Feasibility study of the influence of the diet on the quality characteristics of poultry production

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Abstract. Production of poultry products is one of the cost-effective areas of animal husbandry as a more rapid solution to the problem of providing the country's population with high-value food products. At poultry farms, this allows producing eggs and poultry meat with a low expenditure of labor and other material and technical means per unit of output, that is, almost 2–3 times lower compared to other branches of animal husbandry. Studies of egg production of poultry cross "Highsex Brown" were conducted at the Smetanino poultry farm in the Smolensk region. The aim of the study was to study the effect of protein nutrition of chickens on their egg production and standardization of egg mass, as well as the role of vitamin supplements in the diet of poultry feeding on the quality of the products obtained.

1. Introduction
Import substitution of food products is of great importance for the development of the Russian economy and maintaining food security. It is especially important for the population to increase those products in the market that are most in demand and affordable by price factor. These include poultry products, namely eggs and meat.
Agricultural producers are constantly looking for directions to increase production at the lowest cost. The egg productivity of laying hens is significantly affected by feeding conditions. In this case, feed occupy the largest share in the cost of production. Producers try to optimize feeding diets to increase the economic efficiency of production and improve the quality characteristics of eggs, which are important for consumers of products.
The aim of the study was to study the effect of protein nutrition of chickens on their egg production and standardization of egg mass, as well as the role of vitamin supplements in the diet of poultry feeding on the quality of the products obtained.

2. Materials and Methods
To study the efficiency of the use of amino acids and vitamins in the diet of laying hens, studies were conducted on the Highsex Brown cross in the conditions of Smetanino poultry farm (Smolensk Region) [1]. The poultry farm is an industrial type enterprise, it uses a complete closed technological cycle, which begins with the production process and ends with the sale of finished products (Figure 1).
During the study, two experiments were conducted. The first scientific and economic experience consisted in selecting the optimal protein feeding of laying hens of the Highsex Brown cross in order to reduce the dependence of poultry productivity on age and increase the proportion of eggs with standard weight characteristics. The second experiment was aimed at studying the relationship between the content of vitamins in the diet, poultry productivity and the level of vitamins in food eggs in order to turn them into a functional food product with medicinal properties.

For three groups of laying hens (one control and two experimental), the following indicators were calculated and compared: live weight of the bird (group weighing was carried out every month); livestock safety (case control was carried out every day with the establishment of the cause); feed consumption level (daily weight of distributed feed and its residues was estimated; feed consumption was calculated for 1 head per day, for 10 eggs and 1 kg); egg laying on the initial and middle layers; morphological indicators of eggs and egg quality (shape of white and yolk, shell thickness, relative mass of white, yolk and shell); Vitamin content in eggs.

The content of chemical elements in the feed, manure and eggs obtained during the experiment was evaluated on the basis of the zootechnical analysis technique, which corresponded to GOST.

The specific gravity of the consumed amino acids and vitamins, in other words their availability, was estimated by calculation as the percentage deviation between the amino acids (vitamins) contained in the consumed feed and excreted in relation to the consumed ones.

The data collected in the process of scientific experiments were processed using the analysis package available in Microsoft Office Excel. Absolute and relative gains were calculated, trend models were built, and a correlation-regression analysis was conducted of the relationship between
bird productivity indicators, the content of nutrient and biologically active substances in the egg, and various conditions of protein feeding and an increased content of vitamins in the diet.

3. Formation of the quality of food eggs in protein composition

Egg white is divided into simple proteins and complex proteins (proteids). The latter, in addition to amino acids, contain various substances of the non-white part—from trace elements and vitamins to complex organic compounds. Egg white is rich in mostly simple, highly digestible proteins.

Among the complex proteins (proteids) is small amount of avidin, which contains vitamin H (biotin) and forms an avidinbiotic complex. In such a compound, biotin is not active and is not used by the human body. At the same time, biotin vitamin deficiency (in some cases, allergy) is possible only with a large number of raw eggs eaten. When the eggs are heated, the avidinbiotic ligament is destroyed and the released biotin becomes active.

