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Chapter

Role of Humic Substances in Formation of Safety and Quality of Poultry Meat

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Abstract

The purpose of this chapter was to study the influence of humic substances on the formation of the safety and quality of poultry meat. The high abilities of the natural and organic complex of humic acids "Reasil®HumicHealth" (produced in Russia, Saratov) to sorb and desorb five mycotoxins of compound feed (aflatoxin B1, ochratoxin, toxin T-2, zearalenone and fuminisin B1) were experimentally established. The hepatoprotective ability of humic acids was observed in experiments on broilers using rapeseed meal containing an increased amount of secondary plant metabolites that could cause liver damage. It was found out that the inclusion of humic acids in the amount of 1 and 1.5 g per 1 kg of feed to the main diet of broiler chickens has a more stable positive effect, both in terms of slaughter indicators (yield of semieviscerated carcasses and carcasses of complete evisceration), and in the production of the most valuable natural semi-finished products (breast, chicken legs) due to the intensive growth of muscle tissue. A clear improvement in the morpho-biochemical and immunological parameters of blood and micromorphometric characteristics of the organs of the immune system of poultry was noted with the use of different concentrations of humic acid salts. The use of the additive at the rate of 1 and 1.5 g per 1 kg of feed does not negatively affect the sensory indicators of finished culinary products.

Keywords: humic acids, broiler chickens, safety, quality

1. Introduction

Intensive poultry farming technologies have created the prerequisites for providing the population with dietary meat and high-grade protein. Poultry products have become in demand and, at the same time, they are a source of microbiological, physical and chemical risks. Regular consumption of poultry meat rearing using intensive technologies is the risk of a number of negative effects on human health, including antibiotic resistance of the body. Such factors negate the health benefits of such meat, especially when it is used in medical dietary or baby food.

In this regard, an important task of science and practice is the search for new ways to eliminate the toxic load on agricultural poultry, through the use of environmentally friendly biologically active substances in its diet, which have a stimulating effect on nonspecific factors of the body's natural resistance and increase productivity.

A promising direction in poultry feeding is the use of natural biological compounds - humic acids and their salts - humates, which, after interaction with a living cell, contribute to the output of released energy not on the elimination of adverse environmental influences, but on growth and reproduction, which leads to an increase in the competitiveness of an organism.

The purpose of the work was to study the effect of the liquid water-soluble feed additive of complex action "Reasil®HumicHealth" (produced by LLC "Life Force" on the basis of a concentrated solution of high-molecular sodium salts of humic acids from Leonardite) on the vital indicators of the state of the body of broilers during rearing, their slaughter and meat qualities, dynamics of morpho-biochemical and immunological parameters of blood and micromorphometric characteristics of the organs of the immune system of poultry, as well as on organoleptic indicators and the yield of culinary products from poultry meat.

2. Medical and biological, chemical and functional properties of preparations of humic acids

Humic acids (from Latin humus - earth, soil) were isolated from peat. They have been the object of scientific research by scientists from different countries for over 200 years. Currently, natural substances that are at different stages of humification, located in different parts of the biosphere, have become the sources of obtaining humic preparations. These are compost, peat, brown coal, and sapropel. In this connection, the term "humic substances" is associated with substances of natural origin. It is believed that the formation of humic substances or humification is one of the largest processes of organic matter transformation. Some of the dead remains are mineralized to CO_2 and H_2O, the rest turns into humic substances [1].

Humic acid is a long chain of molecules that, in complex combination with fulvic acid, form a bioavailable complex for the healing of a living organism. Its value is due to the presence of more than 70 different components of minerals, amino acids, vitamins, natural polysaccharides, sterols, hormones, fatty acids, plant pigments, natural antioxidants, etc. Such a concentration of biologically active substances determines the variety of positive effects of humic acids on living organisms [2].

Tests of preparations of humic acids revealed that they do not exhibit carcinogenic, allergenic and anaphylactogenic properties. Humic preparations are not teratogenic, that is, they do not disrupt embryonic development, and do not cause morphological anomalies and malformations in animals. These preparations are not embryotoxic - their use does not provoke intrauterine death, a decrease in the weight and size of the embryo. This allows one to classify them as harmless to animals and humans, which provides significant advantages over classical preparations. Due to this fact, it is possible to produce environmentally friendly natural feed additives on their basis, as well as veterinary preparations for poultry, farm animals, fish and pets.

Using radioisotope labeling, it was proved that animal products do not contain residues of humic acids, which means that they are not absorbed into the blood and lymph, but have therapeutic effect in the gastrointestinal tract and intestinal walls. The healing and prophylactic properties of humic acids are based on their ability to envelop the intestinal mucosa of animals and to reduce or completely prevent the absorption of toxic metabolic products after infection, as well as when feeding poor quality feed. Humic acids are simply mixed into the feed, they are tolerated and do not have any side effects on the animal organism.

