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Research article

The use of chlorella in goose breeding

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Abstract: Currently, the livestock industry around the world is not provided with the necessary amount of feed rich in proteins and biologically active substances (BAS) of natural origin. These can be provided with alternative sources like microalgae with chlorella holding a special place due to its unique chemical composition. This paper introduces the research results on the effect of chlorella suspension on the productive and reproductive qualities of geese of various technological groups. It reveals the optimal doses to be included in the poultry diet. Thus, application of chlorella suspension in the feed rations of geese has increased their safety, live weight, egg production and hatching, improved quality indicators of goose semen production, incubation results, yield of commercial replacement birds, indicators of natural resistance, as well as the digestibility of nutrients at lower feed costs per unit of production and higher goose meat quality.

Keywords: geese; chlorella suspension; semen production; goose meat; morphobiochemical composition of blood; digestibility of nutrients

1. Introduction

The world population is increasing annually and according to experts the population of the Earth being 6.8 billion people in 2010 will grow to 9.3 billion by 2050 that is by 36%. To provide the world's population with protein food products, especially of animal origin, it is necessary to increase production volumes not at the expense of product quality and safety. According to the forecast of OD Consulting Group, over the next 40 years there will be the overall increase in meat by 70.7% and in poultry production by 122.5%.

High development rates of poultry farming are important not only for solving the strategic task of ensuring food security, but also in the social aspect—as a guarantee of the economic availability of food for all social groups of the population.

Further development of poultry industry requires full feeding of birds taking into account their physiological state and productivity. Non-traditional feed additives included in the poultry diet are also essential. They enhance metabolic processes, improve nutrient digestibility and reduce feed costs for unit of production [1–3].

Currently, the most popular feed additives for farm animals and poultry are considered to be microalgae [4]. These are microscopic algae single-celled, photosynthetic organisms that grow in saline or fresh water. They are rich in nutrients and biologically active substances, including protein, amino acids, omega-3-polyunsaturated fatty acids, antioxidants, carotenoids, vitamins and microelements [1].

From numerous species of algae, which are used for mass cultivation, representatives of the genus *Chlorella* take a dominant position, and the planktonic strain *Chlorella vulgaris* IGF No. C-111, which has the ability of free floating and uniform distribution in the culture medium, is more commonly used for the preparation of the feed additive [5–6].

In terms of protein content, essential amino acids, vitamins, trace elements and other biologically active substances, chlorella has an advantage not only over aquatic, but also terrestrial plants [4,7–9].

The introduction of chlorella in the diet of animals and poultry can significantly replace expensive vitamins and drugs. It provides the ways to realize the potential physiological reserves of the bird, increase the body's resistance to adverse factors and the live weight of the young, improve their productive qualities and pay for food [10]. High content of β-1.3-glucan, a bioactive immune-stimulating absorber of free radicals, was found in the cell wall of chlorella [5]. In their studies, Morris et al. [11] used chlorella to treat various diseases, and Pieper et al. [12] established its immune-modulating and anti-cancer properties.

Chlorella contains up to 62% of protein, 30% of carbohydrates, 5% of fats, 3% of mineral salts, polyunsaturated fatty acids, carotenoids, as well as all the necessary amino acids, including essential ones. The content of nucleic acids in *Chlorella* varies from 4 to 7%. *Chlorella* contains almost all vitamins, and a significant amount of vitamin C (1000–2500 mg per 1 kg of dry matter), trace elements—copper, iron, manganese, molybdenum, cobalt, zinc, iodine, etc. [1,13–14]. The use of chlorella suspension can reduce the use of drugs, including antibiotics, for the treatment of animals. Chacon-Lee et al. [15], Kang et al. [16] replaced growth stimulants and antibiotics with various forms of chlorella and tracked the immune response and the condition of the intestinal microflora of chickens.

The research of Lipstein & Hurwitz [17], Combs [18], Gouveia et al. [19], Yun et al. [20], Wang et al. [21] proved the effectiveness of chlorella suspension in the diets of various farm animals and birds. However, the huge potential of using microalgae biomass in the production of eggs and poultry meat has not yet been fully disclosed; the effect of chlorella suspension on the productive qualities and reproductive functions of geese has not been sufficiently studied.

In this regard, the purpose of our research was to identify the effect of chlorella suspension on the productive and reproductive qualities of geese and the effectiveness of its use in the manufacture of goose products.

