



Effect of supplemental Mn, Zn, Fe and Cu and their interactions on the performance of broiler chickens

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Abstract

Based on the results of the analysis of feed materials on the content of micronutrient elements and conducting scientific experiments on broilers chicken, the most effective source of Manganese, Zinc, Iron and Copper in mixed feeds, which contributes to solving the problem of increasing the quality of feeding and intensifying the growth of poultry has been substantiated. The optimum source of essential elements (Mn, Zn, Fe, Cu) for broilers chicken through feeds, the level of their incorporation into mixed fodders have been experimentally determined, and their influence on productivity and feed costs per 1 kg of body weight gain have been investigated. The tasks set in the work have been solved experimentally using analytical (analysis of literature sources), zoo-technical (growth indices, feed intake) and statistical (processing of the results obtained) methods of research. The use of mixed feeds in feeding broilers chicken which contained glycinate of Manganese, Zinc, Iron and Copper making 75 % of the needs, contributes to increasing their body weight by 2.5 % and increasing the growth rate by 2.4 %. Feed costs per 1 kg of broilers chicken growth were 1.5 % lower than the young bird index of the control group.

Key words: broiler chicken; Manganese; Zinc; Iron; Copper; performance.

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1. Introduction

The need for essential trace elements is often compensated by the concentration contained in conventional feeds. However, due to the use of plant resources, which are collected in different biogeochemical provinces, rations may contain a lack of certain trace elements, and the collected plants differ in their digestibility. In connection with the development of intensive poultry farming, domestic ration for farm birds requires adequate supply of essential trace elements.

There are currently a significant number of chemical, structural, and bioavailable differences among the various sources of organic trace elements used in poultry rations. The most common organic sources of Mn, Zn, Fe, Cu can be the compounds with specific amino acids, amino acid complexes, protein, polysaccharides and organic acids.

One of the most popular commercial sources of organic Manganese is Mn-proteinate. However, Wang et al. (2012),

assessing the biological availability of Mn-proteinate and Mn-sulfate in broiler chickens, based on several linear regressions between Mn concentration, superoxide dismutase activity (MnSOD) and mRNA (MnSOD) level in the gray tissue, did not reveal any significant differences ($P > 0.21$) in bioavailability between these sources. Lu et al. (2007) were investigating the influence of various sources of Manganese on slaughter indices, meat quality, lipid oxidation, activity of individual enzymes in internal fat and meat, and the level of mRNA (MnSOD) in broiler meat. The results of this experiment confirm that organic Manganese is more affordable than inorganic. In studies on laying hens, when adding Mn-proteinate to the ration, the scientists received better indices of the weight of birds, the weight of eggs and their strength, the strength of the large tibia versus the use of Mn-sulfate (Yildiz et al., 2011). According to the authors, these positive changes are associated with the redistribution of mineral elements in the body of hens and with a certain

accumulation of Manganese in the bone tissue, which the use of organic forms of Mn contributed.

The results of most experiments performed in recent years have demonstrated a high relative biological availability of organic Zn sources, even if this has not always been reflected in improving the productivity. Brooks et al. (2013) indicate a high relative bioavailability of Zn in the body of broiler chickens with the use of Zinc propionate. When comparing Zinc propionate with sulfate by the body weight of chickens, the Zn concentration in the large ankle and, in fact, the whole bone tissue, the better biological availability, which made 116–119 %, was established. Some positive changes in growth rates and immunological characteristics have been observed when feeding the elevated levels of Zinc (90–120 mg/kg) in the form of glycinate, but no probable difference was observed in these indices between the groups that consumed 120 mg/kg of Zinc of either organic or inorganic origin (Feng et al., 2010). Attia et al. (2013) when feeding different sources of Zinc (oxide and Bio-Plex®) young ducks obtained interesting results. Scientists have found somewhat negative impact of organic Zinc on the performance of ducks compared with oxide, which deserves further study.