In the treatment of intestinal diseases, there is a decrease in pathological impulses from the peripheral nerve endings of the intestine, as well as the restoration of normal peristalsis and tone. Under the influence of humic acids, intestinal immunity is restored in animals exposed to stress, and under a slight tanning effect, the intestinal mucosa thickens, its permeability and excessive secretion of tissue fluid into the intestinal lumen decrease. Thus, dehydration of the body is prevented [2].

Scientists have accumulated extensive material on the effect of preparations with humic acids on animals' immune status. Humic acidsstimulate the body's immune system to defend against foreign influences. Under the influence of humic acids, the phagocytic function of leukocytes is enhanced, the body's defenses are additionally stimulated, and this reduces mortality and improves the safety of young animals [3].

Humic acids supply micronutrients, enriching the immune system, which enables animals to resist disease effectively. In addition, they inhibit the growth of pathogenic bacteria and molds, reduce mycotoxin levels, and improve protein digestion and the absorption of calcium, trace elements and nutrients. The result is high fatness, as well as immunity to disease [4].

The antiviral action of humic acids is considered to be the most effective in the therapy of animals, since the immunomodulatory effect of the preparation plays an important role in recovery. R. Laub (2000) found out that polyphenolic compositions based on humic substances have antimutagenic and antiviral effects.

The high biological activity of preparations with humic acids is also manifested in relation to fungal diseases. In particular, they have a fungicidal effect on *Candida albicans* inhabiting the gastrointestinal tract of animals and humans.

The varied composition of organic acids in humic acid preparations helps to break down food particles in addition to the action of enzymes, thereby having a positive effect on digestibility and feed conversion. This leads to an increase in productivity and in livestock production [5].

A large body of researchshows the absolute safety of humic acids for animals, humans and the environment. Their positive therapeutic effect on almost all types of animals has been proven. The introduction of humic acids into the diet of animals and poultry leads to the activation of their vitality, rapid adaptation to changing environmental conditions, acceleration of feed fermentation due to the development of beneficial microflora of the gastrointestinal tract, and to growth-stimulating and immunomodulatory effects [6].

Back in 1991, T.D. Lotosh noted that preparations based on humic acids can be used in medicine and veterinary medicine as a nonspecific preparations that increases the body's resistance to various adverse factors. The first medical preparation based on humic acids registered in Russia was "Gumisol" - a 0.01% solution of humic acids in isotonic sodium chloride solution [7].

The strengthening of the immune system is evidenced by the fact that humates, forcing the immune system to recognize its own dead cells, thereby reduce the level of infection [4]. The reconstitution of the body's immunity is facilitated by the additional transfer of iodine from foods to the thyroid glands under the influence of huminates [8].

Humic acids in medicine, veterinary medicine, and animal husbandry are considered to be means of increasing the body's resistance to the action of various unfavorable factors. The adaptogenic effect of humates is manifested at the cellular level. In particular, there is a stabilization of the values of the mitotic index, a decrease in abnormal figures of mitosis, an increase in the DNA content to the control level [9]. In Poland, a natural immunomodulator is produced. It consists of many components, including humic acids, which has an interferonogenic effect and is an inducer of tumor necrosis factor [10].

Scientific research allows one to conclude about the antiviral activity of preparations based on humic substances. Humic acids prevent viral replication by acting on the viral protein and block the absorption of viral particles on the cell surface. It is believed that molecules of humic acids encasethe virus in a kind of shell, block its entry into the cell and prevent replication. The antiviral effect of humic acids is more pronounced than the antibacterial, since have immunomodulatory effect on the host organism. The antiviral properties of humic acids are manifested against influenza A and B viruses, Coxsackie A_9 virus, herpes, rhinoviruses, ARVI and even against human immunodeficiency virus [11–15].

3. Development of "green technology" for rearing and fattening of broiler chickens in a production environment

According to experts, the leading place in the development of the world economy in the 21stcentury will be occupied by ecological technologies, colloquially called "green technologies". According to the classification of the Organization for Economic Cooperation and Development (OECD), one of the main purposes of "green technologies"is to eliminate the use of harmful synthetic chemicals in agriculture, as well as to introduce new environmentally friendly technologies in agriculture, animal husbandry and agricultural processing.

One of the stages of environmentally friendly technologies for the production of livestock products is the improvement of livestock and an increase in the productivity of animals and poultry with the help of feed additives, which are natural complexes of biologically active substances with the properties of antioxidants, adsorbents and antibiotics. This trend has led to an increase in the research on the use of alkaline salts of natural humic acids in animal husbandry [16].

The so-called quinones, which have antibiotic properties, have been found in the biological complex of humic substances. Therefore, preparations of humicacids are considered to be a promising alternative to antibiotics and probiotics in stabilizing the intestinal microflora, which no less successfully neutralize pathogenic microflora, while suppressing inflammation and blocking the sites of adhesion of pathogenic pathogens in the intestinal mucosa. Humic acids bind pathogenic *E. coli* by an average of 94%, and endotoxins by 82%. Bacteria and toxins bound by humic acid are clearance naturally [3].

