Influence of chelated forms of trace elements on the live weight and livability of rearing stock of broilers

Elena Pilyukshina[1,*], *Vladimir* Khaustov[1], *Aleksandr* Ozhimkov[2], *Valentina* Rusanova[1], *Alexey* Popelyaev[1], and *Ludmila* Bondyreva [1]

[1]Altai State Agricultural University, 98, Krasnoarmejskij ave., Barnaul, 656049, Russia
[2]Separate subdivision “Novosafonovskaya poultry farm” of Kuzbasskiy broiler LLC, ul. Molodezhnaya, 2a, Novosafonovsky village, Kemerovo region, 653224, Russia

Abstract. Nowadays, organic forms of trace elements, which have a high bioavailability, and, as a consequence, have a beneficial effect on the body of animals and birds, are increasingly used in feeding. In this area, quite a lot of research has been carried out on the use of chelates in poultry feeding, but mainly for broiler chickens and laying hens. Therefore, the purpose of our study was the use of organic forms of trace elements such as iron, manganese, copper, zinc, and selenium in the diets of rearing stock of the parent flock of the ROSS cross. The experiment was carried out in the production conditions of the Novosafonovskaya poultry farm of Kuzbasskiy Broiler LLC and at the Small animal science department of the Altai State Agrarian University in 2020. The results of the experiment indicate that replacing 50% of the need for inorganic forms of iron, manganese, copper, zinc and selenium with organic analogs contributed to an increase in live weight, absolute and average daily gains of rearing stock. There was an increase in the uniformity of the flock in terms of live weight, both males and females. The crop percent of poultry in the experimental group was 3.2-4.6% higher due to a decrease not only in mortality, but also in culled chickens.

1 Introduction

Feeding is a key indicator influencing the growth and development of young birds. Nowadays, at a sufficiently high level of feeding, a search is underway for means to grow strong young birds, from which healthy offspring can be obtained in the future throughout the entire period of use.

Most studies on the inclusion of organic forms of trace elements were carried out on broiler chickens [1-6] and laying hens [7-9]. The positive effect of chelates on growth, development, productivity and product quality has been proven [10-14]. There are almost no studies on the inclusion of chelated forms of trace elements in the diets of rearing stock of broiler breeders, which is relevant.

[*] Corresponding author: lexx-74@bk.ru

2 Materials and Methods

Therefore, the purpose of the study was the use of organic forms of trace elements such as iron, manganese, copper, zinc, and selenium in the diets of rearing stock of broiler breeders.

Experiments on the inclusion of chelated forms of trace elements in the composition of feed for rearing stock were carried out in the production conditions of a separate subdivision “Novosafonovskaya poultry farm” of Kuzbasskiy Broiler LLC and at the Small animal science department of the Altai State Agrarian University in 2020.

The object of the study was the rearing stock of the parent flock of the ROSS cross (hens and cockerels) from one day old to the age of 155 days, when they are transferred to the parent flock.

The subject of research is chelated forms of trace elements (iron, manganese, copper, zinc, selenium).

The experiment was carried out according to the scheme shown in Table 1.

Table 1. Scheme of the experiment.

Group	Feeding features
control	The usual diet, incl. premix (100% inorganic trace elements)
experimental	The usual diet, incl. premix (50% inorganic trace elements + 50% organic trace elements)

Table 1 shows that the hens and cockerels of the control group received compound feed in accordance with the age of the bird with a standard premix containing all the necessary biologically active substances in accordance with the recommendations for growing the ROSS cross. In the experimental group, salts of such trace elements as iron, manganese, copper, zinc, and selenium were replaced by their organic analogs in the amount of 50% of their requirement for this trace element.

All other conditions of feeding and keeping were identical and corresponded to the zootechnical requirements and recommendations for keeping the ROSS cross.

During the experiment, the birds were weighed weekly. Based on these data, the uniformity of the herd, absolute and average daily gains were calculated.

The mortality and culling of birds with an indication of the reasons for leaving were carried out daily.

The research results were subjected to statistical data processing using Microsoft Excel software.

3 Results

Changes in feeding conditions are primarily reflected in live weight, which is a key indicator for rearing stock. The influence of chelated forms of trace elements on the live weight of hens is shown in Table 2.

