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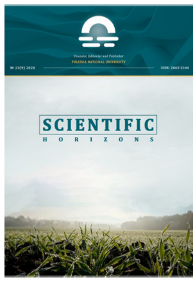

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Immune Status of Turkeys in Industrial Cultivation Conditions

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Abstract. The intensification of turkey farming is accompanied by the impact of various dangerous factors on the poultry's body. This leads to a violation of metabolic processes, an imbalance in the absorption of nutrients, and immunity decrease in turkeys, which determines the relevance of the study in this area. In this regard, figuring out when immunity reduces and, in the future, increasing its effectiveness in the body of turkeys, improving metabolic processes, growth, and development of poultry determined the purpose of this study. It was found that during the first six weeks of intensive cultivation of turkeys, the body's immune response, the activity of non-specific resistance factors on the influence of biological factors and the intensification of poultry feeding processes were effective. However, from 42 days of poultry rearing, depletion of the immune defence of the turkey body and a decrease in the activity of non-specific resistance factors were observed, which is manifested by a likely decrease in the content of total protein, albumins, and class G and M immunoglobulins in the blood of poultry ($P<0.01$). Analysis of the protein spectrum of turkey blood serum indicates an immunosuppressive state of the body, probably caused by the action of biological factors. By 42 days, the bactericidal and lysozyme activity of blood serum, phagocytic activity of neutrophils, and T-cell activity of lymphocytes decrease in turkeys. Non-specific changes in the components of the functional element of the liver were detected, which are accompanied by an increase in the number of lipid inclusions of various sizes, destructive changes in mitochondria, and a decrease in the synthetic activity of cells. Studies of the immune state of the body of turkeys, the activity of factors of non-specific resistance and liver in the cycle of intensive cultivation from 7 to 120 days revealed the presence of a critical period of decrease in the effectiveness of the body's protection and further adequate correction. The results obtained during this study will be used for educational purposes, implemented in growing turkeys in the production conditions of "Indychka" LLC (Sumy Oblast). They are offered to all farms in Ukraine to produce turkey farming products

Keywords: T-lymphocytes, immunoglobulins, albumins, poultry liver

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INTRODUCTION

Turkey farming is one of the most efficient branches of the agro-industrial complex. Presently, in Ukraine, poultry meat production meets 40% of the population's needs for this product (Karpenko, 2016). The development of poultry farming is determined by a single vector – the progress of technological processes. The new strategy is to keep poultry physiologically, provide nutritious feed that positively affects productivity and reduces the cost of poultry production (Petrenko, 2015). This determines the purpose and relevance of the study on this issue.

Authors (Nagaraja *et al.*, 2006; Zamazii *et al.*, 2017) found that the body of animals and turkeys is adversely affected by stress. They indicate that under conditions of non-prolonged stress, the immune system is activated, and more antibodies are synthesised. The proliferation of immune system cells is stimulated. Under conditions of severe stress, the functions of the immune system are suppressed (Zamazii *et al.*, 2017). It was found that regulatory molecules interact with the receptors of immune cells – lymphocytes, monocytes, macrophages, and neutrophils. Stress occurs due to the activated release of adrenaline and norepinephrine into the blood. Their content correlates with the number of B-lymphocytes and T-lymphocytes, as the researchers point out (Kotlyarova *et al.*, 2019; Davison *et al.*, 2008). Adaptive responses to adverse factors are aimed at preserving the body's haemostasis.

Complete feeding is of great importance in the intensification of production of turkey farming products (Ridla *et al.*, 2019; Leeson, 2022). However, the use of high-energy feeds violates the compliance of the needs of the body and the conditions for providing them with energy, violates the conditions of physiological and morphological adaptation of the digestive system to the effective use of feed and requires normalisation of metabolic processes in the poultry's body. Authors (Rychen *et al.*, 2017) suggest correcting the microbiocenosis of the gastrointestinal tract in young turkeys during the immune system development.

Recently, a decrease has been observed in the immune response of poultry to the action of abiotic factors in the conditions of production. The occurrence of acquired (secondary) immunodeficiency is accompanied by a violation of the immunological status of the body, reproductive abilities (Ryabinina *et al.*, 2019).

Minimising the use of biological factors (Khodorovich, 2022) is a topical issue today. It requires determining the immune state of the poultry's body. This is important when using immunocorrectors and preparations. They should not adversely affect the physiological activity of poultry in the conditions of industrial rearing of turkeys.

