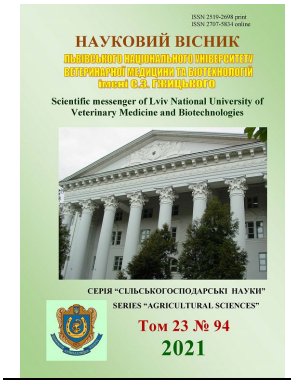

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The influence of selenium additives in compound feed on the chemical composition, energy and biological value of ducklings meat

O. I. Sobolev[1], S. V. Sliusarenko[1], A. O. Sliusarenko[1], R. A. Petryshak[2], I. P. Golodyuk[2], O. S. Naumyuk[2], O. I. Petryshak[2], O. V. Kuliaba[2]

[1]*Bila Tserkva National Agrarian University, Bila Tserkva, Ukraine*
[2]*Stepan Gzhytskyi National University of Veterinary Medicine and Biotechnologies Lviv, Ukraine*

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Bila Tserkva National Agrarian University, 8/1, Soborna Sq., Bila Tserkva, 09117, Ukraine.
Tel.: + 38-096-443-91-50
E-mail: sobolev_a_i@ukr.net

Stepan Gzhytskyi National University of Veterinary Medicine and Biotechnologies Lviv, Pekarska Str., 50, Lviv, 79010, Ukraine.

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According to modern classification of trace elements, which is based on their biological significance for living organisms, selenium is classified as a group of vital or biogenic elements. As a biotic element, it has unique physico-chemical and biochemical properties and, with adequate intake into the body of farm animals and poultry has a positive effect on a number of physiological processes. The discovery of biological properties of selenium became the basis for its use first in the prevention and treatment of many diseases associated with a deficiency of this trace element, and later – as a stimulator of growth and development of young animals, as well as in order to increase egg production, poultry safety, improve the incubation characteristics of eggs and several other productive qualities. Scientists who have studied the effects of selenium on poultry have paid relatively little attention to meat quality. The effect of additives of different selenium doses in compound feed on the chemical composition, energy and biological value of Ukrainian white breed ducklings' meat was studied in the scientific and economic experiment. Four groups of ducklings with 100 heads in each groups were formed to conduct the scientific and economic experiment. The duration of the experiment was 56 days and corresponded to the period of raising ducklings for meat. The ducklings of the first control group did not receive selenium supplementation. Selenium was additionally introduced into compound feed for poultry of the experimental groups in the following amount, mg/kg: the second group – 0.2; the third – 0.4 and the fourth – 0.6. It was established that the introduction of selenium into compound feed in the studied dose did not significantly affect to the quality of ducklings' meat, although it had a positive effect on some indicators that characterize its chemical composition, nutritional and biological value. Among the experimental groups, ducklings of the third and fourth groups, which were injected with selenium into compound feed at the rate of 0.4 and 0.6 mg/kg, stood out in terms of meat quality.

Key words: *selenium, dose, compound feed, ducklings, meat quality.*

Вплив добавок селену в комбікорми на хімічний склад, енергетичну та біологічну цінність м'яса каченят

О. І. Соболєв[1], С. В. Слюсаренко[1], А. О. Слюсаренко[1], Р. А. Петришак[2], І. П. Голодюк[2], О. С. Наумюк[2], О. Й. Петришак[2], О. В. Куляба[2]

[1]*Білоцерківський національний аграрний університет, м. Біла Церква, Україна*
[2]*Львівський національний університет ветеринарної медицини та біотехнологій імені С. З. Ґжицького, м. Львів, Україна*

