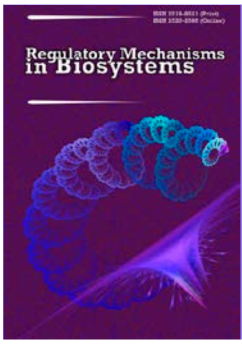

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Enrichment of meat products with selenium by its introduction to mixed feed compounds for birds

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Selenium is a biologically active microelement, contained in a number of hormones and enzymes. In a bird or animal organism selenium performs the following functions: strengthens the immune system, stimulates formation of antibodies, macrophages and interferons. Also, it is a powerful antioxidant agent. It stimulates processes of metabolism in the organism, protects the organism against toxic manifestations of cadmium, lead, thalium and silver; stimulates reproductive function, decreases acute development of inflammatory processes; stabilizes functioning of the nervous system; normalizes functioning of the endocrine system. Furthermore, it stimulates synthesis of hemoglobin, takes part in secretion of erythrocutes, neutralizes toxins, prevents and stops development of malignant tumors. It also has a positive effect on the cardiovascular system of an animal organism: prevents myocardosis and decreases the risk of development of cardiovascular diseases. Deficiency of selenium in the organism causes (depending upon the extent of deficiency) either physiological changes within the regulatory norm, significant disorders of the metabolism, or specific diseases. Around 75 different diseases and symptoms of pain are related to selenium deficiency. In most countries, the level of selenium consumption remains low (20–40 µg/day). There are several ways of improving of the selenium consumption of a population: consumption of selenium as a medication or dietary supplement, producing selenium-enriched bread, growing greens and vegetables rich in selenium, producing selenium-enriched beverages, products of animal origin, which would be rich in selenium. In the scientific-agricultural sphere studies have been made on the influence of adding different doses (0.2–0.6 mg/kg) of selenium in mixed feeds and peculiarities of its depositing and distribution in the muscle tissues of young growth of different species of poultry. It has been found that feeding broiler chickens, baby geese and ducklings with mixed feeds containing selenium in studied doses contributed to a reliable increase in concentration of this microelement in the chest muscles respectively by 21.7–106.7%, 35.1–40.0% and 23.2–66.0% and the leg muscles – by 13.0–85.7%, 57.4–61.7% and 20.5–79.4%. The meat of these types of birds is safe for human consumption from the perspective of food hygiene, for its selenium content is not higher than the TLV of this microelement for meat products (1.0 mg/kg). Consuming selenium-enriched meat of chickens, baby geese and ducklings within recommended physiological norms (115 g of meat products/day) satisfies the daily need of an adult for this microelement (70 µg) y 12.0–23.5%, 29.1–30.6% and 11.3–21.5% respectively. Taking this into account, selenium-enriched bird meat can be considered a dietary foodstuff suitable for biocorrectional function in humans. The viability of enriching bird meat products with selenium by adding selenium-containing premixes to fodder was proven experimentally. It was proven that adding optimum doses of selenium to mixed feeds for young birds bred for meat has a positive effect on the quality of meat, particularly on its biological value.

Keywords: dose; mixed feed; bird meat; accumulation; human

Introduction

The history of the discovery of selenium goes way back to past centuries. According to available information, selenium is considered to be have been discovered around 1300 by alchemist Arnold of Villanova (who lived from about 1235–1310), who studied medicine at the Sorbonne in Paris, and later became a doctor of P. V. Clemens. In the book Rosarium Philosophorum, he describes a red-brown sediment which was left in the furnace after sulfur had been evaporated. It has been suggested that this was an allotropic modification of selenium of a red colour. Unfortunately, the discovery of selenium was forgotten for next 500 years (Baxter, 2005).

The biological role of selenium was first mentioned in the literature in 1842, after the discovery that *Bacillus ferreus* was able to recover conjunctions of selenium. Later studies (in 1885) proved that plants are able to absorb selenium, dissolved for them in water. Futher research proved the impact of selenium on oxidation processes of cell metabolism (Gromova and Gogoleva, 2007). The role of selenium in the diet of animals began to be understood in 1931, after the discovery that the cause to a number of endemic diseases of cattle, swine and poultry in the territory of the Great Plains of America was consumption of plants and seeds with an excessive content of selenium. The manifestations of poisoning by selenium were: loss of weight, hair loss, impacts on articulations, bones, hooves and skin, loss of sight (animals stumbled), paralysis, which caused death from exhaustion.

