Dynamics of correlations between thyroid hormones and biochemical parameters of the laying hens blood in the age aspect

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Abstract. The article assumes that any biosystem is characterized by a certain ordered interconnection between its elements. It turns the organism into a purposefully functioning system. In this regard, structural and functional unity as a general rule of the biosystem existence concerning blood gets a special significance: blood content as an integrative indicator is related to the state of the organism as a whole, to the intensity of metabolism, and to breeding and productive qualities. It is revealed not only at the level of quantitative changes in its parameters, but also at the level of the correlation relationship. The content of thyroid stimulating hormone of the pituitary gland (TSH)) in the blood of laying hens didn’t not reliably depend on the duration of the reproductive period and varied in the range of 0.40 ± 0.003 - 0.41 ± 0.009 μIU/ml. The level of triiodothyronine (T₃) fluctuated practically at the same level, amounting to 3.00 ± 0.11 - 3.25 ± 0.16 pg/ml, although it had a tendency to decrease during the oviparity. The concentration of thyroxine (T₄) depended more significantly on the age of laying hens. The minimum level of the hormone was contained in the blood of 26-week-old laying hens (7.45 ± 0.85 pmol/l), increasing by the 52nd week in 1.22 times; it amounts to 9.10 ± 0.26 pmol/l. At the end of oviparity (80 weeks of age), the T₄ amount was 8.75 ± 0.55 pmol/l. Blood albumin directly influenced the thyroid profile of the organism in laying hens. This was due to the fact that more than 99% of thyroid hormones circulating in the blood are associated with plasma proteins, including the albumin fraction. The number of significant correlations was greatest at 26 and 52 weeks of age, corresponding to periods of maximum egg production, i.e., egg production of laying hens is the result of the relationship between the thyroid profile of the bird's organism and the intensity of metabolic processes. Triiodothyronine, regulating the catalytic activity of AST, maintains the appropriate intensity of catabolic processes, energy synthesis and distribution.

1. Introduction

Ensuring an uninterrupted and sustainable supply of the population with high-quality animal products, including poultry eggs, is the main problem of maintaining the health of the nation and food security of any country [1–6]. Increasing the production of high-quality products is one of the most important tasks.
for the development of animal husbandry, including poultry farming, which is becoming increasingly important due to the growth of the world's population and the satisfaction of humanity's needs for nutritious food. In this regard, a great importance is attached to the development of poultry farming [7–13]. An increase in productivity is inseparably associated with an increase in breeding work [14–24]. All over the world, a breed of laying hens of the Loman-white cross are widely used to obtain market eggs. It is necessary that the breed be adapted to the conditions of industrial production in order to have high productivity indicators. Taking into account a modern level of knowledge, it becomes obvious that a living organism is a biosystem where principles of structural organization work are at the molecular, cellular and tissue levels. At the same time, any biosystem is characterized by a certain ordered interconnection between its elements, which turns the organism into a purposefully functioning system [25–27]. In this regard, structural and functional unity as a general rule of the biosystem existence concerning blood is of the special significance: blood content as an integrative indicator is related to the state of the organism as a whole, to the intensity of metabolism, as well as to breeding and productive qualities, revealed not only at the level of quantitative changes in its parameters, but also the correlation relationship [28–34].

The aim of this work is to study the dynamics of correlations between thyroid hormones and biochemical parameters of the laying hens’ blood in the age aspect according to the reproductive period.

2. Materials and method

The experimental part of the work was carried out at the industrial poultry farm for the market eggs production. The objects of research were laying hens of the same age of the Lohmann-White cross during the oviparity. They were kept in the main production buildings equipped with cage batteries. Three experimental groups were formed according to the principle of balanced groups (n = 10). The first group consisted of laying hens of 26 weeks (beginning of the reproductive period), the second group consisted of laying hens of 52 weeks (a peak of oviparity), and the third group consisted of laying hens of 80 weeks (an end of oviparity). Blood tests were performed applying conventional methods. The concentration of the hormones thyroxine, triiodothyronine and thyroid-stimulating hormone in the blood plasma was calculated by the method of enzyme-linked immunosorbent assay (ELISA). The correlations were calculated by building a linear regression equation using a direct stepwise algorithm.

3. Results

A high level of eggs productivity (82–97%), peculiar for laying hens in conditions of industrial technology, is a consequence of the highly intensive metabolism in their organisms. It forms certain homeostatic constants and interrelationships of blood parameters; they are stable throughout a reproductive cycle. This rate of the organism’s functioning is accompanied by the tension of the endocrine regulation mechanisms. It corresponds to the low and insignificant variability of the concentration of thyroid hormones in the blood of laying hens (figure 1).