In comparison with antibiotics, the mechanism of humic acid therapy manifests rather slowly, within 24–72 hours. In this case, pathogenic microflora is excreted, stimulating the formation of antibodies, and increasing the resistance and defense systems of the animal.

Veterinary control over preparation residues in livestock products is of great importance in production of environmentally friendly antibiotic-free products. Research by K.V. Korsakov and S.V. Kozlova (2019) evidenced that the combined use of the antibiotic "Florfenicol" and the feed additive "Reasil®HumicHealth" based on humic acids in a dose of 1 g/kg of feed accelerates the elimination of the antibacterial preparationby 2 times after the cessation of antimicrobial therapy. Use of the "Reasil®HumicHealth" in a dose of1.5 and 2 g/kg of feed acceleratesits elimination by 4 times after the cessation of antimicrobial therapy. Thus, the preparation of humic acids "Reasil®HumicHealth" is able to bind the metabolites of florfenicol and accelerate the elimination of the antibacterial preparation by 2–4 times, depending on the dose of the additive [17].

The essence of the interaction of a living cell with humic acids is that intact molecules of humic acids and high-molecular residues of their intracellular digestion are localized in the cell walls or in the layer adjacent to the cytoplasmic membrane. A semblance of an active filter appears on the surface of a living cell, which binds heavy metal ions into stable chelate complexes, intercepts molecules of pesticides and other organic xenobiotics, and also binds free radicals formed in the plasma membrane as a result of lipid peroxidation.

With this interaction, the release of energy is noted, which, instead of being spent on compensating for the adverse effects of the external environment, is used by the cell itself for growth and reproduction, which ultimately leads to an increase in its competitiveness [1, 18].

Due to their chemical properties, humic acid preparations bind heavy metal cations, compete with conventional mineral adsorbents (activated carbon, clay) and have adsorptive properties. In this case, humic acids slip between the villi of the intestinal epithelium and create a protective film from the finest particles of humic acid, which protects the tissues of the epithelium and lymph glands.

The adsorptive effect of humic acids is enhanced by their ability to penetrate into the small intestine without changes and to show their ability in the place, where toxic substances are fixed, their absorption slows down and excretion with feces is accelerated.

The high abilities of the natural-organic complex of humic acids "Reasil® HumicHealth" to sorb and desorb 5 mycotoxins of mixed feed - aflatoxin B_1, ochratoxin, toxin T-2, zearalenone and fuminisin B_1 have been experimentally established. At the same time, the feed additive is effective both at the maximum permissible level of mycotoxins in the compound feed, and at the concentration of toxins exceeding 5 MPC [19].

The hepatoprotective ability of humic acids was observed in experiments on broilers using rapeseed meal containing an increased amount of secondary plant metabolites that could cause liver damage. The low AST level in the blood of chickens fed with humic acid indicates its hepatoprotective ability [20].

Use of liquid Reasil®HumicVet in feeding broiler chickens of the Cobb 500 cross at the age of 9 to 34 days and laying hens of the High-Line cross during the period of intensive egg laying in an amount of 0.06 ml per 1 kg of live weight contributed to an increase in productivity and the safety of poultry, an improvement in the morphological state of the liver and a decrease in AST and ALT indicators. This indicates the restoration of liver functions and helps to prevent fatty and toxic degeneration and hepatosis [21].

4. Slaughter and meat qualities of broiler chicken carcasses, depending on the concentration and method of administration of humic acid salts

The productivity of modern crosses of broiler chickens largely depends on the technology of poultry operation, including the use of biologically active additives in feeding, which can have both a positive and a negative effect on the digestion and absorption of nutrients in the diet, which accordingly affects the quantity and quality of meat products.

To characterize the slaughter qualities of broiler chickens, a control slaughter of poultry with an average live weight in a group and anatomical and morphological carving were carried out. A set of the following indicators was assessed: the weight of carcasses, the yield of semieviscerated carcass (without blood and feathers, the intestines with cloaca were removed, the filled goiter, oviduct in females) and carcasses of complete evisceration (all internal organs were removed, the head between the second and third cervical vertebrae, neck without skin at the level of the shoulder joints, legs at the tarsal joint).

Analysis of the results of slaughtering poultry at the age of 31 days (**Table 1**) showed that broilers of the 1st and 2nd experimental groups, who ate a dry feed additive based on unmodified microporous humic acids "Reasil®Humic Health", at a dose of 1 and 1.5 g per 1 kg of compound feed exceeded their counterparts from the control group in terms of the weight of semieviscerated (by 41.34 and 36.34 g) and eviscerated carcasses (by 51.66 and 61.0 g). The yield of carcasses in the groups was, respectively, 84.62 ... 83.98% and 71.17 ... 71.60% versus 81.47 and 67.33% in the control.