Similar symptoms were described in 1856 in a case with horses. But they were not mentioned in relation to selenium toxicosis (Schrauzer et al., 2009). Later, areas with excessive content of selenium in plants and the soil and cases of selenium toxicosis in animals were found in Canada, Ireland, Columbia, Australia, England, countries of the Commonwealth of Independent States and other countries.

Until 1958, selenium was considered only as a toxic microelement. And only in 1958 did K. Schwarz and C. Foltz from the National Institute of Health (USA) prove the vital need for selenium by demonstrating through a series of classic experiments that this particular microelement prevents the development of necrotic degeneration of the liver of rats. This initiated usage of selenium compounds in treatment of alimentary hepatitis of swine, exudative diathesis, encephatomacia of poultry and other diseases (Rocha et al., 2017).

In 1974, the Food and Drug Administration of the USA (FDA) aproved adding selenium to the diet of animals and poultry in the form of sodium selenite in doses of 0.1 mg/kg. Then, 5 years later the FDA reconsidered the maximum permissible level of selenium in mixed feeds, and raised it up to 0.3 mg/kg. Later, due to the studies by a number of authors, this level was raised further up to 0.5–1.0 mg/kg, depending on the country (Arnér, 2012).

Over the following years both Ukrainian and foreign researchers conducted significant amount of work on further study of the biological role and mechanism of selenium in organisms.

Selenium is one of the most efficient antioxidants. The antioxidant properties of selenium affect the ways of activating glutathione peroxidase, one of the key enzymes of the system of glutathione functioning. Deficiency of this metal in the organism causes dysfunctions in forming the active form of glutathione peroxidase, which in its turn is followed by significant disorders in functioning of the entire glutathione system (Kumara and Priyadarsinib, 2014; Prashanth et al., 2015; Hariv and Gutyj, 2016; Khariv et al., 2016; Martyshuk et al., 2016; Reich et al., 2016; Gutyj et al., 2017).

At first, the discovery of biological properties of selenium justified its usage for preventing and treating a number of diseases, connected with selenium deficiency, and later – its usage for stimulating growth and development of young birds, and also for improving egg yield, preservation of poultry, improving incubatory characteristics of eggs and a number of other productive qualities.

Many studies have shown that grain fodders which are used for feeding different species and age groups of poultry are deficient in selenium (Papazjan et al., 2008; Surai et al., 2008; Sobolev and Povoznikov, 2016; Sobolev et al., 2017). Nowadays, providing poultry with selenium can be achieved only by adding nonorganic or organic forms of this microelement to mixed feeds (the commonest way is adding selenium to mixed feed through mineral premix). In the future, it is unlikely, that changing the type of plant nutrients will increase the content of the microelement in the main components of mixed feeds to such level which would fully meet the requirements of highly productive poultry for selenium.

Around 75 different diseases and pain symptoms are related to selenium deficiency (Rayman, 2012). Selenium deficiency is considered as a possible etiological factor for 14 cardiovascular diseases, including congestive cardiomyopathy (Keshan disease), atherosclerosis, ishemic heart disease, myocardial infraction, hypertension, and others (Benstoem et al., 2015). Some scholars consider Kashin-Beck disease to be related to selenium deficiency in soils, plants and food products. This severe osteo-articular human disease (which mostly strikes children) is common in the south-east regions of Chita Oblast in Russia, North Korea, North-East China (Yao et al., 2011).

An inverse relationship has been found between the incidence of cancer among people and the content of selenium in food products, organism and environment. In regions with low content of selenium, the risk of malignant neoplasm in the lungs, stomach, colon, rectum, pancreas, mammary glands, prostatitis is heightened (Zachara et al., 2005; Roman et al., 2014; Cai et al., 2016). Pathogenesis of cataract and fibrocystic disease of the pancreas is related to deficiency of a number of elements, including selenium (Kumar et al., 2014). Also, deficiency of selenium is a cause of chronic hepatitis and rhematoid arthritis (Olesińska and Tuszkiewicz-Misztal, 2005; Khan et al., 2012; Rauf et al., 2012).

