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Bioactive Mineral Feed Additive for Poultry: Therapeutic and Preventive Effects on Haematological Parameters in Chickens

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Abstract: The study aims to investigate the effect of composite feed additive, created from natural mineral rocks of the West Kazakhstan region, on haematological parameters in chickens. Determination of cytological and biochemical indices was carried out using automatic analysers Chem Well 2910 and Mindray BC-2800 Vet. As a result of the application of mineral premix in animals of the experimental group, an increase in the number of erythrocytes by 4.04% ($P<0.01$) and haemoglobin by 7.42% ($P<0.01$) was observed. The greatest positive changes were observed in the indices of protein and mineral metabolism. The local mineral premix, with its bioactive therapeutic properties, increased carcass weight by 292±10.3 g, enabling cost-effective poultry rearing. Its simple preparation makes it suitable for widespread use in broiler breeding across industrial enterprises.

Keywords: Premix; Silica; Montmorillonite clay; Haematological and biochemical parameters; Adsorption capacity

1. Introduction

In Kazakhstan, agriculture is one of the leading areas of the country's economy. Actively developing branches of livestock breeding and plant growing allows the population of the country to food products of their production [1,2]. One of such dynamically developing areas of animal husbandry is poultry farming. Poultry meat and egg products are not only a source of dietary and easily digestible proteins, but due to their low cost and the most affordable livestock products [3].

According to M.I. Sigarev et al.[4] poultry farming in Kazakhstan includes high prices for imported feed additives, which affect the cost of meat and eggs, as well as the lack of scientifically based nutritional standards and approaches in the poultry feeding system. The need to use feed additives to increase productivity and reduce costs in the poultry industry in Kazakhstan is also noted by T.N. Savchenko et al.[5]. To increase the biological completeness of mixed fodders for farm birds, it is important to use biologically active additives – premixes, which contain a complex of amino acids, minerals, vitamins enzymes and other additives that contribute to improving the eatability and digestibility of feed. Different mineral fillers are often used as fillers for premixes. These products have a complex effect on the organism – they contain several trace elements necessary for animals, and additionally may have an adsorbing effect. One such component, which is widespread in Kazakhstan and can be used as a filler is bentonite clay. Furthermore, according to N.S. Montayeva et al.[6], western regions of Kazakhstan are rich in bentonite or montmorillonite clays, which makes these natural minerals the best source of mineral feed for animals and birds. Bentonites are often used in the manufacture of adsorbents and anti-acid additives, which are used with therapeutic and prophylactic effects in cattle breeding when feeding cattle. At the same time, almost all studies were limited to the study of only local action of such preparations, considering that absorption of bentonites in the gastrointestinal tract practically does not occur. This approach limited the studies aimed at studying the effect of bentonite additives on monogastric animals, and even more so on birds, leaving this area poorly studied.

While previous studies have explored the local action of bentonite additives in cattle feeding, there is limited research on their effects on monogastric animals, particularly birds. Therefore, this study seeks to develop a mineral premix for poultry using locally available minerals and evaluate its bioavailability through morphological and biochemical indicators in poultry blood.

Hence, the study aims to develop the composition of mineral composition as a basis for the preparation of premixes for poultry using natural minerals available in Kazakhstan, with the assessment of their bioavailability through morphological and biochemical indicators of the blood of poultry.

Authors hypothesize that incorporating mineral premix, derived from local sedimentary rocks, into the diet of broiler chickens will enhance productivity indicators, such as post-slaughter carcass weight yield, and mitigate the effects of feed stress. This hypothesis is based on the potential of the mineral premix to increase mineral and protein metabolism, stimulate the immune system, and reduce the toxicity of minerals in the diet, ultimately leading to improved growth performance and reduced stress in poultry.

2. Literature Review

Growing interest in optimizing poultry diets by exploring the potential benefits of incorporating natural minerals, particularly bentonite clays. Traditionally, mineral components have been integral to premixes used in livestock feed. However, emerging research suggests that these minerals, when sourced from natural sources like bentonite clays, could offer unique advantages in poultry nutrition. This shift in focus underscores the need for a deeper understanding of the role of natural minerals in poultry diets and their potential impact on poultry health, performance, and overall production efficiency. Hence, investigating the utilization of bentonite clays as a dietary supplement in poultry farming represents a significant advancement in optimizing poultry nutrition and warrants further exploration in the field of animal science and agriculture.

