The effectiveness of using ultrafine copper as part of an enzyme-containing diet for broiler chickens

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Abstract. The purpose of the study was to study the effectiveness of using ultrafine copper particles as part of an enzyme-containing diet for broiler chickens. The research results indicate that each of the components of the proposed strategy influenced a certain functional system of the body with a subsequent range of adaptive changes, which ultimately led to a change in the efficiency of broiler rearing. In particular, it was found that the proposed substances have a growth-stimulating effect to varying degrees. Feeding the enzyme was accompanied by a maximum increase in the live weight of the experimental birds (13.75%), but in this case the maximum palatability of the feed was noted (a difference with the control of 6.7%). The strategy of complex introduction of enzyme and ultrafine copper was more effective and was accompanied by a decrease in feed costs in comparison with the group of introduction of only enzyme, with a difference in live weight with the control of 13.68%.

1 Introduction

At the moment, the diet of broiler chickens is a complex mixture of various components, including substances of various origins, including enzymes. At the same time, the combined use of such additives can cause synergistic or antagonistic effects [1]. Taking into account the problem of antibiotic resistance and the growing trend of using cheap feed in combination with enzymes, there is a need to search for new agents[2]. Such substances should help improve digestion, increase productivity, prevent infections and provide high economic efficiency [3].

Today, exogenous enzymes are used to optimize the nutrition of broiler chickens, by neutralizing the effects of antinutrients, as well as improving the digestibility of nutrients and, consequently, increasing animal productivity. The use of enzymes represents an effective way to overcome the problem of nutrient encapsulation in plant cells and create biologically active oligomers that can stimulate the growth of poultry [4]. Ultrafine particles, due to their biological properties [5], are used in animal husbandry as biosensors, sources of microelements, and also as antibiotic additives [6-7]. They help optimize microflora, stimulate the immune system, correct weight gain and increase feed efficiency.

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Their integration as potential additives in poultry feeds is seen as a way to improve overall health and feed conversion ratio [8]. To improve zootechnical rearing performance, it is necessary to select multifunctional feed additives, taking into account their compatibility, biosafety, synergy [9], principles and technology of administration, as well as economic efficiency [10].

Thus, based on the above, the goal of the work was to study the effectiveness of using ultrafine copper particles as part of an enzyme-containing diet for broiler chickens.

2 Materials and methods

The experiment was carried out on broiler chickens of the Arbor Acres cross in the vivarium of the Federal Scientific Center for Biological Systems and Agricultural Technologies of the Russian Academy. According to the principle of similar groups, a control and two experimental groups (n = 30) were formed. At the same time, the housing and feeding conditions were identical for all groups, in compliance with the basic technology for raising chickens of this cross.

The control group received the basal diet. Group “EM” - received the main diet + enzyme Axtra® XAP 102 TPT (0.05%). The “EM+Cu” group received the basic diet + Axtra® XAP 102 TPT enzyme (0.05%) + copper in ultra-fine form “Platinum” (1.7 mg/kg of feed).

Morphological blood parameters were measured using a URIT-2900 Vet Plus analyzer (URIT Medical Electronic Co., Ltd.), and biochemical studies were performed using a DIRUI CS-T240 analyzer.

Statistical processing was carried out using the Statistica 12 software package (StatSoft Inc., USA).

3 Results

When analyzing the feed consumption for the entire growing period, it was found that in the “EM” group the level of feed consumption was 6.7% higher than the control, in the “EM + Cu” group by 1.78%.

The introduction of the test substances, both in combination and separately, was accompanied by changes in the growth dynamics of the experimental bird (Figure 1.). Thus, in the “EM” group, after 21 days of the experiment, the difference with the control ($P \leq 0.05$) was 16.22%, after five weeks – 13.75%. In the “EM + Cu” group, an ambiguous effect on the growth rate was revealed. Thus, in the first two weeks of the experiment, the dynamics of growth in this group was characterized by pronounced efficiency ($P \leq 0.05$), the difference with the control was 31.43%, but by the end of the experiment this difference was 13.68

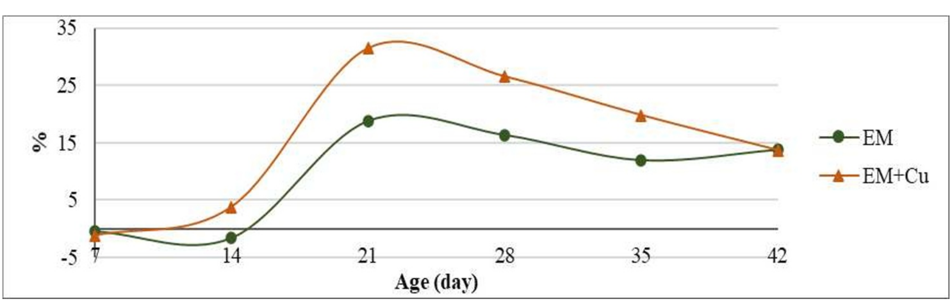

Fig. 1. Difference in the weight of experimental birds between the study groups.

