	3.91 ± 0.10 [a]
Copper, mg/kg	1.21 ± 0.08	1.57 ± 0.12 [c]	1.59 ± 0.10 [b]
* – compared with data on the control group; a – P < 0.001; b – P < 0.01; c – P < 0.05; ns – not significant			

The content of the macro-and microelements in the femurs of the broilers in the experimental groups were within the physiological range. However, the manganese level in the bones of the chickens in the experimental group I exceeded the reference by 20.9 (P < 0.01), in the experimental group II – by 26.1% (P < 0.001); the iron level – by 24.7 (P < 0.001) and 48.9% (P < 0.001); the copper level – by 29.8 (P < 0.05) and 31.4% (P < 0.01); the zinc level – by 18.2 (P < 0.001) and 19.5% (P < 0.001), respectively.

Due to the better digestibility of organic micronutrients based on L-aspartic amino acid, the zinc, iron, manganese, and copper content in the broiler pectoral muscles of the test groups proved to be higher than in the control group – by 17.9 (P < 0.001) and 24.1% (P < 0.001); 3.6 (P < 0.05) and 35.4% (P < 0.001); 25.6 (P < 0.01) and 42.5% (P < 0.001); 30.1 (P < 0.01) and 54.8% (P < 0.001) (Fig. 2).

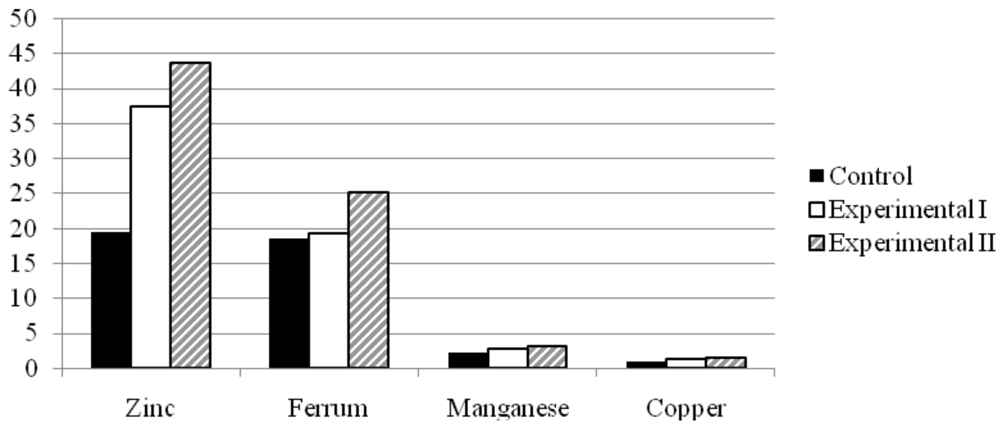


Figure 2: The content of the trace elements in pectoral muscles, mg/kg

The heavy metal content in the pectoral muscles of broiler chickens in the experimental groups has also been found to decrease: the lead content – by 17.8 (P < 0.05) and 30.4% (P < 0.001); the cadmium content – by 28.6 (P < 0.01) and 57.1% (P < 0.001); the mercury content – by 29.4 (P < 0.001) and 47.1% (P < 0.001), compared to the control group. Arsenic is absent in the thoracic muscle in both the control and the experimental groups (Table 5).

Table 5: The concentration of the heavy metals in pectoral muscles (mean ± se)

Indicators*	Groups		
	Control (n = 100)	Experimental I (n = 100)	Experimental II (n = 100)
Lead, mg/kg	0.191 ± 0.011	0.157 ± 0.008 [c]	0.133 ± 0.006 [a]
Cadmium, mg/kg	0.049 ± 0.003	0.035 ± 0.003 [b]	0.021 ± 0.002 [a]
Mercury, mg/kg	0.017 ± 0.001	0.012 ± 0.001 [a]	0.009 ± 0.001 [a]
* – compared with data on the control group; a – P < 0.001; b – P < 0.01; c – P < 0.05; ns – not significant			

The content of the trace elements in the droppings decreased significantly. Thus, the zinc content in the droppings of the chickens in the experimental group I decreased compared to the control group by 41.0% ($P < 0.001$), in the experimental group II – by 64.5% ($P < 0.001$); the iron content – by 12.7 ($P < 0.001$) and 18.9% ($P < 0.001$); the manganese content – by 24.5 ($P < 0.001$) and 49.4% ($P < 0.001$); the copper content – by 17.6 ($P < 0.01$) and 28.7% ($P < 0.001$), respectively (Fig.3).