White blood cells play a special role in protecting the body (Uchida, 2019). They selectively accumulate in tissues affected by adverse factors and provide protective immune responses. The number of killer cells changes under the influence of glucocorticoids. It is proved that the membranes of all immunocytes have receptors for glucocorticoids and catecholamines. Killer cells have high-density adrenoreceptors. Limited-density adrenoreceptors were found on T-lymphocytes. During the development of stress, immunocytes are subject to mobilisation into the bloodstream. They migrate through various body organs. Immunocytes are known to activate or inhibit cytokine synthesis and secretion (Kadmiel & Cidlowski, 2013).

The body of poultry of new crosses (Agunos *et al.*, 2012) has a genetically determined growth rate. Such a poultry is extremely sensitive to minor fluctuations in feeding conditions and to the influence of biological factors. Violation of keeping technology, unbalanced feeding, are the main aetiological factors of immunodeficiency in the body of turkeys. A decrease in the body's natural resistance and reactivity are signs of secondary immune deficits. The bird does not develop intense post-vaccination immunity. Susceptibility to abiotic factors is the main manifestation of severe immunodeficiency (Dougal, 2019).

To increase the safety and productivity of poultry, it is important to identify the period of reduced immunity in turkeys and conduct adequate correction.

Specialists of powerful poultry breeding complexes are developing fundamentally new preventive techniques (Jankowski *et al.*, 2011). They are aimed at increasing the immunity of poultry and their productivity by using environmentally friendly preparations. Reduced effectiveness of the body's immune system (Elmore, 2012) and liver health (Carson & Kunkel, 2017) occupy a considerable part of the processes in the structure of poultry morbidity (Karin *et al.*, 2020). The degree of decrease in the activity of the body's defence mechanisms correlates with dysproteinaemia. When figuring out the state of non-specific reactivity, special attention is paid to the blood protein spectrum. It is important to control the concentration of the γ-globulin fraction, which is the main carrier of antibodies in poultry (Anderson & Transey, 2012).

According to the author (Koncicki *et al.*, 2015) the poultry's immune system begins to function as soon as it hatches from the egg. Non-specific innate immunity is developed quite slowly and is crucial. It is the first to defend the body against foreign agents, being provided by embryonic cells with phagocytic activity. The body is protected by avidin, lysozyme, and immunoglobulins contained in the egg, as well as complement and interferon. Complement lyses cells. Interferon is described by antiviral activity, exhibits the properties of an immunomodulator.

Lymphocytes are involved in the immune response of the poultry's body. They differ in immunological functions. If lymphocytes enter the thymus (Meintlein & Kendall, 2000), they form T-lymphocytes. As they mature, they leave this organ and settle in the lymphoid tissues.

One of the key indicators of immunological restructuring of the body, the intensity of which is a criterion of resistance to bacterial infections, is the phagocytic activity of leukocytes. Pseudoeosinophils protect the body from the effects of abiotic factors in poultry. They have phagocytic activity and bactericidal action. In solving theoretical and practical issues, the estimation of factors of natural resistance of the body (Davison & Karel, 2008), namely the bactericidal activity of blood serum (BABS) and lysozyme activity of blood serum (LABS), occupies a prominent place. According to their data, immunisation adversely affects non-specific humoral immunity.

MATERIALS AND METHODS

The experimental part of this study was performed during 2018 based on the "Indychka" Limited Liability Company (Sumy Oblast).

At the Department of Anatomy, Normal and Pathological Physiology of the Sumy National Agrarian University, blood and liver samples were prepared for research in the conditions of the departments of the Faculty of Veterinary Medicine of the Sumy National Agrarian University. Indicators of the immune state of turkeys were investigated in the research and production laboratory "Hranum", Kharkiv. Liver samples were histologically examined at the S.Z. Gzhytskyi Lviv National University of Veterinary Medicine and Biotechnology, at the Department of Normal and Pathological Morphology and Forensic Veterinary Medicine.

To figure out the manifestation of the critical period of influence of industrial production factors and the effect of biological factors on immunity and liver condition, a group of turkeys was selected in the amount of 250 heads on the 7th day after birth. From 7 to 120 days of life of turkeys, with an interval of 14 days, blood samples were taken from 25 turkeys.

In blood samples, indicators of the body's immune state were found according to the generally accepted methods. Total protein – according to the Reis method. Protein fractional composition – according to the electrophoresis method on cellulose acetate. Microzone electrophoresis Scan Power 300 and Scanion Lira 400, Hospitex Diagnostics, were used. Phagocytic activity of pseudoeosinophils – according to V.Yu. Chumachenko's method.