As substitutes for feed antibiotics Kim et al. (2011) were studying the potential effectiveness of using various sources of Copper (Cu-methioninate and Cu-proteininate) in a total amount of 100 mg/kg of feed. The results of the experiment confirmed the effectiveness of Copper, which contributed to a better growth of broiler chickens and an increase in lactobacillus populations if the amount of E. coli reduced in the intestine compared with the use of avilamycin. Kwiecien et al. (2014) did not detect differences in the performance of broiler chickens when Copper sulfate or glycinate are used, but noted the positive effect of Cu-glycinate on the biomechanical properties of the tibia. Attia et al. (2012) found that such sources of Copper as sulfate and lysinate had no significant effect on the growth rates of ducks, but the conversion of feed was worse in birds that consumed the organic source of Copper. Compared to Copper sulfate, lysinate contributed to increasing the secretion of Copper, its concentration in blood plasma and the reduction of triglycerides in plasma.

We have not found any research of a direct separate comparison of various sources of Iron, but there are a number of publications on the combined effect of microelements on the productive and functional indicators of poultry farm.

In the analysis of experimental studies, it can be argued that the biological availability and efficiency of using organic sources of Mn, Zn, Fe, Cu exceeds inorganic feeds. Accordingly, lower levels of these microelements in rations can be used without causing damage to the productivity of poultry farm, which will contribute to reducing the release of these microelements into the environment through poultry manure, and thus will reduce the potential negative consequences of the poultry industry.

2. Materials and methods

Experimental studies conducted at the P. D. Pshenychnyi Department of Animal Feeding and Feed Technology of the National University of Life and Environmental Sciences of Ukraine.

A comparative analysis to determine the optimum level and source of trace elements (Mn, Zn, Fe, Cu) in mixed fodders for broilers chicken, conducted by means of two separate scientific experiments.

The experiment carried by the method of group-analogues. In accordance with the experimental scheme (Table 1), 500 day-old chickens were selected, from which, based on the analogues, five groups (three subgroups) were formed: control group and four experimental ones. The experiment lasted for 42 days and divided into three periods (1–10, 11–22 and 23–42 days) and six sub-periods, each of them having lasted for 7 days.

Table 1

The scheme of experiment

Group	Source of trace elements	Trace element added to the ration, mg/kg			
		Mn	Zn	Fe	Cu
1	Sulfate	100	100	40	15
2	Glycinate	100	100	40	15
3	Citrate	100	100	40	15
4	Glycinate	75	75	30	11
5	Citrate	75	75	30	11

The ration for broilers chicken consisted of a full-ration mixed fodders that corresponded by the content of energy and basic nutrients to the standards indicated in the relevant cross-recommendations (Broiler Performance & Nutrition Supplement, 2018).

The air temperature and lighting of the premises were in accordance with the sanitary standards adopted in poultry farming. The density of placing the birds per head was in accordance with the standards. Giving a drink took place with nipples based on one nipple for 5 birds. Birds were drinking water and eating fodder *ad libitum*.

During the experiment, daily keeping of the consistence of poultry livestock and balances mixed fodder, weekly – weight gain of birds and feed conversion carried out. The body weight was determined by individual weighing of young birds every week on the weights of F998-6ED with an accuracy of 1 g.

The results of the research subjected to the usual statistical data processing procedures using the MS Excel software with applying the embedded statistical functions (AVERAGE, STDEVP, SQRT, TTEST and ANOVA), analysis of dependencies between the investigated factors and indicators – the construction of the trend line, definition of the regression equation and the coefficient of reliability of approximation (R^2). In calculating the statistical authenticity, it taken into account that the indicator “p” is characterized as follows: *P < 0.05, **P < 0.01 – “Statistically authentic (significant) differences have been revealed”.