Provision of selenium to an organism is considered significant for prevention of neuorodegeneration (Alzheimer's disease, Parkinson's disease) (Loef et al., 2011; Pillai et al., 2014). People with selenium deficiency have dysfunctions in the reproductive system, infertility, impotence, and decline of life expectancy due to premature aging (Oguntibeju et al., 2009; Stoffaneller and Morse, 2015).

Nowadays it is already proven that sudden infant death syndrome is caused by deficiency of selenium and vitamin E (Reid, 2007).

Analysis of the population's actual consumption of selenium with crop and livestock products shows insignificant (or even low) level of the organism's provision with this microelement.

Average human consumption of selenium fluctuates significantly: from 10 µg in selenium-deficient regions to 1400 µg in regions with selenoses. Many countries are characterized by mild or low indicators of selenium consumption, and the indicator has been found to be high (to 200 µg/day and higher) only in Canada, Venezuela, the Philippines, Thailand and Japan (Mishanin, 2008). In most countries, the level of selenium consumption with food products remains low (µg/day): New Guinea – 20; Nepal – 23; India – 27; Egypt – 29; Belgium, Serbia, Slovenia – 30; Turkey – 32; England, Spain, Slovakia – 35; Sweden, France, Portugal – 38; Germany, Italy – 43; Austria – 48. Researchers have obseved an annual decrease in consumption of Seelenium (Surai, 2006).

The daily norm of selenium recomended by experts of FAO/WHO is 50–200 µg and is considered sufficient and safe. The minimum human requirement for selenium, according to some studies, is 14 µg/day for women and 19 µg/day for men (Yang et al., 1987), and 40 µg/day, according to other studies (Whanger, 1998). The upper apropriate (safe) level of selenium consumption is 400 µg/day. Globally, the maximum acceptable dose of daily selenium is 800 µg (Fairweather-Tait et al., 2011; Huang et al., 2013).

A number of countries have developed reccomended norms of selenium consumption, such are (µg/day): Great Britain – 75 (men) and 60 (women), Australia – 85 (men) and 70 (women) (Tinggi, 2003); northern countries – 30–60 (adults); Germany, Austria, Switzerland – 70 (men) and 60 (women) (Kipp et al., 2015); Spain – 70 (men) and 55 (women) (Adame et al., 2012); Canada – 50 (adults) (Rayman, 2000); USA – 55 (adults) (Levander, 1999); Russia – 63 (adults) (Tutel'jan, 2009); Belarus – 70 (adults) (Zajcev et al., 2005); Ukraine – 70 (adults) (Normy, 1999); Finland – 120 (adults) (Alfthan et al., 2005). Extrapolation of the abovementioned numbers taking into account the body weight of infants and teenagers allows one to calculate their physiological requirement for selenium.

There are several ways of improving the selenium-consuption status of the population: consumption of selenium as medications or dietary supplements, producing selenium-enriched bread (mostly from imported grains), cultivating greens and vegetables rich in selenium (dill, radish, garlic, etc.), selenium-enrichement of beverages, producing livestock products enriched with selenium (Gorelikova, 2008). The most safe and efficient way of providing the organism with the necessary amount of selenium is through products of livestock and poultry, through compulsory addition to fodder of premixes containing highly efficient biologically acceptable forms of selenium. This would provide a relatively high content of the microelement in meat and dietary products (eggs and milk) and would prevent cases of toxicosis among the population due to the buffer effect of animal tissues. At the same time, such approach would improve the productive qualities of agricultural animals and poultry.

The aim of our research was to study the peculiarities of depositing and distribution of selenium in the muscle tissues of the young of different species of poultry, in relation to its level in the mixed feeds. Also, as the main source for selenium in the human organism is food products, we were interested in whether increasing its concentration in the meat of chickens, goslings and ducklings fed with mixed feeds containing additions of the microelement is safe from the perspective of food hygiene.