The data in Table 2 indicate that, when tested, the hens of both groups were almost the same, weighed 39 g, on average, and were slightly below normal (by 1 g or 2.5%). In the future, starting from the first week, there is a tendency for more intensive growth of hens in the experimental group by 16-302 g or by 5.1-12.8% ($p \leq 0.001$) compared to the control group. At the end of the experiment, i.e. when transferred to the parent flock, the average live weight of hens receiving chelated forms of microelements in their diet was 2996 g, which is 6.8% more ($p \leq 0.001$) and 12.8% more than in the control group and the group recommended for the ROSS cross, respectively.

Comparing the live weight of the experimental bird with the one recommended for the ROSS cross, it can be concluded that throughout the entire study period, the hens from the experimental group exceeded the norm by 7.6-15.8%, while they were only 4.0 -12.0% in the control group, and even lagged behind in growth from the recommended by 0.1-4.0% in the period from 19 to 21 weeks.

Table 2. Live weight and uniformity of chicken flock.

Age, weeks	Live weight, g			Uniformity, %	
	Norm	Control group	Experimental group	Control group	Experimental group
0	40	39±0.3	39±0.2	69.2	70.2
1	125	141±3.5	157±3.1***	70.4	76.5
2	240	263±4.8	285±4.0***	56.4	66.8
3	360	395±6.1	426±5.9***	54.1	67.7
4	480	533±7.2	573±6.9***	54.2	64.8
5	600	655±7.8	723±7.1***	59.6	66.0
6	740	776±8.3	869±7,9***	68.4	70.6
7	870	920±10.8	999±11.3***	71.4	69.3
8	990	1038±12.5	1126±15.7***	72.7	67.7
9	1100	1157±11.3	1244±13.8***	77.2	68.8
10	1200	1277±16.6	1352±17.9***	77.4	73.3
11	1300	1400±16.9	1474±15.9***	76.5	83.3
12	1400	1509±16.3	1600±16.1***	77.3	82.5
13	1505	1620±17.1	1703±17.0***	79.6	80.7
14	1610	1727±15.3	1824±15.0***	80.2	84.9
15	1715	1827±16.9	1945±16.8***	80.0	87.2
16	1825	1926±21.8	2048±20.6***	76.0	84.9
17	1945	2022±20.4	2170±19.9***	79.6	83.5
18	2070	2121±17.7	2289±19.9***	81.5	79.7
19	2200	2111±18.8	2391±20.5***	79.0	71.0
20	2340	2312±20.2	2517±18.3***	73.0	79.0
21	2495	2492±19,4	2794±21.9***	75.0	70.0
22	2655	2805±20.4	2996±20.1***	81.0	83.0
On average				72.8	75.3

– the difference in comparison with the control group is reliable: *- $p \le 0.05$, **- $p \le 0.01$, ***- $p \le 0.001$

The uniformity in live weight characterizes the uniformity of the bird. The higher the uniformity, the higher the productivity, the easier it is to create optimal feeding and keeping conditions for most individuals, and the easier it is to work with such a herd [15, 16]. Thus, the uniformity of hens in the control group ranged from 54.1-81.5%, and in the experimental group - 64.8-87.2%. On average, according to this indicator, the rearing stock in the experimental group exceeded their peers by 2.5%, which indicates a positive effect of the inclusion of chelates of microelements in the feed on the chickens.

The change in the growth rate of the experimental bird is shown in Table 3.

The analysis of table 3 showed that the most intensive growth of rearing stock was observed before the 7th week of life at the level of 14.6-20.6 g of average daily gain in the control group and at the level of 18.3-21.0 g in the experimental group. Further, there was a moderate growth of hens up to 20 weeks of age. At the same time, the absolute increase in the control and experimental groups ranged from 90-123 g and 102-127 g, respectively. At the end of the experiment (at the age of 21-22 weeks), the absolute and average daily gains were maximum both in the control and in the experimental group. This tendency is typical for rearing stock and contributes to the correct development and formation of chickens.

The use of organic forms of trace elements contributed to the more intensive growth of chickens. Thus, the hens of the experimental group surpassed their peers in absolute and average daily gain by 191 g or 6.9% and by 1.2 g or 6.9%, respectively.