The content of thyroid stimulating hormone of the pituitary gland (TSH) in the blood of laying hens did not reliably depend on the duration of the reproductive period and varied in the range of 0.40 ± 0.003 - 0.41 ± 0.009 μIU/ml. The level of triiodothyronine (T3) fluctuated practically at the same level, to 3.00 ± 0.11 - 3.25 ± 0.16 pg/ml, although it had a tendency to decrease during the oviparity. The concentration of thyroxine (T4) depended more significantly on the age of the laying hens. The minimum level of the hormone was contained in the blood of 26-weeks hens (7.45 ± 0.85 pmol/l), increasing by the 52nd week in 1.22 times, i.e., to 9.10 ± 0.26 pmol/l. At the end of the oviparity (of 80 weeks), a level of T4 8.75 ± 0.55 pmol/l.
Figure 1. Age changes in the hormones. Note: TSH-thyroid-stimulating hormone; T3-triiodothyronine; T4-thyroxine.

Thyroid hormones, in general, are hormones of the "metabolic action" and they have a significant effect on protein metabolism, which determines the oviparity of a species.

We carried out a correlation analysis to identify correlations between indicators of protein metabolism and thyroid hormones, since changes in the number of correlations with the participation of different blood indicators with the same limited set of hormones can correspond to changes in the entire blood system and an organism as a whole. Ultimately, it is reflected in their productive qualities. The results of the correlation analysis of the reproductive period are shown in figures 2–4.

Figure 2. Correlation between hormones and blood biochemical parameters of 26-weeks laying hens.

At the analysis of correlation dependences, it was found that regardless of the age, duration of the reproductive period and a level of egg oviparity of laying hens, the following correlation structures of hormones are formed in the organism of laying hens:

1. Regardless of the thyroxine and triiodothyronine levels in the blood of laying hens, the same type of direct, reliable correlation was found between T3 and T4, on the one hand, and albumin, on the other
hand, during the reproductive period. The value of correlations fluctuated at the level of $r = 0.71\text{-}0.82$ ($p \leq 0.05$) (figures 2, 3, 4).

![Figure 3](image)

**Figure 3.** Correlation of hormones with blood biochemical parameters in 52-weeks laying hens.

Consequently, blood albumin directly affected the thyroid profile of the laying hens’ organism. This was due to the fact that more than 99% of thyroid hormones circulating in the blood are associated with plasma proteins, including the albumin fraction. Triiodothyronine had a lower affinity for albumin than thyroxine (correlation coefficients $r = 0.71\text{-}0.74$; ($p \leq 0.05$) were lower than between $T_4$ and Alb. In turn, thyroid hormones regulated the level of albumin, affecting gene expression, increasing a rate of protein synthesis and the activity of many enzyme systems that determined a rate of cellular reactions in the liver.

![Figure 4](image)

**Figure 4.** Correlation of hormones with blood biochemical parameters in 80-weeks laying hens.
2. During the oviparity, triiodothyronine correlated significantly with the activity of AST. The values of the correlation coefficients ranged within 0.79–0.98 (p≤0.05) (figures 2–4). This type of connection in the thyroid hormone system is of great importance, determining the direction of biochemical reactions in protein metabolism (PM), since the AST enzyme is a metabolone of the Krebs cycle, supplying it with substrates for oxidative decomposition. It forms the energy basis of the metabolic status of the laying hens’ organism and, accordingly, egg oviparity, i.e., triiodothyronine, by regulating the catalytic activity of AST, maintains the appropriate intensity of catabolic processes, energy synthesis and its distribution. It explains the egg oviparity of laying hens at the beginning and at the peak of laying hens at the level of 95–97%. During the reproductive period, the highest T₃ concentrations in the blood of laying hens were found. A decrease in triiodothyronine at the end of oviparity led to a drop in the AST level, which was accompanied by a decrease in egg oviparity up to 82%.

The direct reliable correlation is established between triiodothyronine and ALT activity (r = 0.72-0.75; p≤0.05) of 52 weeks laying hens. It provides an increase in the number of amino acids (UA) involved in gluconeogenesis.

3. The number of the greatest significant correlations was at 26 and 52 weeks; it corresponds to periods of maximum egg oviparity. Consequently, laying hens' egg oviparity is the result of the relationship between the thyroid profile of the bird's body and the intensity of metabolic processes. This is confirmed by the lack of reliable correlations between T₃, T₄, TSH and urea.

4. Only positive correlations were established between the indicators of the thyroid profile and the biochemical parameters of the blood. This confirms the effect of thyroxine, triiodothyronine and thyroid-stimulating hormone on the processes of protein metabolism.

5. At all periods of the reproductive period, T₃ and T₄ were significantly correlated with the concentration of uric acid at the level r = 0.73–0.83 (p≤0.05). This confirms that thyroid hormones regulate uric acid levels through the intensity of nucleic acid metabolism.