Materials and methods

The study was conducted on broiler chickens of COBB 500 cross, goslings of the Gorki breed and ducklings of the Ukrainian white breed (Ukrainian White (UW) line 7), grown for meat. For three scientific-agricultural experiments, we formed three groups of daily young according to principle of analogues with consideration of body weight, origin and physiological condition (moveability, condition of funiculus and feathering). The first scientific-agricultural experiment was conducted on broiler chickens (duration – 42 days), the second – on goslings grown for meat (duration – 75 days), the third – on ducklings grown for meat (duration – 56 days). The duration of every experiment corresponded to a period of growing the species of poultry for meat.

In all scientific-agricultural experiments, the diet of the tested poultry consisted of dry complete mixed feeds, balanced in main nutrient and biologically active components according to the current norms. According to the schemes of experiments, different amounts of selenium were additionaly added to mixed feeds of the poultry from experimental groups (Table 1).

Table 1
The schemes of scientific-agricultural experiments

Group	The number of birds in the group, individuals	Addition of selenium to the mixed feed, mg/kg
I scientific-agricultural experiment		
1 control	100	Main diet (mixed feed) – MD
2 experimental	100	MD + 0.2
3 experimental	100	MD + 0.3
4 experimental	100	MD + 0.4
II scientific-agricultural experiment		
1 control	80	Main diet (mixed feed) – MD
2 experimental	80	MD + 0.4
3 experimental	80	MD + 0.5
4 experimental	80	MD + 0.6
III scientific-agricultural experiment		
1 control	100	Main diet (mixed feed) – MD
2 experimental	100	MD + 0.2
3 experimental	100	MD + 0.4
4 experimental	100	MD + 0.6

Note: selenium was added to the mixed feed for poultry in mineral premixes; as a source of selenium, sodium selenite of "Ch" classification (TC 6-09-17-209-88 registered in identifier of chemical substances (CAS) by the number 10102-18-8), with coefficient of conversion of element into oxide equals 2.19.

The young poultry of all species were reared on deep litter with free access to fodder and water, in compliance with technological parameters of stocking density, microclimate and illumination according to current norms. After scientific-agricultural experiments, we chose 4 individuals (2 females and 2 males) of birds from each group, and executed control slaughter according to the generally accepted method. During anatomical analysis and deboning of meat, we collected average samples of chest and leg muscles for chemical analysis.

The content of selenium in meat was defined through atomic absorption method using AAS "Saturn-3 P1" [Сатурн-3 П1] with air-acetylene flame and provisional humid mineralization of samples. Relative biological meat value was calculated using the micromethod with test-organism of *Tetrahymena pyriformis* ciliate, biological strain WH14. Mathematical analysis of the study results was conducted in Statistica 6.0 (StatSoft Inc., USA). Differences between average values were considered statistically significant at P < 0.05 (ANOVA).

Results and discussion

The data obtained allowed to conclude that increase in the level of selenium in mixed feeds for the young poultry of different species causes increase in selenium concentration in their muscle tissues. Analysis of samples of broiler chickens' muscle tissues showed that selenium concentration in chest muscles of the young from the second experimental group, compared to the control, was significantly higher by 21.7%, from the third group – by 70.0% and from fourth – by 106.7% and in absolute values, it equaled 7.3 µg % (P < 0.05), 10.2 (P < 0.01) and 12.4 µg % (P < 0.001) of fresh tissues (Table 2).

Clearly manifested difference among the broiler chickens from experimental groups was observed also for concentration of selenium in leg muscles. This indicator for the young of the control group equaled 7.7 µg %. At the same time, among the birds of the same age from the second experimental group the indicator was higher by 13.0% (P < 0.01), from the third group – by 57.1 (P < 0.001) and the fourth – by 85.7% (P < 0.001). We should also mention the fact that depositing of selenium in the chest muscles of broiler chickens was manifested less clearly than in the leg muscles, which is possibly related to functional peculiarities of these two groups of muscle tissues.