Researchers such as A.A. Ghazalah et al.[8] have investigated the effects of bentonite clays on poultry health and performance, highlighting their potential as cost-effective dietary additives. Furthermore, studies conducted by M. Pieszka et al.[9] have examined the utilization of silica-based combinations in farm animal feeding, demonstrating their role in enhancing nutrient absorption and overall animal health.

Moreover, the exploration of mineral-based additives extends beyond traditional livestock species. Recent investigations by E. Fortatos et al.[10] have explored the utilization of mineral combinations in rabbit diets, aiming to optimize growth performance and reproductive outcomes. Additionally, studies conducted by M.P. Marin et al.[11] and M. Nadziakiewicza et al.[12] have evaluated the efficacy of zeolites in cattle diets, showcasing their potential in improving nutrient utilization and reducing environmental impacts.

Emerging research has delved into unconventional mineral sources for animal nutrition. Investigations by V. Kanoulas et al.[13] have explored the effects of attapulgite on pig fattening ability, shedding light on its role in gastrointestinal health and nutrient absorption. Similarly, studies conducted by A. Zha et al.[14] and M.O. Razikova[15] have investigated the utilization of sapropels and other unconventional mineral sources in cattle diets, suggesting their potential in enhancing animal performance and welfare.

The main effect of adding clay minerals is their adsorption capacity to most mycotoxins and other toxic products. These properties of bentonites are emphasised by R.F. Resende et al.[16] and V. Kondratiuk et al.[17]. Besides toxins, they can remove radionuclides from the organism, which is relevant for livestock farming in the Semipalatinsk test site area[18]. According to Z Lin et al.[19], the adsorption properties of bentonites in different composite ratios with other components of vitamin-mineral premixes remain an important point. However, according to C.T. Elliott et al.[20], these properties of sorbents can also have negative consequences. The authors point out the decrease in the level of nutrients and pharmacological substances under the influence of feed additives with adsorbing effects.

Different sources of trace elements used as fillers for animal premixes can provide the required minerals to a certain extent. The bioavailability of such elements in different compounds varies considerably. According to L. Byrne and R.A. Murphy[21], specific compounds' absorption is affected by the species of animal to which they are fed. At the same time, the variation of assimilation rates for the same indicator can vary from 56 to 335% concerning the reference substance. Therefore, it is incorrect to rely on assimilation levels obtained as a result of studies conducted on pigs or cows[22]. In this connection, it is more logical to use the results obtained in experiments on poultry of different productivity directions. E. Gümüş[23] indicates the positive effect of sodium bentonite on meat productivity and feed conversion in Japanese quails. Similar results were obtained by R.A. Chudak et al.[24] using the Bischofit mineral supplement. Another, no less important quality of bentonite clays is pointed out by F.Sh. Nazarova and O.F. Soatov[25], say that the minerals contained in alumina have anti-inflammatory and soothing effects on the gastrointestinal tract of animals. F.M.F. Hayajneh et al.[26] also provide an example of a milder course of coccidiosis in birds when bentonite is used.

Despite the rather large amount of information on the use of bentonites in the feeding of different animals, there is no information on the study of the complex action of fossil minerals on the organism of poultry at the industrial method of breeding.

3. Materials and Methods

In preparation for a composite base of premixes for poultry, fossil mineral-containing rocks, deposits of which were found in the territory of the West Kazakhstan region, were used. Cristobalite silica from the Taskalinskoye deposit, montmorillonite clay from the Pogadaevskoye deposit and Cretaceous rock from the Chalky Gorki

deposit were used for premix production. The content of components and individual elements in the rocks was determined according to the information contained in the documents accompanying the raw materials[27].