3. Results and discussion

Broiler chickens feeding twice a day with full-ration mixed fodder that corresponded with the need of birds of this very species, age and productivity type in the energy content and the main nutritional elements. The composition of mixed feed and the content of energy and nutrients of mixed feeds in it presented in Table 2.

Table 2
Composition of mixed fodder and its nutritional value

Composition, %	Content in 100 g		
	1–10 days	11–22 days	23–42 days
Corn	55.0	54.0	59.5
Soybean meal	33.0	31.5	22.0
Sunflower meal	4.0	7.0	10.0
Fish meal	3.0	–	–
Vegetable oil	1.0	3.0	4.0
Limestone	1.0	1.5	1.5
Premix*	3.0	3.0	3.0
Analysis			
Metabolizable energy, kcal	300.00	308.00	317.00
Crude protein	22.00	19.00	18.94
Crude fiber	4.27	4.70	4.66
Lysine	1.20	1.10	1.05
Methionine	0.61	0.58	0.58
Calcium	1.00	0.96	0.90
Available Phosphorus	0.45	0.41	0.39
Sodium	0.20	0.17	0.16

*Premix contained (with respect to 1 kg of combined feed):

at 1-10 days of age: Mn – 100 mg, Zn – 100 mg, Fe – 40 mg, Cu – 15 mg, Se – 0.3 mg, I – 1.0 mg, Vitamin A – 13 KIU, Vitamin E – 80 mg, Vitamin D₃ – 5 KIU, Vitamin K₃ – 4 mg, Vitamin B₁ – 4 mg, Vitamin B₂ – 9 mg, Vitamin B₃ – 60 mg, Vitamin B₄ – 400 mg, Vitamin B₅ – 15 mg, Vitamin B₆ – 4 mg, Vitamin B₁₂ – 0.02 mg, Vitamin B_c – 2 mg, Vitamin H – 0.15 mg;

at the 11-22-day age: Mn – 100 mg, Zn – 100 mg, Fe – 40 mg, Cu – 15 mg, Se – 0.3 mg, I – 1.0 mg, Vitamin A – 11 KIU, Vitamin E – 60 mg, Vitamin D₃ – 5 KIU, Vitamin K₃ – 3 mg, Vitamin B₁ – 2 mg, Vitamin B₂ – 8 mg, Vitamin B₃ – 60 mg, Vitamin B₄ – 400 mg, Vitamin B₅ – 12 mg, Vitamin B₆ – 4 mg, Vitamin B₁₂ – 0.01 mg, Vitamin B_c – 2 mg, Vitamin H – 0.20 mg;

at 23-42 days of age: Mn – 100 mg, Zn – 100 mg, Fe – 40 mg, Cu – 15 mg, Se – 0.3 mg, I – 1.0 mg, Vitamin A – 10 KIU, Vitamin E – 50 mg, Vitamin D₃ – 5 KIU, Vitamin K₃ – 3 mg, Vitamin B₁ – 2 mg, Vitamin B₂ – 8 mg, Vitamin B₃ – 50 mg, Vitamin B₄ – 350 mg, Vitamin B₅ – 12 mg, Vitamin B₆ – 3 mg, Vitamin B₁₂ – 0.01 mg, Vitamin B_c – 1.5 mg, Vitamin H – 0.12 mg.

After analyzing the results of the conducted scientific and economic experiment, it found that the body weight of the experimental chicken broilers varied depending on the

feed factor (source and level of trace elements – Mn, Zn, Fe, Cu) in the mixed fodders (Table 3).

