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PHYSIOLOGICAL STATUS AND ENZYMATIC ACTIVITY IN THE BLOOD OF BROILER CHICKENS SUPPLEMENTED WITH ZINC COMPLEX COMPOUNDS

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This article presents the results of an experimental study into the effect of synthesised zinc chelate compounds (methionate, glycinate and lysinate) on the physiological condition, haematological parameters and enzymatic activity of the blood in Cobb-500 broiler chickens. The relevance of this work stems from the need to improve the bioavailability of trace elements in poultry feed and the search for effective alternatives to traditional inorganic zinc salts, which are characterised by low absorption rates.

The aim of the study was to assess the effect of organic forms of zinc as premix components on blood parameters and metabolic processes in broiler chickens. The experiment was conducted on four groups of chicks (20 birds each) over a period of 42 days. The control group received zinc sulphate, whilst the experimental groups received zinc methionate, glycinate and lysinate. The physiological status was assessed using haematological, biochemical and enzymatic blood parameters.

It has been established that the use of organic forms of zinc helps to stabilise the body's metabolic status. The most pronounced effect on erythropoiesis was observed with the use of zinc methionate, where the red blood cell count increased by 43% compared to the control group. Zinc lysinate also caused a significant increase in this parameter by 16%, whilst haemoglobin and white blood cell levels remained within the physiological norm. An increase in blood glucose concentration was observed following the administration of zinc methionate, indicating the activation of energy metabolism. At the same time, zinc glycinate and zinc lysinate caused a moderate decrease in total protein, which may be associated with the intensive utilisation of amino acids in growth processes.

Analysis of enzymatic activity showed a decrease in alkaline phosphatase and amylase levels with the use of zinc glycinate and lysinate, which correlates with the completion of intensive growth and the stabilisation of metabolic processes. The activity of transaminases, gamma-glutamyltransferase and catalase did not change significantly, indicating no adverse effect on liver function or the antioxidant system.

The results obtained confirm the high biological efficacy and physiological safety of zinc chelate compounds. Their use helps maintain homeostasis, stimulate haematopoiesis and optimise metabolic processes, which justifies the use of organic forms of zinc in the feeding of broiler chickens as an alternative to inorganic sources of this trace element.

Key words: *zinc glycinates, methionates, and lysinates; broiler chickens; hematological parameters; meta.*

Чепіль Л.В. Фізіологічний стан та ферментативна активність крові курчат-бройлерів при введенні до раціону хелатних сполук цинку

У статті представлено результати експериментального дослідження впливу синтезованих хелатних сполук цинку (метіонату, гліцинату та лізинату) на фізіологічний стан, гематологічні показники та ферментативну активність крові курчат-бройлерів кросу Cobb-500. Актуальність роботи зумовлена необхідністю підвищення біодоступності мікроелементів у годівлі птиці та пошуком ефективних альтернатив традиційним неорганічним солям цинку, які характеризуються низьким рівнем засвоєння.

Метою дослідження було оцінити вплив органічних форм цинку як компонентів премісів на показники крові та метаболічні процеси в організмі бройлерів. Експеримент проведено на чотирьох групах курчат (по 20 голів) упродовж 42 діб. Контрольна група отримувала сульфат цинку, тоді як дослідні - метіонат, гліцинат та лізинат цинку. Оцінку фізіологічного стану здійснювали за гематологічними, біохімічними та ферментативними показниками крові.

Встановлено, що застосування органічних форм цинку сприяє стабілізації метаболічного статусу організму. Найбільш виражений вплив на еритропоез виявлено при використанні метіонату цинку, де кількість еритроцитів зросла на 43% порівняно з контролем. Лізинат цинку також зумовив достовірне підвищення цього показника на 16%, тоді як рівень гемоглобіну та лейкоцитів залишався в межах фізіологічної норми. Виявлено підвищення концентрації глюкози в крові при введенні метіонату цинку, що свідчить про активацію енергетичного обміну. Водночас гліцинат і лізинат цинку спричинили помірне зниження загального білка, що може бути пов'язано з інтенсивним використанням амінокислот у процесах росту.