Indices of the 2nd experimental group, according to the analyzed parameters, retain its position until the end of rearing (practically at the same level with the control).

Currently, the topical issue is the organization of production of high-quality natural poultry meat and bone semi-finished products. To study the development of meat forms of carcasses of broiler chickens, eviscerated carcasses after maturation in a refrigerating chamber (0 ± 4 °C, 24 hours) were dismembered into following parts: breast - lophosteon with ribs and muscles adjacent on both sides; leg - thigh and lower leg with attached muscles; shin - the tibia with adjacent muscles; thigh - femur with attached muscles; wing - humerus, radius, and ulna with adjacent muscles; skeleton - dorsal-scapular and lumbosacral parts of the carcass. Then the muscle tissue, skin, and bones were anatomically separated. The yield of a part of a carcass was determined by the ratio of the mass of the corresponding part of a carcass to the mass of a carcass of complete evisceration (%). The yield of muscle tissue, skin and bone tissue was determined by the ratio of the mass of a part of the carcass to the mass of the unknown tissue (%). The research results are shown in **Tables 2** and **3**.

It was found out that feeding the studied preparation based on humic acids in the composition of the compound feed of the experimental poultry does not have a negative effect on the weight and yield of the carcass components. Thus, the yield of the breast part of carcasses in broilers of the experimental groups, according to the results of their slaughter at the age of 31 days, increases from 31.81% in the control to 34.06–35.91% in the groups with humates due to a slight decrease in the yield of other components - leg and skeleton.

When broiler chickens were slaughtered at 36 days of age, their carcasses were characterized by the same yield of the compared anatomical parts in all experimental groups. However, with the subsequent slaughter of poultry, on the 38th day of the fattening, the ratio of parts of carcasses during carving changed.

In poultry carcasses that ate 1 g of humates per 1 kg of feed (1st experimental group), the percentage of the breast, leg and wing was almost equal to the control, however, the yield of the dorsal-scapular and lumbosacral parts (skeleton) decreased by 2.06%.

In the 2nd experimental group of broilers (1.5 g of the preparation per 1 kg of feed), there was an increase in the yield from the carcass of legs by 1.27, 0.79 and 1.53% in comparison with carcasses from the control, 1st and 3rd experimental groups, respectively. Such changes are primarily due to a decrease in the development of the breast of the carcass (yield - 37.27%).

The highest yield of the breast (40.11%) and forelimbs torso - wing (13.46%) during slaughter and carving was in the 3rd experimental, where broilers were fed with 2 g of the preparation with humic acids per 1 kg of feed.

However, the best results of the influence of humic acids on the intensity of development of the breast part of carcasses were during prolonged poultry feeding, that is, at the final stage of the fattening (42 days). During this period

Index	Control	1st experimental group	2nd experimental group	3rd experimental group
At the age of 31 days				
Preslaughterlive weight	1412.00 ± 89	1408.33 ± 77.98	1413.00 ± 79.05	1262.33 ± 102.22
Weightofsemieviscerated carcass, g	1150.33 ± 67.06	1191.67 ± 58.72	1186.67 ± 91.03	1024.67 ± 87.56
%	81.47	84.62	83.98	81.17
Weightofeviscerated carcass, g	950.67 ± 52.83	1002.33 ± 61.68	1011.67 ± 96.04	885.67 ± 67.54
%	67.33	71.17	71.60	70.16
At the age of 36 days				
Preslaughterlive weight	1782.50 ± 67.50	1734.00 ± 76.00	1729.00 ± 35.00	1681.50 ± 63.50
Weightofsemieviscerated carcass, g	1502.50 ± 36.50	1469.00 ± 90.00	1448.00 ± 34.00	1407.00 ± 92.00
%	84.29	84.72	83.75	83.70
Weightofeviscerated carcass, g	1305.50 ± 44.50	1271.00 ± 57.00	1251.50 ± 15.50	1210.50 ± 70.50
%	73.24	73.30	72.38	71.99
At the age of 38 days				
Preslaughterlive weight	1981.50 ± 61.50	1844.00 ± 79.00	1806.50 ± 63.50	1967.00 ± 145.00
Weightofsemieviscerated carcass, g	1712.00 ± 80.00	1557.00 ± 51.00	1549.50 ± 51.50	1680.50 ± 132.50
%	86.42	84.44	85.80	85.43
Weightofeviscerated carcass, g	1442.00 ± 67.00	1300.50 ± 54.50	1307.50 ± 25.50	1435.00 ± 151.50
%	72.79	70.50	72.38	72.95

Index	Control	1st experimental group	2nd experimental group	3rd experimental group
At the age of 42 days				
Preslaughterlive weight	2402.00 ± 14.00	2197.00 ± 27.00	2139.0 ± 11.0	2511.0 ± 91.0
Weightofsemieviscerated carcass, g	2060.00 ± 14.0	1794.00 ± 39.0	1842.00 ± 6.00	2222.00 ± 10.0
%	85.76	81.66	86.12	88.49
Weightofeviscerated carcass, g	1774.00 ± 14.00	1530.00 ± 38.00	1577.00 ± 23.00	1910.50 ± 95.50
%	73.86	69.64	73.73	76.09

Table 1.
Slaughter qualities of experimental birds (n = 3).