2. Materials and Method

The studies were conducted on the geese of the parent flock, replacement youngsters and goslings grown for meat in the conditions of the goose farm of LLC 'Bashkirskaya Ptitza' (Bashkir Bird) located in the Blagovarsky District of the Republic of Bashkortostan.

A suspension of Chlorella was cultivated in 4 h special installations. These are the photo-bioreactors FBR-150 (produced by LLC «Delo» located in Lunino Village, Penza Region, Russian Federation). Their total volume is 600 L. The installations have a vertical cylindrical glass tubes with stationary phyto-lamps DNAT 250 GIB Lighting Pure Bloom Spectrum XTreme Output 250 W (high-pressure sodium lamp with a transparent external bulb, a luminous flux of 32000 Lm, made in Germany) in them. At first, a nutrient medium was prepared to cultivate Chlorella. To do this, the photo-bioreactor was filled with water at the rate of 90% of the total solution volume at temperature of 28 ± 2 ℃. Then the reagents were introduced sequentially (per 1 liter of tap water): ammonium nitrate 1 g, superphosphate 10% solution 1 mL, ferric chloride 1% solution 0.15 mL, cobalt nitric acid 1 mg, sulfuric copper 1 mg and the solution was thoroughly mixed after the introduction of each of them. Uterine culture of the plankton strain Chlorella vulgaris IGF №C-111 with a concentration of 30–40 million cells in 1 mL at the rate of 10% of the volume was poured into the prepared nutrient medium. The total number of microorganisms in the suspension was determined by the method of direct counting of cells in the Goryaev chamber. To start cultivation of Chlorella phyto-lamps were switched on and artificial lighting with an illumination of 900 lx was provided for 18 hours. When cultivating the Chlorella suspension, the temperature of the medium was maintained by the thermostat at 28 ± 2 ℃, the stability and uniformity of the temperature were ensured by the operation of the fan associated with the thermostat. Every day during the first 3 days for the intensive development of microalgae, a bacterial suspension saturated with carbon dioxide, formed due to the activity of cellulose bacteria during the decomposition of cellulose-containing material (wheat straw) in the amount of 1% of the volume of the container, was poured into the photo-bioreactor. On the fourth day, the Chlorella suspension was ready for use with the optical density being about 1.0–1.2. The optical density was determined by the suspension density meter SDM-03, designed to measure this indicator directly in the tank where the test organism is grown (chlorella algae). Microalgae were grown daily that provided the discharge of the finished suspension and the addition of a nutrient solution. The obtained microalgae concentrate was stored in closed glass containers at a temperature of 8–10 ℃ and consumed as needed, after mixing well. The quality of the suspension was determined by the optical density of the suspension density meter SDM-03.

To conduct the research on the parent flock of geese, 6 groups, the control and 5 experimental ones of 72 birds each, were formed. In the experimental 1–5 groups, the suspension was introduced into the diet at a dose of 40, 50, 60, 70 and 80 mL/head per day, respectively. Studies on the replacement of young geese were conducted on 1 control and 3 experimental groups of 300 birds each. The goslings of the experimental 1, 2 and 3 groups aged from one day to three weeks received a suspension of chlorella in the amount of 15, 20 and 25 mL/head per day, respectively. Starting from three weeks and until the end of cultivation they were given 40, 50 and 60 mL/head per day. To assess the growth, development, and meat qualities of goslings grown for meat using chlorella suspension, 1 control and 4 experimental groups of 100 birds each were formed. Up to 3 weeks goslings of the experimental 1, 2, 3 and 4 groups, in addition to the basic diet, received suspension of chlorella in the volume of 10, 15, 20 and 25 mL, and after 3 weeks, 20, 30, 40 and 50 mL/head per day, respectively. In all studies, the parent flock and the young geese of the control groups received the basic diet without the chlorella suspension. The chlorella suspension was introduced by watering, as well as when giving semi-moist food.