Аналіз ферментативної активності показав зниження рівня лужної фосфатази та амілази при застосуванні гліцинату і лізинату цинку, що корелює із завершенням інтенсивного росту та стабілізацією обмінних процесів. Активність трансаміназ, гамма-глутамілтрансферази та каталази істотно не змінювалась, що свідчить про відсутність негативного впливу на функціональний стан печінки та антиоксидантну систему.

Отримані результати підтверджують високу біологічну ефективність і фізіологічну безпечність хелатних сполук цинку. Їх застосування сприяє підтриманню гомеостазу, активізації кровотворення та оптимізації метаболічних процесів, що обґрунтовує доцільність використання органічних форм цинку у годівлі курчат-бройлерів як альтернативи неорганічним джерелам мікроелемента.

Ключові слова: *гліцинати, метіонати та лізинати цинку, курчата-бройлери, гематологічні показники, обмін речовин.*

Introduction. Zinc is one of the most important essential trace elements in poultry farming, as it is a component of over 300 metalloproteins that regulate virtually all types of metabolism: protein, carbohydrate and lipid. Its role in ensuring high-intensity metabolic processes in tissues is crucial for realising the genetic potential of modern poultry breeds [1, 9]. As the chicken's body has no stored zinc reserves, a deficiency in the diet leads to the rapid onset of pathological conditions, including stunted growth, deterioration in plumage quality, the development of dermatitis and skeletal deformities [5, 10].

The traditional use of inorganic zinc salts (primarily sulphates) in premixes is often accompanied by low bioavailability of the element due to antagonistic interactions with other feed components in the gastrointestinal tract. Current trends in poultry feeding are moving towards the use of organic forms of trace elements, particularly chelated compounds. Such metal complexes with amino acids (glycinates, methionates, lysinates) are characterised by greater stability, better absorption and the ability to protect cells from the potential toxic effects of free metal ions through the formation of intracellular complexes with thiol groups [4, 6].

Assessing physiological status and haematological parameters is a reliable method for evaluating the efficacy of new feed additives. Changes in the activity of blood plasma enzymes, such as alkaline phosphatase, amylase and transaminases, allow for the timely identification of the impact of nutrients on liver function and the growth rate of poultry [2, 7]. Despite a significant body of work on zinc nanoparticles and general mineral mixtures, the comparative efficacy of various zinc amino acid chelates (methionate, glycinate and lysinate) and their specific effects on the enzymatic profile of broiler blood remain insufficiently explored [3, 8].

The relevance of this issue stems from the need to identify optimal forms of trace elements that would ensure the stability of the organism's metabolic status without causing undue physiological stress.

The aim of our study was to investigate the effect of synthesised zinc chelates (methionate, glycinate and lysinate) as premix additives on haematological parameters, enzymatic activity and the state of carbohydrate, lipid and protein metabolism in the tissues of Cobb-500 broiler chickens.

Materials and Methods. The research was conducted in the vivarium of the National University of Life and Environmental Sciences of Ukraine. Four experimental groups of day-old Cobb-500 broiler chickens (n=20 per group) were formed to study the effects of zinc chelates. The trial lasted 42 days, during which the birds were kept in cages with free access to feed and water.

The control group received zinc sulfate (K) as its zinc source. Experimental groups received zinc methionate (1 D), zinc glycinate (2 D), and zinc lysinate (3 D). On day 42, physiological parameters were measured. Post-slaughter blood and liver samples were collected for biochemical analysis. Hemoglobin concentration was determined via the hemoglobincyanide method. Glucose was measured by the ortho-toluidine reaction.Leukocyte and erythrocyte counts were determined using a Goryayev chamber. Total plasma protein was analyzed using Biuret reagent. Total lipids were assessed using "Lachema" reagents. Enzymatic activity (ALT, AST, GGT, α-amylase, and ALP) was determined according to methods by Kamyshnikov V.S. and Melnychuk D.O. Catalase activity was analyzed by the method of Bach and Zubkova. Statistical processing was performed in Microsoft Excel using Student's t-test.

Results and Discussion. The study showed that hemoglobin levels and leukocyte counts in experimental groups remained unchanged compared to the control (Table 1).

