



Studying the Efficiency of Natural and Synthetic Adsorbents in Combined Feed for Broiler Chickens

ZEMFIRA VLADIMIROVNA PSHATSIYEVA¹, NATALIA ALEXANDROVNA YURINA^{2*}, BORIS VLADIMIROVICH KHORIN³, NATALIA DENISOVNA LABUTINA⁴, ALEXANDRA ALEXANDROVNA DANILOVA⁴, TAISIYA ARKADEVNA USTYUZHANINOVA⁵

¹Gorsky State Agrarian University, Vladikavkaz

²Kuban State Agrarian University named after I.T. Trubilin, Krasnodar

³LLC Agrokon, Krasnodar

⁴Krasnodar Research Centre for Animal Husbandry and Veterinary Medicine, Krasnodar

⁵Maikop State Technological University, Maikop

Abstract | This work was aimed at studying the efficiency of adsorbents of various origins – natural bentonite and synthetic Kovelos-Sorb based on silicon dioxide – in feeding broiler chickens. It was found that feeding the studied additives contributed to increasing the intensity of growth of young poultry by 8.0–9.4 %, as evidenced by the increase in the amounts of total blood serum protein by 2.3–2.5 %, in the number of colony forming *Lactobacillus* in the contents of ceca by 17.5–31.3 %, and in the content of heavy metals in the muscle tissues of the chickens by 16.7–60.0 %. Based on biochemical, microbiological and toxicological studies, it can be argued that the use of sorbents, both natural bentonite and synthetic Kovelos-Sorb, has a positive effect on the physiological indicators of broiler chickens, which is manifested in an increase in the rate of their growth and a decrease in feed consumption per unit of product by 4.8–5.9 %.

Keywords | Broiler chickens, Adsorbents, Live weight, Total gain, Feed cost

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***Correspondence** | Natalia Alexandrovna Yurina, Kuban State Agrarian University named after I.T. Trubilin, Krasnodar; **Email:** naden8277@mail.ru

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INTRODUCTION

The most important task of the agro-industrial complex is increasing the level of livestock production, as these products fully meet the needs of the population in high-quality protein (Mysik, 2007; Yurina et al., 2018). Increasing meat production may be achieved by ensuring high quality of poultry feed and reducing the conversion for obtaining 1 kg of the product (Tedtova, 2007; Temirae, 2002).

Given the adverse ecological state of the environment, in particular, in the region of North Ossetia-Alania, it is necessary to introduce adsorbents into poultry feed, which have a positive effect on the quality and safety of poultry products. The soil and plants in the Republic and,

consequently, all animal products are mainly contaminated with heavy metals, such as copper, cadmium, lead, nickel, and zinc in the acid-soluble form, which get into the environment with emissions from industrial oil-refining and mining and metallurgical enterprises. According to some authors, the content of heavy metal salts in the potable water at livestock farms of the Republic exceeds the maximum permissible concentration several times: zinc–3 to 6 times, copper–5 times, cadmium–2 to 5 times and lead – 3 to 5 times (Kairov et al., 2007; Tedtova, 2007, Temirae, 2002; Pskhatsieva et al., 2018; Tsogoeva et al., 2018).

The adsorbents efficiently remove salts of heavy metals from the animal organism, preventing them from getting into the final product. The adsorbents may be natural or

synthetic (Ovsepian et al., 2015; Pskhatsieva, et al., 2018; Tsogoeva et al., 2018).

Bentonite clays have been often used recently for farm animals and poultry. Natural adsorbents are more advantageous in terms of cost and show lower activity against vitamins and amino acids. One should pay attention to the fact that clay materials can release macro- and microelements under the influence of the acidic environment of the stomach; therefore, almost all of them are used as mineral feed additives (Pskhatsieva et al., 2018).