In the course of research, the safety of livestock (%) was determined by daily accounting of dead and culled birds with the identification of the causes of the withdrawal; egg production by an average layer—by dividing the number of eggs laid in a group for a certain period by the average number of geese for the same period; assessment of morphological and physicochemical parameters of eggs was carried out in accordance with the methodological recommendations of the All-Russian Research and Technological Institute of Poultry (ARRTIP) (2010); the results of egg incubation—according to the guidelines for biological control in the incubation of poultry eggs (ARRTIP, 2014); eggs fertilization (%)—the ratio of the number of fertilized eggs to the number laid for incubation; hatching (%)—the ratio of the number of hatching conditioned hatchlings to the number of eggs laid for incubation; the content of carotenoids and vitamins in the yolk of eggs—by standard methods described in the manual of Skurikhina and Shabaeva [22]. Goose-gander sperm quality was assessed by three indicators: the volume of the ejaculate in the sperm collector (cm^3), sperm concentration in the ejaculate (billion/cm^3) examined under a microscope, enlarged 300 times, sperm activity on a 10-point scale.

The morphological and biochemical composition of blood and indicators of natural resistance were determined according to generally accepted methods described in the manual of Sukhanova et al. (2017); digestibility and nutrient utilization of feed (%)—by carrying out balance experiments in accordance with the methodology of ARRTIP (2004). Laboratory analyzes were carried out in analytical laboratories of the Bashkir State Agrarian University and the Bashkir Research Institute of Agriculture.

The recipe of complete feed for young stock and geese of the parent flock is presented in Table 1.

The conditions of feeding, growing and keeping of geese in each study were identical in all groups and corresponded to the methodological recommendations of the All-Russian Research and Technological Institute of Poultry (ARRTIP) taking into account the breed characteristics of birds with the exception of the factor under study.

Table 1. Recipe complete feed for young animals and adult geese (Producer—Open Joint-Stock Company Bogdanovichsky feed mill, Russian Federation, Sverdlovsk region, Bogdanovich city).

Composition	For young geese (%)	For geese of the parent flock (%)
Wheat	44.0	52.5
Barley	15.0	10.0
Oats	-	5.0
Peas	3.0	-
Sunflower cake	8.0	10.0
Protein-vitamin-mineral supplement*	14.4	7.5
Herbal flour Alfalfa	5.0	5.0
Fodder yeast	5.0	5.0
Limestone flour	1.1	3.5
Sunflower oil-	2.5	1.5
Premix	2.0	-

*Protein-vitamin-mineral supplement—a homogeneous mixture of high-protein, mineral feed and biologically active substances.

3. Results and Discussion

The introduction of chlorella suspension into the diet of geese of the parent flock contributed to the improvement of their viability (Figure 1).

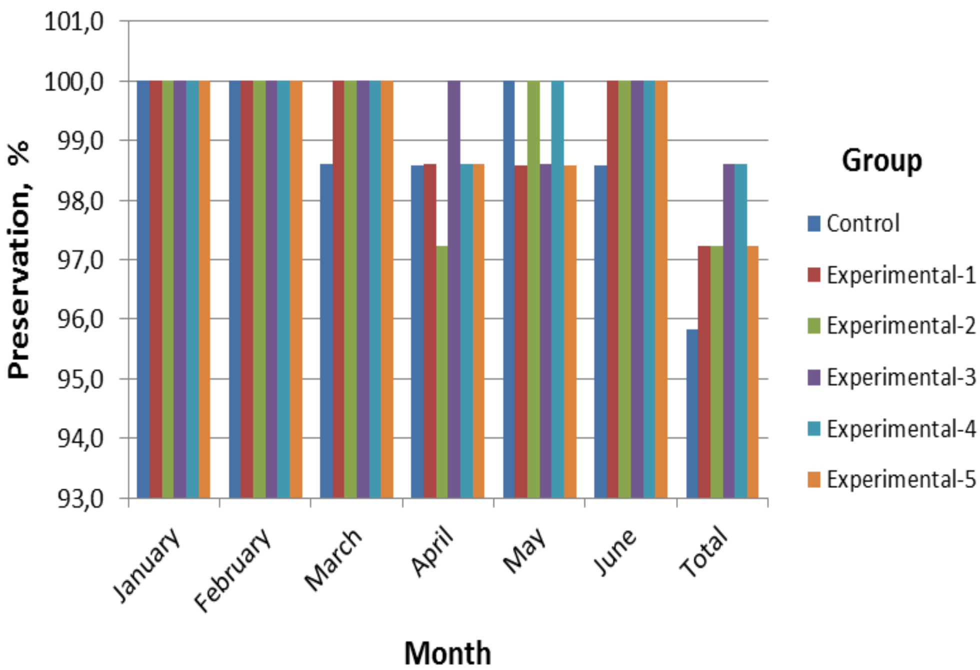

Figure 1. Viability of the geese of the parent flock, %.