Table 3. Growth rate of hens.

Age, weeks	Absolute gain, g		Average daily gain, g	
	Control group	Experimental group	Control group	Experimental group
1	102	118	14.6	16.9
2	122	128	17.4	18.3
3	132	141	18.9	20.1
4	138	147	19.7	21.0
5	122	150	17.4	21.4
6	121	146	17.3	20,9
7	144	130	20.6	18.6
8	118	127	16.9	18.1
9	119	118	17.0	16.9
10	120	108	17.1	15.4
11	123	122	17.6	17.4
12	109	126	15.6	18.0
13	111	103	15.9	14.7
14	107	121	15.3	17.3
15	100	121	14.3	17.3
16	99	103	14.1	14.7
17	96	122	13.7	17.4
18	99	119	14.1	17.0
19	90	102	12.9	14.6
20	101	126	14.4	18.0
21	180	277	25.7	39.6
22	313	202	44.7	28.9
Total	2766	2957		
On average			18.0	19.2

The dynamics of live weight and uniformity of a flock of cockerels under the influence of chelated forms of trace elements is presented in Table 4.

Analyzing table 4, we came to the conclusion that cockerels of the control group up to 7 weeks of age lagged behind by 0.2-4.4% in live weight, and then exceeded the recommended norm by 3.3-13.1%. Throughout the study, cockerels from the experimental group had a live weight higher than the recommended one for the ROSS cross by 10.0-24.3%, with the greatest relative difference observed in the first 10 weeks of life, which decreased with age.

The inclusion of chelates of trace elements in the diet of rearing cockerels contributed to an increase in the live weight of the bird by 3.9-27.2% in comparison with analogs from the control group. When transferred to the parent flock at 155 days of age, the cockerels of the experimental group exceeded the norm and their peers from the control group by 567 g or 17.0% and by 281 g or 7.7%, respectively.

The use of organic trace elements in the feeding of rearing cockerels affected the uniformity of the flock. Thus, the uniformity of the flock of cockerels in the experimental group and at the end of the experiment was 85.0%, while it was only 76.0% in the control group. At the same time, this indicator, on average for the entire period of the study, was higher in the experimental group by 6.1% compared to the control one.

For a more detailed assessment of the growth rate, the absolute and average daily gain of cockerels was calculated (Table 5).

Table 4. Live weight and uniformity of a flock of cockerels.

Age, weeks	Live weight, g			Uniformity, %	
	Norm	Control group	Experimental group	Control group	Experimental group
0	40	40±0.3	40±0.3	85.0	84.7
1	150	147±3.8	165±3.6***	72.3	76.0
2	310	360±5.1	400±4.9***	67.6	70.5
3	505	511±8.7	649±8.3***	51.5	67.1
4	720	698±9.2	856±8.8***	50.7	54.2
5	900	860±11.5	1084±10.4***	46.4	54.2
6	1075	1050±10.8	1336±12.7***	61.4	53.3
7	1230	1227±12.5	1529±11.9***	64.8	61.5
8	1375	1421±13.4	1669±12.6***	66.6	58.8
9	1510	1566±15.0	1847±14.1***	62.7	67.8
10	1640	1760±17.2	2006±18.9***	66.6	72.8
11	1770	1912±21.1	2162±19.4***	71.6	76.9
12	1900	2035±20.7	2268±18.3***	69.9	78.6
13	2030	2226±21.2	2410±20.2***	73.3	72.4
14	2160	2442±20.7	2539±21.5***	63.5	84.2
15	2290	2559±25.5	2686±26.7***	70.9	75.4
16	2430	2674±24.2	2813±22.2***	72.6	80.5
17	2575	2836±33.3	2970±29.4***	59.4	79.6
18	2725	2990±28.2	3106±27.7***	71.7	74.3
19	2880	3130±30.4	3301±28.8***	66.0	73.3
20	3035	3234±32.7	3408±29.1***	65.0	73.0
21	3195	3385±33.2	3686±30.6***	65.0	75.0
22	3345	3631±30.5	3912±28.5***	76.0	85.0
On average				66.1	72.2

– the difference in comparison with the control group is reliable: *- p≤0.05, **- p≤0.01, ***- p≤0.001

Based on the data in Table 5, it can be concluded that the most intensive growth of cockerels in the control group was observed up to 8 weeks of life at the level of 21.6-30.4 g of average daily gain, and in the experimental group up to 7 weeks of age - at the level of 27, 6-35.6 g. Further, there was a slowdown in the growth of young birds in the experimental groups until 21-22 weeks of life, which is associated with the peculiarities of growing rearing stock.

