Influence of diets with the various nutrient provision on the mineral metabolism in broiler chicken’s organism

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Abstract. The intensive development of industry in recent years led to the problem of the environment pollution and the survival of humanity in these circumstances became the central challenge today and affected all spheres of human activity. In some cases, technological processes have gone out of control resulting in the rapid accumulation of substances which are uncharacteristic for biosphere (radionuclides, heavy metals, and other toxicants).

As it is known, the blood system and organs of hematopoiesis are the most sensitive, so-called “critical systems”. In some cases, changes in the blood occur under relatively small doses of substances and may be the only diagnostic indicators of diseases and their consequences. Studying the influence of the feeding level on mineral metabolism causes some interest due to the application of different poultry feeding modes. In addition, the application of some new food means reduces the overall consumption of fodder due to low palatability, which proves the importance of such research once more.

1. Introduction

The intensive development of industry in recent years led to the problem of the environment pollution and the survival of humanity in these circumstances became the central challenge today and affected all spheres of human activity. In some cases, technological processes have gone out of control resulting in the rapid accumulation of substances which are uncharacteristic for biosphere (radionuclides, heavy metals, and other toxicants) [1].

As it is known, the blood system and organs of hematopoiesis are the most sensitive, so-called “critical systems”. In some cases, changes in the blood occur under relatively small doses of substances and may be the only diagnostic indicators of diseases and their consequences. Studying the influence of the feeding level on mineral metabolism causes some interest due to the application of different poultry feeding modes. In addition, the application of some new food means reduces the overall consumption of fodder due to low palatability, which proves the importance of such research once more [2-4].

2. Materials and methods

In order to study the impact of the nutrient provision on hematopoiesis in birds, there were selected 120 10-day broiler chickens that formed four groups (n = 30). The difference between the groups was in the level of metabolizable energy and the content of regulated trace elements in the diet.

After the completion of the preparatory period, the birds of experimental group 1 were moved onto the “amineral” diet. Broilers of experimental group 2 received a diet with the content of metabolizable
energy at 13.2 MJ/kg of dry matter (DM) not normed on trace elements. The third experimental group received the main diet with the content of metabolisable energy at 13.4 MJ/kg DM with the addition of a mineral premix made under recommendations by Federal Scientific Center All-Russian Research and Technological Poultry Institute RAS (2004), including salts of manganese, iron, zinc, copper, cobalt, iodine, and selenium (table 1).

Feeding the experimental birds was held 2 times a day. Watering the birds was without restrictions. The microclimate in the room complied with the requirements of the All-Union Norms for Process Design AUNPD-4-88.

Table 1. Circuit of the first series of the study

| Group                | Stage of the experiment | preparatory age, days | preparatory |
|----------------------|-------------------------|-----------------------|-------------|
| control              |                         | 10-20                 | 21-50       |
| I experimental       | MR                      |                       | MR1         |
| II experimental      |                         |                       | MR2         |
| III experimental     | MR                      |                       | MR3         |

Note: MR – the main ration in the preparatory stage; MR1 – the main ration in the experimental (registry) stage; MR2 – «Amineral» ration; MR3 – the main ration without a mineral premix; MR4 - the main ration with a mineral premix.

3. Results and discussion

Analyzing the myelogram of birds under different levels of feeding, we found that the number of cells of different blood shoots changed depending on both the level of feeding and the period of the study. In the next phase, we conducted a study of element content changes in the body and the red bone marrow of birds depending on the level of feeding [5].

We revealed that, by the end of the experiment, the arsenic content in the body of birds significantly rose in all groups with the maximum of 6.7 times for the third group (p < 0.001), and minimally by 1.4 times for the first group (p < 0.05), a somewhat different pattern is observed in the red bone marrow: animals in the third and the first groups showed an increase of this element by 2.1 and 1.7 times, and in the control and the second groups – a decline by 3.1 and 2.6 times, respectively (p < 0.01).

The boron content in the body decreased throughout the experiment and on day 50 was lower than the initial values: in the third group by 28.6%; in the control by 14.5%; in the second one by 31.8% and in first group by 35.0% (p < 0.001), similar changes were registered in the red bone marrow (61.6%, 54.7%, 57.0%, and 31.4% lower, respectively) (p<0.01).

The concentration of cobalt was in decline except for the body content on the control group: by 8.7% in the body and by 6.0% in the red bone marrow of the third group; by 26.09% and 4.2 times in the second group (p < 0.001); by 34.8% and 4.7 times in the first group (p<0.01).

The copper content significantly decreased 2.0-4.0 (p < 0.001) times in the body and the red bone marrow of the birds by the end of the experiment in all groups; the iron content was characterized with 28.6% and 3.4 times declines; the lithium one with 2.0-9.0 times (p < 0.001) decline; manganese – 1.8-3.0 times (p < 0.01); potassium – 1.5-4.0 times; aluminum –10.5% to trace contents; cadmium –1.5-5.0 times (p < 0.01).