Group	Weight of eviscerated carcass	Breast	Leg, including		Wing	Skeleton	Technical waste and process losses
			lower leg	thigh			
At the age of 31 days							
Control	920.0 ± 64.51	292.67 ± 35.07	125.33 ± 2.40	155.33 ± 2.91	100.67 ± 2.40	216.67 ± 13.68	29.33 ± 14.71
1st experimental	956.0 ± 40.84	343.33 ± 10.48	126.67 ± 9.68	141.33 ± 7.06	98.0 ± 7.57	201.33 ± 17.68	45.34 ± 4.16
2nd experimental	974.67 ± 86.35	332.0 ± 38.07	130.0 ± 10.58	150.67 ± 2.91	106.67 ± 6.57	226.0 ± 16.0	29.33 ± 14.71
3rd experimental	835.33 ± 66.03	284.67 ± 28.85	116.67 ± 8.74	118.0 ± 19.23	91.33 ± 5.70	194.67 ± 19.06	29.99 ± 10.26
At the age of 36 days							
Control	1305.5 ± 44.5	515.0 ± 5.0	171.0 ± 17.0	190.0 ± 6.0	131.0 ± 11.0	264.0 ± 4.0	34.50 ± 0.5
1st experimental	1271.0 ± 57.0	490.0 ± 56.0	164.0 ± 6.0	190.0 ± 0.0	135.0 ± 5.0	245.0 ± 15.0	47.0 ± 27.0
2nd experimental	1251.5 ± 15.5	476.0 ± 6.0	165.0 ± 9.0	187.0 ± 5.0	134.0 ± 6.0	256.0 ± 26.0	33.5 ± 15.5
3rd experimental	1210.5 ± 70.5	461.0 ± 27.0	167.0 ± 9.0	178.0 ± 8.0	125.0 ± 3.0	246.0 ± 28.0	33.0 ± 1.5
At the age of 38 days							
Control	1442.0 ± 67.0	569.0 ± 51.0	203.0 ± 3.0	259.0 ± 1.0	167.0 ± 15.0	233.0 ± 21.0	11.00 ± 7.0
1st experimental	1390.0 ± 42.0	542.0 ± 22.0	197.0 ± 1.0	255.0 ± 13.0	171.0 ± 5.0	196.0 ± 8.0	29.0 ± 12.0
2nd experimental	1414.0 ± 48.0	527.0 ± 1.0	207.0 ± 3.0	264.0 ± 4.0	173.5 ± 12.5	211.0 ± 4.0	31.5 ± 1.0
3rd experimental	1501.0 ± 115.0	602.0 ± 64.0	218.0 ± 12.0	259.0 ± 1.0	202.0 ± 36.0	206.0 ± 2.0	14.0 ± 2.0
At the age of 42 days							
Control	1798.0 ± 132.0	726.0 ± 108.0	230.0 ± 4.0	266.0 ± 22.0	188.0 ± 2.0	344.0 ± 2.0	44.0 ± 3.0
1st experimental	1545.0 ± 383.0	678.0 ± 182.0	177.0 ± 25.0	215.0 ± 51.0	159.0 ± 250	289.0 ± 83.0	27.0 ± 17.0
2nd experimental	1553.0 ± 23.0	705.0 ± 1.0	182.0 ± 10.0	217.0 ± 9.0	157.0 ± 5.0	283.0 ± 55.0	9.0 ± 7.0
3rd experimental	1919.0 ± 89.0	835.0 ± 45.0	252.0 ± 20.0	314.0 ± 6.0	237.0 ± 3.0	261.0 ± 23.0	20.0 ± 8.0

*Note: *P ≤ 0,95to the control.*

Table 2.
The ratio of parts of poultry carcasses of experimental groups, (n = 3).

Carcass part	Group			
	Control	1st experimental	2nd experimental	3rd experimental
Fattening period - 31 days				
Breast	31.81	35.91	34.06	34.08
Leg	30.51	28.03	28.80	28.09
Wing	10.94	10.25	10.94	10.93
Skeleton	23.55	21.06	23.19	23.30
Technical waste and process losses	3.19	4.75	3.01	3.60
Fattening period – 36 days				
Breast	39.46	38.55	38.05	38.08
Leg	27.65	27.85	28.13	28.50
Wing	10.03	10.62	10.71	10.33
Skeleton	20.22	19.28	20.46	20.32
Technical waste and process losses	2.64	3.70	2.65	2.77
Fattening period – 38 days				
Breast	39.46	38.99	37.27	40.11
Leg	32.04	32.52	33.31	31.78
Wing	11.58	12.30	12.27	13.46
Skeleton	16.16	14.10	14.92	13.72
Technical waste and process losses	0.76	2.09	2.23	0.93
Fattening period – 42 days				
Breast	40.38	43.88	45.40	43.51
Leg	27.59	25.37	25.69	29.49
Wing	10.46	10.29	10.11	12.35
Skeleton	19.13	18.71	18.22	13.60
Technical waste and process losses	2.46	1.75	0.58	1.05

Table 3.
Yield of carcass parts, %.

of the study the yield of the carcasses of specimen in the control was 40.38%, then in the carcasses of their analogs in the 1stexperimental group it was 43.88%, in the 2nd - 45.40%, in the 3rd group 43.51% or more, respectively, by 3.50; 5.02 and 3.13%.