The best indicators of preservation were in experimental groups 3 and 4 that received the chlorella suspension in a volume of 60 and 70 mL per 1 head per day, respectively, and amounted to 98.61%, being 2.78% higher than in the control. This is probably due to the positive effect of the chlorella suspension on the bird’s body due to its immune-stimulating properties, as evidenced by the indicators of natural resistance.

The introduction of the chlorella suspension into the diet of geese had a positive effect on their egg production (Table 2).

Table 2. Egg production per average layer, pieces.

Month	Group					
	Control	Experimental-1	Experimental-2	Experimental-3	Experimental-4	Experimental-5
January	-	-	0.12 ±0.02	0.17 ±0.01	0.14 ±0.03	0.12 ±0.02
February	3.80 ±0.63	3.82 ±0.69	3.85 ±0.71	3.90 ±0.76	3.89 ±0.69	3.86 ±0.73
March	14.25 ±0.57	14.47 ±0.48	14.55 ±0.43	14.68 ±0.46	14.68 ±0.51	14.71 ±0.45
April	15.86 ±0.19	16.10 ±0.23	16.14 ±0.16	16.43 ±0.20*	16.44 ±0.18*	16.45 ±0.24
May	13.93 ±0.12	14.12 ±0.14	14.23 ±0.18	14.37 ±0.15*	14.39 ±0.17*	14.40 ±0.27
June	3.36 ±0.25	3,45 ±0.29	3.48 ±0.41	3.63 ±0.34	3.56 ±0.32	3.51 ±0.31
Total	51.2 ±0.52	51.9 ±0.41	52.4 ±0.53	53.2 ±0.57*	53.1 ±0.49*	53.0 ±0.46

Note: hereinafter *—$p < 0.05$; **—$p < 0.01$; ***—$p < 0.001$.

From February to the end of the productivity, the egg production of geese treated with the chlorella suspension was 1.5–3.9% higher than in the control group. In April, the egg production in the experimental groups surpassed the control by 1.51–3.72%. It should be also noted that during the productive period, geese of the experimental groups 3 and 4 receiving 60 and 70 mL of chlorella suspension per 1 head per day had the highest egg production with 53.2 and 53.1 pieces of eggs against 51.2 pcs. in the control group.

Thus, the chlorella suspension included in the composition of the geese ration during the productive period contributed to an increase in egg production per average layer. In our opinion, it is due to the high content of protein and biologically active substances in it.

To determine the incubation qualities of eggs, we assessed the morphobiochemical composition and physical properties of eggs at the peak of the goose productivity (Table 3).

Eggs laid by the control group geese were inferior in weight to those in experimental groups by 0.3–1.5% and corresponded to the breed standard. By weight of protein, yolk and egg shells, geese from 3–5 experimental groups were in the lead, which exceeded the control indicators by 1.40–1.46%, 1.72–1.92% and 0.63–0.68% respectively.

Indicators of specific density of eggs were the greatest in 3–5 experimental groups and amounted to 1096–1097 g/cm^3, which is 0.2–0.3% higher than in the control.

Comparing the egg shape index, it should be noted that in the control group it was lower than in the experimental group by 0.1–1.0% and complied with the requirements imposed on the quality of hatching goose eggs (63–70%). Indicators of the How unit in the experimental groups slightly exceeded those of the control group.

Table 3. Morphobiochemical composition and physical properties of goose eggs (n=10 in each group).