Table 1

Hematological parameters of broiler chickens, M±m, n=10

Group	Erythrocytes, T/L	Leukocytes, g /L	Hemoglobin, g/L
K	2,65±0,06	13,69±2,08	118,90±5,74
1 D	3,73±0,13*	13,72±1,83	124,92±3,25
2 D	2,55±0,03	13,64±2,67	118,47±2,85
3 D	3,25±0,07*	13,86±1,64	118,99±4,53

**P<0.05 compared to control.*

Zinc methionate and lysinate were found to influence erythrocyte counts, with increases of 43 % (Group 1) and 16 % (Group 3). Zinc methionate also led to a 14 % increase in blood glucose levels. No significant changes in total lipids were detected, suggesting these zinc compounds have a less pronounced effect on lipid metabolism (Table 2).

Table 2

Metabolic parameters in broiler chicken blood plasma, M±m, n=10

Group	Indicator		
	Glucose, mmol/L	Total Lipids, g/L	Total Protein, g/L
K	25,30±0,81	0,29±0,03	39,35±0,80
1 D	28,97±0,73*	0,35±0,03	36,13±1,98
2 D	26,65±0,65	0,28+0,02	34,85±0,86*
3 D	26,80±0,74	0,31±0,03	33,10±1,02*

**P<0.05 compared to control.*

Total protein levels decreased by 12 % and 16 % in Groups 2 and 3, indicating a slight reduction in the protein-synthesizing function of the liver. While AST activity showed an upward trend, ALT and GGT activities remained at control levels.

Table 3

Enzymatic activity in the blood and plasma of broiler chickens, μmol/ml/h, M±m, n=10

Enzymes	Group			
	K	1 D	2 D	3 D
Catalase, g/L	53,53±7,41	54,45±5,86	48,67±7,41	52,87±6,33
AST	0,68±0,03	0,72±0,02	0,69±0,03	0,70±0,04
ALT	1,07±0,01	1,07±0,02	1,08±0,03	1,11±0,02
ALP	57,68±2,49	52,30±4,08	38,16±3,62*	35,02±3,60*
GGT	1,76±0,11	1,88±0,16	1,62±0,07	1,75±0,17
Amylase, g/h·L	12,02±0,57	11,25±1,86	5,26±0,62*	4,27±0,48*

**P<0.05 compared to control.*

Alkaline phosphatase (ALP) activity decreased by 34 % and 39 % in Groups 2 and 3, which may relate to the completion of active bird growth. Amylase activity also decreased significantly (by 56 % and 65 %) in these groups. Catalase and GGT activities remained unchanged across all groups.

Conclusions

1. Haematological status and erythropoiesis. It has been established that the use of organic zinc compounds stimulates the haematopoietic system. The most pronounced effect was observed in the group receiving zinc methionate (1 D), where the red blood cell count increased by 43 %. Zinc lysinate (3 D) also contributed to a significant increase in red blood cell count by 16 %. At the same time, haemoglobin levels and the leukocyte profile remained stable in all groups, indicating the absence of inflammatory processes and toxic effects of chelates on the birds' bodies.

2. Carbohydrate, lipid and protein metabolism. The administration of zinc methionate led to a 14 % increase in plasma glucose concentration, indicating an intensification of energy metabolism. In contrast, zinc glycinate (2 D) and zinc lysinate (3 D) caused a moderate decrease in total protein levels of 12–16 %, which may be associated with the redistribution of the amino acid pool to meet the needs of tissue synthesis during the final stage of growth. Total lipid levels did not undergo significant changes, confirming the neutral effect of the studied compounds on lipid metabolism.

3. Enzymatic activity and homeostasis. Specific changes in the activity of hydrolytic enzymes were observed. In the groups receiving zinc glycinate and zinc lysinate, a significant reduction in alkaline phosphatase activity (by 34% and 39%, respectively) and alpha-amylase (by 56% and 65%), which correlates with the completion of the active bone growth phase and the stabilisation of digestive processes. The absence of changes in ALT, GGT and catalase activity indicates the preservation of the functional integrity of hepatocytes and the stability of the body's antioxidant defence when inorganic zinc sulphate is replaced by its amino acid chelates.

4. Synthesised zinc chelates are more biologically active forms of the trace element compared to inorganic salts. They support physiological homeostasis and stimulate erythropoiesis, making them suitable for recommendation as effective components of premixes for broiler chickens to optimise metabolic status.

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