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EFFECTS OF NANOSTRUCTURED SAPROPEL ON THE LIVE WEIGHT OF GEESE AND THE QUALITY OF THEIR MEAT

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ABSTRACT

Sapropel is a natural raw material containing biologically active substances - proteins, fats, carbohydrates, vitamins, and a wide range of macro- and micro-elements of natural origin. It is possible to use sapropel as a feed additive for increasing the productivity of farm animals and improving product quality. A nanostructured sapropel with 50-180nm particle sizes was made from the natural sapropel of Lake Beloye deposit in the Russian Federation. It demonstrated significant biological effects in living organisms. Its use for growing broiler geese in the conditions of peasant farming contributed to an increase in meat productivity. Adding nanostructured sapropel to the feeding of geese in the doses of 0.5, 1.0, and 1.5% of the dry matter led to an increase in geese live weights up to 11.1% in comparison with the control group. Weights of eviscerated carcasses were also more than in the control group, and meat yield was up to 2.5% higher. In goose meat, the toxic chemical elements content, e.g. cadmium, lead, and nickel, was significantly lower than the permissible amounts, less than 0.02 mg/kg. Zinc content decreased by 6.7-17.1% and copper content by 30.3-42.4%, providing the production of high-quality, environmentally friendly poultry meat products.

Disciplinary: Agricultural and Animal Sciences, Biology, Biotechnology, Ecology, Veterinary Medicine, Chemistry.

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1. INTRODUCTION

Such a rapidly developing poultry industry as fast-gaining poultry for the population plays an important role in ensuring the food security of our country (Fisinin et al., 2019).

In the last few years, there is an increased interest in the production of goose meat as a dietary product with high biological and energy values. In the course of determining the quality parameters of goose meat, the authors studied the content of saturated fatty acids and chemical elements in pectoral and femoral muscle groups compared together. It was established that the content of polyunsaturated fatty acids, calcium, iron, magnesium, phosphorus, and zinc is higher in femoral muscles than in pectoral ones. Pectoral muscles contain more monounsaturated fatty acids, protein, fat, sodium, and iron (Oz and Celik, 2015).

Current trends in goose breeding allow controlling production processes by adding feed additives into geese diets. The authors showed the possibility of obtaining functional goose breeding products with high selenium content in meat raw materials what is highly demanded in the regions of selenium deficiency in the environment. It was found that adding feed additives based on organic selenium and vitamin E in the doses of 0.3 and 100 mg/kg to the diet of geese contributes to the production of selenized goose breeding products. Selenium content in birds that consumed these feed additives exceeded the control values in muscle tissues by 1.88-2.25 times, and in the liver by 1.68 times (Lukaszewicz, et al., 2016).

Studies performed by the authors demonstrated the positive effect of Bio-Sorb-Selenium feed additive on the increase in live weight and meat quality of Italian white broiler geese. It was found that additives in feed in the doses of 500 and 1,000 g/t contributed to an increase in average daily gain by 5.26 and 6.54% in comparison with the control group. The best results were achieved while using additive at the dose of 1,000 g/t of feed; this resulted in a decreased moisture content in muscle tissue by 0.66%, increased protein content by 0.14%, fat content – by 0.60%, and an increase in energy nutrition by 4.15% compared to the control group (Marshania, 2019).

The authors demonstrated an increase in the meat productivity of Yangzhou broiler geese as a result of increasing feed conversion by using copper additive in their diets. Its use in the doses of 4.17; 8.17; 12.17 and 16.17 mg/kg increased the gain in live weight of geese and slaughter yield of carcasses. The content of minerals in feces and liver was also defined. It was found that the concentration of copper in the liver ranged from 8.77-11.6 mg/kg and corresponded to optimal values (Yang, et al., 2018).

Studies carried out by the authors also showed an increase in the meat productivity of geese due to improved digestibility of nutrients of the feed enriched with lithium in different doses. A positive effect on the digestive processes was established. The best results were achieved while using lithium at a dose of 0.15 mg/kg of body weight. The authors noted a significant ($P < 0.05$) increase in the digestibility of organic matter by 1.4%, crude protein by 1.5%, crude fat by 0.8%, crude fiber by 2.3%, and nitrogen-free extractive substances by 1.0% compared with the parameters of the geese in the control group (Sobolev et al., 2019).