4. Discussion
The greatest number of significant correlations was at 26 and 52 weeks of laying hens. It corresponds to periods of maximum egg oviparity, i.e., egg oviparity of laying hens is the result of the relationship between the thyroid profile of the bird's organism and the intensity of metabolic processes. Triiodothyronine, regulating the catalytic activity of AST, maintains the appropriate intensity of catabolic processes, energy synthesis and distribution. The similar data was obtained in research results of Rani, M.P., Ahmad, N.N., Prasad, P.E., Latha, C.S. Rath, N.C., Anthony, N.B., Kannan, L., Huff, W.E., Huff, G.R., Chapman, H.D., Erf, G.F., Wakenell, P., Ya, Rebezov, O. Gorelik, M. Rebezov, T. Bezhinari, M. Derkho, S. Safronov, N. Vinogradova, I. Knysh, N. Fedoseeva, F. Khaziakhmetov, A. Khabirov.

5. Conclusion
Based on the foregoing, it follows that the thyroid profile affects the activity and the ratio of anabolic and catabolic processes in the protein metabolism of the laying hens, which determines the quantitative variability of indicators and the nature of their correlation with the level of hormones. This structure of relationships, formed in the biosystem (an organism of the laying hens), is, on the one hand, a characteristic of the realization of its productive potential. On the other hand, it is the basis for the formation of the qualitative and quantitative content of eggs.

References
[1] Akhmetova S, Suleimenova M and Rebezov M 2019 Mechanism of an improvement of business processes management system for food production: case of meat products enterprise Entrepreneurship and sustainability issues 7(2) 1015-35 doi: 10.9770/jesi.2019.7.2(16)
[2] Assenova B et al. 2020 Effect of germinated wheat (triticum aestivum) on chemical, amino acid and organoleptic properties of meat pate Potravinarstvo 14 503-9 doi: 10.5219/1273
[3] Igenbayev A, Okuskanova E, Nurgazezova A, Rebezov Yu, Kassymov S, Nurymkhan G, Tazeddinova D, Mironova I and Rebezov M 2019 Fatty Acid Composition of Female Turkey Muscles in Kazakhstan Journal of World’s Poultry Research 9(2) 78-81 doi: 10.36380/jwpr.2019.9

[4] Kambarova A et al. 2020 Improvement of quality characteristics of turkey pâté through optimization of a protein rich ingredient: physicochemical analysis and sensory evaluation Food Sci. Technol Available from: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0101-20612020005022201&lng=en&nrm=iso> https://doi.org/10.1590/fst.00720

[5] Khabirov A et al. 2021 Effect of Normosil Probiotic Supplementation on the Growth Performance and Blood Parameters of Broiler Chickens Indian J of Pharmaceutical Education and Research 55(1) doi: 10.5530/ijper.54.2.s.x

[6] Rebezov M, Naumova N, Lukin A, Alkhamova G and Khayrullin M 2011 Food behavior of consumers (for example, Chelyabinsk) Voprosy Pitaniia 80(6) 23-6

[7] Novikova M and Lebedeva I 2018 Improvement of reproductive potential of chicken hens from parent broiler flock by means of the use of supplements based on triterpene spirits Reproduction in Domestic Animals 53(52) 174

[8] Sabban E et al. 2001 Stress-triggered activation of gene expression in catecholaminergic systems: dynamics of transcriptional events Trends in Neurosciences 24 91-8

[9] Matur E et al. 2015 The effects of environmental enrichment and transport stress on the weights of lymphoid organs, cell-mediated immune response, heterophil functions and antibody production in laying hens Japanese Society of Animal Science 2 284-92

[10] Rozenboim I et al. 2007 The effect of heat stress on ovarian function of laying hens Poult Sci. 86 1760-5

[11] Marjani A 2012 Effect of peppermint oil on serum lipid peroxidation and hepatic enzymes after immobility stress in mice The Open Biochim. J. 6 51-5

[12] Soleimani A F et al. 2010 Effects of high ambient temperature on blood parameters in Red Jungle Fowl Village Fowl and broiler chickens J. of Animal and Veterinary Advances. 9 1201-7

[13] Cheng J et al. 2016 Oxidative Stress and Histological Alterations of Chicken Brain Induced by Oral Administration of Chromium(III) Biol Trace Elem Res. China

[14] Allison RW et al. 2012 Laboratory evaluation of plasma and serum proteins Veterinary Hematology and Clinical Chemistry (Ames, IA: Willey-Blackwell, JohnWilley and Sons)

