The elemental status of broiler chickens when used the cocoa husks in the diet

V V Grechkina¹,³, S A Medvedev¹, S V Lebedev¹, E P Miroshnikova², O V Shoshina¹ and I S Miroshnikov¹

¹ Federal State Budgetary Scientific Institution «Federal Research Centre of Biological Systems and Agrotechnologies of the Russian Academy of Sciences» Orenburg, Russia
² Orenburg State University, Orenburg, Russia
³ E-mail: Viktoria1985too@mail.ru

Abstract. Cocoa husk can become a desirable feedstock and mineral source for poultry farming due to its nutritional value and valuable bioactive compounds. The article deals with the biological effect of cocoa husk on the metabolism and elemental status of broiler chickens of the Arbor-Icres cross. When replacing 5% of wheat treated with alkali in the amount of 45 g/kg in the diet of broiler chickens of the II experimental group with cocoa husk, there was an increase in the elements lithium – by 66.5% (p≤0.05), cadmium – by 25.8% and phosphorus – by 18.5%, nickel – by 31.1% (p≤0.05), cobalt – by 33.9%, iron – by 21.5%, manganese – by 15.6%, selenium – by 41.0%, iodine – by 40.1% (p < 0.05), aluminum – by 43.7% (p < 0.05), against the background of a decrease in toxic, relative to the control bird. Cocoa husk in experiments has a protective effect on toxic elements, reducing mercury in the body – by 53.5% (p < 0.05), lead – by 18.2%, tin – by 69.4% (p < 0.05) and strontium – by 26.3%. Thus, cocoa husk is a valuable by-product of the food industry, which can be used in the cultivation of broiler chickens.

1. Introduction
Cocoa husk is a rich source of dietary fiber and protein, as well as valuable biologically active compounds (theobromine, caffeine, flavonoids, etc.). Due to its composition, they can be used for further use as an energy source in the agricultural industry [1-2]. In addition, the extraction of Cocoa husk has a high economic value, since it is a cheap raw material for the extraction of various components and can be used as a source of dietary supplements in poultry farming. However, the safety of cocoa husk should be investigated more carefully, as they are treated with various pesticides and may contain heavy metals and aflatoxins [3].

Cocoa husk contains 16.23% crude protein, which is comparable to bran. The content of crude fiber and nitrogen-free extractives in cocoa husk – 21.55 and 38.56% against 7.3% and 60.08, respectively, in bran, reduces its nutritional value, compared with the latter. However, the positive characteristics of cocoa husk include its saturation with macro and microelements [4]. At the same time, a number of questions arise related to the effectiveness of the use of confectionery waste on metabolism, in particular on mineral metabolism [5-6].
2. Materials and methods

2.1. Animals and feed
The research was carried out on broiler chickens of the Arbor-Aikres cross in the laboratory of biological tests and examinations and the Center for Collective Use (Federal Research Centre of Biological Systems and Agrotechnologies of the Russian Academy of Sciences).

The experimental part of the work was performed in accordance with the protocols of the Geneva Convention and the principles of good laboratory practice (National Standard of the Russian Federation GOST R 53434-2009), the rules of laboratory practice in conducting preclinical studies in the Russian Federation (GOST 3 51000.4-96). The experimental research on animals was conducted according to instructions, recommended by the Russian Regulations, 1987 (Order No. 755 on 12.08.1977 the USSR Ministry of Health) and “The Guide for Care and Use of Laboratory Animals (National Academy Press Washington, D.C. 1996”).

The poultry was kept in specialized KUN-05 cages with an area of 4050 cm² (90×45×45 cm). The bird was marked with plastic foot tags.

2.2. Observation, estimated indicators
4 groups (n=30) of seven-day-old broiler chickens were formed to conduct a laboratory study on the principle of analog pairs. After the preparatory period, from the age of 15 days, the poultry was transferred to the main accounting period: the control group received the main diet (basic diet, recommendations of Russian Research Veterinary Institute of Poultry Farming (2014). I, II and III experimental groups have basic diet with the replacement of 2.5, 5.0 and 7.5% of the grain part with native cocoa husk treated with alkali in the amount of 45 g/kg, respectively. Trace element analysis was studied by atomic emission spectrometry (Optima 2000 V, "Perkin Elmer", USA) and mass spectrometry (Elan 9000, "Perkin Elmer", USA) according to the manufacturer's recommendations.

The rate of accumulation of chemical elements was calculated based on the analysis of the content of elements in the feed and body of broiler chickens according to the formula:

\[
\frac{(E_k-E_n)(M_k+M_n)/2 \times W^{0.75}}{K_c},
\]

where: \(E_k-E_n\) – the content of chemical elements in the body at the beginning and at the end of the experiment, mg/head; \(M_k+M_n\) – live weight at the end and beginning of the experiment, respectively, kg; \(K_c\) – the number of experiment days; \(W^{0.75}\) - the coefficient of conversion to live weight.

2.3. Statistical processing
Statistical analysis was performed using ANOVA techniques (Statistica 10.0 software package, StatSoft Inc., USA) and Microsoft Excel. Statistical processing included the calculation of the mean (M) and the standard errors of the mean (±SEM). The reliability of the differences in the compared indicators was determined by the Student's t-test. The level of significant difference was set at \(p\leq0.05\). All comparisons were carried out as a ratio with the results of the control group.

3. Results
Analyzing the rate of accumulation of essential and conditionally essential elements, it was found that the use of 2.5% of cocoa husk from the weight of the diet when feeding broiler chickens contributed to an increase in the rate of accumulation of iodine by 15.6% and a decrease in nickel by 10.9% (\(p<0.05\)). The inclusion in the structure of the broiler chickens diet in the experimental group II of 5% of the chemically treated cocoa mass contributed to a decrease in the rate of accumulation of nickel, iron, manganese and iodine by 22.8, 13.5, 10.9 and 35.4% (\(p < 0.05\)), respectively, relative to the control broilers.