The authors report on the positive effect of “Levisil SB plus” yeast probiotic on the meat productivity of geese in the conditions of research and production experiments. It was found that this preparation in the doses of 500 and 1,000 g/t in geese diets caused an increase in the weight of eviscerated carcasses by 5.74% (131.0 g) and 9.63% (219.7 g), an increase in meat yield by 1.24 and 2.01%. Edible parts of a carcass increased by 7.26 and 12.3%, muscle tissue yield by 7.88 and

14.17%, pectoral muscles by 4.41, and 12.41% in comparison with the animals in the control group (Kornienko, 2018).

Implementation of innovative poultry farming technologies and using new-generation feed additives with active nanoparticles contribute to increasing meat productivity and improving meat quality parameters; the latest helps to increase the effectiveness of additive action in birds. The authors analyzed the current state of using nanoparticles in the form of feed additives in bird diets. The advantages of using nanoparticles due to their large contact surface area and high absorption were stated. It was shown that silver, being currently the most common nanoparticle, contributes to the improvement of the microbiota of broiler chicks. The authors concluded that nanoparticles can be used for direct targeted delivery to organs and systems without their degradation what significantly expands and adds to the knowledge about the mechanism of action of nanoparticles in living organisms (Gangadoo et al., 2016).

In this review, the authors present their studies on using copper nanoparticles (Cu-NP) as an alternative to the stimulators of growth and development for animals and birds. The high bioavailability and immunomodulating properties of copper nanoparticles were described here. At the same time, lack of information was noted on the doses and duration of giving nanosupplements to animals; the need for further confirmation of the bioavailability of copper nanoparticles was mentioned (Abdullah Scott, et al., 2018).

Scientific literature of recent years includes published studies by the authors on the development and use of nanostructured agro-minerals based on natural nonmetallic raw materials from deposits of the Russian Federation for feeding of farm animals and birds. The authors studied the issues of biological and toxicological safety of their use, established optimal doses for nanostructured phosphorites and nanosized bentonites in animal diets (Ezhkova et al., 2015).

Sapropel is a unique natural compound that contains mineral and organic components: a wide range of macro- and micro-elements, low molecular weight protein complexes, vitamins, enzymes, etc. (Yapparov et al., 2014; Mityukov et al., 2016). Using sapropel for feeding farm animals increases their productivity and improves product quality by the content of high-grade protein and mineral components (Ezhkova et al., 2014).

Different options for processing sapropel allow changing its physicochemical properties and obtaining new materials containing active nanoparticles that enhance or change known biological effects in a living organism (Rumyantsev et al., 2016; Ezhkov et al., 2016).

In this connection, this work aimed to study the effect of sapropel and different doses of nanostructured sapropel in the form of feed additives on the meat productivity of Linda geese and the quality of their meat. Tasks were defined as follows:

1. To study the average daily gain and live weight of geese.
2. To study meat productivity parameters of geese.
3. To study the content of chemical elements in goose meat.
4. To find an optimal dose of nanostructured sapropel for feeding geese.

2. MATERIALS AND METHODS

Research materials include sapropel from Lake Beloye, Russian Federation; nanostructured sapropel obtained from it with the particle content of 50.0-180.0 nm; Linda geese aged 30-120 days, meat.

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Manufacturing of nanostructured sapropel was carried out by ultrasonic dispersion of sapropel dried to a moisture content of 1.0%, mechanically crushed, and sieved through a sieve (0.18 mm). An ultrasonic homogenizer UZV 28/200 MP RELTEC (Russia) was used at the frequency of 15.0 kHz (± 10%), the output power of the device was 100 W, and the exposure time was 20-22 minutes. The particle size of a nanostructured sapropel was defined using Brookhaven 90Plus/MAS nanoparticle analyzer (USA) (Ezhkov et al., 2014).

Research and production experiments were carried out in the summer-autumn period based on "Akhmetov R.Kh." peasant-farm in the Vysokogorsky district of the Republic of Tatarstan (Figure 1). Geese at the age of 30 days were divided into five groups, 500 animals in each, according to the principle of analogue groups by age, live weight, and sex.

Figure 1: Geese of the Lindovskaya Breed, Research and Production Experiments of this study.

Geese of the control group 1 received "GKZ complete feed for geese" all-in-one feed (BD). This feed has the following composition (%): wheat 30.78; corn 35; sunflower meal 19.5; soybean meal 3.0; extruded soybeans 7.0; monocalcium phosphate 0.9; chalk 2.3; table salt 0.3; lysine 0.2; methionine 0.02; premix 1.0. Geese of the experimental group 2, in addition to BD, received sapropel in the optimal dose for waterfowl of 3.0% of the dry matter of diet (Ezhkova et al., 2014). Birds of experimental groups 3, 4, and 5 received nanostructured sapropel in the doses of 1.5; 1.0, and 0.5% of the dry matter of diet, respectively. Watering was centralized, with running water. Geese were kept in a brick building with a jointless concrete floor, floor housed, on a bed of sawdust. Ventilation in the building was natural and supply. Clinical and physiological condition of geese and livability of their livestock were taken into account in the course of this experiment. An increase in live weight was determined at the age of 4, 8, 12, and 17 weeks by individual weighing on "Mercury 315" electronic scales (Russia).