The content of T-lymphocytes, B-lymphocytes, and NK cells in EDTA-stabilised blood was investigated using monoclonal antibodies and the immunofluorescence method. Class G and M immunoglobulins were detected using in vitro test systems according to the ELISA method and using a Thermo Scientific Multiskan FC photometer.

The organs of the immune system – the cloacal sac, thymus, and liver of turkeys – were histologically examined. A 10% neutral formalin solution was used to fix the organ pieces. Dehydration was provided in an ascending series of alcohols. Tissue compaction was performed in chloroform and chloroform paraffin. Filling was carried out in paraffin blocks.

Histosections were made on a sledge microtome MC-2, 5-7 μm thick and stained with haematoxylin and eosin. For histochemical detection of RNA and DNA, histosections were stained with methyl green pyronin (Brache). Preparations were photoregistered using light microscopy. For this purpose, a Leica DM-2500 microscope (Switzerland) was used. For ultra-thin sections, liver fragments were selected and fixed in a Millonig retainer, pH 7.36. The preparations were retained for 2 hours. The process took place in a thermos at the melting temperature of ice. Subsequently, the preparations were washed in chilled Millonig's phosphate buffer. The samples were dehydrated in high-strength ethanol for 10 minutes. The samples were incubated in 3 servings of absolute ethanol for 10 minutes. Subsequently, semi-thin sections with a thickness of 1 μm were made. The process was performed on an LKB-2188 ultramicrotome (Sweden).

Sections were stained with methylene blue and basic fuchsin. For electron microscopy studies, ultra-thin sections with a thickness of 90 nm were passed through water. The sections were dried for 2 hours at t=60°C. Contrast was performed with Reynolds' uranyl acetate and lead citrate. The sections were washed and then dried. The samples were examined in a Tesla-BS 500 electron microscope at an accelerating voltage of 60 kW. Photoregistration was performed on PT-41P films. The resulting negatives were digitized. For this, a photo scanner and Epson Perfection V 500 software were used. Ethical principles were observed during experiments on poultry. The obtained material is processed statistically, with the determination of probability according to the student's t-test.

RESULTS AND DISCUSSION

The production of turkey farming products in conditions of intensive cultivation is accompanied by the impact of adverse factors on the poultry's body. In turn, this requires figuring out the time of decrease in the immune state of the poultry's body under the conditions of using various rearing schemes and carrying out timely, adequate correction.

Analysis of the protein spectrum (Table 1) in the blood serum of turkeys from 7 to 28 days of life allowed establishing that the total protein content was within 29.05±0.87–30.23±0.77 g/l, which corresponds to the physiological norm for poultry of this age. On the 42nd day after the birth of turkeys, in conditions of intensive production and exposure to abiotic factors, a decrease in the total protein content was observed by 23.02% ($p<0.05$). On the 56th day, its level was only 25.37±0.59 g/l, and on the 70th day – 25.02±1.12 g/l, which is 12.68% and 13.87% lower than in turkeys of 28 days of age, respectively.

***Table 1**. Indicators of protein fractions of turkey blood (n=25, M±m)*

Days	Total protein, g/l	Albumin, %	γ-globulin, %	β-globulin, %	α-globulin, %
7	30.23±0.77	52.43±0.73	29.63±0.71	8.24±0.41	9.66±0.37
14	29.18±0.32	52.25±0.59	26.36±0.56	8.25±0.37	13.14±0.94
28	29.05±0.87	52.77±0.63	29.44±0.64	8.47±0.93	9.32±1.03
42	22.36±0.74***	40.13±0.93***	34.06±0.62***	9.03±0.57**	16.78±1.12***
56	25.37±0.59**	46.24±1.09**	34.65±1.05***	8.06±0.66	11.0±1.07*
70	25.02±1.12**	52.22±1.21	32.92±1.02**	7.52±0.34	7.34±0.96
84	35.35±1.01	49.33±0.56	30.72±0.84	7.07±0.43	12.88±0.92
100	40.27±0.77	52.96±1.07	27.97±1.03	6.33±0.43	12.74±0.72
120	39.53±1.07	53.05±1.03	28.62±0.76	6.01±0.39	12.32±0.73

***Note:** the degree of probability for indicators on the 28th day: *p<0.05; **p<0.01; *** p<0.001*
***Source:** compiled by the authors*

However, in turkeys aged 84-120 days, a tendency was found for the total protein content to increase in the blood serum of poultry, which positively correlates with body weight indicators. In older turkeys, as the results of research prove, the body adapts to the conditions of industrial production and a gradual increase in the indicator under study to the physiological norms for poultry of the corresponding age.