Concentrations of selenium in muscle tissues of goslings was quite different (Table 3). Among the birds from the control group, concentration of selenium was higher in the chest muscles (11.5 against 13.1 µg %). Feeding goslings of the experimental groups while they were reared on mixed feeds enriched with different doses of selenium contributed to better accumulation of the microelement in the muscle tissues. Leg muscles of the young from the experimental groups (except the fourth group) contained more selenium than chest muscles. Leg muscles of goslings from the second experimental group contained the concentration of the microelement which was reliably higher (P < 0.001) by 57.4%, from the third group – by 60.0 and from the fourth – by 61.7% compared to the corresponding indicator of the control group (11.5 µg %).

Compared to the control group, the difference in concentration in chest muscles was higher among birds from the experimental groups (2–4) and was only 35.1%, 38.9% and 42.0% respectively, though this had a high probability (P < 0.001).

It should also be mentioned that the concentration of selenium in chest and leg muscles of goslings from the fourth experimental group, where selenium was added to the mixed feed in amount of 0.6 mg/kg, was the same and equaled 18.6 µg %. Analysis of the character of the microelemnt deposits allows us to state that increase in the level of selenium in mixed feeds for goslings slows the increase in its concentration in the muscles. The obtained results indicate that the birds' ability to accumulate selenium in the organs and tissues is limited.

Table 2
Concentration of selenium in muscle tissues of broiler chickens (µg %, x ± SD, n = 4)

Group of muscles	Group			
	1 control	2 experimental	3 experimental	4 experimental
Chest muscles	6.0 ± 0.34	7.3 ± 0.23*	10.2 ± 0.71**	12.4 ± 0.70***
Leg muscles	7.7 ± 0.17	8.7 ± 0.13**	12.1 ± 0.32***	14.3 ± 0.43***

Note: in this and next tables significant difference between the control and the experimental groups: * – P < 0.05, ** – P < 0.01, *** – P < 0.001.

The results of the analysis of duck meat showed that selenium was found in all studied samples. The meat of ducklings which were fed with mixed feed with addition of selenium contained a larger concentration of the microelement (Table 4). The concentration of selenium in chest and leg muscles of ducklings from the control group was only 5.6 and 7.3 µg % respectively.

The level of selenium in muscles of ducklings from the experimental groups was related to its concentration in the mixed feeds. It was higher in chest muscles of ducklings from the second experimental group by 23.2% (P < 0.05), from the third – by 60.7% (P < 0.01) and from the fourth – by 66.0% (P < 0.01) than among birds of control group. The concentration of selenium in leg muscles of the young from the second experimental group increased to 8.8 µg %, from the third – to 12.8 and from the fourth – to 13.1 µg %. The difference in relation to the control group was 20.5%, 75.3% (P < 0.001) and 79.4% (P < 0.001) respectively. It should also be mentioned that ducklings grown for meat from the control and experimental groups were different from broiler chickens and goslings grown for meat in their relatively lower cumulative capacities, which is probably related to species, genetic and physiological factors.

Growing young poultry for meat is related to significant expenses for basic means of production, inputs and labour resources, which pay off only if the final product meets technological requirements. Therefore the ultimate indicator of efficiency of poultry meat production is the quality of the goods, its ability to satisfy clients. Analysis of data from the available literature showed that researchers who studied the impact of selenium on bird organisms, have covered the aspect of meat quality insignificantly. Researchers were first of all studying the quantative indicators (live weight and preservation of birds, conversion of fodder, morphological compound of carcass, etc.), and only then analyzing the qualitative compound of meat (content of water, protein, fat and mineral substances). The impact of selenium additives to mixed feeds on the biological meat value of different species of poultry, its physical and chemical and organoleptic properties has remained almost unresearched. It is known, that chemical compound of meat does not fully determine the biological value of product, but has a certain importance in evaluating its quality. The real value of a product depends on the extent of its absorption by and safety for the human organism.

Nowadays, more complex evaluation of quality of poultry meat in scientific stydies uses biological express methods. Among the criteria recommended for evaluation of meat quality, the most objective is the indicator of the biological value, which determines the level of a product's accordance to optimum needs of humans and which guarantees safety in compliance with physiological norms. Toxic-biological evaluation of meat products uses one of the most promising test objects – *Tetrahymena pyriformis*. The intensity of ciliates' breeding in meat samples indicates its biological value, and number of dead ciliates and altered forms of ciliates indicate the toxicity of samples.