We recorded similar changes for nickel and silicon: a decline of their concentration in all groups, and for the red bone marrow of the third group – a 2.3-2.8 times increase (p<0.001). The content of zinc and lead in the red bone marrow of the first group increased by 65.0% – 2.0 times (p < 0.001), also there was noted an increase of zinc in the body by 2.5%, and for all other groups – a statistically significant decline.
Reducing the feeding level changes concentrations of chemical elements in the body as follows:

\[ \begin{align*}
\text{Cr, Cu, Mn, V, Zn, Na} & \uparrow \\
\text{As, Co, Ni, Se, Cd, Hg, Pb, Sn, Ca, Mg, P} & \downarrow \\
\text{Na, P, B, Cr, Fe, Zn, Pb} & \uparrow \\
\text{Ca, As, Co, Cu, Ni, Se, Cd, Sr} & \downarrow
\end{align*} \]

In the red bone marrow:

Next, we carried out the correlation analysis of the influence of element contents in the body and the red bone marrow on myelogram. As a result, we found that the total number of cells in the bone marrow, the cells of granulation and erythroid groups fall under significant influence with reverse dependency by the concentration of lead in the red bone marrow; the cells of the monocytic group – mainly by the content of zinc in the red bone marrow and cadmium in the body (with reverse dependency); the cells of megakaryocytic group – by the content of zinc in the body with direct dependency and of copper and cobalt in the body with reverse dependency; the cells in the stages of mitosis – by the chromium content in the body with direct dependency and the cadmium one in the body and the copper one in the red bone marrow with reverse dependency (p<0.05).

**Table 2.** The summary of H-statistics of Kruskal-Wallis in groups of macro- and microelements in the bone marrow of laboratory animals

| Microelements | 4 groups on day 50 of the experiment | Value of H-statistics | p-level |
|---------------|-------------------------------------|-----------------------|--------|
| Al            | 12.449                              | 0.014                 |        |
| As            | 13.106                              | 0.011                 |        |
| B             | 12.723                              | 0.013                 |        |
| Ca            | 11.175                              | 0.025                 |        |
| Cd            | 13.045                              | 0.011                 |        |
| Co            | 12.638                              | 0.013                 |        |
| Cr            | 9.575                               | 0.048                 |        |
| Cu            | 12.665                              | 0.013                 |        |
| Fe            | 12.375                              | 0.015                 |        |
| Hg            | 13.402                              | 0.010                 |        |
| I             | 14.000                              | 0.007                 |        |
| K             | 12.660                              | 0.013                 |        |
| Li            | 6.542                               | **0.162**             |        |
| Mg            | 11.778                              | 0.019                 |        |
| Mn            | 13.198                              | 0.010                 |        |
| Na            | 12.863                              | 0.012                 |        |
| Ni            | 12.660                              | 0.013                 |        |
| P             | 9.038                               | 0.060                 |        |
| Pb            | 13.281                              | 0.010                 |        |
| Se            | 12.624                              | 0.013                 |        |
| Si            | 12.975                              | 0.011                 |        |
| Sn            | **0.000**                           | **1.000**             |        |
| Sr            | 10.059                              | 0.040                 |        |
| V             | 13.473                              | 0.009                 |        |
| Zn            | 12.975                              | 0.011                 |        |

Obtained in the course of the experiment data was best suited for the application of statistical
algorithms. A priority task in this direction is considered analyzing the similarity (difference) between the mean values of trace elements in groups, which allows determining the effect of feeding conditions on the elemental status of the bone marrow in laboratory animals. And, as a consequence, the effectiveness of the undertaken activities gets identified.

We will study the similarity (difference) between the mean values for all of the groups on day 50 of the experiment. The statistical practice has a large set of quantitative and non-parametric tests for these purposes.

As the method, we chose the Kruskal-Wallis test, which is used to test a hypothesis $H_0$: $k$ samples with the volume of $n_1, n_2, n_k$ are obtained from one general totality, i.e. the means of these groups are similar (table 2).

According to the data, we made the following conclusion: the null hypothesis was confirmed on two occasions – for Li and Sn. In other cases, the means of the analyzed groups were different.

We observed the following: there were changes of microelement contents in the red bone marrow of the laboratory animals during the experiment.

4. Conclusion
Summing up the results of the statistical analysis, one can draw a conclusion about the effectiveness of the experiment, i.e. different levels of bird feeding affect the elemental composition of the red bone marrow[6-8].

1. Reducing the level of nutrient provision of broilers on chemical elements leads to changes in the elemental status and the bone marrow blood formation [9-15].

2. There is a relationship between the content of elements in the body, the red bone marrow, and myelogram of hens. The cells of granulation and erythroid groups are influenced by the Pb content with reverse dependency; the cells of the monocytic group are mainly influenced by the Zn and Cd contents (with reverse dependency); the cells of megalocytectic group – by the Zn content (direct dependency) and by the Cu and Co contents (reverse); the cells in the stages of mitosis – by the Cd and Cu contents (reverse) (p<0.05).

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Conflict of Interest: Authors declares that they has no conflict of interest.

Ethical approval: All applicable international, national, and/or institutional guidelines for the care and use of animals were followed

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