Unlike natural mineral adsorbents derived from clays, synthetic silica adsorbents do not contain ballast substances that reduce the biological value of the product and which may cause excessive accumulation of mineral substances. Synthetic adsorbents have the ability to bind toxins of various origins and prevent their absorption in the digestive tract. Due to the special nanoporous structure of particles of amorphous silicon dioxide, vitamins and amino acids remain intact, and toxins disappear from the organism (Galushin and Kovalev, 2009; Ovsepian et al., 2015; Pskhatsieva et al., 2018).

From this, it follows that the potential of the substances that are promising as sorbents is high, diverse, but has not been fully studied. The rich assortment of the natural and artificial adsorbents obtained technologically imposes serious obligations on both scientists and practitioners in terms of identification and rational use of optimal substances (Galushin and Kovalev, 2009).

This research was aimed at comparing the characteristics of using adsorbents of different origins (natural and synthetic) for feeding broiler chickens. Specifically, we aim to determine the dosage of feeding bentonite clay to broiler chickens as part of combined feeds, based on free access to eating it. Additionally, to analyze changes in the dynamics of the live weight gain, the average daily weight gains, feed consumption, preservation rate of broiler chickens fed on the studied adsorbents; studying the content of total protein and its fractions in the blood serum of the experimental broiler chickens; identifying and analyzing the composition and changes in the microflora of poultry's ceca; and analyzing the quantitative composition of heavy metals in the meat of the experimental chickens fed on the studied feed additives.

MATERIALS AND METHODS

The experiments were performed at the poultry farm of JSC Mikhailovskaya in the Republic of North Ossetia-Alania. The chickens were kept in KBU-3 cage batteries with free access to water and feed mixtures. The microclimatic

conditions: the light and temperature conditions, air humidity and density of placing in cages, feeding, and watering, were consistent with the recommended parameters. Hybrid chickens of the Kobb-500 cross were used for the experiment. The studies in this project were performed according to the scheme shown in Table 1.

Table 1: Scheme of the experiment.

Group	Feeding peculiarities
1	MD (main diet)
2	MD+ freely available bentonite
3	MD + Kovelos-Sorb 0.1 % of the weight of the feed

The clay from the eastern suburbs of settlement Zamankul in the Pravoberezhny district of the Republic of North Ossetia-Alania was used in the studies. Bentonite clays contain motile forms of calcium, phosphorus, potassium, iron, copper, cobalt, manganese, and other mineral elements required for the functioning of the organism. By its mineral composition, bentonite clay from the Zamankul field differs from other zeolite-like clays by lower content of iron oxide and sulfur oxide.

Kovelos-Sorb (Ecocremniy LLC) is high purity silicon dioxide (SiO₂) obtained synthetically. This white tasteless odorless powder is an adsorbent of toxins and heavy metals.

During the scientific-economic and physiological experiments, experimental broiler chickens were fed ad libitum on dry complete feeds balanced by the content of nutrients in accordance with the Guidelines for Feeding Poultry (VNITIP, 2004) (Fisinin, 2004).

The combined feed was prepared directly in the feedcenter of the farm. The grain part of the diet was represented by maize (45–50 %) and wheat (9–10 %). The base for balancing the diet by protein was fish meal (5–6 %), yeast (1–4 %), soybean meal (7.5–11 %), and sunflower cake (13–12 %). Mineral components of the diet, in addition to all other ingredients, were bone meal and limestone.

With that, the amount of bentonite consumed by one chicken from special feeders was accounted for, which in the first phase on average amounted to 0.1–0.3 g per chicken, and in the second phase–0.9 to 1.2 g per chicken (Table 2).

Table 2: Consumption of bentonite freely available to chickens, g (n = 100).

Indicators	Age, days				
	1–14	15–21	22–28	29–35	36–42
Average daily consumption, g/chicken	0.1	0.3	0.9	1.1	1.2
Consumed over the period, gh	1.4	2.1	6.3	7.7	8.4

On average over the entire period of the study, one broiler consumed 25.9 g of bentonite, or 0.6 g per day.