When analysing the blood serum of turkeys according to the protein spectrum, in certain periods of the poultry's life, an immunosuppressive state was noted, probably caused by the influence of biological factors, especially in the period after vaccination. The content of the γ-globulin fraction in the blood of turkeys on the 42nd and 56th days of the study was 34.06±0.62% and 34.65±1.08%, respectively, which indicates a prominent activity of the protective and adaptive capabilities of the poultry's body after exposure to abiotic stimuli. Turkeys aged 70 days showed a decrease in the γ-globulin fraction. However, during the study period (from 7 to 120 days of life of turkeys), the γ-globulin fraction stayed at an elevated level.

In sections of the liver of 28-day-old turkeys, hepatocyte nuclei, homogeneous cytoplasm, and intra-sinusoidal capillaries were clearly visible, in the lumen of which single red blood cells were located (Fig. 1). At the same time, in the liver of turkeys on the 50th day of life, a decrease in the content of RNA and the activity of reductases was noted. Glycogen was detected between fatty inclusions in the cytoplasm of hepatocytes (Fig. 2).

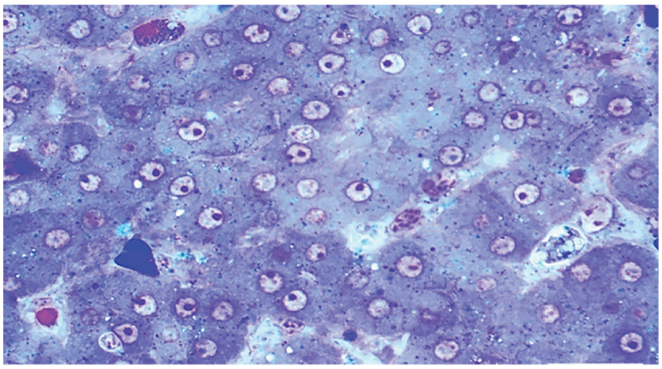

***Figure 1**. Turkey liver, 28 days*
***Note:** hepatocytes with uniformly coloured cytoplasm and centrally placed round nuclei. Semi-thin cut. Methylene blue. 10 oc x 100 ob*
***Source:** photographed by the author V.M. Petrenko*

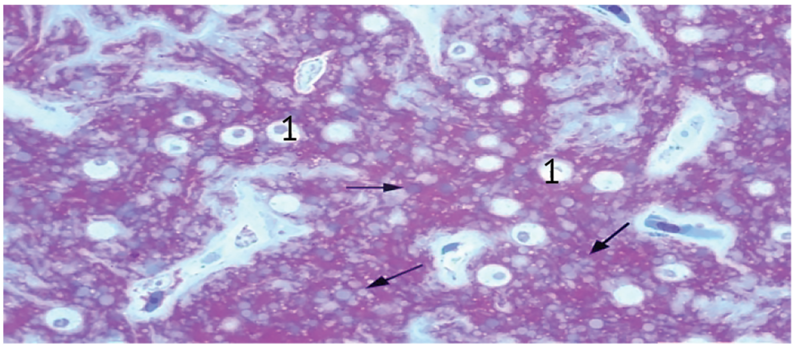

***Figure 2**. key liver, 50th day*
***Note:** semi-thin section. Methylene blue with additional staining – periodic acid-Schiff reaction. Lipid inclusions are blue (shown by the arrow), hepatocyte nuclei (1), and glycogen (pink). 10 oc x 100 ob*
***Source:** photographed by the author V.M. Petrenko*

According to electron microscopic examination of the liver of turkeys on the 42nd day of life, the cytoplasm of hepatocytes contains a large number of mitochondria, an extensive network of channels of the granular and agranular endoplasmic reticulum, single lipoprotein granules of medium electron density. The mitochondria and channels of the endoplasmic reticulum are surrounded by fine-grained hyaloplasm, which contains granules of α-glycogen. Mitochondria are described by the presence of outer and inner membranes. They form an insignificant number of crysts surrounded by the mitochondrial matrix.

