Influence of iodine based exogenous antioxidants on the productive indicators of laying hens

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Abstract. The effect of the liposomal form of the antioxidant Polysol Omega-3 on laying hens and on the egg productivity was stated in article. Hens feeding by liposomal form of the antioxidant on protein content in the egg (p≤0.01), the height of dense protein (p≤0.001), the average diameter of dense protein (p≤0.01), the height of the yolk (p≤0.01), the average diameter of the yolk (p≤0.001) and the quality of the protein in units of How (p≤0.001), by 5.02 g (13.4%), 1.00 mm (20.6%), 1.00 cm (6.99%), 2.2 mm (15.94%), 6.4 mm (13.68%) and 7.4 units. (11.35%) had an impact respectively. An increase in the porosity of the eggs shell in the laying hens of the experimental group was proved by a significant decrease in the Ca content by 0.49 g (p≤0.01). A positive trend in the content of iodine in the eggs of hens of the experimental group at the end of the third month of the experiment was noted at 35.8 µg (828.2 %).

1. Introduction
External technological factors negatively affect the poultry growing and lead to a decrease in productivity [1]. The level of consumption of nutrients that are responsible for combating stress increases therefore feed consumption decreases [2]. Under stress, the adaptation of the bird is due to its use of natural antioxidants, and therefore, the possibility of providing additional poultry diets with a set of important nutrients can be considered as one of the main elements of a successful fight against stress factors. [3].

The bird's body is completely deprived of protection from stress factors. During evolution, living organisms developed special antioxidant defense mechanisms, which in the world scientific literature were called general definition “antioxidant system” [4]. This system is diverse, it is responsible for protecting cells from the action of free radicals and includes following components: natural fat-soluble and water-soluble antioxidants, antioxidant enzymes. Protective antioxidant compounds are located in organelles, subcellular compounds or extracellular space, providing maximum protection for cells [5].

World practice shows that consumers say great attention to the quality of animal products, therefore the main task of the food industry is based on the quality of meat having high external characteristics. These indicators include texture, appearance, flavor, tenderness, juiciness and other subjective characteristics [6]. Formation of free radicals causes destruction of the cell membrane structure, muscle tissue with a fuzzy texture is formed, for example, dry, or smeared, pale colored, or, conversely, too
bright red, etc. [7]. Compounds, which include exogenous antioxidants, are divided into two groups: biological and synthetic [8].

Scientists have found that endogenous antioxidants present in the body, but the severity of their action depends on the correct interaction of the components of antioxidant protection, on their concentration, reactivity to free radicals, and the status of the antioxidants with which it interacts [9].

The interest to natural antioxidants in the context of growing poultry has increased in recent years. Natural antioxidants are safer, cheaper, they are also able to prevent oxidative reactions in products during storage and do not cause metabolic diseases in animals and birds [10].

Exogenous antioxidants, having natural structure, affect not only the metabolism in the body of the bird during the growing period, but also the oxidation of lipids in meat after slaughter during its storage. Poultry meat usually remains unused during storage due to oxidative degradation of lipids: biological membranes, enzymes and proteins in meat are damaged [11]. Lipid oxidation is initiated by the fraction of unsaturated fatty acids by auto-oxidation. The compounds formed by lipid oxidation (aldehydes, ketones, acids, alcohols, etc.) are toxic to human and can cause various chronic diseases [12].

Including natural antioxidants in food is a natural way to increase the internal concentration of antioxidants that reduce the oxidative effects in meat [13].

The form of the use of antioxidants is still an urgent issue. Antioxidants are not able to overcome the cell membranes in pure form due to their low degree of solubility. The selective delivery of antioxidants to tissues in sufficient concentrations of the liposomal form will equally effectively transport vital structures: water-soluble, fat-soluble, combinations of various antioxidants, etc. [14]. It was found that antioxidants in the liposomal form increase the detoxication activity of laying hens’ liver and reduce the content of xenobiotics, nitrites and nitrates, and the accumulation of residual heavy metals present in the diet was prevented due to their increased excretion from the body of chickens [15]. Adding of liposomal nanoform of silymarin at a dose of 200 g per 1 ton of feed to the diet of broiler chickens caused positive changes in the main physiological and productivity indicators in poultry [16]. Russian scientists proved the effectiveness of the use of liposomal forms of antioxidants of other types of farm animals [17].