Replacement of 7.5% of wheat in the broiler chickens diet of the III experimental group with cocoa husk treated with alkali was accompanied by an increase in the rate of accumulation of nickel – by 27.8%, cobalt – by 93.6% (\(p\leq0.05\)), iron – by 58.8%, manganese – by 68.0% (\(p\leq0.05\)), zinc – by 19.45%
and a decrease in the rate of accumulation of iodine by 43.1% (p<0.05) relative to the same indicator of the control group. According to the results of the analysis, the rate of accumulation of toxic elements showed that the replacement of 5% of wheat with cocoa flour led to an increase in the rate of accumulation of cadmium by 26.6-34.9% and a decrease in this indicator for mercury – by 19.1-50.7% and strontium-by 3.5-24.5%. The rate of accumulation of aluminum, lead and tin in the I experimental group was 37.2, 17.9 and 34.8% (p < 0.05), respectively, higher than in the control group.

In the poultry of the experimental group III, the lead accumulation rate was 60.1% higher, and for aluminum by 14.9% (p < 0.05) less than in the control group. The partial replacement of wheat in the diet of broiler chickens with cocoa husk had a direct impact on the rate of accumulation of macronutrients. As the results of the study showed, the body of the experimental bird accumulated calcium by 2.9-8.8% and potassium by 3.4-10.7% worse than analogues from the control group. The rate of accumulation of magnesium, sodium and phosphorus by 4.9-10.3, 3.6-36.2 and 9.4-17.7% (p < 0.05), respectively, in the body of the experimental bird was higher than in the control one. Evaluating the efficiency of the conversion of chemical elements from the food substrate into the body of broiler chickens, it was found that in the II experimental group it was accompanied by an increase in the efficiency of the body's use of boron-by 48.5% (p<0.05), lithium – by 59.1% (p<0.05), vanadium – by 20.6%, cadmium – by 24.7%, sodium – by 24.6% and phosphorus – by 15.1% and a decrease in the sorption of arsenic – by 18.6%, nickel – by 21.6%, cobalt – by 24.9% (p < 0.05), iron – by 17.4%, mercury – by 24.8%, tin – by 49.1% (p < 0.05), strontium – by 21.2% (p < 0.05) and potassium – by 13.1%, relative to the poultry contained in the control diet.

Broiler chickens diet containing 5% cocoa husk increased the conversion rate of boron-by 66.9% (p<0.05), lithium – by 66.5% (p < 0.05), cadmium – by 25.8% and phosphorus – by 18.5%, nickel – by 31.1%, cobalt – by 33.9% (p < 0.05), iron – by 21.5%, manganese – by 15.6%, selenium – by 41.0% (p<0.05), iodine – by 40.1%, aluminum – by 43.7% (p < 0.05), with a decrease in mercury – by 53.5% (p < 0.05), lead – by 18.2%, tin – by 69.4% (p < 0.05) and strontium – by 26.3%, relative to the control bird.

Drawing an analogy between the results on the rate of accumulation and the efficiency of the chemical elements use, a number of coincidences are established. They can be expressed in the formula

\[
\frac{\text{B,Li,V,Na,P,Cd}}{\text{As,Hg,Sr}} \uparrow
\]

which indicates an increase in the participation of these elements in the metabolic processes occurring in the body when using cocoa husk in the structure of the diet.

4. Discussion

The authors [7-8] found that the use of waste from the flour milling industry (bran) has already become traditional, reaching 5% in mixed feeds. At the same time, the use of waste from other industries is not widespread. It leads to their accumulation, spoilage and rotting, which negatively affects the state of the environment. Among these is the husk of cocoa beans (cacaovella), which is not inferior to wheat bran in its nutritional value [9]. In our experimental study, the replacement of 5% wheat with cocoa husk with treated alkali in the amount of 45 g/kg in the II experimental group improved the state of mineral metabolism for essential and conditionally essential elements. In the bird of the experimental group III with a replacement of 7.5%, the rate of accumulation of toxic elements was higher compared to the bird of the experimental group I and II.

Processing cocoa husk with different concentrations of alkali partially destroys the hard surface of the husk, it swells, becomes soft, the initial chemical composition changes. With an increase in the amount of introduced alkali, there is a noticeable decrease in the fiber content, compared with the original product from 21.55% to 10.55%, while the amount of protein increases from 16.23 to 18.67% (p < 0.05) and nitrogen-free extractive substance from 38.56 to 48.55% (p < 0.05) in the husk treated with alkali in the amount of 60 g/kg, compared with the original product. At the same time, the content of toxic substances in the bird's body decreases by 11-12% [10].
The stability of the chemical composition is one of the most important and necessary conditions for the normal functioning of the body. Therefore, the identification and evaluation of deviations in the exchange of macro and microelements, as well as their correction, is a promising direction of modern agricultural biology [11-12]. Kakaovala contributed to the degree of availability of mineral substances contained in the product, which was expressed in an increase in essential elements from 14.42 to 21.87% (p<0.05).

5. Conclusion
The results obtained prove the modeling role of cocoa husk in the exchange of micro-and macronutrients. Cocoa husk in experiments has a protective effect on toxic elements, reducing their content in the body, and also has bioactive properties when replacing wheat with 5% cocoa husk. The potential of using cocoa husk as a mineral source to improve performance in poultry is significant. In this regard, for the effectiveness of its action, it is necessary to constantly monitor the elemental status of the body to develop methods of correction for macro-and microelements. The analysis shows that cocoa husk is a valuable by-product of the food industry, which can be used in poultry farming.

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