Immunosuppressive effect on the 42nd day of life in turkeys was not manifested. At that time, the content of the γ-globulin fraction remained at the level of 28th day, and the content of albumins in the blood serum of poultry decreased. The level of α-globulins fluctuated during the life of turkeys under intensive rearing conditions. From the 42nd day, an increase in the content of α-globulin was found by 7.41% and on the 56th day – by 1.72%. The analysis of these indicators suggests that it is during these periods of the life of turkeys that, against the background of stress factors and various biological factors, considerable changes occur in the immune system. Changes in the level of β-globulins were insignificant, and only on the 42nd day of life of turkeys, its increase was noted, respectively, by 6.61%. From 56 to 120 days of the poultry's life, its level tended to decrease.

There was a slight fluctuation in the level of β-globulins, α-globulins, an increase in the γ-globulin fraction of proteins in the blood in the period after vaccination. During intensive cultivation of turkeys, it was found that in the period from 28 to 42 days, the indicators of the immune defence of the poultry's body were at a prominent level due to biological stimuli. On the 56th day, and especially in turkeys aged 70 days, the content of Immunoglobulin G decreased by 2.03 and 3.21 times ($p<0.001$), respectively.

The content of immunoglobulin M decreased during this period by 2.70 and 4.48 times ($p<0.001$), respectively. The tendency for the content of Ig G and Ig M immunoglobulins to decrease in the blood serum of turkeys persisted for up to 120 days. The detected increase in the level of Ig A in the period from 28 to 42 days can be associated with the activation of secretory immunoglobulin synthesis. It is synthesised in the mucous membranes and enters the blood through epithelial cells, where it is included in the Ig A monomer molecule and takes part in the formation of immunity, especially under oral and aerosol exposure to biological factors.

The results of studies show (Table 2) that the BABS of turkeys from 7 to 28 days was at 72.92±2.76% and 89.74±3.70%, respectively. On the 42nd day, a decrease in its activity was found by 1.17 times ($p<0.05$) compared to the indicator of turkeys aged 28 days. In turkeys aged 70 days, BABS activity was at 72.30±5.0% and indicated a decrease in non-specific resistance and suppression of the immune reactivity of the poultry's body.

***Table 2**. Indicators of non-specific resistance of the body of turkeys (n=25, M±m)*

Poultry age, day	Indicators		
	BABS, %	LABS, %	NPA, %
7	72.92±2.76	54.24±2.22	23.72±1.24
14	84.34±3.56	59.36±4.34	27.26±1.36
28	89.74±3.70	59.72±2.66	27.93±0.91
42	76.96±2.62*	46.84±2.12**	21.12±1.60**

Table 2, Continued

Poultry age, day	Indicators		
	BABS, %	LABS, %	NPA, %
70	72.30±3.85***	51.14±3.32*	20.48±1.32**
84	72.12±4.22	49.16±3.34	20.77±0.81
100	70.96±2.94	45.28±2.26	19.36±1.32
120	68.14±4.32	41.4±1.90	19.14±0.92

Note: *the degree of reliability for indicators on the 28th day: *p<0.05; **p<0.01; ***p<0.001*
Source: *compiled by the authors*

The lysozyme activity of turkey blood serum repeats the dynamics of its bactericidal activity. Thus, analysing the LABS of turkeys from day 7 to day 28, it was noted that lysozyme activity ranged from 54.24±2.22% on the 7th day and amounted to 59.72±2.66% on the 28th day. In the period from 28 to 42 days of life of turkeys, a decrease in LABS was found by 12.90%, on the 56th day – by 14.00%, and on the 70th day – by 8.60%. From day 84 to day 120, the LABS activity of turkey was stable, from 49.16±3.34% to 41.44±1.90%. On the 42nd day of commercial rearing of turkeys, a significant decrease in the phagocytic activity of pseudoeosinophils was observed by 24.38%, on the 56th day – by 29.32% (p<0.001) and on the 70th day – by 28.68% (p<0.001) compared to this indicator on the 28th day.

Thus, with intensive rearing of turkeys and the action of abiotic factors, a decrease in BABS, LABS, and neutrophil phagocytic activity (NPA) was established from the 42nd to the 70th day of poultry life. From the 42nd to the 70th day, a decrease in the concentration of class G, M and A immunoglobulins in the blood of turkeys was observed. Assessment of the level of T- and B-lymphocytes in the blood of turkeys at 120 days of age indicates instability and changes in the cellular defence system. The level of T-lymphocytes in the blood of turkeys from 7-14 days ranged from 6.92±0.43 g/l to 8.12±0.21 g/l. This may be due to the immune response and the appearance of antibodies after exposure to biological factors. Then, both on the 28th and 42nd days of life of turkeys, a secondary immune response was noted, due to the strengthening of both cellular and humoral immunity. The secondary immune response in turkeys develops rapidly and is accompanied by a sharp increase in the content of Ig G and intensive proliferation of B-lymphocytes, which is especially clearly noted in the period from 28 to 42 days of poultry life (Table 3). The level of B-lymphocytes on the 56th day of life of turkeys significantly decreases by 37.93% (p<0.001) against the background of this indicator of turkeys on the 28th day and indicates secondary immunological insufficiency, which leads to partial loss of immunity.

