Influence of unconventional mineral complexes on the biochemical and hematological parameters of the blood of broiler chickens

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Abstract. The research results of the measurements of biochemical and hematological blood parameters of broiler chickens of the cross “Ross 308” depending on the inclusion of mineral additives based on industrial wastes into diet are presented in this article. The researches were conducted in 2017 at the premises of LLC “YeniseiAgroSoyuz” of Sukhobuzimsky district of Krasnoyarsk region and the stock-raising farm of the Institute of Applied Biotechnology and Veterinary Medicine of Krasnoyarsk State Agrarian University of the Ministry of Agriculture of Russia. The purpose of the research was to justify the use of mineral sources of Krasnoyarsk region as a part of animal feed for poultry. It has been established that the use of belite sludge and oxidized brown coal is one of the promising areas of non-waste technology for processing and mining of alumina and brown coal in the territory of Krasnoyarsk region.

1. Introduction
The high-quality, healthful, safe and at the same time cheap animal feed adequacy and compliance with veterinary and sanitary requirements largely determine the level of development and the economy of poultry farming [1]. The search for new non traditional sources, nutrients and biologically active substances is one of the most important areas in the scientific research on poultry feeding. In recent years, the increasing attention of scientists and practitioners has been attracted by the problems of using by-products of industrial enterprises for feed purposes. Siberia has a large number of metallurgical plants; by-products of these enterprises are rich in mineral nutrients, which make it possible to include them in the diets of feeding farm animals and poultry [2, 3].

According to Russian researches - A.A. Arkova [4], K.Ya. Motovilova [5], A.L. Sidorova [6], M.G. Aleksandrova [7], A.V. Pobedinsky [8], the development of mixed feed formula from local cheap and affordable conventional and unconventional feed products is extremely urgent. As sources of minerals, along with conventional supplementary feeding, natural minerals began to be used in livestock breeding, such as: curyurites, belite sludge, peat, sapropel, oxidized brown coal, etc. In this regard, there is a need to develop and create mineral complexes based on mineral sources of Krasnoyarsk region in the production of animal feed. The purpose of the research was to justify the use of mineral sources of Krasnoyarsk region as a part of animal feed for poultry.

2. Materials and methods
The chemical composition and energy nutrition of the animal feed were studied before the experiment. As a matter of record feed mixtures were developed that were made in the conditions of the feed
factory of the stock-raising farm of the Institute of Applied Biotechnology and Veterinary Medicine of Krasnoyarsk State Agrarian University of the Ministry of Agriculture of Russia.

The researches were carried out in two stages. The purpose of the first stage of the scientific and economic experiment was to determine the dosage of the mineral mixture based on local mineral raw materials. At the second stage, the effect of the developed mineral mixture on the hematological parameters of the experimental poultry was studied. The experimental groups were formed at the premises of LLC “YeniseiAgroSoyuz” of Sukhobuzimsky district of Krasnoyarsk region on the principle of analogues (cross, age, live weight) from broiler chickens of the cross “Ross 308” at the age of ten days, 20 chickens in each group. Housing conditions, cage density, front of feeding and watering, microclimate parameters in all groups were the same in compliance with methodological recommendations for working with broiler chickens of the cross “Ross 308”. Feeding of chickens was carried out twice a day; ad lib watering was carried out from nipple drinkers.

Broiler chickens of the control group received a balanced basic diet (BD), compounded by standards of All-Russian Research and Technological Institute of Poultry, but in the diets of experimental groups there was partial or complete replacement of limestone and monocalcium phosphate with oxidized brown coal, belite sludge, vermiculate and peat; the grain part remained unchanged.

At the first stage five groups were formed (one control group and four experimental groups). In the first group 0.2% of monocalcium phosphate and 0.6% of limestone were replaced by 0.8% of oxidized brown coal. In the second experimental group 1.2% of limestone and 0.35% of monocalcium phosphate were replaced by 0.35% of peat, 0.5% of vermiculate and 0.7% of oxidized brown coal. In the third experimental group 0.7% of oxidized brown coal, 0.7% of belite sludge and 0.7% of vermiculate were introduced instead of limestone and monocalcium phosphate. In the fourth experimental group the following components were introduced: vermiculate (0.4%), belite sludge (0.4%), oxidized brown coal (0.4%), limestone (0.9%).