The composition of silica rock of the Taskalinskoye deposit was as follows: silicon oxide 55-79%, aluminosilicates – 16-22%, calcite – less than 6%, quartz elements – 5-7%, mica – 2-4%, organic residues up to 12%. Montmorillonite clay (bentonite) of the Pogadaevskoe deposit contained 65-70% aluminosilicates, 20-25% quartz, 10-12% hydromica, 5-7% hematite. In Cretaceous rocks, the main components were calcium carbonate – 88.98-95.23% and magnesium carbonate – 0.33-1.57%. After grinding the rocks to a fraction of 0.3-1.5 mm, the composition was prepared in the following percentage ratio – silica rock 35-40%, montmorillonite clay – 25-30%, and chalk – 30-40%. After mixing of all components, further grinding, and sieving through a sieve with a pore size of 0.315 mm was carried out. The obtained conglomerate was used as a mineral premix in feeding poultry meat production. Determination of harmlessness and biosafety of the prepared premix was carried out in the laboratory of toxicology of polymers and chemicals "Scientific and Research Centre of Sanitary and Epidemiological Expertise and Monitoring of the National Centre of Public Health under the Ministry of Health of the Republic of Kazakhstan" (Almaty).

Experimental studies on the influence of the developed composite feed additive on the organism were carried out on broiler chickens of 30 days of age in conditions of industrial floor housing in the agricultural production co-operative (SPK) "Shamshyrak" (Uralsk), in compliance with the requirements of ART RK GOST R 52337-2011 "Feeds, mixed fodder, mixed fodder raw materials. Methods of determination of general toxicity"[28]. For this purpose, two groups of chickens were formed according to the principle of analogues – experimental and control groups of 15 heads each, identical in weight and genotype. The animals of the experimental group together with feed were fed a prepared mineral premix at a concentration of 2.5% of the total amount of feed for 30 days, while the chickens of the control group were fed only grain feed without mineral supplements. At the time of the experiment, the farm was free from poultry infectious diseases and all chicks were clinically healthy.

During the control period, from the experiment to the end of broiler fattening, periodic blood sampling was carried out in birds of both groups from the subclavian vein at intervals of 10 days to assess morphological changes in the organism under the influence of mineral substances. Furthermore, a number of biochemical blood parameters in animals of both groups were determined to study the effect of premix on the activity of metabolic processes and enzymes of the blood system. These processes were monitored by the following indicators: the number of erythrocytes, haemoglobin level, total protein and protein fractions, glucose, urea, level of asparagine (AST) and alanine (ALT) aminotransferases, as well as the content of some macro- and microelements in blood serum. Biochemical and haematological blood parameters were determined using automatic analysers – Chem Well 2910 (C) and Mindray BC-2800 Vet in conditions of the veterinary clinic of West Kazakhstan Agrarian-Technical University named after Zhangir Khan.

The obtained haematological and biochemical parameters were mathematically processed in TIBCO Statistica 14.1.0 software, for further statistical analysis to form conclusions and suggestions for production.

4. Results

All changes in the animal organism are first of all reflected in morphological and blood biochemical indices. Blood, as the basis of the internal environment of the organism, reacts to changes not only in environmental conditions but also to other factors, including feed factors. In this case, the first to change are the levels of indicators that predetermine the physiological adaptability (adaptation) of the organism, and subsequently the productive characteristics of poultry. At the cellular adaptation mechanisms level, changes in the number of blood formers, namely the content of erythrocytes and leucocytes, are the first to occur. If the level of erythrocytes and haemoglobin allows us to judge about the intensity of redox processes in the poultry organism, the levels of white blood cells are markers of the intensity of the stress state of animals, including in response to feed conditions.

Regulation of the number of erythrocytes can be carried out in two ways: from blood depots and by accelerated erythropoiesis under the influence of the hormone-like substance erythropoietin. Since the time required for differentiation of a full-fledged erythrocyte is 7-10 days, such a period makes it possible to determine the influence of the feed factor on the organism. Haematological studies of birds of control and experimental groups have shown that mineral feed additives included in the diet of experimental birds have a pronounced effect on the organism. Table 1 shows the dynamics of changes in the number of blood-forming elements in broiler chickens under the action of composite mineral premixes.

Table 1. Dynamic changes in erythrocyte, leucocyte and haemoglobin counts in experimental broiler chickens (n=15).