Well-digestible proteins are found not only in the egg white, but also in the yolk. Chicken yolk has the most protein phosphoproteins, which are built from simple protein and phosphoric acid. Complex vitamins in yolk include: vitellin (65%), lipovitellin (16%), levitin (10%), phosphovitin and others. Most yolk proteins form lipoproteins and glycoproteins. The biochemical composition of the yolk and white determines the various functional properties of the chicken egg.

In addition to white and yolk, proteins are contained in a small amount in the shell, shell membranes. Thus, proteins are present in all the constituent parts of the chicken egg: 50% in the white, about 45% in the yolk, 3-4% in the shell membranes and 2-4% in the shell.

More than 200 thousand tons of amino acids are produced annually in the world, which are used as biologically active additives to human food and feed additives for animals. The largest quantities of amino acids produced are methionine, lysine, glycine, threonine and glutamic acid. Therefore, only a few of the essential amino acids can be added to the chicken diet, mainly methionine and lysine, as well as threonine.

The main source of filling the amino acid deficiency is animal protein feed containing essential amino acids in the required (optimal) ratio. The fullness of the protein nutrition of laying hens is controlled by the presence of these amino acids in the diet (feed). If it is impossible to use animal feed to balance the diet of the bird, synthetic analogues of amino acids are used: methionine, lysine, threonine.

Proteins are the most important and expensive component of bird nutrition. In this regard, the cost-effective use of protein feed is of great importance. Most often, fish, meat and meat-and-bone meal, legumes, soybean, sunflower meal and oilcake are included in compound feeds of laying hens. Note that in all feeds, proteins are represented by simple proteins.

In industrial poultry, the problem of protein nutrition of chickens is successfully solved through the use of balanced full-feed mixed fodders, they contain the optimal amount of crude protein (16-17%) and metabolic energy (260-270 kcal/100 g). The protein utilization (transformation) ratio is 20 -25%.

Simple arithmetic calculations show the following. With an average egg weight of about 65 g, about 7.5 g of crude protein is removed, including 0.3 g of methionine, 0.2 g of cystine, 0.25 g of lysine. At the same time, about 1 g of protein per day is spent on maintaining protein metabolism in the body of a bird. In this regard, for the biosynthesis of 1 g of egg mass, 145 mg of feed protein or 125 mg of digested protein is needed.

If the chicken lays an egg daily, then its protein requirement will be about 18 g per day, if it is half absorbed. When the protein content in the feed increases, the birds become obese, however, when there is a lack of protein, the chicken body proteins begin to be used, and the birds lose weight. In case of violation of the amino acid composition of the diet, the increased content of various amino acids is used by the bird organism not for protein synthesis, but for energy consumption. These genetic features also need to be considered when rationing compound feeds when feeding birds.

A change in the protein content and amino acid composition of the feed leads to a change in egg mass, dry matter content in the white and in the yolk. However, within the usual standard diets, in which the protein is about 18%, their effect on the quality of eggs is stable. Significant fluctuations in
the balance of diets are necessary in order to significantly change the amino acid composition of eggs.

The high level of protein in the feed (19% or more) affects the appearance of eggs with blood and meat inclusions. Studies have shown that with an increase in crude protein in the diet to 19%, the specific gravity of the dense layer of white in eggs increases by 5.5%, which is very significant. At the same time, “barley” diets change the ratio between dense and liquid white not for the better - in favor of the latter. This reduces the main quality indicators of egg white: density, index, Haugh unit.

An important factor in a balanced diet is the level of protein and the ratio of amino acids, the content of metabolic energy and linoleic acid in animal feed. Satisfying the needs of the poultry organism in proteins is carried out due to the irreplaceable and interchangeable amino acids in feed in equal proportions. With a decrease in the content of even one essential amino acid, protein synthesis in the egg ceases.