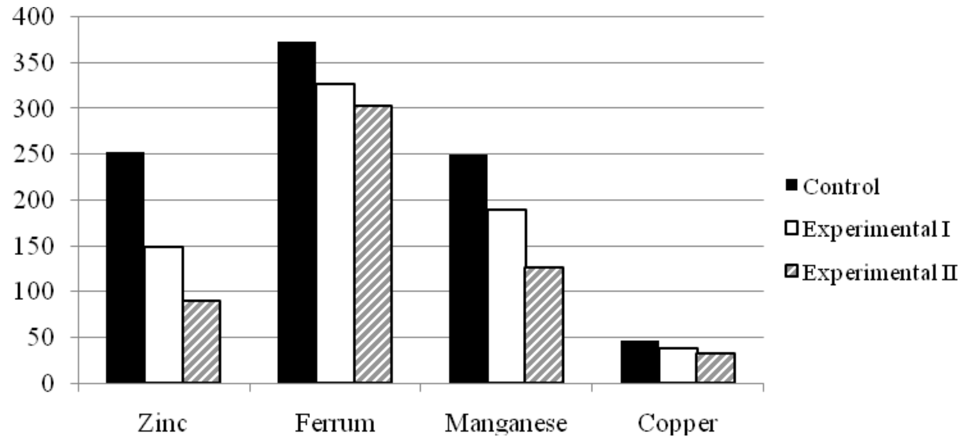


Figure 3: The microelements content in the droppings, mg/kg

There was some reduction of heavy metals in the droppings (Table 6). The lead content in the droppings of the chickens in the experimental group I decreased compared to the control group by 3.6 ($P < 0.05$) and 5.4% ($P < 0.001$); the cadmium content – by 18.1 for ($P < 0.01$) and 36.1% ($P < 0.001$); the mercury content – by 3.8 (ns) and 9.4% ($P < 0.05$). The arsenic content in the droppings of the chickens in the experimental groups was at the level of the control group – 0.11 mg/kg on average.

Table 6: The heavy metals content in the droppings (mean ± se)

Indicators*	Groups		
	Control (n = 100)	Experimental I (n = 100)	Experimental II (n = 100)
Lead, mg/kg	3.31 ± 0.04	3.19 ± 0.03 [c]	3.13 ± 0.03 [a]
Cadmium, mg/kg	1.55 ± 0.07	1.27 ± 0.06 [b]	0.99 ± 0.05 [a]
Mercury, mg/kg	0.053 ± 0.002	0.051 ± 0.002 [ns]	0.048 ± 0.001 [c]
Arsenium, mg/kg	0.11 ± 0.01	0.11 ± 0.02 [ns]	0.11 ± 0.01 [ns]

* – compared with data on the control group;
a – $P < 0.001$; b – $P < 0.01$; c – $P < 0.05$; ns – not significant

DISCUSSION

In recent years, a high-tech production process of the natural L-aspartic amino acid have developed, and on its basis, preparation Asparkam-L has been elaborated, which is used in medical practice, as well as a trace mineral complex of vital metals, designed to enrich the diets of farm animals and birds. Comprehensive comparative assessment showed the efficacy and safety of Asparkam-L that is comparable to Pananginum and Potassium magnesium aspartate (KMA). Based on the dynamics of the improvement in the clinical status and the prevention of relapse of the acute myocardial infarction, it surpasses the reference drugs. The feed supplement OMEC is a source of bioavailable manganese, copper, iron, and zinc.

In course of the investigation it has been found that L-aspartates of the micronutrients (OMEC) in the diets of broiler chickens have significantly improved the digestibility of the key diet nutrients. The possibility to reduce the studied trace element content in the premix compared to the accepted norms guaranteed based on the active substance has been proved, as well as the possibility to normalize these trace elements more accurately, keeping their required deposition in backbone and muscles of broilers due to the high bioavailability of the mineral complexes. This is in agreement with the results obtained by several authors [13; 14].

Nutritional intervention with L-aspartates of the trace minerals (OMEC) to the broiler chickens diet contributed to a significant increase in the digestibility of essential nutrients of the feed. The obtained results are consistent with several studies, conducted by Kim et al. [15], Shindea et al. [16], Egorov et al. [17].

The use of manganese, iron, copper, and zinc L-aspartates in feeding broiler chickens allows to reduce the micronutrient content in the premix compared to the accepted norms guaranteed based on the active substance due to its high bioavailability and provides the necessary deposition of the trace elements in the bones of the broilers. Similar results were obtained recently [18; 19; 20; 21].

CONCLUSION

L-aspartate-complexed minerals are more efficient to use in feeding Cobb500 broiler chickens, since they improve the assimilation of zinc, copper, iron, and manganese, normalize these trace elements more accurately, and maintain the health of animals, their productive and reproductive qualities. Furthermore, organic minerals significantly reduce the environmental pollution due to the decrease of their concentration in the droppings.

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