Value	Reference range	Group					
		10 days		20 days		30 days	
		C	E	C	E	C	E
Red blood cells, 10^{12}/L	1.9-4.2	2.5±0.1	2.5±0.1	2.5±0.2	25±0.4	2.5±0.2	2.6±0.5
White blood cells, 10^{9}/l	22-40	34.2±0.2	34±0.3	34.6±0.4	32.5±0.3	34.8±0.5	31.1±0.1
Haemoglobin, g/l	80.7-120.5	97±1.8	98.1±1.5	97.6±1.3	98.9±2	98.4±1.6	104.3±1.8

Note: C – control group; E – experiment group.
Source: compiled by the authors based on conducted experiments.

The number of erythrocytes and haemoglobin in animals of both groups at the beginning of the experimental period were at the same level and were within the reference range. In the first decade of the use of mineral premix in animals, no increase in erythrocytes was detected, which indicates the absence of their influence on the places of blood deposition in the body. The increase in the number of erythrocytes by 4.04% ($P<0.01$) was observed in the third decade of the controlled period and coincided with an increase in the amount of haemoglobin by 7.42% ($P<0.01$) in animals of the experimental group. This may be a consequence of the effect of mineral components of premix on the level of metabolic processes in the poultry organism, which could contribute to an increase in erythropoiesis in chickens. Therefore, the next study stage is to analyse the productive characteristics of poultry (in terms of carcass quantitative characteristics and meat quality) as a result of mineral premixes application.

The level of blood leucocytes in the chickens of the experimental group decreased by 5.61% during the whole control period, while in the control group, their number remained at the same level. There are two logical assumptions for this influence. The first one is the presence of elements in premixes that have adaptogenic properties and thus improve the physiological state of poultry. The second, more probable, is related to the presence of silica rocks, which are included in the composition of the composite mineral feed additive, and adsorption properties. Due to this effect, a significant part of mycotoxins and metabolic products are bound and eliminated from the organism, reducing the immunological load, and thus contributing to a decrease in the level of leucocytes. This is the reason for the longer period preceding the reduction of their level.

Further studies, in continuation of cytological works on haematological characteristics, were related to the determination of the chemical composition of the blood of birds of control and experimental groups. Due to significant financial costs for biochemical studies and the cost of reagents, a one-time determination of these parameters was decided only at the end of the experimental period, 30 days after the start of mineral premix feeding. This made it possible to assess the general condition of the poultry organism during rearing by the indicators of the intensity of metabolism and physiological processes, as well as to evaluate their health. The obtained biochemical values are given in Table 2.

Table 2. Blood biochemistry parameters of broiler chickens of control and experimental groups (n=15).

Value	Reference range	Group	
		C	E
Total protein, g/l	35.8-52.2	40.37±0.5	42.92±0.62
Albumin, g/l	11.7-27.4	21.31±0.44	23.12±0.33
Relative, %	51-65	52.13±0.2	53.24±0.18
Globulins, g/l	17-61	19.78±0.18	21.12±0.22
Relative, %	40-50	47.08±0.34	46.12±0.28
Incl.: α-globulins	17-19	16.54±0.26	16.34±0.5
β-globulins	11-13	6.73±0.31	5.14±1.16
γ-globulins	30-35	24.32±0.4	25.12±1.16
AST, units/l	170-320	217.4±2.72	236.3±3.1
ALT, units/l	1.2-3.7	3.39±0.22	3.49±0.34

Value	Reference range	Group	
		C	E
Glucose, mmol/l	11.1-25.8	6.87±0.16	7.29±0.14
Total lipids, g/l	4.6-17.2	4.16±0.08	4.12±0.07
Alkaline phosphatase, units/L	568-8831	1150±8.45	1883±9.12

Note: C – control group; E – experiment group.
Source: compiled by the authors based on conducted experiments.

The results of blood biochemical analysis of experimental animals showed that the used mineral premix, in comparison with similar indicators of birds of the control group, caused an increase in both the total protein level in blood serum and most of its fractions. The content of total protein in the blood serum of chickens receiving bioactive mineral feed supplement for 30 days was higher than the control by 2.55 g/l or 6.31% ($P<0.05$), which indicates a more intensive metabolism in the organism of broilers of the experimental group. There was also a significant difference between the groups in the albumin fraction of the chickens to which premix was added, the level of albumin was 1.81% higher ($P<0.05$) than in the animals of the control group. This situation was evidence of more intensive metabolic processes occurring in the organism. Of other protein fractions, the γ-globulin fraction, which is associated with an indicator of the state of the immune system, is also of interest. It was found that the content of γ-globulins was higher in chickens of the experimental group by 0.75% ($P<0.05$) compared to the control. This indicator against the background of a decrease in the number of leukocytes indicates the prevalence of the humoral component of immunity, which provides a longer protection of the organism.