Index	Group					
	Control	Experimental-1	Experimental-2	Experimental-3	Experimental-4	Experimental-5
Egg weight, g	151.52 ±2.14	151.93 ±2.15	152.21 ±2.20	153.65 ±2.15	153.79 ±2.11	153.83 ±2.19
Weight of egg constituents, g:						
albumin	78.31 ±0.31	78.52 ±0.27	78.61 ±0.34	79.39 ±0.31*	79.43 ±0.27*	79.45 ±0.33
yolk	54.08 ±0.18	54.26 ±0.19	54.42 ±0.21	55.01 ±0.17*	55.10 ±0.21*	55.12 ±0.25
Egg shell	19.13 ±0.14	19.15 ±0.11	19.18 ±0.18	19.25 ±0.15	19.26 ±0.14	19.26 ±0.19
Egg shell width, mm	0.568 ±0.022	0.575 ±0.024	0.583 ±0.020	0.589 ±0.018	0.591 ±0.021	0.592 ±0.020
elasticity, mkm	18.8 ±1.50	18.60 ±1.54	18.60 ±1.46	18.50 ±1.42	18.50 ±1.48	18.50 ±1.52
Unit How	84.42 ±1.18	84.51 ±1.28	84.58 ±1.23	84.67 ±1.30	84.70 ±1.26	84.72 ±1.31
Relative density, g/cmi	1.094 ±0.003	1.095 ±0.002	1.095 ±0.001	1.096 ±0.003	1.096 ±0.002	1.097 ±0.002
Form index, %	64.90 ±0.72	64.96 ±0.84	65.11 ±0.83	65.49 ±0.77	65.53 ±0.68	65.55 ±0.75
Content in egg yolk, mkg/g:						
carotinoids	15.50 ±0.20	15.74 ±0.18	16.11 ±0.25	16.52 ±0.31*	16.47 ±0.26*	16.27 ±0.23*
vitamin A	9.21 ±0.19	9.49 ±0.14	9.62 ±0.18	9.86 ±0.23*	9.84 ±0.20*	9.72 ±0.18
vitamin B_2	7.79 ±0.18	7.91 ±0.16	7.96 ±0.22	8.15 ±0.24	8.12 ±0.19	8.05 ±0.21

*—$p < 0.05$.

The content of carotenoids in the yolk of the experimental groups 3 and 4 was the highest and amounted to 16.52 and 16.47 mg/g, being higher by 6.3–6.6% than in the control. This can be explained by the fact that in its chemical composition chlorella contains a large amount of carotenoids. The birds of the control group received 3136 mg of carotenoids per 1 head per day in the diet, and its content in the experimental groups ranged from 3156 to 3206 mg. Similar results were received in studies conducted on laying hens by Kotrbacek et al. [23].

According to the content of vitamins A and B_2 in the egg yolk, the geese of the control group were inferior to the experimental ones that received 3.0–7.1 and 1.5–7.1% of the chlorella suspension, respectively.

Improved biochemical composition of chicken eggs under the influence of chlorella was established by Skrivan et al. [24]. The scientists An et al. [25] found that the feed supplemented with algae *Chlorella* had a positive effect on the hatching quality of chicken eggs.

Adding chlorella to chicken feed not only increased the concentration of lutein and zeaxanthin in eggs, but also improved feed conversion, egg shell quality and increased oxidative stability of egg yolk lipids [26].

The inclusion of the chlorella suspension in the diet had a beneficial effect on the reproductive functions of goose-ganders (Figure 2), especially in experimental groups 3 and 4. At the age of 48 weeks the quality of sperm products in goose-ganders of experimental groups exceeded the control by volume by 1.6–11.3%, by concentration—by 3.4–10.2%, by sperm activity—by 2.4–7.3%.

Better quality indicators of goose-gander sperm production in the experimental groups is explained by the fact that the high content of nutrients and biologically active substances in the chlorella suspension, including protein, amino acids, antioxidants, carotenoids, vitamins, macro-, microelements, including copper, iron, zinc and others, advanced the full realization of physiological reserves of the body, improving the reproductive function of poultry, as evidenced by the results of egg incubation.