During the experiment, the authors weighed the poultry at the beginning and at the end of the experiment, and based on these values, the total and average daily weight gains were calculated, and feed consumption was determined for each group.

The blood was subjected to biochemical analysis at the Republican Veterinary Laboratory (Vladikavkaz). The content of total protein and its fractions was studied on refractometer IRF-22.

Spectral analysis on heavy metal (zinc, cadmium, copper, lead) contents in the thigh and breast muscles and in the blood of chickens was performed at the laboratory of the Agrokhimlaboratoria Research Institute at Gorsky SAU using the atomic absorption method (GOST 30178-96. Raw material and food-stuffs. Atomic absorption method for determination of toxic elements).

For studying the microbiocenosis of the intestinal contents of broiler chickens, bacteriological studies were performed using meat-and-peptone broth, Kessler's, Endo's medium, Ploskirev's medium, Gis media and staining Gram smears. The average number of colonies grown in three parallel Petri dishes from the same dilution – CFU (colony forming units) – was determined.

RESULTS AND DISCUSSION

Indicators of the feed additives effect on the organism of broiler chickens are the livestock preservation rate, growth rate, and feed cost per 1 kg of live weight gain (Table 3).

Table 3: Main zootechnical indicators of growing broiler chickens, n = 100

Indicator	Groups		
	1	2	3
Live weight at the age of 1 day, g	40.1±0.5	40.2±0.4	40.1±0.5
Live weight at the age of 42 days, g	2,240.5±5.3	2,447.6±6.1	2,418.8±6.8
Gross gain, g	2,200.4	2,407.4	2,378.7
Average daily gain, g	52.4	57.3	56.6
As % to the reference	100.0	109.4	108.0
Preservation rate, %	98.0	98.0	98.0
Feed consumption per 1 kg of weight gain	1.88	1.77	1.79
As % to the reference	100.0	94.1	95.2

It was found that the live weight of broiler chickens was

higher in the groups where adsorbents were used: in the second–by 9.2 %, in the third–by 7.8 %, compared to the reference. With that, the average daily weight gain in these groups was higher than the reference value, by 9.4 and 8.0 %, respectively. The livestock preservation rate was similar in all groups. The cost of feed per 1 kg of weight gain in the second experimental group was lower by 5.9 %, in the third group – by 4.8 %. Feeding adsorbents of different origins was therefore efficient in both cases.

The content of total protein and its fractions in the blood serum of broiler chickens with the use of feed adsorbents of different origins in mixed feeds is shown in Table 4.

Table 4: The content of total protein and its fractions in the blood serum of broiler chickens, % (n = 5).

Indicator	Groups		
	1	2	3
Total protein, g/l	75.0 ± 0.6	76.9 ± 0.3*	76.7 ± 0.3*
Albumins, %	48.0 ± 0.3	48.5 ± 0.5	47.9 ± 0.3
Globulins, %	52.0 ± 0.5	51.5 ± 0.5	52.1 ± 0.28
α-globulins	15.7 ± 0.3	15.1 ± 0.2	15.6 ± 0.1
β-globulins	13.0 ± 0.2	12.6 ± 0.3	12.9 ± 0.2
γ-globulins	23.3 ± 0.4	23.8 ± 0.3	23.6 ± 0.4
A/G ratio	0.92	0.94	0.92

Note: *P ≤ 0.05

The results of the biochemical study of the blood serum have revealed that the total protein content was within the norm, but its amount was veraciously higher (p < 0.05) by 2.3 – 2.5 % in the second and the third groups, compared to the first group. The content of albumins in the experimental groups was virtually the same in all groups.

In the experimental groups, the amount of γ-globulin and protective proteins of the immune system tended to increase by 1.2 – 2.1 %.

Based on the biochemical studies, it can be argued that the use of adsorbents, such as bentonite and Kovelos-Sorb, has a positive effect on the physiological indicators of broiler chickens.