Among the markers of protein metabolism intensity, specific enzyme systems are also of significant importance. Aspartate aminotransferase (AST) and alanine aminotransferase (ALT) catalyse reactions of amino acids overamination in metabolic reactions and their activity is related to the intensity of processes occurring in the liver. Indices of aminotransferase activity in birds were within the physiological norm regardless of the group, but AST level in broiler chickens of the experimental group increased by 18.9 units/l (8.69%; $P<0.05$), which was evidence of significantly more intensive protein synthesising function of the liver in control chickens. Besides the increase in the intensity of protein metabolism in broilers of the experimental group, there were also signs of increased mineral metabolism in the body. Such biochemical marker in the blood system was the activity of alkaline phosphatase. In the experimental group in comparison with the control, its activity increased by 63.7% ($P<0.001$). Subsequently, the concentration of individual mineral elements in blood serum was determined, the results of which are presented in Table 3.

Table 3. Content of mineral elements in the blood of experimental broiler chickens (n=15).

Value	Reference range	Group					
		10 days		20 days		30 days	
		C	E	C	E	C	E
Calcium, mmol/l	2-3.25	2.3±0.2	2.3±0.3	2.3±0.5	2.4±0.3	2.3±0.3	2.5±0.3
Phosphates, mmol/l	3.6-11.4	2.2±0.02	2.2±0.1	2.2±0.05	2.3±0.1	2.2±0.04	2.3±0.02
Magnesium, mmol/l	0.66-1.45	0.96±0.03	0.96±0.05	0.96±0.04	0.99±0.1	0.96±0.06	1.05±0.03
Sodium, mmol/l	145-154	158.5±1.5	158.4±1.6	159±1.5	158±1.5	159±1.2	159.4±1.5
Potassium, mmol/l	1.9-5.2	4.3±0.02	4.3±0.03	4.3±0.03	4.3±0.06	4.3±0.02	4.5±0.03
Copper, µg/100 ml	2.4-5.1	3.5±0.07	3.5±0.09	3.4±0.09	3.5±0.06	3.4 ±0.06	3.5±0.08
Zinc, µg/100 ml	20-35	24.2±0.2	24.3±0.4	24.2±0.5	25.5±0.5	24.3±0.5	25.9±0.2

Note: C – control group; E – experiment group.
Source: compiled by the authors based on conducted experiments.

Macro- and microelements in the blood of animals of the control group throughout the entire period of research were practically at the same level and were within the reference range, while in broilers of the experimental group, the dynamics of changes in these elements corresponded to the cumulative effect. Since most of the chemical elements studied are part of enzymes, vitamins or other biologically active substances, their increase had a positive effect on acceleration and increase in digestibility of feed nutrients by chickens of the

experimental groups, and as a consequence, improved their growth and development. At each blood test, carried out at intervals of 10 days, their gradual growth was observed. At the end of the experimental period in the blood of chickens of the experimental group compared to the control group, the content of calcium was higher by 10.57% ($P<0.05$), phosphorus – by 6.1% ($P<0.05$), magnesium – by 9.37% ($P<0.05$), zinc – by 7.48% ($P<0.05$), potassium – by 3.96% ($P<0.05$), respectively. However, the highest increase in plasma concentration was observed in compounds containing silicon – by 84.74 ($P<0.01$), most likely this was due to the silicon base of all the components of the mineral premix.

Summarising the results of studies on the influence of mineral premix from fossil breeds of the West-Kazakhstan region on health indicators and fattening characteristics of broilers, it was found that the addition of such an additive at a concentration of 2.5% increased protein and mineral metabolism in the body. In addition, feeding this mineral supplement increased adaptogenic properties in birds, and the presence of silica removed additional toxic load on the body due to its adsorption properties. Such complex therapeutic and prophylactic effects of premix also improved the fattening characteristics of broilers of the experimental group. According to the results of the control slaughtering of animals, carried out at the end of 30 days of premix feeding, it was found that the carcass weight of the experimental group chicken after gutting exceeded the weight of birds of the control group by 292±10.3 g or 12.8% ($P<0.001$).