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The need for basic essential amino acids is balanced by the addition of their synthetic forms (DL-methionine, D-lysine). Violation of the amino acid composition of the feed leads to metabolic disorders in the body of the bird, which is expressed in a decrease in the laying capacity of chickens.

The most important essential amino acid for chickens besides methionin is lysine. It is necessary for poultry growth and white synthesis. This amino acid is part of many enzyme systems and hormones, is involved in the metabolism of carbohydrates and lipids during metabolism.

With a sufficient content of this amino acid in the diet, not only the laying capacity of the layers increases, but also the mass of eggs. Sulfur-containing amino acids, methionine and cystine, also have a great influence on this indicator and egg quality. The named amino acids, as well as threonine, tryptophan and arginine are classified as limiting. In total, the dietary requirements and compound feeds for egg hens take into account the norms of need and the content of 13 amino acids in the feed. However, the main amino acid necessary for the normal functioning of the bird's body is methionin. It is used not only for the implementation of white biosynthesis processes, but serves as a kind of marker of protein exchange and metabolism. Methionine is one of the limiting amino acids that determines the level of use of all the others.

If the diet is unbalanced, the reduction in methionine and lysine content can reach 20%; in this regard, synthetic analogues of these amino acids are in significant demand in the production of poultry products. Compound feeds for chicken crosses most often take into account the most important essential amino acids, which also include cystine, tryptophan, threonine and arginine [2].

The size and nutritional value of chicken eggs directly depends on the age and diet of laying hens. Regulation of the average mass of eggs is as follows. The content of metabolic energy, protein, methionine, linoleic acid in rations of hens is normalized for four age periods. They control the bird's need for amino acids: methionine, cystine lysine, tryptophan, as well as macroelements: calcium, phosphorus, sodium (7 microelements and 14 vitamins).

The essence of the method is to periodically decrease the level of protein, methionine and metabolic energy in the feed with age. In this case, high-grade feeds are used: corn, wheat, soybean cake, fish and meat meal, as well as feed additives. Each transition to a new diet is carried out gradually—over two weeks. The mathematical accuracy of control over the quality of the feed and all the parameters of the complete feed allows getting food eggs with a given standard weight.

As a result of studies, a relationship was found between the age of laying hens (phases 1, 2, 3), their productivity and the content of amino acids in the feed (Figure 1, Figure 2).

In this regard, zootechnics of poultry farms should take into account the following criteria for the formation of complete protein and amino acid composition of rations for feeding birds: the age of the bird, its live weight, productivity, and the amount of feed consumed.
Figure 2. Optimal protein composition of the diet for laying hens by age phases

Thus, it was experimentally established that the dynamics of the dependence of the productivity of laying hens on age in the phases studied was: a laying hen requires 2.4 g of protein in the feed mixture in the first age phase (150-300 days). In the second phase (301-420), the amount of protein consumed will decrease to 2.1 g. In the third phase (421-510) of productive age, the protein mass will be 1.8 g.

Figure 3. Dependence of productivity of laying hens on age

The dependence of the productivity of laying hens shows that the greatest peak egg production in hens falls in earlier age categories (from 7 to 9 months). Next is a decrease in bird productivity, almost reaching the level of 24 weeks of age. However, studies have shown that through the selection of optimal protein feeding, it is possible to smooth out the decrease in bird productivity from age.

Until the 58-week-old laying age, it is possible to maintain an average egg mass of 64-65 g. After 58 weeks of egg production, chickens form many large and defective eggs. This is a kind of "signal" to the end of the productive period. It should be noted that the Highsex Brown cross chickens are characterized by a long high egg production, which lasts for 60 weeks or 14 months. At the same time, the average egg laying intensity remains at the level of 80% or more.