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To identify the general physiological state and metabolic changes of broiler chickens, blood serum parameters were assessed. All blood parameters studied were within the physiological norm of broiler chickens.

The results of the general analysis (Figure 2) showed an increase in red blood cells in the “EM” group by 3.57%, in “EM + Cu” by 5.49% compared to the control group (P≤0.05). An increase in hematocrit by 1.68% and 2.6% was also recorded in comparison with control values, respectively (P≤0.05). Hemoglobin concentration is higher in the “EM + Cu” group by 12.48% (P≤0.01). In addition, the average hemoglobin content in erythrocytes in the control group was 60.92 pg, in the “EM” group - 62.78 pg, in “EM + Cu” - 63.02 pg, thus the difference in the experimental groups was - 3 .05% and 3.45% (P≤0.01). Among the indicators involved in blood clotting, we note a slight tendency towards an increase in platelet levels in the experimental groups.

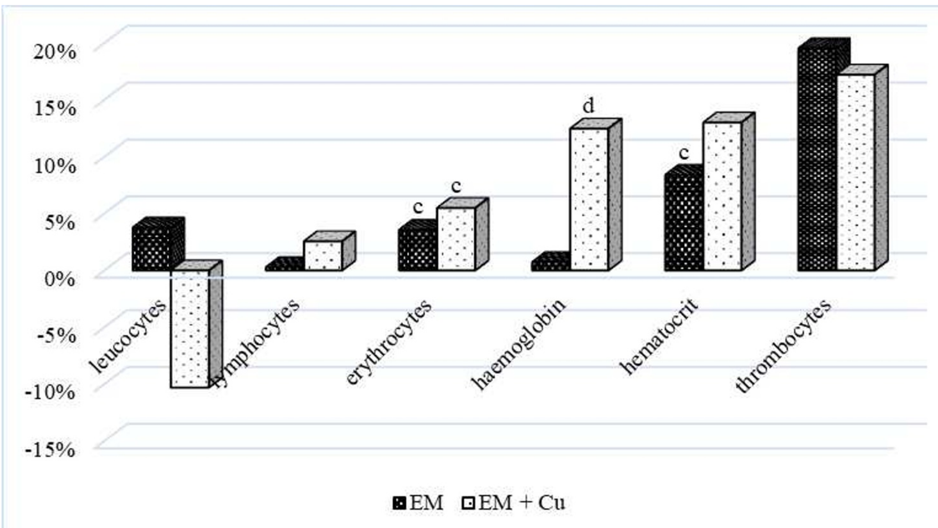

Fig. 2. Changes in the general blood test of broiler chickens under the influence of the studied factors. Note: c - P≤0.05; d - P≤0.01, when comparing the control and experimental groups.

According to the analysis of biochemical parameters of the blood serum of broiler chickens, statistically significant differences were identified in some of them (Table 1). For example, among markers of protein metabolism, the level of total protein in the EM group was 3.7% higher than in the control group. The urea concentration also turned out to be higher in the experimental groups by 14.29% and 33.3%, respectively, compared to the control group (P≤0.05).

Changes in lipid metabolism were manifested by a decrease in cholesterol levels in the "EM" group by 9.12% (P≤0.01) and a decrease in triglyceride concentrations by 31.25% (P≤0.01) in the "EM" group and by 25 .1% (P≤0.01) in the “EM + Cu” group compared with the control group. When assessing serum enzymatic parameters, an increase in the amount of α-amylase in the EM group was observed by 2.79% (P≤0.05) compared to the control group. The use of the enzyme in combination with ultrafine copper also led to a decrease in the amount of ALT by 9.25% (P≤0.05) compared to the control group.

Table 1. Biochemical parameters of the blood of experimental birds under the influence of the studied factors.

Indicator	Group		
	Control	**EM**	**EM + Cu**
Glucose, mmol/l	11.22 ± 0.52	11.66 ± 0.32	11.47 ±0.21
Total protein, g/l	32.83 ± 0.09	34.04 ± 0.61[c]	33.7 ± 1.53
Albumen, g/l	14.80 ± 0.37	15.04 ± 0.32	14.61 ± 0.5
ALAT, u/l	8.00 ± 0.17	6.82 ± 0.64	7.26 ± 0.25[c]
ASAT, u/l	314.0 ± 14.74	305.1 ± 10.93	335.8 ± 18.41
Cholesterine, mmol/l	2.85 ± 0.06	2.59 ± 0.13[c]	2.79 ± 0.12
Triglycerides, mmol/l	0.32 ± 0.01	0.22 ± 0.03[d]	0.24 ± 0.01 [d]
Magnesium, mmol/l L	1.12 ± 0.04	1.16 ± 0.05 [d]	1.03 ± 0.04
Calcium, mmol/l	2.86±0.06	2.92 ±0.01 [c]	2.77±0.12
Phosphorus, mmol/l	2.29±0.07	2.38±0.05 [c]	2.53±0.08 [c]
α-Амилаза, Ед/л	113.62±0.27	116.8±0.8 [d]	114.6±4.38

Note: c - P≤0.05; d - P≤0.01, when comparing groups relative to control.