Thus, the use of liposomal forms of antioxidants is an important part of further agroecological research in the field of agricultural production aimed at ensuring environmentally friendly technologies in the course of further development in the agro-industrial complex [18].

According to literary data, we conclude that there is a high interest of scientists who studies all over the world to natural sources of antioxidants. Feed additives from plants with their high content of natural antioxidants allow increasing the efficiency of poultry growing without loss of quality of products. The liposomal form of antioxidants will allow selective delivery of vital compounds to tissues in optimal concentrations.

In this connection, the main purpose of the research was to study the effect of the liposomal form of the antioxidant Polysol Omega-3 on laying hens and on the egg productivity.

2. Materials and methods
Fifty five Hisex white cross laying hens were used in the experiment. The age of the hens at the beginning of the experiment was 73 weeks. The duration of the experiment was three months. Water was available ad libitum. Laying hens were divided into experimental and control groups. The experimental group received the feed additive Polysol Omega-3 (obtained on the basis of liposomal technologies) at the rate of 2.67 g per 10 birds. Both groups of laying hens received the common diet. 1 kg of forage accounts for exchange energy of 2750 kcal / kg, crude protein – 17.0 %. The feed was balanced to meet the developmental needs of the hens. Egg productivity was assessed by weighing 15 eggs every ten days from each group. The quality of the eggs was determined monthly, five eggs from each group. Indicators: egg mass, the mass of egg shell, yolk and egg white, shape index (ratio of large egg diameter to small), dense egg white height, average dense egg white diameter, yolk height, yolk diameter, egg white quality in units of Haugh. Shell index was calculated according to A. Molnar et al. (2016) [19]. The porosity of the shell was determined by staining its inner surface with an alcohol of 0.5 % solution of Methyleneum coeruleum (methylene blue) until a solution appears in the pores on
the outer surface of the shell. Painted and clearly visible pores are counted per cm$^2$. Before dyeing, the membrane is removed, and to count the so-called “blind” pores, the shell is boiled for 10-15 minutes in a 10% NaOH solution.

3. Study of egg productivity in laying hens

When weighing laying hens at the end of the first month of experiment, the bird from the control group was characterized by an average live weight of 1589.4 g, which is 55.2 g (or 3.5%) less in comparison with the bird from the experimental group. The difference is not significant. In the following months of experiment, a similar pattern was preserved: the second month - 34 grams, and the third - 60 grams.

During the first month of the experiment, no significant difference in the main morphological characteristics was observed.

Results of the second month of the experiment: the weight of egg white from experimental group prevailed from the control one by 7.4 g (20.3%) (p≤0.001). A significant advantage of laying hens of the experimental group over the control was preserved in such indicators as the dense egg white height (p≤0.001), the height of the yolk (p≤0.05), the average diameter of the yolk (p≤0.05) and the quality of the egg white in units of Haugh (p≤0.001), of 5.02 g (13.4%), 1.00

| Table 1. Morphological characteristics of the eggs of laying hens, $\bar{X} \pm S_x$, n=5 |
|-----------------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Indicator | First | Second | Third | First | Second | Third |
|-----------|-------|--------|-------|-------|--------|-------|
| Mass of shell | 9.0±0.2 | 9.0±0.2 | 10.7±0.2 | 10.5±0.32 | 10.3±0.2 | 10.5±0.3 |
| g egg white | 37.2±0.5 | 37.4±0.4 | 44.1±1.2*** | 36.7±0.9 | 42.4±0.6** | 37.4±1.1 |
| yolk | 18.4±0.8 | 17.8±0.5 | 21.8±0.5 | 21.5±0.8 | 20.7±0.6 | 19.6±0.7 |
| Form index (lf) | 1.14±0.01 | 1.14±0.01 | 1.18±0.02 | 1.16±0.01 | 1.21±0.01 | 1.22±0.01 |
| The dense egg white height, mm | 5.4±0.1 | 5.4±0.1 | 6.0±0.1*** | 5.2±0.1 | 5.8±0.1*** | 4.8±0.1 |
| The average dense diameter of the egg white, cm | 13.1±0.8 | 11.8±0.3 | 15.5±0.2* | 14.9±0.2 | 15.3±0.2 | 14.3±0.2 |
| Yolk height, mm | 10.9±1.7 | 11.7±0.6 | 16.0±0.5* | 14.6±0.4 | 16.0±0.4*** | 13.8±0.5 |
| The average dense diameter of the yolk, cm | 4.0±0.1 | 3.9±0.1 | 5.4±0.9* | 5.0±1.1 | 5.3±1.0*** | 4.7±1.2 |
| Haugh Unit | 69.6±1.4 | 70.4±1.3 | 74.0±0.7*** | 66.8±0.6 | 72.6±0.8*** | 65.2±1.0 |
| Shell index | 85.9±0.3 | 85.6±0.3 | 90.9±0.7** | 87.9±0.5 | 89.7±0.5* | 87.5±0.7 |