[15] Bueno J P R et al. 2017 Effect of age and cyclical heat stress on the serum biochemical profile of broiler chickens Influência da idade e do estresseecílico de calor no perfilbioquímicoséricoemfrangos de corte Semina: CiênciasAgrárias Londrina 38(3) 1383-92 doi: 10.5433/1679-0359.2017v38n3p1383

[16] Capitelli R and Crosta L 2013 Overview of psittacine blood analysis and comparative retrospective study of clinical diagnosis, hematology and blood chemistry in selected psittacine species VeterinaryClinics: ExoticAnimalPractice 16(1) 71-120 doi:10.1016/j.cvex.2012.10.002

[17] Faixová Z, Faix S, Borutová R and Leng L 2010 Effects of feeding diets contaminated with Fusariummycotoxins on blood biochemical parameters of broiler chickens Acta Veterinaria Hungarica 58(3) 275-85 doi: 10.1556/AVet.58.2010.3.1

[18] Gueguinou N, Huin-Schohn C, Ouzren-Zarhloul N, Ghislin S and Frippiat J 2014 Molecular cloning and expression analysis of Pleurodeleswalitl complement component C3 under normal physiological conditions and environmental stresses Developmental & Comparative Immunology 46(2) 180-5.doi: 10.1016/j.dci.2014.04.011

[19] Hosseini-Vashan S, Golian A and Yaghobfar A 2016 Growth immune antioxidant and bone responses of heat stress-exposed broilers fed diets supplemented with tomato pomace International Journal of Biometeorology 60(8) 1183-92 doi:10.1007/s00484-015-1112-9

[20] Kulshreshtha G et al. 2016 Red seaweeds sarcodiothecagaudichaudii and chondruscrispus down
regulate virulence factors of salmonella enteritidis and induce immune responses in caenorhabditis elegans Frontiers in Microbiology 7(421) 1-12 doi: 10.3389/fmicb.2016.00421

[21] Piotrowska A, Burlikowska K and Szymbczko R 2011 Changes in blood chemistry in broiler chickens during the fattening period Folia Biologica (Krakow) 59(3-4) 183-7 doi: 10.3409/fb59_3-4.183-187

[22] Rani M P, Ahmad N N, Prasad P E and Latha C S 2011 Hematological and Biochemical changes of stunting syndrome in Broiler chicken Veterinary World 4(3) 124-5

[23] Rath N C et al. 2009 Serum ovotransferrin as a biomarker of inflammatory diseases in chickens Poultry Science 88(10) 2069-74 doi:10.3382/ps.2009-00076

[24] Tóthová C, Sesztáková E, Bielik B and Nagy O 2019 Changes of total protein and protein fractions in broiler chickens during the fattening period Veterinary World 12(4) 598-604 doi: 10.14202/vetworld.2019.598-604

[25] Yadegari M, Ghahri H and Daneshyar M 2019 Efficiency of Savory (Satureja Khuzestanica Jamzad) Essential Oil on Performance Carcass traits, Some Blood Parameters and Immune Function of Male Ross 308 Heat Stressed Broiler Chicks Ukrainian Journal of Ecology 9(4) 515-20

[26] Belay T and Teeter R G 1993 Broiler water balance and thermo-balance during thermoneutral and high ambient temperature exposure Poult Sci. 72 116-24

[27] Lee K et al. 2003 Effects of dietary essential oil components on growth performance, digestive enzymes and lipid metabolism in female broiler chickens Br.Poult.Sci. 44 450-7

[28] May J D and Lott B D 1992 Feed and water intake patterns of broilers at high environmental temperatures Poult Sci. 71 331-6

[29] Mohamed M A and Mohamed M H 2009 Haemato-biochemical and pathological studies on aflatoxicosis and treatment of broiler chicks in Egypt Veterinaria Italiana 45 323-37

[30] Harlap S J et al. 2020 The relationship of hematological parameters with growth indicators of young laying hens IOP Conf. Ser.: Earth Environ. Sci. 548 082011 doi:10.1088/1755-1315/548/8/082011

[31] Gorelik O et al. 2020 Dynamics of Hematological Indicators of Chickens under Stress-Inducing Influence Ukrainian Journal of Ecology 10(2) 264-7 doi: 10.15421/2020 94

[32] Gorelik O et al. 2020 Influence of Transport Stress on the Adaptation Potential of Chickens Ukrainian Journal of Ecology 10(2) 260-3 doi: 10.15421/2020 93

[33] Rebezov Y et al. 2020 Features of the Morphologic Composition of Blood of Turkeys International Journal of Psychosocial Rehabilitation 24(8) 7868-75 doi: 10.37200/IJPR/V248/PR280799

[34] Rebezov Y et al. 2020 The Immunological Reactivity of Turkeys of Different Genotypes on the Action of Environmental Factors Ukrainian Journal of Ecology 10(2) 260-3 doi: 10.15421/2020 92