***Table 3**. Factors of specific immunity of the blood of turkeys during intensive cultivation (M±m, n=25)*

Poultry age, day	Indicators, g/l	
	T-lymphocytes	B-lymphocytes
7	6.92±0.43	2.37±0.05
14	8.12±0.21	3.72±0.08
28	9.07±0.02	5.75±0.05
42	8.21±0.17*	5.88±0.08
56	6.39±0.26**	3.65±0.05***
70	6.34±0.81**	3.42±0.06***
84	5.92±0.54	3.40±0.11
100	4.27±0.34	3.33±0.12
120	3.22±0.31	3.28±0.08

Note: *the degree of reliability for indicators on the 28th day: *p<0.05; **p<0.01; ***p<0.001*
Source: *compiled by the authors*

In experimental turkeys from the 7th to the 42nd days of life, the level of T- and B-lymphocytes was at a fairly elevated level, providing an active immune response, while from the 56th day, under the influence of abiotic factors, a significant decrease in the level of all lymphocytes and the development of secondary immunological insufficiency were found.

Thus, turkey farming is an ideal branch of poultry farming. The technological process is described by well-established feeding mechanisms and veterinary measures in the scheme of growing turkey meat crosses. Complex vaccination schemes, the use of high-energy feeds and biological preparations lead to functional overload of the body, a decrease in natural resistance due to the development of stress. The effect of abiotic factors in poultry farming is one of the key points affecting the productivity of turkeys, since it is directly related to the metabolic processes in the poultry's body, its detoxification properties (Petrenko, 2015). The indicators of the protein fractions of blood serum indicate that under intensive cultivation and the action of abiotic factors on the body of turkeys, hypoproteinaemia is observed, caused by a decrease in the content of albumin in the blood from the 42nd to the 70th day of the poultry's life. Due to the influence of abiotic factors, the protein content in the blood decreases. A similar dynamics of protein fractions in poultry blood under the influence of abiotic factors was observed by another researcher (Davison & Karel, 2008). Hypoproteinaemia is probably a consequence of inhibition of plasma protein synthesis in the liver. The reason may be a decrease in the absorption of amino acids into the blood (Boyko *et al.*, 2015). (Romanovych *et al.*, 2019) and (Wynn, 2009) believe that the reason for the decrease in the protein content in the blood may be the fact that there is a violation of the absorption of amino acids. The emergence of "protein loss syndrome" in the intestine is the cause of hypoproteinaemia. Furthermore, protein deficiency increases due to reduced absorption of fats and carbohydrates. To prevent violations of the use of amino acids in the gastrointestinal tract, it is proposed to use probiotics.

Protein metabolism (Stepchenko, 2004) is defined by the influence of many exo- and endogenous factors. Deviations in the physiological state of the body are reflected in protein metabolism. The introduction of humic preparations into the diet of chicken broilers was accompanied by a decrease in the content of albumins in the blood. At the end of the experiment (85 days), their content remained 10% less in experimental chickens. They attribute this to the intensification of the breakdown of albumins or their transformation into globulins.

The concentration of total protein, class G immunoglobulins, and alkaline phosphatase activity in the blood of 10-, 20-, and 30-day-old turkeys was significantly (1.31, 1.36, 1.34 times; 1.28, 1.31, 1, 24 times, and 1.5, 2.15, 1.47 times, respectively) lower compared to the control under the effects of a thermal stimulus (Kambur *et al.*, 2009). Under the influence of Hydrohumate, the concentration of immunoglobulin G (Kovalenko & Stepchenko, 2008), which handles antitoxic, antibacterial, and antiviral antigenic activity, decreased in 10-day-old broiler chickens to 6.24±0.36 mg/ml against 7.04±0. 60 mg/ml in control. The concentration of immunoglobulin G (Kovalenko & Stepchenko, 2008), which is responsible for antitoxic, antibacterial and antiviral antigenic activity, in 10-day-old broiler chickens under the influence of Hydrohumate decreased to 6.24±0.36 mg/ml against 7.04±0.60 mg/ml in control.