The criteria of relative biological meat value is the number (expressed in percents) of ciliates grown over three days in experimental samples compared to number of ciliates grown in control samples. Considering the significance of this issue, we also studied the impact of adding different doses of selenium to mixed feeds on biological value of muscle tissues of broiler chickens, goslings and ducklings, grown for meat. Data provided in Table 5 shows that adding different doses of selenium to mixed feeds generally had a positive, although mixed, effect on the biological meat value of broiler chickens.

The relative biological value of chest muscles of broiler chickens from the experimental groups increased by 3.9–5.4% compared to the control group. It should be mentioned that of all selenium doses, the biggest impact on biological value of chest muscles of the young was achieved with the dose of 0.2 mg/kg. With addition of selenium in doses of 0.3 and 0.4 mg/kg to mixed feeds, a tendency of gradual decrease in the indicator of relative biological value of chest muscles was observed.

A tendency of increase in relative biological value of hip muscles was observed only among the young from the third and the fourth experimental groups – by 2.8 and 1.7% respectively; at the same time among birds from the second experimental group it was lower by 1.0% compared to the control. Study of muscular tissue samples of goslings showed that the young from experimental groups mainly had slightly better indicators of meat quality. Despite the absence of reliable differences between groups, values of the biological value of chest and leg muscles of birds from experimental groups in a certain way indicates the impact of adding selenium (Table 6). The number of grown ciliates in the samples of chest muscles of goslings from the experimental groups was higher compared to the control samples: in the second group – by 4.0%, in the third – by 3.0% and in the fourth – by 2.9%. The difference between the groups according to the similar indicator of leg muscles was lower – respectively 3.4%, 2.8% and 2.1% (higher in the experimental groups). The data provided in able 7 shows that feeding goslings with complete mixed feeds enriched with selenium in a dose of 0.2 mg/kg, resulted in indicators practically similar to the control group. The difference between the control and the second experimental group in the number of grown ciliates in samples of chest and leg muscles was 1.2% and 1.0% relatively.

Table 3
Concentration of selenium in muscle tissues of goslings reared for meat (µg %, x ± SD, n = 4)

Group of muscles	Group			
	1 control	2 experimental	3 experimental	4 experimental
Chest muscles	13.1 ± 0.29	17.7 ± 0.58***	18.2 ± 0.66***	18.6 ± 0.39***
Leg muscles	11.5 ± 0.31	18.1 ± 0.71***	18.4 ± 1.12***	18.6 ± 0.36***

Table 4
Concentration of selenium in muscle tissues of ducklings grown for meat (µg %, x ± SD, n = 4)

Group of muscles	Group			
	1 control	2 experimental	3 experimental	4 experimental
Chest muscles	5.6 ± 0.19	6.9 ± 0.38*	9.0 ± 0.54**	9.3 ± 0.54**
Leg muscles	7.3 ± 0.36	8.8 ± 1.77	12.8 ± 0.18***	13.1 ± 0.31***

Table 5
Biological value meat of broiler chickens (x ± SD, n = 4)

Indicator	Group			
	1 control	2 experimental	3 experimental	4 experimental
	Chest muscles			
Number of grown ciliates, individuals/ml	$6.41 \pm 0.274 \times 10^4$	$6.76 \pm 0.109 \times 10^4$	$6.71 \pm 0.153 \times 10^4$	$6.66 \pm 0.108 \times 10^4$
Relative biological value, %	100.0	105.4	104.7	103.9
	Leg muscles			
Number of grown ciliates, individuals/ml	$8.69 \pm 0.266 \times 10^4$	$8.60 \pm 0.330 \times 10^4$	$8.93 \pm 0.086 \times 10^4$	$8.84 \pm 0.117 \times 10^4$
Relative biological value, %	100.0	99.0	102.8	101.7

Table 6
Biological value of meat of goslings (x ± SD, n = 4)