Today it is known that with the age of chickens not only the mass of eggs increases, but also the content of certain amino acids, vitamins and carotenoids in them. At the same time, the number of non-standard eggs with defects in the shell, two-yolk eggs, and super-large eggs increases markedly. The task of specialists is to maintain a balance of economic and productive indicators of the industrial herd for as long as possible, and then timely replace the laying hens with young (17-18 weeks) hens.

4. Formation of the quality of food eggs in vitamin composition

The need of poultry in vitamins due to the main components of animal feed is not fully satisfied. Therefore, vitamins at the rate of g/t are introduced into the mixed feeds of laying hens of the industrial herd in the following amounts: A - 8 (million ME), D - 2.5 (million ME), E - 10, K - 1, B1, B2 - 4, B3 - 20, B4 - 250, B5 (PP) - 20, B6 - 4, Bc (folic acid) - 1, N (biotin) - 0.1.

Usually these are synthetic vitamin preparations (in dry or liquid form), which are available in the form of feed microadditives, both separately and as part of vitamin-mineral premixes. The disadvantage of the current standards for the introduction of vitamins in feed for hybrid laying hens is
that they are designed for high egg production, excluding the content of vitamins in the egg.

For hatching eggs from breeding egg chickens, the requirements for the content of vitamins are as follows (at least, $\mu g/g$):

- in the yolk: carotenoids - 15, vitamin A - 7, vitamin B2 - 4;
- in protein: vitamin B2-3.

Numerous experiments on chickens of both breeding and industrial herds showed that eggs can be enriched (saturated) with vitamins, varying the composition of the diet of laying hens. It is bad if there are not enough vitamins in the feed, but their excess also negatively affects the quality, especially of hatching eggs. The introduction of increased vitamins in feed for breeding chickens ensures the optimal content of vitamin A and carotenoids, as well as vitamins E and B2 in hatching eggs.

A large amount of vitamin A (retinol) in laying hens leads to depigmentation of the skin, decreased productivity, as well as to a decrease in the absorption of vitamin E. High levels of vitamin D in chicken diets increase the cholesterol content in the egg. Therefore, it is very important to know the maximum permissible (tolerant) doses of vitamins in the feed. For vitamin A, they are 10-30 times higher than normal, 100 time higher for vitamin E, and 1000 times higher for vitamins K, B1, Bc and C.

Fat-soluble vitamins, especially A and E, are of the greatest importance for poultry. They are the main factors in the growth of young animals and the reproductive ability of birds. A similar role is played by these vitamins in other animals and humans. Vitamin E together with organic selenium actively participate in cellular metabolism, prevent the formation of free radicals in the body and their negative effects.

The first for chickens is vitamin A, which, participating in metabolic processes, contributes to the normal development of young animals, increase the body's immunity. Its rationing is carried out taking into account the intake of carotenoids (mainly p-carotene), which are precursors of vitamin A. It is believed that only natural carotenoids in food eggs exhibit antioxidant and therapeutic properties.

Birds, unlike other animals, make better use of carotene: two molecules of vitamin A can be synthesized from one molecule of p-carotene in the body. However, carotene is absorbed in the intestines worse than vitamin A, since this provitamin is in plants in a protein-bound state. With appropriate processing of vegetable feed—drying, silage, sublimation, extrusion—carotene is cleaved from protein and better absorbed by birds.

With the addition of vitamin A (10 million ME per 1 ton of feed), its content in the yolk remains within the normal range of 6-8 $\mu g/g$ of yolk. Higher doses of the drug (1.5-2.0 times) can increase the retinol content in the yolk of eggs by 50% or more (up to 13-15 $\mu g/g$). With its lack of feed, the egg production of chickens and vitamin in eggs and liver is reduced. Retinol deficiency in feed is believed to be one of the causes of blood in the egg. Vitamin K, for its part, reduces the incidence of these inclusions in the yolk. The rate of input of vitamin K into the feed is 1-2 g/t. This vitamin also prevents hemorrhagic phenomena caused by an increased dose of the vitamin.