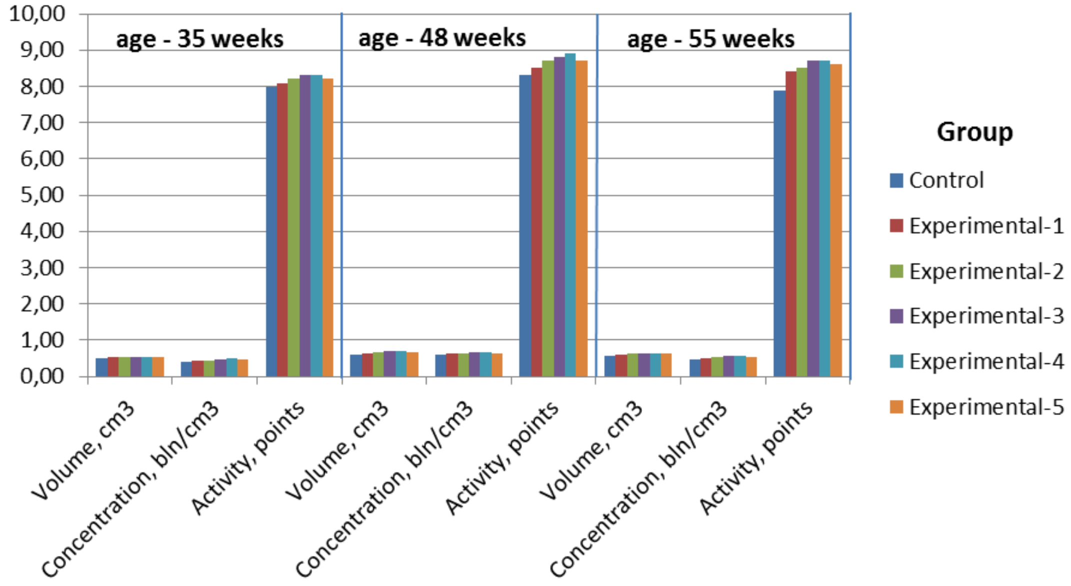

Figure 2. The quality of goose-ganders sperm (n = 3 in each group).

So, the yield of hatching eggs in the experimental groups was higher by 0.4–1.4% in comparison with the control group. The fertilization of eggs in the experimental groups 3 and 4 exceeded the control index by 1.8 and 1.9% (Figure 3). The hatching percentage was higher by 3.8 and 4.0% (Figure 4) with hatchability of 78.8 and 78.9%, respectively.

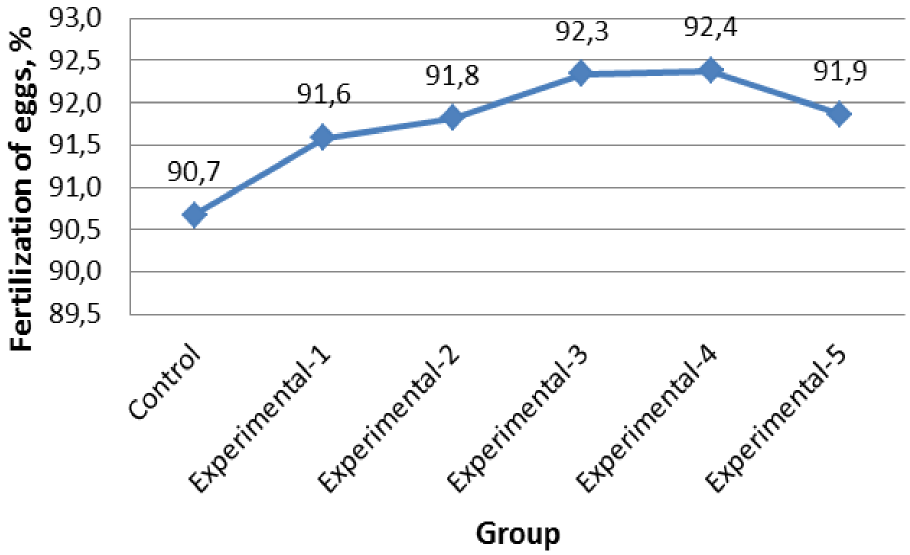

Figure 3. Fertilization of eggs, %.

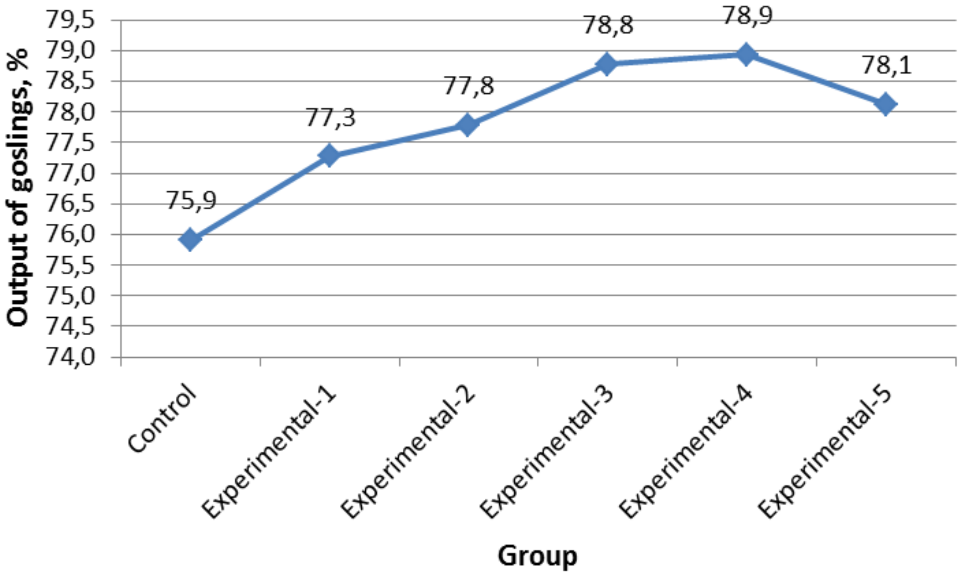

Figure 4. Output of goslings, %.