The study of the morphological composition of carcasses of broiler chickens at the age of 31 and 42 days made it possible to establish the yield of various muscle groups: pectoral, femoral, as well as muscles of the lower leg and trunk, the ratio of edible (the mass of all muscles, skin with subcutaneous fat, liver, heart, muscular stomach, lungs, kidneys, internal fat) parts and inedible ones (head, legs, intestines with pancreas, bones, cuticle of the muscular stomach, glandular stomach, gallbladder, spleen, trachea, esophagus, goiter, thyroid and thymus glands, testes, ovary), the ratio of muscles to bones.

Index	Group			
	Control	1st experimental	2nd experimental	3rd experimental
At the age of 31 days				
Muscle yield to the eviscerated carcass mass, including	56.18	60.14	60.49	65.46
pectoral	28.05	31.25	30.66	26.31
femoral	10.11	11.64	12.04	16.61
muscles of the lower leg	7.06	7.76	8.30	8.92
muscles of the trunk	7.25	5.18	5.84	7.36
muscles of wings and neck	3.26	4.31	3.65	6.26
Ratioofediblepartstoinedible	1.09	1.40	1.36	1.32
Muscle-to-boneratio	2.08	1.99	2.05	1.92
At the age of 42 days				
Muscle yield to the eviscerated carcass mass, including	57.89	63.0	57.64	59.4
pectoral	29.88	40.30	30.79	31.47
femoral	11.88	7.94	9.54	11.08
muscles of the lower leg	8.50	6.94	7.12	7.07
muscles of the trunk	4.13	5.46	6.62	4.66
muscles of wings and neck	3.50	2.36	3.57	5.12
Ratioofediblepartstoinedible	1.47	1.93	1.67	1.88
Muscle-to-boneratio	1.75	2.24	1.97	2.08

Table 4.
Morphological composition of broiler chicken carcasses, %.

It was found out that the yield of muscle tissue in the carcasses of broilers of the experimental groups during slaughter on the 31st day of rearing had a significant difference, exceeding the value of the analogs of the control group by 3.96, 4.31 and 9.28%, respectively (**Table 4**).

The higher meat yield from the carcasses of broilers of the 1st and 2nd experimental groups is mainly due to the better growth of the pectoral muscles (31.25 ... 30.66%) and muscle tissue of the limbs (19.40 and 20.34%), in the 3rd group – of the femoral muscles (16.61%) and lower leg (8.92%), muscles of the wings and neck (6.26%). This was the result of the stimulating effect of the pretreated feed with the preparation with humates on the digestion processes and muscle tissue synthesis.

In the studied period of poultry slaughter the ratio of the mass of the carcass edible parts to the mass of inedible parts is 1.40; 1.36 and 1.32 respectively, which is higher than in the control group (1.09).

According to the results of poultry slaughter at the end of fattening, broilers in the experimental groups also exceeded the control ones, especially chickens that ate feed treated with a preparation with minimum humate content (1st experimental group). Their carcasses had high meat qualities - the ratio of edible parts to inedible ones was 1.93, muscles-to-bones ratio - 2.24, and the yield of pectoral muscles was 40.30%.

On the basis of experimental data, it can be stated that the inclusion of a dry feed additive based on unmodified microporous humic acids in the amount of 1 and 1.5 g per 1 kg of compound feed to the main diet of broiler chickens gives a more stable positive effect, both in terms of slaughter indicators (the yield of semi-eviscerated and eviscerated carcasses), and in the production of the most valuable natural semi-finished products (breast, legs) due to the intensive growth of muscle tissue.

5. Dynamics of morpho-biochemical and immunological parameters of blood and micromorphometric characteristics of the organs of the immune system of poultry using different concentrations of humic acid salts

The problem of natural resistance of poultry to diseases and unfavorable environmental factors has been studied by many researchers. Currently, interest in this issue is growing, which is explained by the need to know the features of the manifestation of the body's protective adaptations, that is, its resistance under different conditions of poultry rearing, feeding rations, etc. Nonspecific protective factors and adaptive capacity are in the body. It has a number of non-specific means of defense, neutralizing xenogeneic factors independently or in combination with each other [3, 22].