On average, over the experiment, the cockerels of the control group were inferior to their counterparts from the experimental group, which were fed organic trace elements in the composition of compound feeds, in absolute and average daily gain by 281 g or 8.1% and 1.8 g or 8.1%, respectively.

An important indicator when raising poultry is the livability of poultry, which determines the crop percent of young birds and, consequently, the number of parent flock. Fig. 1 shows the crop percent of hens, and Fig. 2 shows the crop percent of cockerels.

Fig. 1 shows that throughout the experiment, the crop percent of rearing stock of chickens in the experimental group, in which the bird received trace elements in organic form along with the feed, was 0.1-1.8% higher than in the control group. At the end of the experiment, the difference between the control and experimental groups for this indicator was 3.3% in favor of the experimental one.

Table 5. Growth rate of cockerels.

Age, weeks	Absolute gain, g		Average daily gain, g	
	Control group	Experimental group	Control group	Experimental group
1	107	125	15.3	17.9
2	213	235	30.4	33.6
3	151	249	21.6	35.6
4	187	207	26.7	29.6
5	162	228	23.1	32.6
6	190	252	27.1	36.0
7	177	193	25.3	27.6
8	194	140	27.7	20.0
9	145	178	20.7	25.4
10	194	159	27.7	22.7
11	152	156	21.7	22.3
12	123	106	17.6	15.1
13	191	142	27.3	20.3
14	216	129	30.9	18.4
15	117	147	16.7	21.0
16	115	127	16.4	18.1
17	162	157	23.1	22.4
18	154	136	22.0	19.4
19	140	195	20.0	27.9
20	104	107	14.9	15.3
21	151	278	21.6	39.7
22	246	226	35.1	32.3
Total	3591	3872		
On average			23.3	25.1

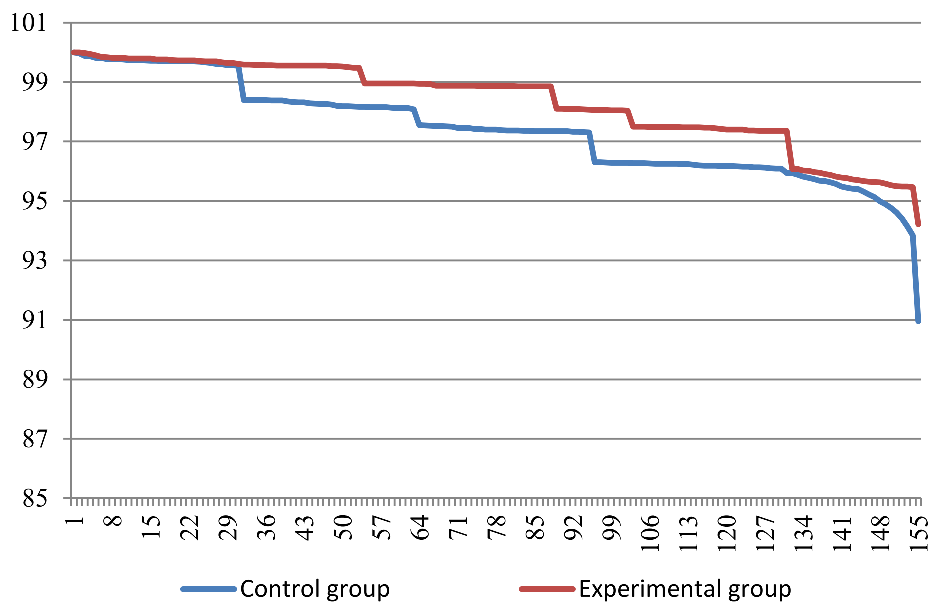

Fig. 1. Crop percent of hens by rearing periods, %.