The positive effect of chlorella on the incubation quality of poultry eggs was also revealed in studies conducted by Halle et al. [27], Janczyk et al. [28]. Thus, the results of studies on laying hens showed that *Chlorella vulgaris* contributed to improving the hatchability of eggs, the color of the yolk.

Daily youngsters of experimental groups 3 and 4 were more homogeneous in live weight being 98.2–98.5 g at average.

In the analysis of blood parameters (Table 4), the highest content of erythrocytes and hemoglobin was found in the blood of birds of the experimental groups 3 and 4, reaching 2.31–2.33 × 10^{12}/L and 130.19–130.71 g/L, that was higher by 6.0–6.9% and 7.5% ($p < 0.05$)–7.9% ($p < 0.01$) compared with the control group, respectively. The hemoglobin content in one erythrocyte in groups varied within 1.67–1.69, and in the experimental group 3 it was 1.69 and exceeded the control by 1.2%.

Table 4. The morphobiochemical composition of the goose blood (n = 3♂ + 3♀ in each group).

Group	Index				
	Erythrocytes, × 10^{12}/L	Hemoglobin, g/L	Color index	Leukocytes, × 10^{9}/L	Alkali reserve, mg%
Control	2.18 ± 0.10	121.10 ± 2.19	1.67 ± 0.17	21.28 ± 1.11	560.07 ± 6.36
Experimental-1	2.22 ± 0.08	124.09 ± 2.23	1.68 ± 0.25	21.49 ± 1.09	567.79 ± 6.27
Experimental-2	2.25 ± 0.12	125.91 ± 2.27	1.68 ± 0.18	21.71 ± 1.12	571.41 ± 5.72
Experimental-3	2.31 ± 0.09	130.19 ± 2.16*	1.69 ± 0.23	22.08 ± 1.14	577.69 ± 6.12*
Experimental-4	2.33 ± 0.15	130.71 ± 2.24**	1.68 ± 0.21	22.13 ± 1.18	578.48 ± 6.48*
Experimental-5	2.29 ± 0.14	128.35 ± 2.15*	1.68 ± 0.19	21.85 ± 1.10	574.36 ± 6.51

*—$p < 0.05$; **—$p < 0.01$.

The introduction of chlorella suspension into the diet contributed to an increase in the alkaline reserve of geese of the experimental groups by 1.4–3.3%. The highest alkaline reserve at the peak of productivity was observed in geese from the experimental groups 3 and 4—577.69 and 578.48 mg %, which was 3.1% and 3.3% higher compared to the control, respectively.

Indicators of humoral factors of nonspecific immunity (Table 5) during the period of productivity were more pronounced in geese of the experimental groups 3 and 4.

Thus, the bactericidal activity of blood serum in these groups was 47.32% and 47.41%, which is 3.21% and 3.40% higher than in the control group, respectively. The lysozyme and phagocytosis activity of the blood serum of geese from the experimental groups was 0.73–5.17% higher than from the control and 0.58–2.33%, respectively.

Table 5. Indicators of natural resistance of goose parent flock (n = 3♂ + 3♀ in each group).

Index	Group					
	Control	Experimental-1	Experimental-2	Experimental-3	Experimental-4	Experimental-5
Bactericidal activity, %	45.85 ±3.32	46.24 ±3.72	46.51 ±2.91	47.32 ±3.74	47.41 ±2.68	46.79 ±3.05
Lysozyme activity, %	21.67 ±1.29	21.83 ±1.08	22.17 ±1.46	22.74 ±1.39	22.79 ±1.25	22.54 ±1.14
Phagocytic activity, %	63.85 ±1.67	64.22 ±1.49	64.68 ±1.58	65.28 ±1.89	65.34 ±1.33	65.03 ±1.46
Phagocytic number	4.49 ±0.11	4.71 ±0.17	4.83 ±0.10*	4.93 ±0.14*	4.95 ±0.19*	4.89 ±0.12*
Phagocytic index	7.19 ±0.18	7.33 ±0.23	7.47 ±0.26	7.55 ±0.16*	7.58 ±0.12*	7.52 ±0.23
Phagocytic capacity, thous.mic.pcs	158.36 ±8.17	160.74 ±7.85	161.93 ±7.61	162.65 ±8.29	162.74 ±8.14	162.29 ±7.78

*—$p < 0.05$.