The contents of copper, zinc, nickel, lead and cadmium compounds in meat were defined in accordance with GOST 30538-97 using Agilent 4210 microwave plasma-atomic emission spectrometer (USA).

3. RESULTS

Sapropel is bottom sediment in lakes that contain many biologically active substances, such as fats, proteins, carbohydrates, mineral components, vitamins, humic and hormone-like compounds, enzymes that activate many functional systems in farm animals and birds (Yakimov and et al., 2002) (Figure 2).

Figure 2: Sapropel dried deposits of Lake Beloye (Russia).

Using sapropel and nanostructured sapropel in different doses for feeding geese resulted in increased live weight gain (Table 1).

Table 1: Average daily gain, live weight, and livability of geese livestock (*P<0.05).

Age, weeks	Groups of geese (n=50)				
	1	2	3	4	5
4	1,790.0±11.2	1,790.0±10.4	1,810.0±14.1	1,820.0±12.3	1,800.0±11.3
8	3,770.0±25.3	3,800.0±22.1	3,820.0±20.4	3,860.0±23.7	3,850.0±19.2
Average daily gain, g	66.0±2.4	67.0±2.2	67.0±1.8	68.0±2.1	68.3±1.7
12	4,710.0±43.6	4,790.0±51.2	4,810.0±40.4	4,900.0±35.2	4,880.0±28.3
Average daily gain, g	31.3±1.8	33.0±1.5	33.0±1.1	34.6±1.8	34.3±1.4
17	5,670.0±98.2	5,985.0±80.1	6,120.0±74.3	6,300.0±81.0*	6,200.0±94.1*
Average daily gain, g	32.0±3.4	39.8±4.3	43.6±4.1	46.7±4.8	44.0±3.9
Absolute gain, g	3,880.0±30.2	4,195.0±28.8	4,310.0±31.4	4,480.0±35.4	4,400.0±27.1
Relative gain, g	100.0	105.5	107.9	111.1	109.3
Livability of livestock, % (birds)	98.2 (9)	98.6 (7)	99.0 (5)	99.2 (4)	99.2 (4)

It was noted that in the period from four to eight weeks of age, average daily live weight gain in geese was the highest: it was 67.0 ± 2.2 ... 68.3 ± 1.7 g in experimental birds and 66.0 ± 2.4 g in control ones. At the age from eight to twelve weeks, the average daily gain was 33.0 ± 1.1 ... 34.6 ± 1.8 and 31.3 ± 1.8 g, respectively. At the age of seventeen weeks (pre-slaughter), these parameters in experimental birds amounted to 39.8 ± 4.3 ... 46.7 ± 4.8 g and significantly exceeded control values of 32.0 ± 3.4 g. Obtained results of average daily gain in experimental geese corresponded to the parameters of genetic growth potential for the birds of this breed and to the periods of their physiological growth and development with a definite advantage over their equals in the age of the control group.

It was established that by the period of technological slaughter, the live weight of geese receiving sapropel in the form of feed additive increased by 5.5%, or by 315.0 g per bird in comparison with the values in the control group. The best results were achieved in the group of geese receiving nanostructured sapropel in the dose of 1.0% – the increase amounted to 11.1%, or 630.0 g (P <0.05) per bird in comparison with the values in the control group. Adding nanostructured sapropel to geese feed at the dose of 1.5% and 0.5% of the dry matter of feed contributed to an increase in their live weight by 7.9 and 9.3%, or 450 and 530 g per bird, respectively, in comparison with the control group. It was noted that the highest dose of nanostructured sapropel was less effective in comparison with lesser doses of the additive.

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The technological slaughter of geese was carried out at 17 weeks of age. Parameters of meat productivity of birds depending on forms and doses of sapropel additives are shown in Table 2.