Under conditions of exposure to stress on chickens (Baidevlyatov & Baidevlyatov, 2017), a 5.9% decrease in the level of total protein in the blood of the experimental group's poultry was found, and γ-globulin – by 18%. The researcher (Khodorovych, 2022) proves that the adverse impact of immunisation is less pronounced if vaccination is performed in ovo. Under the conditions of vaccination of poultry, it is suggested to use a high-purity solution of sodium hypochlorite. Its use prevents the destruction of follicles of lymphoid formations, causes lymphoreticular hyperplasia, and ensures expansion of the area of lymphoid nodules (Stoyanovsky *et al.*, 2010).

The influence of biological factors, the intensification of feeding processes (Havilei & Pankova, 2022) and the maintenance of turkeys adversely affects not only the immune system of poultry, but also liver cells, slowing down the synthesis of serum albumin (Kambur *et al.*, 2018). In sections of the liver of 28-day-old turkeys, hepatocyte nuclei and homogeneous cytoplasm, and intra-sinusoidal capillaries were clearly visible, in the lumen of which single red blood cells were located. At the same time, in the liver of turkeys on the 50th day of life, a decrease in the content of RNA and the activity of reductases was noted. Glycogen was detected between fatty inclusions in the cytoplasm of hepatocytes.

Intensification of growth and development of broiler chickens with biologically active substances (Kush & Musienko, 2008) from 25 to 30 days of rearing was manifested by a morphological reaction of liver protective structures. Delayed development of the liver lymphoid complex was detected. It was manifested by a decrease in the number of lymphoid formations, plasmocytes.

There was a slight fluctuation in the level of β-globulins, α-globulins, an increase in the γ-globulin fraction of proteins in the blood of turkeys in the period after vaccination. During intensive cultivation of turkeys, it was found that in the period from 28 to 42 days, the indicators of the immune defence of the poultry's body were at a prominent level due to biological stimuli. On the 56th day, and especially in turkeys aged 70 days, the content of Immunoglobulin G decreased by 2.03 and 3.21 times ($p<0.001$), respectively. Researchers (Stepchenko, 2004), (Kambur *et al.*, 2018) point out that immunisation causes a decrease in the body's immune defence. Under the intensive cultivation of turkeys and the influence of abiotic factors, a decrease in BABS, LABS and neutrophil phagocytic activity was established in the period from the 42nd to the 70th days of the poultry's life. A decrease in BABS, LABS, and fibronectin was observed

(Kovalenko & Stepchenko, 2008) in chickens from 10 to 39 days of rearing. Under the influence of Hydrohumate, the concentration of fibronectin decreased from 207.43±4.12 μg/ml to 201.89±4.75 μg/ml, and then increased and amounted to 222.8±3 μg/ml in the plasma of 39-day-old broiler chickens.

In experimental turkeys from the 7th to the 42nd days of life, the level of T- and B-lymphocytes was at a fairly elevated level, providing an active immune response, while from the 56th day, under the influence of abiotic factors, a significant decrease in the level of all lymphocytes and the development of secondary immunological insufficiency were found.

The formation of the immunophysiological status of the organism of quails of the Pharaoh breed in production conditions occurs through critical periods of postnatal ontogenesis (Stoyanovskyi *et al.*, 2016). Low activity of humoral and cellular factors of non-specific resistance of the quail organism was detected at 85 days of age, while at 20 days of age, the values of BABS and LABS reliably increased by 13.6%, and the values of the phagocytic index and phagocytic activity increased by only 20.3% at the age of 75 days. A critically low level of immunoreactivity is observed up to 75 days of age, as evidenced by a decrease in T-helpers at this stage of ontogenesis by 30.8-33.7%. At the age o 90 days, the number of T-active lymphocytes increases by 16.3-26.7%, the number of T-suppressors decreases by 39.9-55.7%. The number of B-lymphocytes with high receptor capacity increased by 41.6-51.7%, and the immunoregulatory index increased by 1.8-2.2 times compared to the 5-day age of quails. The action of industrial stress at various stages of development is accompanied by suppression of the humoral and cellular link of non-specific resistance of the poultry organism, which is evidenced by a decrease in BABS indicators by 23.6%, LABS – by 20.0%, phagocytic activity – by 14.1%, phagocytic index – by 21.4%. It was noted that under the complex influence of technological stress factors on the 20th day of life (stage of resistance), the blood system of quails reacted with a decrease in the numerical values of the formed elements, with an increase in the number of leukocytes against the background of a low lymphocyte content. With repeated exposure to a stressful stimulus, the haematopoietic function of blood in quails aged 41 to 75 days had a similar dynamic. Adaptive changes in the glands under the influence of a complex of technological stress factors were found. A decrease in the secretory activity of the adrenal glands and liver is observed in 41-75-day-old quails after repeated exposure to the stimulus (Stoyanovskyi *et al.*, 2016).