At the end of the third month of experiment, similar pattern is preserved. A significant advantage of the indicators of eggs of laying hens from the experimental group over the control one is preserved according to the protein content in the egg (p≤0.01), the height of dense egg white (p≤0.001), the average dense diameter of dense egg white (p≤0.01), the height of the yolk (p≤0.01), the average diameter of the yolk (p≤0.001) and the quality of the egg white in units of Haugh (p≤0.001), of 5.02 g (13.4%), 1.00
mm (20.6%), 1.00 cm (6.99%), 2.2 mm (15.94%), 6.4 mm (13.68%) and 7.4 units (11.35%), respectively.

To evaluate the morphology of eggs objectively, the percentage ratio of shell, egg white and eggs yolk was calculated. The mass fraction of the shell of eggs from the experimental group varies from 13.9 to 14.0%, while from the control group this figure varies from 13.5 to 15.6%. The mass fraction of yolk from the eggs of the hens from the experimental group varies in the range of 28.2 - 28.5%, while the same from the control group was 27.9 - 31.2%. The mass fraction of egg white in laying hens of the experimental group varies from 57.6% in the first month of experience to 57.8% in the last month of experience, while for the control group, the mass fraction of egg white in the egg decreases from 58.6% in the first month of experiment up to 55.4% during the last month. Thus, totally, the egg white and yolk from eggs laid by the hens from the experimental group is 86.0%, and for the control one - 1.6% less.

Egg shell quality is important one of the quality of egg productivity. The integrity of the shell and the stable state of the pores increase the resistance of eggs to the penetration of pathogenic microorganisms and mold fungi, which increases food safety [20]. The dynamics of the formation of the indicator of the shell thickness of laying hens’ eggs is shown in Figure 2. In the first month of the experiment, the shell thickness does not have a significant difference between the groups and varies from 0.30 to 0.32 mm. In the second month of the experiment, a significant advantage was observed for the laying hens’ eggs from the experimental group. The difference between the experimental and control group was 0.04 mm or 14.7% (p≤0.01). A similar pattern was maintained for the third month of experiment: 0.04 mm or 13.2% (p≤0.01) (Figure 1).

The percentage of soft and broken eggs in the experimental group of laying hens is 1.7% over the entire period of experiment on average, and in laying hens of the control group – 2.4% (Figure 2).

Most authors came to the following general conclusion. Eggs of various crosses of chickens with different shades on the quality of the shell were investigated. It was found that the weight and thickness of the shell is primarily due to the influence of external factors. [21]. These conclusions coincide with the data obtained during our experiment. A significant influence of the external factor on the shell thickness in hens of Hisex white cross was noted.

Gas exchange and loss of moisture in bird eggs occur through the pores. It is established that the length of the pores (diffusion path) is equal to the shell thickness. The thicker shell to a certain extent prevents the intensive gas diffusion [22].

In order to study the factors affecting the strength of eggs, we investigated the porosity of the shell and the calcium content in the shell. In table 2 shows the egg porosity data during the experiment. Eggshell of one egg contains up to 3 g of Ca, therefore, the diet of hens should contain a sufficient amount of Ca. It has been established that from the age of 38 weeks the content of such an important element in the shell as calcium begins to decrease and the strength of the shell decreases [21].
Table 2. Porosity of eggs of laying hens in experiment, pores per cm²

| Month of experiment | Group of laying hens |
|---------------------|---------------------|
|                     | Experimental | Control |
| First               | 121.5±1.8      | 123.1±3.1 |
| Second              | 118.6±1.0      | 129.3±1.9* |
| Third               | 120.5±1.9      | 134.3±2.5*** |

We analyzed the content of calcium in the eggshell. The difference in the content of calcium in the egg shell between the control and experimental groups is established. Calcium in the control group it is 3.92±0.13 g (p≤0.01), and in the experimental group it is 3.43±0.05 g. Thus, an increase in the porosity of the eggs shell in the laying hens of the experimental group was proved by a significant decrease in the Ca content.