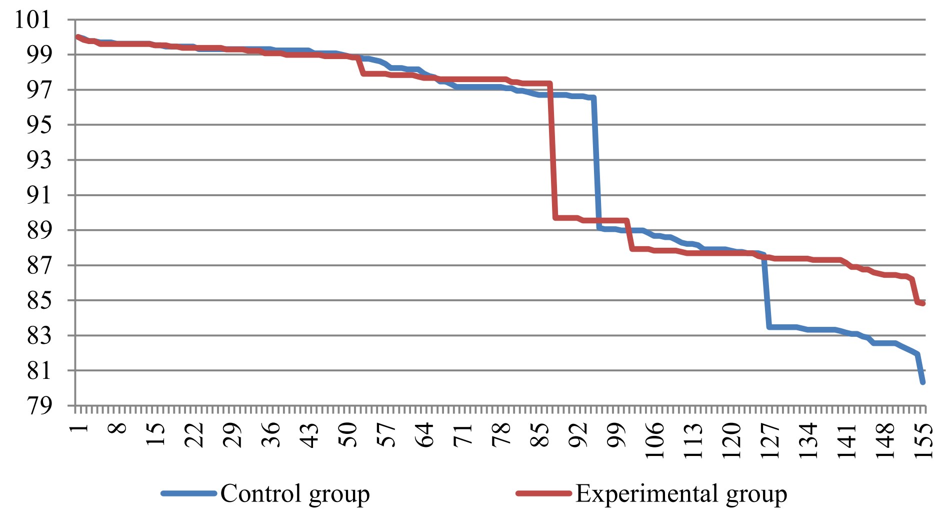

Fig. 2. Crop percent of cockerels by rearing periods, %.

The analysis of Fig. 2 showed that a sharp decrease in the number of cockerels was observed at the age of 13-14 weeks, at 18 weeks (only in control group), and when transferred to the parent flock, which is associated with the culling of young birds. Up to 18 weeks of age, the difference between the control and experimental group in terms of the crop percent of young birds was insignificant (up to 1.1%). When transferred to a parent flock, there were 4.5% more cockerels in the experimental group.

The percentage of disposed birds due to mortality and culling can be seen in Table 6.

Table 6. Disposal of rearing stock, %.

Indicator	Control group		Experimental group	
	hens	cockerels	hens	cockerels
Mortality during rearing	3.7	7.0	1.5	3.7
Culling during rearing	5.4	12.7	4.3	11.4
Total disposal	9.0	19.7	5.8	15.1
Livability	91.0	80.3	94.2	84.9

From table 5 it can be concluded that during the rearing period under the influence of chelated forms of trace elements, the mortality of hens and cockerels decreased by 2.2% and 3.3%, culling decreased by 1.1% and 1.3%, which contributed to an increase in livability by 3.2% and 4.6%, respectively.

4 Conclusions

Thus, 50% replacement of inorganic forms of trace elements with organic ones contributed to a more intensive growth of rearing stock of broiler breeders, an increase in the uniformity of the flock, and an increase in livability due to a decrease in the number of dead and culled poultry.

References

1. Ł. Jarosz, A. Marek, Z. Grądzki, M. Kwiecień, M. Kalinowski, The effect of feed supplementation with zinc chelate and zinc sulphate on selected humoral and cell-

mediated immune parameters and cytokine concentration in broiler chickens, *Research in Veterinary Science,* **112** 59-65 (2017) https://doi.org/10.1016/j.rvsc.2016.09.007