The purpose of the research was to study the dynamics of morpho-biochemical and immunological parameters of blood and micromorphometric characteristics of the organs of the immune system of poultry using different concentrations of humic acid salts. The functional and ontogenetic features of the first stage of poultry development were taken into account during the experiment.

According to the results of the studies, at 22 days of age, the morphological and biochemical parameters of blood in broiler chickens, both in the intact and experimental groups, were at the same level. So, the total protein level was 32 ± 0.4 g/l, the glucose level - 3.5 ± 0.05 mmol/l, the urea concentration was 3.7 ± 0.25 mmol/l, the hemoglobin level was 103 g/l, the number of leukocytes and erythrocytes - 26 × 109/l and 3.25 × 1012/l, respectively.

By the age of 35 days, a general increase in protein was observed in all study groups. The greatest increase was in birds of the 1st experimental group - 5 g/l. The glucose level increased in the intact group by 1.1 mmol/l, in the 1st experimental group by 1 mmol/l, in the 2nd - by 1.2 mmol/l, and in the 3rd group - by 1.1 mmol/l. The concentration of urea decreased and amounted to 1.2 mmol/l in the 1st and 3rd experimental groups, and 1.3 mmol/l in the control and 2nd experimental groups., In the 3rd experimental group the hemoglobin level decreased and amounted to 91 g/l, while in the intact group, this indicator was 87 g/l. The number of leukocytes was within the norm, and ranged from 21.2 × 109/l in the control group and up to 22.7 × 109/l in the 2nd experimental group. Compared with the 22nd day of the experiment, there was a decrease in the number of leukocytes. The number of erythrocytes decreased and amounted to 2.3 × 1012/l in chickens of the intact group, and in chickens of the 1st, 2nd and 3rd experimental groups it was 2.07, 2.07 and 2.32 × 1012/l, respectively.

By the age of 41 days, the highest total blood protein was in the 3rd experimental group (46 ± 0.4 g/l). The glucose level in all studied groups was the same and amounted to 5.5 ± 0.14 mmol/l. The concentration of urea, in comparison with 35th day, increased and amounted to: 1.4 ± 0.05 mmol/l in the control group, 1.3 ± 0.05 mmol/l in the 2nd experimental group, 1.1 ± 0.05 mmol/l and 1.03 ± 0.05 mmol/l in the 1st and 3rd experimental groups, respectively. The hemoglobin level increased by 10 g/l in chickens from the intact and 2nd experimental groups, by 18 g/l - in the 3rd experimental group.

The number of leukocytes in the blood of chickens of all studied groups increased. The greatest increase was in the experimental chickens of the 3rd group and amounted to 24.2 × 109/l. The smallest number of leukocytes was in the control group - 23.4 × 109/l. Compared to the 35th day of the experiment, the number of erythrocytes in control chickens increased by 0.05 × 1012/l and amounted to 2.35 × 1012/l, which was the smallest indicator of all studied groups. The largest number of erythrocytes, on 35th and 41st days of the experiment, was in the experimental chickens of the 3rd group - 3.15 × 1012/l.

Analysis of the research results showed that by the end of the experiment, the indicators of lysozyme and bactericidal activity of the blood serum of broiler chickens indicate a positive effect of different concentrations of humic acid salts on the indicators of nonspecific resistance of the poultry organism.

In chickens of the experimental groups, lysozyme activity of blood serum exceeded the analogs from the control by - 10.40, 12.09 and 12.28%, bactericidal activity of blood serum was higher than in the control group by 1.58, 1.76 and 1.79%, respectively.

When using the feed additive "Reasil®HumicHealth" based on humic acids at a dose of 1.5 and 2 g/kg of feed, indicators of lysozyme activity of blood serum of broiler chickens of the 2nd and 3rd experimental groups are statistically significant ($P < 0.05$) in relation to the control. Any statistically significant differences in the bactericidal activity of blood serum were not observed in all studied groups ($P < 0.05$).

An increase of hemoglobin by 12 g/l, erythrocytes - 0.8 × 1012/l, total protein - 4 g/l, leukocytes - 0.8 × 109/l, as well as lysozyme and bactericidal activity in all experimental groups indicates an increase in nonspecific resistance organism. The maximum dynamics was in the 3rd experimental group, where the additive was used at a dose of 2 g/kg of feed.

By the end of the experiment, the micromorphometric characteristics of the immune system organs of broiler chickens (by the age of 41 days) were characterized as follows. In the spleen of experimental poultry groups, in contrast to the intact, the average number and diameter of follicles exceeded by 11.94, 12.43, and 12.82%, respectively. The number and diameter of germ cents were higher by 30.18, 30.48, and 30.87%, respectively. In the factory bursa, in all experimental chickens, in contrast to the control group, the number and relative area of follicles were 28.6, 29.34, and 32.30% higher, respectively. The relative areas of the cortex and medulla of the follicles exceeded by 23.57, 27.16 and 30.32%, respectively. In the thymus of experimental chickens, in contrast to the intact ones, the relative area of the lobules of the cortical and medullary layers was greater by 18.46, 22.14 and 27.47%, respectively. The number of Hassal's bodies in experimental broiler chickens was 27.15% higher than in the control group.