When assessing the effectiveness of adding biologically active substances, one of the stages is to study how effectively the nutritional components of the feed are absorbed by the body, which is reflected in the digestibility coefficients of nutrients. For example, in the "EM" group there was an increase in the digestibility coefficients of crude protein and crude fiber by 2.47% (P≤0.05) and 1.87% (P≤0.05), respectively, compared to control values. In the "EM + Cu" group, the coefficients of use of crude fat, crude fiber and nitrogen-free extractives also exceeded the control values by 2.01% (P≤0.01), 5.75% (P≤0.05) and 1.94 % (P≤0.01), respectively.

The study showed that the additives introduced affect the level of gross feed energy utilization. The combination of enzyme and ultrafine copper (EM + Cu) resulted in the highest net energy gain values. In this group, the net energy gain was 12.74 MJ/bird, which is equal to 24.78% of the total gross feed energy, while in the control group this figure was 11.28 MJ/bird. The control group had the lowest values of energy gain with energy loss through litter of 33.21% and a level of energy release through heat production of 43.47%. The difference in the “EM” group in terms of energy loss with litter was 1.1%, in the “EM + Cu” group - 2.41% compared to the control.

4 Discussion

The price of feed ingredients significantly influences the overall cost of production, so optimizing broiler feeding strategy becomes a key aspect in the current market conditions [11]. Traditionally, grain products make up a significant part of the feed supply of poultry. Cereals have a complex structure with cell walls that have different chemical compositions and properties. The basis of the broiler diet is usually wheat, barley, sunflower products, rapeseed and others. These crops have a high content of non-starch polysaccharides [12-13]. Consumption of large amounts of water-soluble and indigestible carbohydrates by broilers leads to thickening of the digestive tract, and coarse feed particles can damage the intestinal mucosa [1].

Each of the components of the proposed strategy influenced a certain functional system of the body with a subsequent range of adaptive changes, which ultimately led to a change in the efficiency of broiler rearing. In particular, it has been established that all the proposed substances have a growth-stimulating effect to varying degrees. Feeding the enzyme was accompanied by a maximum increase in growth, but in this case, maximum feed costs were also noted.

The strategy of complex introduction of enzyme and ultrafine copper was accompanied by a lower value of feed costs in comparison with the group of introduction of only enzyme. It is likely that the proposed complex with copper helps suppress appetite in broiler chickens, which will subsequently affect the economic component of the growing process. The identified shifts in blood parameters indicate varying degrees of the stimulating effect of the proposed complexes on metabolic processes in the body of poultry [9]. The oxidation of macronutrients produces energy to support the body's vital functions.

Modern technological conditions significantly influence the efficiency of feed energy use in broilers. Several factors, such as the amount of feed consumed, nutrient composition, presence of anti-nutrients and the gut microbiome, play a key role in this process [10].

Our studies showed that the addition of enzyme to the diet of broilers contributed to more efficient use of feed energy compared to the control group. A particularly high increase in net energy was noted when using ultrafine copper, exceeding the control group by 12.9%. This indicates that these complexes affect the body's adaptation and the restructuring of energy metabolism. The proposed strategies help to increase metabolic energy and reduce unproductive energy losses, which ensures effective feed conversion [12]. It has been scientifically proven that the studied substances increase the intensity of digestive processes, which has a beneficial effect on energy metabolism in the bird's body, ensuring better digestibility and absorption of nutrients.

5 Conclusion

Thus, the research results indicate that each of the components of the proposed strategy influenced a certain functional system of the body with a subsequent range of adaptive changes, which ultimately led to a change in the efficiency of broiler rearing. In particular, it was found that the proposed substances have a growth-stimulating effect to varying degrees. Feeding the enzyme was accompanied by a maximum increase in the live weight of the experimental birds (13.75%), but in this case the maximum palatability of the feed was noted (a difference with the control of 6.7%). The strategy of complex introduction of enzyme and ultrafine copper was more effective and was accompanied by a decrease in feed costs in comparison with the group of introduction of only enzyme, with a difference in live weight with the control of 13.68%.

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