At the second stage three groups were formed (one control group and 2 experimental groups). The first experimental group received limestone (0.4%), oxidized brown coal (0.4%), belite sludge (0.4%), vermiculate (0.4%), peat (0.3%) as a part of compound feed. In the second experimental group monocalcium phosphate (0.3%), limestone (0.4%), oxidized brown coal (0.4%), belite sludge (0.4%), vermiculate (0.4%) were introduced.

Feed consumption was determined by taking into account given feed and its orts. Liveability of livestock was monitored daily by taking into account mortality and culling. Live weight of broiler chikens was checked by individual (according to the numbers of winglets) daily weighing. Hematological parameters were studied in the experimental poultry of forty-two days old. Hemoglobin, erythrocyte, leucocyte, crude protein and albumen were determined. Blood analysis of broiler chickens were carried out according to the modern methods for the study of biochemical parameters [9].

The reliability of the obtained data was estimated by the method of variation statistics using Student’s t-test. Arithmetic mean values (x) and their errors (Sx) were calculated. The difference in indicators was considered significant when P≥0.95. Statistical data processing was performed using application programs Microsoft Office Excel 2013.

3. Results

As result of the research, it was found that feeding mineral complexes based on industrial wastes has a multidirectional effect on the hematological parameters of the experimental poultry.

It is known that total protein plays an important role in maintaining the osmotic pressure of the blood; it is an important buffer system and is involved in the transport of hormones, nutrients and vitamins [9]. We found that the maximum content of crude protein was observed in the first experimental group. It is more than 6% higher than in the control group (P≥0.95). The minimum level of crude protein in blood serum was observed in poultry of the second and third experimental groups, it is 15% lower than in the control group and almost 20% less than the indicators of the first and fourth
experimental groups \((P \geq 0.99)\). The level of crude protein in the fourth experimental group was 5% behind the control values (table 1).

Blood protein contains albumen, globulin and fibrinogen. It was found that introduction of mineral mixtures into the diet of broiler chickens of the first experimental group did not have a negative impact on albumen in the blood serum; its level did not significantly differ from the control poultry. At the same time, albumen content of broiler chickens of the second, third and fourth experimental groups were significantly behind the control values by 13.3%, 17.8% and 22.5% respectively \((P \geq 0.95)\).

One of the most important macronutrients in the body is calcium. It reduces the excitability of nervous and muscle tissue, influence the effectiveness of hormones; it is the basis of the bone tissue of the body and is involved in blood coagulation. In the first experimental group the calcium content exceeded the control group by 10.8%. The minimum level of total calcium was observed in the second and fourth experimental groups. It was 1.97 \(\pm\) 0.04 mmol/L and 2.14 \(\pm\) 0.06 mmol/L respectively, that was significantly behind the control values \((P \geq 0.99)\).

**Table 1.** Biochemical blood parameters of broiler chickens when mineral mixtures were included into the diet (stage 1), \(n=10\).

| N  | Group     | Calcium, mmol/L | Albumen, g/l | Phosphorus, mmol/L | Crude protein, g/l |
|----|-----------|-----------------|--------------|--------------------|-------------------|
| 1  | Control   | 2.73 \(\pm\) 0.06 | 20.86 \(\pm\) 0.06 | 2.10 \(\pm\) 0.14 | 35.5 \(\pm\) 0.22 |
| 2  | Experiment 1 | 2.88 \(\pm\) 0.04 | 19.15 \(\pm\) 0.17 | 2.80 \(\pm\) 0.06 \* | 37.7 \(\pm\) 0.17 \* |
| 3  | Experiment 2 | 1.97 \(\pm\) 0.04 \* | 18.08 \(\pm\) 0.13 \* | 2.34 \(\pm\) 0.11 | 30.2 \(\pm\) 0.12 \* |
| 4  | Experiment 3 | 2.44 \(\pm\) 0.11 | 17.15 \(\pm\) 0.13 \* | 2.34 \(\pm\) 0.17 | 30.0 \(\pm\) 0.19 \* |
| 5  | Experiment 4 | 2.14 \(\pm\) 0.06 \* | 16.16 \(\pm\) 0.09 \* | 2.41 \(\pm\) 0.09 | 33.5 \(\pm\) 0.11 \* |