A similar effect was found in their research of Kotrbacek et al. [29], when replacing 0.5% chlorella feed in broiler chickens, and phagocytic activity of leukocytes and development of lymphatic tissue increased, and Rezvani et al. [30] observed a numerical increase in the response to phytohemagglutinin-P.

The introduction of the chlorella suspension into the diet of geese during the productive period contributed to the improvement of the digestibility of protein, fat, fiber, Nitrogen-Free Extractives (NFE) and the better use of nitrogen, calcium and phosphorus feed (Table 6).

The digestibility of protein in the experimental group 4 was 79.7%, which is higher compared with other experimental groups by 0.1–1.2% and 1.7% than in the control group. The digestibility of fat, fiber and NFE showed a similar trend. The introduction of the chlorella suspension in the diet contributed to an increase in the use of nitrogen, phosphorus and calcium by 0.4–1.4%, 0.4–1.2%, 0.2–1.1% compared with the control group, respectively.

Thus, due to its chemical composition, chlorella has a beneficial effect on the geese and has contributed to a more complete manifestation of the genetic potential of their productivity, increased body resistance to adverse environmental factors, stimulated the immune response, improved reproductive functions and digestibility of nutrients of the feed, resulting in increase in viability, productive and reproductive qualities, as well as improved payment for food products.

The introduction of the chlorella suspension in the diet also contributed to the improvement of the viability and yield of young stock. In the experimental group 2, the yield of commercial young birds was the highest, reaching 64.0%, that is, more by 4.0% compared with the control.

Table 6. Feed digestability and nutrient use, % (n = 3♂ + 3♀ in each group).

Index	Group					
	Control	Experimental-1	Experimental-2	Experimental-3	Experimental-4	Experimental-5
Digestability:						
Protein	78.0 ±0.10	78.5 ±0.12*	78.8 ±0.14**	79.6 ±0.18***	79.7 ±0.14***	79.5 ±0.15***
Fat	55.1 ±0.13	55.7 ±0.18**	56.0 ±0.12***	56.5 ±0.15***	56.3 ±0.17**	56.1 ±0.12**
Fibre	53.9 ±0.18	54.1 ±0.17	54.3 ±0.21	54.6 ±0.20*	54.8 ±0.19*	54.4 ±0.22
NFE	61.9±0.33	62.2 ±0.29	62.5 ±0.31	62.8 ±0.34	62.8 ±0.38	62.6 ±0.36
Use:						
Nitrogen	47.2 ±0.16	47.6 ±0.12	47.9 ±0.15*	48.4 ±0.18**	48.6 ±0.15**	48.1 ±0.17*
Calcium	42.3 ±0.21	42.7 ±0.28	43.0 ±0.29	43.3 ±0.22*	43.5 ±0.26*	43.2 ±0.21*
Phosphorus	37.9 ±0.14	38.1 ±0.11	38.3 ±0.12	38.7 ±0.14**	39.0 ±0.16**	38.5 ±0.16*

*—$p < 0.05$; **—$p < 0.01$; ***—$p < 0.001$.

Applying the chlorella suspension in the volume of 20 mL up to 3 weeks and 40 mL/head after 3 weeks of age when growing goslings for meat contributed to an increase in live weight by 5.1%, the yield of edible parts by 8.9% and the level of profitability of the goose meat production by 11.4% compared with the control. The positive effect of chlorella on the body of broiler chickens has also been established by other scientists [14,31].

4. Conclusions

Thus, chlorella included in the diet of geese contributed to strengthening the body's defense against the microbial effects of the environment in line with better metabolism in their bodies. It enhanced their productive and reproductive qualities. Immune-modulating properties of Chlorella in the feeding of farm animals and poultry were found in studies by Bogdanov [32], Morris et al. [11] and Pieper et al. [12].

The best effect was found when using the chlorella suspension in the volume of 60–70 mL per head per day for the geese of the parent flock; 20 mL up to 3 weeks and 50 mL from 3 weeks for replacement young geese; 20 mL up to 3 weeks and 40 ml after 3 weeks for goslings grown for meat.

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