5. Discussion

The use of vitamin-mineral premixes in industrial poultry farming contributes to the growth of efficiency of the industry, it is associated with an increase in meat and egg productivity, as well as reducing costs from poultry mortality. However, the use of premixes of imported origin leads to a significant increase in the cost of production, which has already been discussed by the Kazakh researchers – M.I. Sigarev et al.[4]. Therefore, the search for budget-friendly natural analogues of local origin to replace the products of the chemical or microbiological industry, which are used in the production of imported premixes will bring the poultry industry of the Republic of Kazakhstan to a new level.

N.B. Mukhtarova and B.A. Aliev[29] highlight the digestive benefits of bentonites, including adsorption, ion exchange, dispersibility, and catalytic activity, which enhance digestion and food absorption. In this study, a composite premix was created using silica rocks from the Taskalinskiy deposit and montmorillonite clays from the Pogadaevskiy deposit, both abundant in the West Kazakhstan region. These components exhibit additional adsorbing effects, effectively binding mycotoxins, heavy metals, toxins, radionuclides, and metabolic by-products in the intestine.

The main positive effect of the action of the composite mineral supplement on the organism of chickens was observed in the strengthening of mineral and protein metabolism in their organism[30]. Considering that the main component of the complex supplement is a set of macro- and microelements important for the growth and development of poultry, which in the body fulfil the function of building material and activators of most enzyme systems, the increase in the amount of all elements in the blood has quite a rational explanation. The content of a significant amount of calcium in premix components is a prerequisite for the active growth of broiler chickens. As it is necessary for the formation of bone and connective tissues and normal metabolism in the body. R. Xing et al.[31] indicate that a high level of inorganic calcium in poultry diets is equal to the effect of growth stimulants. When significant amounts of this element were fed, weight gain in chickens and a decrease in feed conversion ratio were observed ($P<0.05$). The organs responsible for humoral immunity also increased, and the activity of digestive enzymes increased ($P<0.05$). In the studies described using the proposed premix of minerals from the West Kazakhstan region, similar results were observed in one-month-old birds, which was due to the content of a high concentration of inorganic calcium. Therefore, the use of the proposed mineral supplement containing local sedimentary rocks will increase the efficiency of meat poultry farming in Kazakhstan and given the low cost of such natural sources of calcium, will reduce the cost of growing broilers and thereby increase the profitability of the meat industry.

Along with the increase in the number of mineral elements in the blood of controlled chickens, changes in protein metabolism were also observed. These changes may be associated with the activation of enzymes that take part in protein synthesis, as well as in the reduction of toxic load on the liver, due to the adsorbing properties of premix components. The results of a biochemical study of blood parameters showed that in the organism of experimental chickens, there was a simultaneous increase in all protein fractions, as well as an increase in the activity of several enzymes that take a direct part in the process of protein biosynthesis. This indicates that the use of mineral premix promoted systemic activation of practically all mechanisms of protein metabolism in the organism and thus improved growth and fattening parameters in meat poultry production. Similar outcomes were observed by R.A. Chudak et al.[24] with their "Multigain" mineral premix. Experimental chickens showed higher live weights and improved carcass characteristics post-fattening. Blood parameters, including erythrocyte count, hemoglobin levels, and protein metabolism markers, closely matched those in this study. However, no significant effects were noted on carbohydrate or fat metabolism.

The hematology findings from both this study and R.A. Chudak et al.[24] support the positive impact of composite

premixes based on natural silica and clay rocks on poultry protein metabolism and fattening outcomes. Notably, the main deviation was observed in leukocyte levels. While "Multigen" premix increased leukocytes, the composite premix from West Kazakhstan reduced leukocyte levels in chickens. This difference likely stems from decreased toxicity from bacterial products in the gastrointestinal tract and feed. This effect can be attributed to the adsorbing property of silica in the minerals. This property allows for reducing the level of feed stress by reducing the concentration in the intestinal lumen of a variety of toxic substances or breakdown products[32]. This ability of the composite premix provides it with adaptogenic properties when used in animal feeding. The second effect is based on the ability of silicon to create ionic colloidal systems in the intestinal cavity, which have the property of layering on themselves microbial agents – viruses and bacterial cells that are not typical for poultry and removing them from the body.[33-35]

