Monitoring the exchange of toxic elements in poultry nutrition

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Abstract. Currently, the problem of the ecological purity of food products is becoming urgent. Food safety assessment includes monitoring the content of toxic elements, while carrying out the necessary analysis for the presence of aluminum, lead, cadmium, tin and strontium using the method of atomic emission spectrometry and mass spectrometry. A relatively new and safe method of detoxification is the use of probiotic strains with the ability to bind heavy metals. The purpose of our study is to form control of the quality of food raw materials by determining the level of toxic elements in poultry products to assess the safety of the product, with the additional inclusion of a probiotic preparation. Based on the studies carried out, a method has been developed for determining low concentrations of toxic elements in food raw materials, which will allow one to further strengthen control of the quality and safety of food and reduce the incidence of diseases caused by alimentary factors.

1. Introduction
Poultry farming is an important and dynamically developing sector of the economy in many countries. In the structure of Russian poultry production, broilers account for 97 %, turkey – 2 %, and alternative poultry products (duck, geese, quail) make up only 1 %. The task of increasing the competitiveness of the national poultry industry is aimed to produce high-quality products which would be environmentally safe [1].

In feeding poultry, diets are balanced in terms of chemical and mineral composition [2]. In the bird’s body, not all elements are absorbed, some elements are absorbed in the small intestine and participates in metabolic processes affecting productivity [3], the other elements are absorbed in the blind intestine, etc. [4].

The digestibility of individual chemical elements depends on the component feed composition, as well as the presence of anti-nutritional factors. Against the background of a positive effect on metabolism and productive qualities, microelements have a negative effect on bacteria [5] and intestinal microflora [6, 7], which is eliminated by including probiotic drugs in the diet [8].

Under certain conditions, microorganisms can immobilize the toxic effects of heavy metals. Thus, studies of the early 1980s explained that bifidobacteria interact with a number of toxic metals, including cadmium lead. This ability was due to the differences between the surface charges of bacteria and metals. After binding to the cell wall of metals, most of the metal cations were bound and deposited on the cell wall of microorganisms.

It is believed that the presence of binding proteins in microorganisms, such as metallothioneins and phytochelatins, can also contribute to the absorption of metals. In addition, there are several microorganisms that perform metal detoxification using plasmid genes.
Adding strains of microorganisms to the diet improves feed efficiency and contributes to the release of endogenous trace elements from the depot, including heavy metal loss, which will play a huge role in livestock and poultry farming [9].

The purpose of the study is to study the effect of a mineral-deficient diet and the additional inclusion of probiotic strain Bifidobacterium longum on the content of toxic elements in the biological tissues of broiler chickens.

2. Materials and methods
The studies were carried out on Smena 8 cross broilers under vivarium conditions (Center for the collective use of scientific equipment of the Federal Research Center for Biological Systems and Agricultural Technologies of the Russian Academy of Sciences, 2019). The birds aged from 7 to 21 days of age were fed with the basic diet. Experimental birds were fed with compound feed developed according to the recommendations of VNITIP (2004). Combined feeds were formed on the basis of wheat-barley-corn feed mixture. One kilogram of mixed feed contained exchange energy – 12.34 MJ; crude fat – 71.9 g. Crude fiber was 42.5 g/kg.

During the main accounting period, two groups consisting of 30 birds were formed by the method of analogues. The birds were fed with a mineral-deficient diet, they drank distilled water and ate rice prepared in a special way (boiling polished rice was cooked for 15 minutes, then broth was removed and rice was washed in distilled water). In order to prevent vitamin deficiencies, a multivitamin complex containing vitamins A, D, C, K, E, B1, B2, B3, B4, B5, B6, Bc, B12 at dosages recommended by L.F. Ordinal (2001) was added. In addition, the birds of the experimental group received liquid probiotic Soya-bifidum at a dosage of 0.7 ml/kg feed.

The elemental composition of biosubstrates was studied using atomic emission and mass spectrometry (AES–ICP and MS–ISP) in the laboratory of ANO "Center for Biotic Medicine", Moscow. When performing research using AES–ICP and MS–ICP methods, ashing was carried out using the MD-2000 microwave decomposition system (USA). The content of elements in the resulting ash was estimated using an Elan 9000 mass spectrometer (PerkinElmer, USA) and an Optima 2000 V atomic emission spectrometer (Perkin Elmer, USA).

Statistical analysis. Numerical data were processed by the one-way analysis of variance (ANOVA) and the results were presented as mean values for groups and standard errors of the mean (StatSoft Inc. 2009).

3. Results and discussion
The experimental study identified a positive effect of probiotic strain Bifidobacterium longum on the live weight of broiler chickens. Thus, the difference was 7.96 %, and eatability in group II was 100 %.

Currently, in assessing meat quality, special attention is paid to the content of heavy metals, which can accumulate and pose a threat to human health.

The actual change in the content of toxic elements in the liver, pectoral and femoral muscles of broiler chickens is presented in Tables.

When determining the concentration of toxic metals in the liver of broiler chickens, it was found that the additional inclusion of probiotic strains contributed to a significant decrease in aluminum by 1.5 times (p = 0.048), lead – by 2.0 times (p = 0.008) and tin – by 3 times ( p = 0.0064), compared with group I (Table 1).