Indicator	Group			
	1 control	2 experimental	3 experimental	4 experimental
	Chest muscles			
Number of grown ciliates, individuals/ml	$6.23 \pm 0.352 \times 10^4$	$6.48 \pm 0.169 \times 10^4$	$6.42 \pm 0.341 \times 10^4$	$6.41 \pm 0.196 \times 10^4$
Relative biological value, %	100.0	104.0	103.0	102.9
	Leg muscles			
Number of grown ciliates, individuals/ml	$8.08 \pm 0.229 \times 10^4$	$8.36 \pm 0.144 \times 10^4$	$8.31 \pm 0.206 \times 10^4$	$8.25 \pm 0.220 \times 10^4$
Relative biological value, %	100.0	103.4	102.8	102.1

Table 7
Biological value of meat of ducklings, (x ± SD, n = 4)

Indicator	Group			
	1 control	2 experimental	3 experimental	4 experimental
	Chest muscles			
Number of grown ciliates, individuals/ml	5.79 ± 0.083 × 10^4	5.86 ± 0.143 × 10^4	6.14 ± 0.075 × 10^4*	6.11 ± 0.095 × 10^4*
Relative biological value, %	100.0	101.2	106.0	105.5
	Leg muscles			
Number of grown ciliates, individuals/ml	7.72 ± 0.095 × 10^4	7.73 ± 0.124 × 10^4	8.01 ± 0.073 × 10^4*	7.94 ± 0.101 × 10^4
Relative biological value, %	100.0	100.1	103.7	102.8

Note: see Table 2.

After higher doses of selenium in mixed feeds (0.4 and 0.6 mg/kg), the intensity of breeding of ciliates was higher in the meat of the young from the experimental groups compared to the control, though the difference was significantly higher. The indicator for the samples of chest muscles of ducklings from the control group was 5.79 × 10^4 individuals/ml, whereas for the poultry from the third and the fourth experimental groups, the indicator was significantly higher ($P < 0.05$) by 6.0% and 5.5% respectively. Relative biological value of leg muscles of ducklings from the third and the fourth experimental groups was higher by 3.7 ($P < 0.05$) and 2.8% respectively compared to the control. We should also mention the fact that in all studied samples of meat of broiler chickens, ducklings and goslings we found no dead or altered ciliates after 24 hours of incubation, which indicates non-toxicity of the samples, therefore safety for human.

Researchers who studied the connection between selenium and quality of poultry meat products explain increase in biological meat value through positive changes in content and profiles of essential amino acids in proteins and fatty-acid compound of lypids, on the one hand, and through slowing of oxydation of proteins and unsaturated fatty acids in lypids, and decomposition of formed peroxids, on the other hand. Thus, the possibility of enriching poultry meat products with selenium by adding selenium-containing premixes to fodders was experimentally proven. Such approach achieves a dampening effect for humans and eliminates the possibility of toxicoses, which would be possible due to specific dietary preferences of particular individuals and binge consumption of a product enriched with micronutrient.

Considering the obtained results, we can state that meat of the young of different poultry, which were given selenium additives of the abovementioned doses in mixed feeds, is a good source of this microelement for humans, where it appears in the most useful form as protein metalorganic complexes. Consuming selenium-enriched meat of chickens, goslings and ducklings within the recommended physiological norm (115 g of meat products a day) would satisfy an adult's daily need in the microelement (70 μg) by 12.0–23.5%, 29.1–30.6% and 11.3–21.5% respectively.

Therefore, our studies showed that adding optimum doses of selenium to mixed feeds of the young poultry grown for meat, positively affects the quality of the meat, particularly its biological value.

Conclusions

Feeding broiler chickens, goslings and ducklings with mixed feeds with additions of selenium in the studied doses, which are considered to be safe from the perspective of food hygene, increases the concentration of this microelement in chest muscles by 21.7–106.7%, 35.1–40.0% and 23.2–66.0% respectively and in leg muscles – by 13.0–85.7%, 57.4–61.7% and 20.5–79.4%, which does not exceed TLV for meat products (1.0 mg/kg).

The value of selenium deposits in muscle tissues is related to species of poultry, group of muscles and its level in mixed feeds.

Considering the abovementioned evidence, selenium-enriched poultry meat can be considered a dietary food product of functional significance for humans, with biocorrectional effect.

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