The change in the degree of drying of eggs at a storage temperature of 1 °C for 3 months is stated in Table 3. For three months of observations after the end of the experiment, the loss of moisture varies from 12.5 to 13.7% within the limits of statistic error.

Correlations between the egg mass, the shell weight and the thickness of the egg shell were calculated. The results are presented in the table 4.

Table 3. The percentage of moisture loss of eggs for three months

| Group of laying hens | 1st month | 2nd month | 3rd month |
|----------------------|-----------|-----------|-----------|
|                      | Experimental | Control | Experimental | Control |
| X ± S(%)             | 12.5±0.4 | 13.7±0.4 | 11.3 | 10.2 |

Table 4. Correlations between the egg mass, the shell weight and the thickness of the egg shell

|                       | 1st month | 2nd month | 3rd month |
|-----------------------|-----------|-----------|-----------|
|                       | Egg mass | Egg shell mass | Egg mass | Egg shell mass | Egg mass | Egg shell mass |
| Experimental Egg shell thickness | 0.56*** | 0.34 | -0.16 | 0.15 | -0.49* | -0.2 |
| Experimental Egg mass | - | 0.92*** | - | 0.62** | - | 0.87*** |
| Control Egg shell thickness | 0.77*** | 0.48** | 0.42 | 0.4 | 0.87*** | 0.92*** |
| Control Egg mass | - | 0.76*** | - | 0.3 | - | 0.78*** |

The correlation between egg mass and egg shell thickness in the hens of the experimental group changed as follows. In the first month of the experiment, this indicator had a positive value. The same significance noted in hens of the control group − 0.56 (p≤0.01) and 0.77 (p≤0.001). In the course of the experiment, this indicator is replaced by reliably negative up to -0.49 (p≤0.01). Interrelation between egg shell mass and egg shell thickness does not have certain patterns, but between egg shell mass and egg mass has a positive character in an analogy with the control ones and vary 0.62–0.92 (p≤0.001).

Although, the egg mass and the egg shell mass in control hens positively correlated with egg shell thickness at the end of the experiment: 0.87 (p≤0.001) and 0.92 (p≤0.001). The pattern is similar with the experimental group on the relationship of egg shell mass and egg mass: varies within 0.76–0.78 (p≤0.001) during the whole experiment.

An increase of iodine consumption by animals promotes greater content of this element in food products of animal origin, which may, as a result, contribute to the prevention of iodine deficiency in
human [23]. Gjorgovska et al. [24] reports that iodine-enriched yolk is the best source of iodine and can replenish 11 to 15% of daily needs for adults if they consume even one egg per day.

The results of iodine accumulation in eggs of laying hens of Hisex white cross in the experiment when they were fed with Polysol Omega-3 are next. There is a positive trend in iodine content in eggs on the third month of experiment. This indicator increases by 35.8 μg (828.2 %) comprised to control (4.32±0.62 μg); at the end of the third month of the experiment, the iodine content will increase to 40.1±2.5μg.

4. Conclusion
Differences in live weight in laying hens are not significant. This figure varies from 1.43 to 1.68 kg. The average weight of laying-laying eggs that received liposomal antioxidants varies from 62.5 to 65.6 grams at the end of the experiment. The weight of eggs of chickens in the control group averages 62.4 g during the whole experiment. The advantage of indicators of eggs of laying hens of the experimental group over the control analogues is noted: according to the protein content in the egg (p≤0.01), the height of dense protein (p≤0.001), the average diameter of dense protein (p≤0.01), the height of the yolk (p≤0.01), the average diameter of the yolk (p≤0.001) and the quality of the protein in units of How (p≤0.001), by 5.02 g (13.4%), 1.00 mm (20.6%), 1.00 cm (6.99%), 2.2 mm (15.94%), 6.4 mm (13.68%) and 7.4 units. Thus, an increase in the porosity of the eggs shell in the laying hens of the experimental group was proved by a significant decrease in the Ca content by 0.49 g (p≤0.01). A positive trend in the content of iodine in the eggs of the hens of the experimental group at the end of the third month of the experiment, 35.8 μg (828.2 %) in comparison with the control was noted.

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