For studying the intestinal microflora, the contents of ceca in the small intestine of broiler chickens were studied. The obtained data are shown in Table 5.

The number of *Enterococcus* in the first group was higher by 7.9 and 15.3 %, compared to the experimental groups. The content of *Staphylococcus* in the first group was 2.1×10⁴ CFU/g, which was 1.4–1.6 times higher than in the experimental groups. The same trend was also observed in the content of *E. coli*, namely, its content in the first group

exceeded the content in the second and the third groups by 15.2 and 38.9 %. Against this background, the number of *Lactobacillus* reduced in the first group by 17.5 and 31.3 %, respectively, compared to the experimental groups. This is explained by the fact that when adsorbents were used in the experimental groups, the growth of pathogenic bacteria slowed down, the growth of *Lactobacillus* accelerated, which was an evidence of a positive effect of the studied feed additives of various origins.

Table 5: Microbiocenosis in the intestines of broiler chickens, CFU/g (n = 5).

Indicator	Groups		
	1	2	3
<i>Enterococcus</i> , 10 ⁷ CFU in 1 g	6.8 ± 0.1	6.3 ± 0.2	5.9 ± 0.3**
<i>Staphylococcus</i> , 10 ⁴ CFU in 1 g	2.1 ± 0.2	1.5 ± 0.2	1.3 ± 0.1**
<i>E. coli</i> , 10 ⁷ CFU in 1 g	7.5 ± 0.2	6.6 ± 0.2*	5.4 ± 0.3***
<i>Lactobacillus</i> , 10 ⁷ CFU in 1 g	3.3 ± 0.2	4.0 ± 0.2*	4.8 ± 0.2***

Note: **p ≤ 0.01; ***p ≤ 0.001

To determine the content of heavy metals, breast and thigh muscles of broiler chickens were studied. The obtained data are shown in Table 6.

Table 6: The content of heavy metals in the homogenate of chickens muscle tissues (mg/kg) (n = 5).

Indicators	Group		
	1	2	3
Zinc	30.0 ± 0.6	25.0 ± 0.2***	24.5 ± 0.9***
Cadmium	0.08 ± 0.003	0.05 ± 0.001**	0.05 ± 0.003**
Lead	0.95 ± 0.08	0.70 ± 0.06**	0.69 ± 0.1**

Note: **p ≤ 0.01; ***p ≤ 0.001

The content of zinc in the muscles of chickens in the second and the third groups was veraciously lower by 16.7 and 18.3 % (P ≤ 0.001), respectively, compared to the first group. The content of cadmium in the muscle tissues of the chickens in the experimental groups was also veraciously lower, compared to the first group, by 60.0 % (P ≤ 0.01). The same tendency was observed in the content of lead in the meat of the broiler chickens: in the experimental groups, its content was veraciously lower by 26.3 and 27.4 % (P ≤ 0.01), compared to the reference.

Considering the high anthropogenic load and the complex ecological state of the environment in the Republic of North Ossetia–Alania, we find it necessary to feed sorbents of different origin in the composition of feed for broiler chickens, which significantly reduces the content of heavy metals in poultry products. In this case, it is possible to

get not only safer broiler meat, but also an increase in live weight gain with lower feed costs. This statement is consistent with the opinion of a number of authors (Galushin and Kovalev, 2009; Ovsepiyan et al., 2015; Pskhatsieva et al., 2018; Tedtova, 2007; Temiraev, 2002; Tsogoeva et al., 2018).

CONCLUSION

From the obtained results it is clear that the use of both natural (bentonite) and synthetic (Kovelos-Sorb) adsorbents has a positive effect on the poultry growth rate, the development of the intestinal microflora, and sanitary-hygienic characteristics of broiler chickens meat.

AUTHORS CONTRIBUTION

All authors contributed equally to the manuscript.

CONFLICT OF INTEREST

There are no conflict of interests.

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