6. Organoleptic characteristics and yield of culinary products from poultry meat

The taste qualities of the meat of the experimental poultry were evaluated by tasting, which allows one to reveal the influence of feed additives on it. The meat was subjected to mechanical (chopped semi-finished products) and heat treatment (cooking, frying. The smell (aroma), texture (hardness, tenderness), taste were determined. When developing culinary products, weight loss and the yield of the finished product were taken into account.

Analysis of the data shown in **Table 5** suggests that fattening broilers with feed based on humates increases the yield of culinary products from poultry meat after heat treatment.

For the periods of the study, the best results were in the production of chopped semi-finished products - chicken cutlets and croquettes, cooked by frying in the oven. This is probably due to the highest content in the poultry meat of the

Index	Group			
	Control	1st experimental	2nd experimental	3rd experimental
Fattening period - 31 days				
Boiled breast	55.41 ± 7.64	63.59 ± 6.84	52.50 ± 4.53	48.33 ± 4.64
Fried drumstick	54.63 ± 3.01	53.02 ± 7.81	50.79 ± 8.98	47.64 ± 11.55
Cutletfromminced mass	66.85 ± 3.25	74.81 ± 2.53	76.93 ± 1.04	78.29 ± 0.72
Ground-meatcroquette	94.86 ± 1.68	94.61 ± 0.47	95.65 ± 0.71	96.45 ± 0.45
Fattening period - 36 days				
Boiled breast	65.54 ± 1.24	66.01 ± 0.49	67.80 ± 11.5	64.95 ± 0.27
Fried drumstick	51.6 ± 2.26	54.59 ± 1.55	52.39 ± 0.16	52.23 ± 0.21
Cutletfromminced mass	63.75 ± 1.77	61.25 ± 1.77	60 ± 0.0	65 ± 0.0
Ground-meatcroquette	89.43 ± 1.49	93.08 ± 3.06	91.97 ± 1.49	88.01 ± 4.1
Fattening period - 38 days				
Boiled breast	69.28 ± 3.30	70.87 ± 1.46	69.63 ± 1.9	70.14 ± 2.88
Fried drumstick	56.08 ± 0.74	56.72 ± 0.14	66.27 ± 3.71	58.56 ± 0.09
Cutletfromminced mass	71.11 ± 1.57	79.47 ± 0.74	78.10 ± 2.69	86.95 ± 2.69
Ground-meatcroquette	92.13 ± 0.65	92.96 ± 0.52	94.94 ± 2.28	92.73 ± 0.19
Fattening period - 42 days				
Boiled breast	65.45 ± 1.23	71.11 ± 0.83	69.90 ± 1.8	66.61 ± 0.82
Fried drumstick	64.01 ± 0.40	69.98 ± 10.74	66.01 ± 2.02	63.21 ± 1.53
Cutletfromminced mass	64.86 ± 0.0	67.57 ± 3.83	67.57 ± 3.83	64.86 ± 0.0
Ground-meatcroquette	90.16 ± 0.23	90.31 ± 0.45	93.44 ± 0.16	90.48 ± 0.22

*Note: *P ≤ 0,90; **P ≤ 0,95 tothecontrol.*

Table 5.
Yield of finished products, %.

experimental groups of muscle tissue, which includes a protein capable of binding and retaining free moisture. However, it is necessary to take into account the fact that less weight loss when frying croquettes can be explained by the presence of fillers in the recipe, in particular bread, the starch of which partially binds the water released during the denaturation of meat proteins.

It should also be noted that the use of the studied feed additive in the amount of 1 and 1.5 g per kg of feed during 42 days of rearing and stockkeeping by the end of fattening contributes to the production of natural semi-finished products from carcasses - breast and drumstick. Their yieldaftercookingwas 71.11–69.90% and 69.98–66.01%, respectively.

During the tasting, there was a clear tendency: an increase in the concentration of humic acids in the broiler diet leads to a decrease in the taste of culinary products. It was found out that the maximum concentration of humates (2 g per 1 kg of feed) provoked the formation of an unpleasant metallic taste in products after heat treatment. However, the use of the additive at the rate of 1 and 1.5 g per 1 kg of feed does not have a negative effect on the sensory parameters of finished culinary products. They are similar in taste, color and texture to products of poultry fed with the basic diet.

7. Conclusion

Thus, based on the results of the studies, it has been established that the introduction of a liquid water-soluble feed additive of complex action "Reasil®HumicHealth" (produced on the basis of a concentrated solution of high-molecular sodium salts of humic acids from Leonardite) into poultry feed contributes to the development of sustainable safe processes of meat production of broiler chickens and finished products from it, forming the specified characteristics aimed at production of safe and high-qualified food products.

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