Notes: * \(P \geq 0.95\); ** \(P \geq 0.99\); *** \(P \geq 0.999\) compared with Control group

Phosphorus is necessary for a full metabolism in the body; its metabolism is closely connected with calcium. Phosphorus is the second component of bone tissue, participates in maintaining the osmotic pressure of the blood, in the synthesis of various energy compounds; it is a participant in the exchange of nucleic acids, as well as proteins, fats and carbohydrates.

The introduction of mineral mixtures into the diet of broiler chickens of the experimental groups contributed to an increase in the phosphorus content in the blood serum. The amount of inorganic phosphorus in poultry of the first experimental group exceeded the control indicators by more than 33% \((P \geq 0.95)\), in the second and third groups by 11.4%, and in the fourth group by almost 15%.

Regardless of the composition of mineral mixtures introduced into the diet of an experimental poultry at the first stage of research, no significant changes in the total content of red blood cells were established (table 2). At the same time, broiler chickens in all experimental groups had an increase in the total leukocyte count, which indicates the development of leukocytosis. White blood cell count significantly exceeded control values: in the first experimental group almost by 18%, in the second experimental group by 24%, in the third experimental group by 44%, in the fourth experimental group by 20% \((P \geq 0.999)\).

Hematological researches have revealed that all experimental chickens had low hemoglobin levels (table 2). In the first group the hemoglobin content practically did not differ from the control values, and in the second and third groups it was 2 and 1.6 times lower, respectively \((P \geq 0.999)\).

**Table 2.** Hematological blood parameters of broiler chickens when mineral mixtures were included into the diet (stage 1), \(n=10\).

| N  | Group     | Leukocyte, \(\times 10^7/\text{l}\) | Erythrocyte, \(\times 10^7/\text{l}\) | Hemoglobin, g/l |
|----|-----------|-----------------------------------|-------------------------------|----------------|
| 1  | Control   | 38.7 \(\pm\) 0.80                 | 4.65 \(\pm\) 0.10              | 4.76 \(\pm\) 0.05 |
| 2  | Experiment 1 | 45.5 \(\pm\) 0.32 \***             | 4.59 \(\pm\) 0.14              | 4.73 \(\pm\) 0.11 |
| 3  | Experiment 2 | 48.0 \(\pm\) 0.16 \***             | 5.19 \(\pm\) 2.83              | 2.38 \(\pm\) 0.10 \*** |
The obtained data indicated the possibility of a negative effect of the developed additives on the blood formation processes of broiler chickens. This necessitated the adjustment of the composition of mineral mixtures and the second stage of scientific and economic experiment.

As a result of biochemical blood tests, a positive effect of mineral mixtures introduced into the diet of broiler chickens was established. An increase in the level of crude protein in the first and second experimental groups was noted by 13% (P≥0.99) and 16% P≥0.95 respectively, compared with the control indicators (table 3). While the albumen content decreased by 6.5% in the first experimental group and by 2.4% in the second experimental group (P≥0.95), but it remained at the level of physiological form.