The natural intestinal microflora does not agglutinate with silica colloidal systems and remains in the intestine, thus providing natural defence. If, according to the results of premix use, the cellular component of the immune system under the action of premix stabilised, the humoral component, on the contrary, only strengthened, which was confirmed by an increase in the level of γ-globulins in the blood serum of experimental chickens. A similar result was also observed in the studies conducted by R. Xing et al.[29] In this work, an increase in the size of the main organs responsible for immunity in chickens – spleen, thymus, and bursa – was observed. This allowed us to assume that premix, in addition to the direct effect on metabolism in the body can stimulate the immune system, which provides it with and therapeutic and preventive effect[36,37]. Therefore, the proposed recipe of composite premix for growing chickens, prepared from fossil breeds of the West Kazakhstan region, has a complex effect on the organism of poultry at its industrial growing. It can provide bioactive therapeutic and prophylactic action necessary to achieve the required level of growth of broilers.

The research presented in this paper is limited only to the study of overall growth and biochemical blood parameters of chickens during their fattening period when using mineral composite premix, while the issues of meat productivity and post-slaughter yield were not raised in it. This problem will be considered in the next scientific work of the author.

The results of this study significantly contribute to the existing body of knowledge in poultry farming, particularly in Kazakhstan. Firstly, it addresses the issue of high costs associated with imported feed additives by proposing a natural alternative derived from local sedimentary rocks, such as bentonite and montmorillonite clays. By utilizing these readily available resources, the study suggests a cost-effective solution to enhance productivity in the poultry industry while reducing production expenses. Moreover, the research demonstrates the effectiveness of the mineral premix derived from local minerals in improving mineral and protein metabolism in broiler chickens. This is evidenced by the observed increase in various blood parameters related to protein synthesis and mineral concentration. The study also highlights the ability of the mineral premix to mitigate the effects of feed stress, as indicated by a decrease in the number of leucocytes in the peripheral blood of experimental chickens.

6. Conclusions

Based on the results obtained during cytological and biochemical studies of the blood of broiler chickens, which during the growing period were fed composite mineral premix, prepared from sedimentary rocks of the West Kazakhstan region, the following conclusions and suggestions for further studies can be made.

The use of mineral premix, prepared according to the proposed recipe, during the period of intensive growth of chickens allowed us to obtain higher productivity indicators at the same levels of animal feeding. This was expressed in the increase of post-slaughter carcass weight yield by 292±10.3 g in comparison with the chickens of the control group. Such a level of productivity was promoted by an increase in the intensity of mineral and protein metabolism in organisms that was expressed in an increase in the blood of chickens of an experimental group of all kinds of protein fractions and the growth of activity of enzymes participating in processes of protein synthesis. In addition, the mineral premix increased the concentration of macro- and microelements in the blood serum of chickens. Moreover, its use for 30 days reduced the effect of feed stress on the experimental group, evidenced by a decrease in peripheral blood leucocyte count. This reduction can be attributed to the premix's adsorption effect, binding toxic products present in the feed. The increase in the γ-globulin fraction indicates stimulation of the chicken's humoral immune system and enhancement of its defense mechanisms. Therefore, the use in fodder production of mineral premix prepared with the use of local raw materials, due to its bioactive and therapeutic and prophylactic effect on the organism of birds allows to ensure its effective cultivation with minimal costs, which is an urgent problem of Kazakh poultry farming.

These results underscore the potential of locally sourced mineral premixes to enhance the efficiency and sustainability of poultry farming in Kazakhstan, offering a cost-effective solution for producers. However, further research is warranted to explore the influence of the mineral premix on quantitative characteristics of carcasses and the quality of poultry meat. Future studies should also investigate the economic efficiency of implementing the proposed mineral premix in poultry farming operations, considering factors such as production costs, feed conversion ratios, and overall profitability. By continuing

to investigate the efficacy and economic viability of mineral premixes in poultry nutrition, can further optimize poultry production practices in Kazakhstan and contribute to the advancement of sustainable agriculture in the region.

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