Table 2: Meat productivity of geese, g (*P<0.05)

Parameter	Groups of geese (n=10)				
	1	2	3	4	5
Pre-slaughter weight	5,670.0±98.2	5,985.0±80.1	6,120.0±74.3	6,300.0±81.0*	6,200.0±94.1*
Weight of semi-eviscerated carcass	4,380.6±92.1	4,680.2±84.2	4,870.5±90.1	5,100.3±93.1*	4,970.4±84.5
Yield of semi-eviscerated carcass,%	77.2±3.2	78.2±3.4	79.6±4.1	80.9±3.4	80.2±5.0
Weight of eviscerated carcass	3,240.2±70.4	3,460.3±76.2	3,590.0±82.1	3,754.8±89.7	3,680.8±94.3
Yield of eviscerated carcass,%	57.1±1.1	57.8±1.3	58.7±1.2	59.6±1.3*	59.3±1.0*

The best values were achieved in the group of geese that received different doses of nanostructured sapropel with feed. The weight of their eviscerated carcasses was 349.8; 514.6 and 440.6 g more than of control ones; this parameter in the sapropel group amounted to 220.1 g. The yield of eviscerated carcasses of geese that received nanostructured sapropel at the doses of 1.0 and 0.5% was significantly higher compared with the control group by 2.5 (P <0.05) and 2.2% (P <0.05).

Goose meat was tested for the content of several chemical elements (Table 3).

Table 3: Content of chemical elements in the meat of geese, mg/kg (*P<0.05).

Parameters	Allowable amount	Groups of geese (n=7)				
		1	2	3	4	5
Cadmium	no more than 0.05	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Lead	no more than 0.5	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Zinc	20.0	15.98±4.79	15.23±4.21	13.24±3.97	14.14±4.18	14.90±4.12
Copper	5.0	5.35±0.21	4.94±0.92	3.83±0.17*	4.24±0.12	4.52±0.14
Nickel	no more than 0.5	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02

It was established that the amount of regulated highly dangerous chemical elements, cadmium, and lead, as well as dangerous nickel in goose meat, was less than 0.02 mg/kg of weight what indicates the compliance of meat raw materials with hygienic requirements (SanPiN, 2001). Zinc content in goose meat was within its allowable range for meat raw materials. The copper level exceeded requirements by 1.07 times. It is well known that a complex of biologically active substances makes it possible to correct the content of heavy metals in living organisms and to obtain safe products (Donnik et al., 2019; Poryvaeva et al., 2019; Mikolaychik et al., 2020). Many authors note the unique character of the complex of biologically active substances in sapropel and mention its possibility of sorbing toxins of various nature (Mityukov et al., 2016).

Long-term use of natural sapropel reduced zinc content in goose meat by 4.7% in comparison with control animals. In the meat of geese treated with nanostructured sapropel, a more significant decrease in zinc content was found; sorption levels showed a dose-dependent tendency. In the meat of geese which received the highest dose of nano-additive, zinc content was 17.1% lower than in the control samples. In the meat of geese treated with nanostructured sapropel in the dose of 1.0%, the decrease was 11.5%. The smallest dose of nanostructured additive caused a decrease in zinc amount by 6.7% in comparison with the control group.

Using sapropel for bird feeding led to a decrease in copper content by 7.7% in comparison with control animals. In the meat of geese treated with nanostructured sapropel, copper content decreased

by 28.4; 20.7, and 15.5%, respectively, regarding the experimental groups 3, 4, and 5. The dose-dependent nature of this decline remained. It was noted that even the smallest dose of nanostructured sapropel 0.5% of the dry matter of diet demonstrated comparatively greater sorption properties than natural sapropel.

4. CONCLUSION

Using sapropel feed additives for growing geese contributed to an increase in average daily gain in comparison with control animals. By the period of technological slaughtering, the increase in the live weight of geese was 5.5% when using sapropel, and 7.9%, 11.1%, and 9.3% when using nanostructured sapropel in the doses of 1.5%; 1.0%, and 0.5%, respectively.

The yield of eviscerated carcasses of geese that received nanostructured sapropel with the diet at the doses of 1.0 and 0.5% was significantly higher by 2.5% and 2.2% in comparison with the control group. Adding sapropel feed additives to the feed of geese led to a decreased level of zinc (by 4.7%) and lead (by 7.7%) compounds in meat in comparison with the control samples. Nanostructured sapropel showed higher sorption properties with an evident dose-dependent nature. A dose of 1.5% resulted in the decrease in zinc by 17.1% and copper by 28.4%; at the dose of 1.0%, the decrease amounted to 11.5% and 20.7%; and at the dose of 0.5%, the decrease in zinc and copper level was 6.7% and 15.5% in comparison with the control values.

The best results for increasing the meat productivity of geese and improving the biological value of their meat were achieved with the use of nanostructured sapropel in bird feeding at the dose of 1.0% of the dry matter of diet.

5. AVAILABILITY OF DATA AND MATERIAL

Information can be made available by contacting the corresponding author.

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