Table 3
Body weight of broiler chickens, g

Age, days	Group					SEM	P (ANOVA)
	1	2	3	4	5		
1	44.4	44.9	44.9	44.5	44.0	0.446	0.588
7	174.9	175.1	176.9	178.0	175.6	1.620	0.627
14	422.3	428.9	431.8	441.2*	427.0	5.295	0.132
21	888.3	904.8	903.9	921.6**	906.3	8.287	0.088
28	1460.2	1498.2*	1493.9	1507.7**	1499.9*	12.094	0.056
35	2101.9	2156.1*	2136.5	2173.2**	2153.9*	16.807	0.037
42	2779.5	2839.4*	2816.8	2847.8**	2832.4*	18.171	0.069

*P < 0.05; **P < 0.01 in relation to the first group

Body weight of broiler chickens at the 1- and 7-day age did not significantly change in the experimental groups. From the 14th day of age, the probable difference in the body weight of the chickens fed the combined feed with the Mn, Zn, Fe, Cu glycinate, 75 % of the need observed. In particular, the weight of young birds at 14- and 21-day-old age was 4.5 % (P < 0.05) and 3.8 % (P < 0.01), respectively, higher if compared with the control group, while the weight of other experimental groups was not believably greater than control. A similar trend was also observed with weighing the broiler chickens of the fourth group at 28-, 35- and 42-day-old age, where the chickens of this group were respectively 3.3 % (P < 0.01), 3.4 % (P < 0.01) and 2.5 % (P < 0.01) bigger than those fed the Mn, Zn, Fe, Cu sulfates in their ration. The broiler chickens, fed the Mn, Zn, Fe, Cu

glycinates 100 % of their need, and Mn, Zn, Fe, Cu citrates 75 % of the need at 28–42 days of age also had a significantly larger body mass compared to control respectively by 1.9–2.7 % (P < 0.05).

The ANOVA statistical analysis confirmed the probability of a difference in body weight among the experimental poultry chickens at 35-day age (P = 0.037). The difference between the weight of birds at the slaughter age was not significant (P = 0.069), but was close to the probability threshold.

Thus, the use of mixed fodder containing Mn, Zn, Fe, Cu in the form of glycinate at a level of 75 % of the requirement offered by the cross-originator, contributes to an increase in body weight compared to the mixed fodder containing the sulfates of these trace elements. The use of Mn,

Zn, Fe, Cu citrates 100 and 75 % of the need had a positive result in relation to control, but broiler chickens of these groups gave way to body weight of the fourth group.

The most representative in evaluating the results of the growth of young birds in the meat production direction is

the homogeneity of the population; therefore, for the analysis of the productivity of broiler chickens, their distribution by body weight at the slaughter age was analyzed (Figure 1).

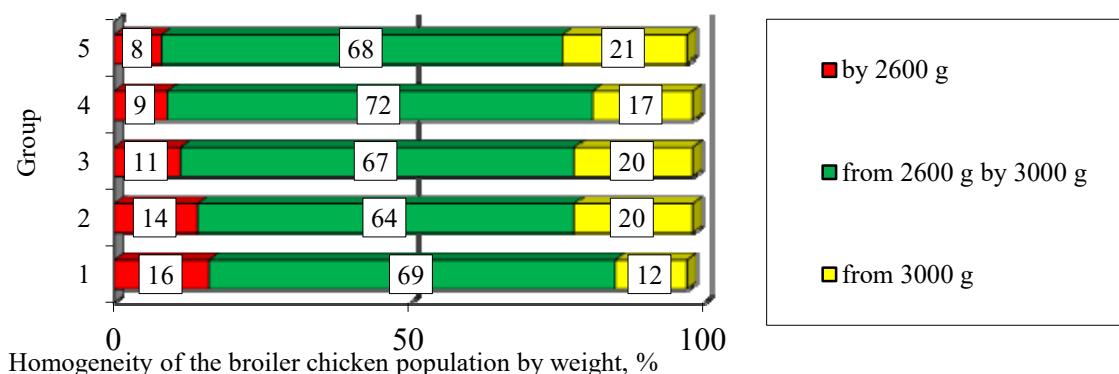


Fig. 1. Distribution of chicken population by body weight

The number of chickens weighing up to 2600 g was reduced in groups from control to fifth. The most homogeneous population was in the control group, whose chickens received sulfates of trace elements (Mn, Zn, Fe, Cu) in their ration.