2. J.Zhao, R.B.Shirley, M.Vazquez-Anon, J.J.Dibner, J.D.Richards, P.Fisher, T.Hampton, K.D.Christensen, J.P.Allard, A.F.Giesen, Effects of chelated trace minerals on growth performance, breast meat yield, and footpad health in commercial meat broilers, *Journal of Applied Poultry Research,* 1,**19**, Issue 4 Pages 365-372 (2010) https://doi.org/10.3382/japr.2009-00020
3. B. Owens, M. E. E. McCann, C. Preston The effect of substitution of inorganic zinc with proteinated or chelated zinc on broiler chick performance, *Journal of Applied Poultry Research* 1, **18**, 4, 789-794 (2009) https://doi.org/10.3382/japr.2008-00122
4. G.-B.Kim, Y.M.Seo, K.S.Shin, A.R.Rhee, J.Han, I.K.Paik, Effects of supplemental copper-methionine chelate and copper-soy proteinate on the performance, blood parameters, liver mineral content, and intestinal microflora of broiler chickens, *Journal of Applied Poultry Research,* **20**, 1, 21-32 (2011) https://doi.org/10.3382/japr.2010-00177
5. M. Kwiecień, A. Winiarska-Mieczan, A. Milczarek, E. Tomaszewska, J. Matras, Effects of zinc glycine chelate on growth performance, carcass characteristics, bone quality, and mineral content in bone of broiler chicken, *Livestock Science* , **191**, 43-50 (2016) https://doi.org/10.1016/j.livsci.2016.07.005
6. Ao, T, Pierce J.L., Power R., Pescatore A.J., Cantor A.H., Dawson K.A., Ford M.J., Effects of feeding different forms of zinc and copper on the performance and tissue mineral content of chicks, *Poultry Science*1, **88**, 10, 2171-2175 (2009) https://doi.org/10.3382/ps.2009-00117
7. M. A. Trindade Neto, J. C. Dadalt, M. L. P. Tse, Dietary combination of chelated zinc and threonine and effects on egg production, egg quality and nutrient balance of Brown laying hens from 20 to 49 weeks of age, *Animal Feed Science and Technology* **267,** 114555 (2020) https://doi.org/10.1016/j.anifeedsci.2020.114555
8. C. Xie, H. A. M. Elwan, S. S. Elnesr, X. Y. Dong, X. T. Zou Effect of iron glycine chelate supplementation on egg quality and egg iron enrichment in laying hens, *Poultry Science* **98**, 12, 7101-7109 (2019) https://doi.org/10.3382/ps/pez421
9. Y.N.Min, F.X.Liu, X Qi, S Ji, S.X.Ma,X Liu, Z.P.Wang, Y.P.Gao Effects of methionine hydroxyl analog chelated zinc on laying performance, eggshell quality, eggshell mineral deposition, and activities of Zn-containing enzymes in aged laying hens, *Poultry Science,* 1 **97,** 10, 3587-3593 (2018) https://doi.org/10.3382/ps/pey203
10. D. W. Kellogg, E. B. Kegley *Encyclopedia of Dairy Sciences*, 981-984 (2020) https://doi.org/10.1016/B0-12-227235-8/00367-9
11. Adel Mohammadi, Shokoufe Ghazanfari, Seyed Davood Sharifi, Comparative effects of dietary organic, inorganic, and Nano-selenium complexes and rosemary essential oil on performance, meat quality and selenium deposition in muscles of broiler chickens, *Livestock Science,* **226,** 21-30 (2019) https://doi.org/10.1016/j.livsci.2019.06.001
12. M. K. Manangi, M. Vazques-Añon, J. D. Richards, S. Carter, C. D. Knight The impact of feeding supplemental chelated trace minerals on shell quality, tibia breaking strength, and immune response in laying hens, *Journal of Applied Poultry Research,* **1** (2015).https://doi.org/10.3382/japr/pfv029
13. M. K. Manangi, M. Vazquez-Añon, J. D. Richards, S. Carter, K. D. Christensen Impact of feeding lower levels of chelated trace minerals versus industry levels of inorganic trace minerals on broiler performance, yield, footpad health, and litter mineral

concentration, *Journal of Applied Poultry Research,* **1** (2012) https://doi.org/10.3382/japr.2012-00531

14. J. Zhao, R.B. Shirley, M. Vazquez-Anon, J.J. Dibner, J.D. Richards, P. Fisher, T. Hampton, K.D. Christensen, J.P. Allard, A.F. Giesen Effects of chelated trace minerals on growth performance, breast meat yield, and footpad health in commercial meat broilers, *J. Appl. Poult. Res*., **19**, 365-372 (2010)
15. A.Sh. Kavtarashvili, E.N. Novotorov, T.N. Kolokolnikova, Ways to improve the uniformity of a poultry flock, *Poultry and poultry products*, **4**, 24-27 (2012)
16. A.Sh. Kavtarashvili, E.N. Novotorov, T.N. Kolokolnikova Some techniques for maximizing the uniformity of a poultry flock, *Suchasne ptahivnitstvo*, **6**, 20-23 (2012)