The optimal concentration of vitamin E (tocopherol) in the yolk of the eggs is observed when the usual norm of additives is 10-20 g per 1 ton of feed. The need for chickens in vitamin E depends on the content of selenium in the diet. With an increase in the level of linoleic acid in the diet of laying hens, tocopherol is administered at a rate of 30 g per 1 ton of feed through the use of vegetable oils and synthetic vitamin preparations A.

In the production of enriched eggs, the dose of vitamin E supplements in animal feed can be increased to 100 g/t. In this case, the concentration of tocopherol in the yolk is 250-300 $\mu g/g$ (the norm is 60-70 $\mu g/g$). Micronutrient selenium supplements in laying rations contribute to an increase in vitamin E content in the yolk.

Vitamin D, which regulates calcium and phosphorus metabolism, contributes to the formation of high-quality shells, plays an important role in chicken feeding. If this vitamin is not enough, then mineral metabolism is disturbed, chickens lay eggs with a thin shell. Due to insufficient mobilization of calcium and phosphorus, even egg laying is delayed. Increased doses of vitamin D in combination with ultraviolet irradiation of laying hens improve the strength of the shell, reduce the breakage and
cracking of eggs, and there is more vitamin in them.

An egg weighing 60 g contains an average of 230 micrograms of vitamin B2, with a maximum of 300 micrograms. To increase the concentration of this vitamin in eggs, chickens should receive it with a feed of 6 mg/kg. In the production of enriched eggs with a high content of B vitamins, higher doses are required for 1 ton of compound feed compared to the application rate.

Vitamin B12 has a notable effect on chicken productivity and egg quality. It helps lower cholesterol in the egg and blood of the bird. This vitamin, as well as choline, lecithin and methionine, protects laying hens from obesity in the liver. In addition, the use of vitamin B12 promotes enhanced accumulation of vitamin A and carotenoids in the egg. The content of this vitamin in the egg can satisfy the daily requirement of the human body. In order to increase the content of this vitamin in chicken eggs, it is recommended to add it (50 mg/t) into the mixed feed for laying hens.

Data from many studies show that there is a linear relationship between the amount of vitamins in animal feed and their transfer to the egg. Today it is proved that when feeding vitamin-containing preparations in high doses to laying hens, the concentration of vitamins in eggs increases by 50% or more. However, increasing doses of vitamins in the diet and their accumulation in the egg cannot be unlimited.

Certain vitamins, other biologically active substances and compounds (amino acids, phospholipids, bioelements) are medicines themselves or their components. Increasing the level of vitamins to the norm of a person’s daily need for food eggs turns them into a functional food product with medicinal properties [3], [4].

Among these bioelements, iron should be distinguished, the content of which in a fresh egg and egg products can fully satisfy the needs of the human body and prevent the occurrence of anemia. Iron in chicken eggs is in organic form, which, along with the richness of eggs in protein and amino acid composition, trace elements, determines the dietary properties of eggs.

The chemical composition of chicken eggs is not constant and depends mainly (quantitatively and qualitatively) on the diet. However, using the appropriate diet, feed additives, you can get eggs with the desired composition, taking into account macro and micro elements.

5. Conclusion

Thus, studies have shown that with the help of enzymatic preparations, 10-20% and barley can be included in the feed composition in the amount of 10-20% and 45-60% of barley, while obtaining chicken egg production of up to 300 eggs per year and average daily growth of broilers of 42-48 g. Another element of resource saving in the production of eggs can be limited feeding of rearing birds and the parent herd of birds, reducing the ration by 5, 10, 15 and 50%, respectively, of voluntary intake from 4-6 weeks of life to 20 weeks. In addition, optimization of protein-vitamin and mineral nutrition of poultry enables maximum preservation of the livestock, increases its live weight by 3-6.8%, reduces feed costs per 1 kg of growth by 1.1-3.5%.

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