Table 3. Biochemical blood parameters of broiler chickens when mineral mixtures were included into the diet (stage 2), n=10.

| №  | Group        | Calcium, mmol/L | Albumen, g/l | Phosphorus, mmol/L | Crude protein, g/l |
|----|--------------|-----------------|--------------|-------------------|-------------------|
| 1  | Control      | 2.76 ± 0.06     | 17.29 ± 0.08 | 1.54 ± 0.19       | 27.53 ± 0.27      |
| 2  | Experiment 1 | 2.66 ± 0.10     | 16.16 ± 0.09 | 2.31 ± 0.10       | 31.10 ± 0.12      |
| 3  | Experiment 2 | 2.28 ± 0.05*    | 16.88 ± 0.13 | 1.53 ± 0.11*      | 32.10 ± 0.41*     |

Notes: * P≥0.95; ** P≥0.99; *** P≥0.999 compared with Control group

The phosphorus content reached the optimal value in the poultry of the first experimental group and amounted to 2.31±0.10 mmol/L, which was 1.5 times higher than the control indicators (P≥0.99). At the same time, in the second experimental group, the phosphorus level did not differ from the data of the control group. However, in poultry of the second experimental group, a significant reduction calcium level in the blood serum by 17.4% was noted in comparison with the control group (P≥0.95).

The analysis of hematological parameters in the second stage of the experiment revealed the absence of negative effects of mineral mixtures introduced into the diet of broiler chickens on the total content of leukocyte, erythrocyte, hemoglobin (table 4). The erythrocyte content in both experimental groups was within the physiological norm and exceeded the control parameters by 10.3% and 17.4% (P≥0.99).

Table 4. Hematological blood parameters of broiler chickens when mineral mixtures were included into the diet (stage 2), n=10.

| №  | Group        | Leukocyte, ×10^9/l | Erythrocyte, ×10^12/l | Hemoglobin, g/l |
|----|--------------|--------------------|-----------------------|----------------|
| 1  | Control      | 57.26 ± 0.22       | 2.82 ± 0.06           | 7.88 ± 0.06    |
| 2  | Experiment 1 | 31.75 ± 0.34***    | 3.11 ± 0.04**         | 8.07 ± 0.04*   |
| 3  | Experiment 2 | 34.22 ± 0.27***    | 3.31 ± 0.05**         | 8.46 ± 0.07*   |

Notes: * P≥0.95; ** P≥0.99; *** P≥0.999 compared with Control group

The total leukocyte count in the poultry of the first and second groups was also within the physiological norm and was respectively lower than the control values 44.6% and 40.2% (P≥0.999). In addition, a significant excess of hemoglobin level in experimental chickens was established compared to control indicators.

4. Conclusion

Oxidized brown coal, belite sludge, vermiculite, peat in feeding broiler chickens improve the physiological state and metabolic processes in the body, as evidenced by the biochemical and hematological blood parameters of experimental poultry.
The use of belite sludge and oxidized brown coal is one of the promising areas of non-waste technology for processing and mining of alumina and brown coal in the territory of Krasnoyarsk region.

References
[1] Dmitrieva M E 2016 The modern approaches to solving urgent veterinary problems in industrial poultry farming Effective livestock 2 9-11
[2] Venediktov A M, Duborezova G A, Simonov G A and Kozlovsky S B 1998 Feed additives (Moscow: Kolos)
[3] Kozlova L G 2002 Physiological rationale for the use of vermiculite in poultry farming (Trotsk )
[4] Arkov A A 2002 Mineral feed additive for poultry Patent RU 2213488Cl (Volgograd)
[5] Motovilov K Ya 2008 Mineral additives used in animal breeding Feeding of agricultural animals and feed production 11 60-6
[6] Sidorova A L 2009 Active zeolites in calf diets Zootchniya 4 11-13
[7] Aleksandrova M G, Tabakov N A and Tyurina L E 2010 The influence of feeding a mineral mixture based on belite sludge on the physiological state of dairy cows Feeding of agricultural animals and feed production 4 12-5
[8] Pobedinsky A V 2011 Efficiency of the use of expanded vermiculite in feeding of dry cows (Krasnoyarsk)
[9] Afanasyeva A I, Sarychev E N, Pshenichnikova A I, Ashenbrenner A I and Kronevald E A 2018 Modern methods for the study of biochemical blood parameters (Barnaul: Altaisky SAU)