In the study, the consumption of feed by broiler chickens of all groups was recorded (Table 4).

Table 4
Average daily consumption of mixed feed, g

Age of chickens, days	Group				
	1	2	3	4	5
1-7	23.5	23.1	23.8	24.1	23.7
8-14	53.1	53.6	53.8	54.1	53.3
15-21	93.2	93.9	93.5	94.2	94.0
22-28	132.2	134.6	133.8	133.1	134.3
29-35	171.2	173.3	171.6	175.1	172.8
36-42	196.5	198.1	197.5	195.9	196.2
For the whole period of the experiment	4688	4736	4718	4736	4720

The uneven growth rate of broiler chickens due to different sources and content of trace elements (Mn, Zn, Fe, Cu)

in combined feed contributed to feed costs per feed conversion to productivity (Table 5).

Table 5
Feed conversion of broiler chickens, kg

Age period, days	Group				
	1	2	3	4	5
1-7	1.260	1.242	1.263	1.264	1.262
8-14	1.504	1.478	1.477	1.440	1.485
15-21	1.400	1.381	1.386	1.373	1.373
22-28	1.618	1.588	1.587	1.590	1.585
29-35	1.867	1.844	1.870	1.842	1.844
36-42	2.030	2.029	2.032	2.033	2.029
During the period of experiment	1.714	1.695	1.702	1.689	1.693

Calculations of feed conversion during the growing season indicate that broiler chickens consuming combined feed containing 75 % of the requirement for trace element glycinate (Mn, Zn, Fe, Cu) spent 1.5 % less than the control.

The evaluation of the results of growing broiler chickens by comparing feed intake and its conversion into productivity shown in Figure 2.

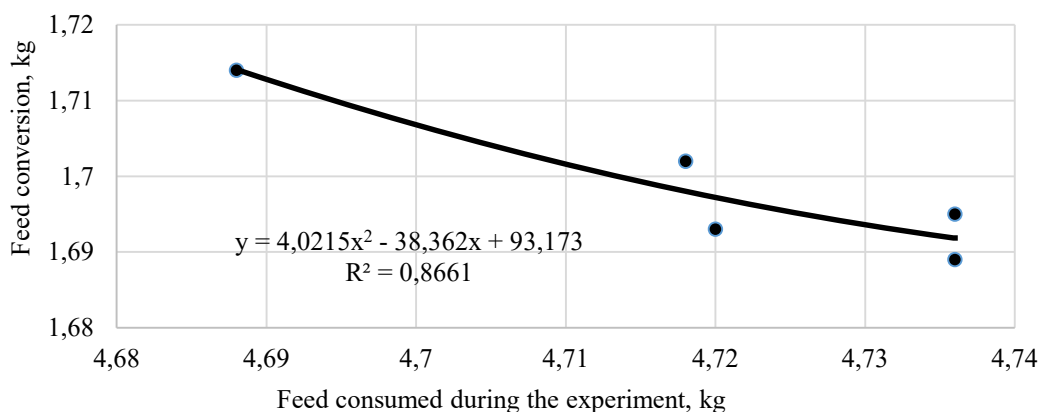


Fig. 2. Comparing feed intake and its conversion into productivity

4. Conclusions

Based on the results of the analysis of feed raw materials on the content of trace elements and conducting scientific experiments on broiler chickens, the most effective source of Manganese, Zinc, Iron and Copper in mixed fodders is reasonably found to contribute to solving the problem of increasing the full value feeding and intensifying the growth of growing poultry.

The use of mixed fodders in feeding the broiler chickens containing Manganese, Zinc, Iron, and Copper glycinates 75 % of their need, contributes to the increase of their body weight by 2.5 % and increases the growth rate by 2.5 %. Feed conversion per 1 kg growth in broiler chickens were 1.5 % lower than the control birds.

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