CONCLUSIONS

1. In the conditions of industrial production, on the 42nd day of keeping turkeys, the body's defence mechanisms decrease under the influence of biological factors.

2. On the 42nd day, the total protein content in the blood serum of turkeys decreases by 23.02% ($p<0.01$) compared to the indicator on the 28th day, and on the 56th day it is 12.68% lower, which is probably a consequence of inhibition of plasma protein synthesis in the liver.

3. On thin liver sections of the 28-day-old turkeys, hepatocyte nuclei, their homogeneous cytoplasm and intrasinusoidal capillaries with single red blood cells are clearly visible, and on the 50th day, NPA content and reductase activity are reduced, glycogen is detected between fatty inclusions in the cytoplasm of hepatocytes.

4. The BABS of turkeys aged from 7 to 28 days was at 72.92±2.76% and 89.74±3.70%, respectively, and on the 42nd day there was a decrease in its activity by 1.16 times ($p<0.05$) in comparison with turkeys aged 28 days under conditions of intensive cultivation and exposure to abiotic factors.

5. On the 56th and 70th days of life, the level of Immunoglobulin G in the blood serum decreased by 2.03-3.21 times, and the level of Immunoglobulin M – by 2.70-4.48 times ($p<0.001$). The tendency to decrease the level of Ig G and Ig M in the blood serum of turkeys persisted until the age of 120 days.

6. The content of Ig A and Ig M in the blood of 56-day-old turkeys was 1.98-2.70 times lower than in 28-day-old turkeys ($p<0.001$). The level of Ig M in the blood of 28-day-old turkeys was 2.96 times higher than in 42-day-old turkeys and 5.25 times higher in 120-day-old turkeys ($p<0.001$), which indicates a decrease in immunity in poultry, starting from 42-day-old under the influence of intensive rearing factors.

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Імунний статус індиків в умовах промислового вирощування

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Анотація. Інтенсифікація виробництва продуктів індиківництва супроводжується впливом різноманітних небезпечних факторів на організм птиці. Це призводить до порушення обмінних процесів, дисбалансу засвоєння поживних речовин, зниження імунітету у індиків, що визначає актуальність досліджень даного напряму. У зв'язку з цим, визначення часу зниження імунітету та, в наступному, підвищення його ефективності в організмі індиків, покращення обмінних процесів, росту та розвитку птиці зумовило мету науково-дослідної роботи. Встановлено, що продовж перших шести тижнів інтенсивного вирощування індиків імунна відповідь організму, активність факторів неспецифічної резистентності на вплив біологічних чинників та інтенсифікацію процесів годівлі птиці виявилась ефективною. Однак, з 42 доби вирощування птиці спостерігали виснажування імунного захисту організму індиків та зниження активності факторів неспецифічної резистентності, що проявляється вірогідним зниженням вмісту загального білка у крові птиці, альбумінів та імуноглобулінів класу G та M ($p<0{,}01$). Аналіз білкового спектру сироватки крові індиків свідчить про імуносупресивний стан організму, ймовірно, викликаний дією біологічних чинників. До 42 доби у індиків знижується бактерицидна та лізоцимна активність сироватки крові, фагоцитарна активність нейтрофілів, Т-клітинна активність лімфоцитів. Виявлені неспецифічні зміни компонентів функціонального елементу печінки, які супроводжуються збільшенням кількості ліпідних включень різної величини, деструктивними змінами в мітохондріях, зниженням синтетичної активності клітин. Дослідження імунного стану організму індиків, активності факторів неспецифічної резистентності та печінки у циклі інтенсивного вирощування від 7 до 120 доби дозволили виявити наявність критичного періоду зниження ефективності захисту організму та подальшого проведення адекватної корекції. Результати отримані в процесі досліджень використовуються у навчальному процесі, впроваджені у процес вирощування індиків в умовах виробництва ТОВ «Індичка» (Сумська область). Пропонуються усім господарствам України з виробництва продуктів індиківництва

Ключові слова: птиця, Т-лімфоцити, імуноглобуліни, альбуміни, печінка птиці