Considering the content of toxic elements in the pectoral muscles, it should be noted that the levels of lead, tin and strontium were at the same level and amounted to 0.01 mg/kg; 0.004 mg/kg and 0.05 mg/kg, respectively (Table 2). However, there was a significant decrease in aluminum by 54.6 % (p = 0.005) and cadmium by 55.6 % (p = 0.005).
Table 1. The content of toxic elements in the liver of broiler chickens, mg/kg

| Indicator | I   | Q₁–Q₃ | II  | Q₁–Q₃ | p  |
|-----------|-----|-------|-----|-------|----|
| Al        | 1.1 | 0.75–1.3 | 0.73 | 0.62–0.85 | 0.048 |
| Cd        | 0.04 | 0.03–0.051 | 0.04 | 0.02–0.055 | 0.121 |
| Pb        | 0.02 | 0.01–0.031 | 0.01 | 0.08–0.018 | 0.008 |
| Sn        | 0.03 | 0.02–0.038 | 0.01 | 0.08–0.015 | 0.0064 |
| Sr        | 0.08 | 0.06–0.093 | 0.06 | 0.052–0.068 | 0.212 |

Table 2. The content of toxic elements in the pectoral muscles of broiler chickens, mg/kg

| Indicator | I   | Q₁–Q₃ | II  | Q₁–Q₃ | p  |
|-----------|-----|-------|-----|-------|----|
| Al        | 0.88 | 0.75–0.92 | 0.4 | 0.31–0.48 | 0.005 |
| Cd        | 0.0009 | 0.0008–0.0012 | 0.0004 | 0.0003–0.00048 | 0.005 |
| Pb        | 0.01 | 0.0075–0.014 | 0.01 | 0.007–0.016 | 0.13 |
| Sn        | 0.004 | 0.0034–0.0046 | 0.004 | 0.0037–0.0051 | 0.22 |
| Sr        | 0.05 | 0.034–0.062 | 0.05 | 0.043–0.061 | 0.16 |

Similar changes were observed in the femoral muscles. Soya-bifidum had a direct effect on the reduction of toxic elements: cadmium – by 2 times (p = 0.006), lead – by 4.0 times (p = 0.001) and strontium – by 2.0 times (p = 0.013). The similar results were obtained in studies [10]. A decrease in aluminum and tin was observed, but the changes were unreliable (Table 3).

Table 3. The content of toxic elements in the femoral muscles of broiler chickens, mg/kg

| Indicator | I   | Q₁–Q₃ | II  | Q₁–Q₃ | p  |
|-----------|-----|-------|-----|-------|----|
| Al        | 0.6 | 0.49–0.74 | 0.48 | 0.23–0.61 | 0.14 |
| Cd        | 0.0004 | 0.00035–0.00051 | 0.0002 | 0.00018–0.00028 | 0.006 |
| Pb        | 0.04 | 0.034–0.047 | 0.01 | 0.0076–0.015 | 0.001 |
| Sn        | 0.0009 | 0.00075–0.0012 | 0.001 | 0.00064–0.0017 | 0.17 |
| Sr        | 0.04 | 0.032–0.048 | 0.02 | 0.015–0.031 | 0.013 |

It is known that the ability to accumulate metals, including heavy ones, is very widespread among various organisms. Microorganisms can extract them from the environment are. Data accumulated suggest that the microflora of the gastrointestinal tract plays an important role in the detoxification of endogenous and exogenous toxic substances. Of great interest is the study of this ability among the microorganisms that make up the probiotic preparations [11].

The harmful effects of heavy metal ions are associated with various processes: displacement of metals by toxic metals; the binding of part of the macromolecule required for the normal functioning of the body [12]; the formation of biological aggregates harmful to the body; depolymerization of biologically important macromolecules; directed base pairing of nucleotides and appearance of errors in protein synthesis [13].

Pb²⁺ ions are especially dangerous. They activate the hemokinase enzyme, which decomposes heme, and cadmium has the same effect. The loss of animal heme leads to the hemoglobin deficiency and development of anemia. Activation of peroxide and free radical oxidation were observed in ions of lead, cadmium, strontium, and other metals [14]. As a result of this activation, some proteins, nucleic acids, lipids, and biomembranes become damaged.

Probiotic drugs can have a protective effect on toxic elements, reducing their content in the body, and also have bioactive properties that can have a regulatory effect on the intensity of metabolic processes, enhance the functional activity of organs and systems, increasing the level of natural resistance [15].
Bifidobacteria are widely known as classic probiotic microorganisms. The beneficial effect of bifidobacteria on the host organism is great. They participate in enzymatic processes, perform a vitamin-forming function (synthesis of B vitamins, vitamin K, folic and nicotinic acids), improve indicators of protein, lipid and mineral metabolism, contribute to the synthesis of essential amino acids, better absorption of calcium salts, vitamin D, etc. [16].

*Bifidobacterium longum* refers to endogenous (autochthonous, resident, obligate) microflora – the constant part of normoflora, which plays an important role in the metabolism of the host, and protects the body from infections [17]. For this group of microorganisms, a binding and inactivating effect in relation to toxic elements and the ability to assimilate essential ones are characteristic.

4. Conclusion

Thus, the probiotic strain *Bifidobacterium longum* contributed to the maximum elimination of toxic elements, reducing intoxication of the whole body.

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