Згідно з сучасною класифікацією мікроелементів, в основі якої лежить їх біологічне значення для живих організмів, селен віднесено до групи життєво необхідних, або біогенних елементів. Як біотичний елемент він володіє унікальними фізико-хімічними та біохімічними властивостями і при адекватному надходженні в організм сільськогосподарських тварин і птиці здійснює позитивний вплив на ряд фізіологічних процесів. Відкриття біологічних властивостей селену стало підставою для використання його спочатку у профілактиці та лікуванні багатьох хвороб, пов'язаних із дефіцитом цього мікроелементу, а згодом – як стимулятора росту і розвитку молодняку, а також з метою підвищення несучості, збереженості птиці, поліпшення інкубаційних характеристик яєць та низки інших продуктивних якостей. Вчені, які вивчали дію селену на організм сільськогосподарської птиці, приділяли відносно мало уваги якості м'яса. У науково-господарському досліді вивчено вплив добавок різних доз селену в комбікорми на хімічний склад, енергетичну та біологічну цінність м'яса каченят української білої породи. Для проведення науково-господарського досліду було сформовано чотири групи каченят по 100 голів у кожній. Тривалість досліду становила 56 дні і відповідала періоду вирощування каченят на м'ясо. Каченята першої контрольної групи добавку селену не одержували. У комбікорми для птиці дослідних груп додатково вводили селен у такій кількості, мг/кг: друга група – 0,2; третя – 0,4 та четверта – 0,6. Встановлено, що введення в комбікорми селену, в дозах які вивчалися, істотно не вплинуло на якість м'яса каченят, хоча позитивно позначилося на деяких показниках, що характеризують його хімічний склад, поживну та біологічну цінність. Серед дослідних груп, вигідно виділялися за якістю м'яса каченята третьої та четвертої групи, яким у комбікорми вводили селен із розрахунку 0,4 та 0,6 мг/кг відповідно.

Ключові слова: *селен, доза, комбікорм, каченята, якість м'яса.*

Introduction

The poultry meat production is the most dynamic branch of agro-industrial complex, capable in the coming years to radically improve the provision of high-quality dietary food products to the population of Ukraine and strengthen the food security of the state.

The results of numerous research and world experience in this industry show that the key to maximum realization of genetic potential, high productivity and preservation of livestock, as well as rational use of feed resources are full-fledged feeding of poultry. The modern system of rationed feeding provides full satisfaction of the individual needs of different poultry species in metabolic energy, nutrients and biologically active substances, including trace elements (Bratyshko et al., 2013).

In spite of the fact that there is a significant number of scientific works on the problem of mineral nutrition of poultry, the list of trace elements used in its diet is clearly insufficient. According to scientists, selenium is one of the trace elements that must be included in poultry feed.

According to the current classification of trace elements, which is based on their biological significance to the body and their effect on the immune system, selenium is classified as vital elements (Oberlis et al., 2008; Surai et al., 2018).

According to the results of numerous scientific studies, selenium is a trace element with a wide spectrum of biological action (Sobolev et al., 2018). It has antioxidant (Surai, 2002; Zoidis et al., 2018), radioprotective (Brown et al., 2010; Graupner et al., 2016), immuno stimulating (Surai & Taylor-Pickard, 2008; Huang et al., 2012), antiviral (Read-Snyder et al., 2009; Shojadoost et al., 2019), antitoxic (Mughal et al., 2017; Zwolak, 2020), adaptogenic (Habibian et al., 2015; Shakeri et al., 2020) and other properties.

The discovery of biological properties of selenium became the basis for its use first in the prevention and treatment of many diseases associated with a deficiency of this trace element, and later – as a stimulator of growth and development of young animals, as well as in order to increase egg production, poultry safety, improve the incubation characteristics of eggs and several other productive qualities (Sobolev & Pacelja, 2015; Surai, 2018).

The first attempts to use selenium in zootechnical practice already allowed us to obtain results that prove the absolute need to determine effective standards for introducing it into compound feed for poultry and, in particular, for ducklings.

Analysis of available literature sources shows that there are too few published data on the optimal rates of selenium introduction in compound feed for ducklings raised for meat and they are contradictory. However, it is well known that the minimum selenium requirement for all poultry species is 0.10 mg/kg of feed (Pardechi et al., 2020).

European standards for the introduction of trace elements in compound feed for ducklings provide the addition of selenium at a dose of 0.14 mg/kg (Egorov et al., 2000).

Scientists from Russia believe that the guaranteed addition of selenium to compound feed for fattening ducklings should be 0.2 mg/kg of feed (Okolelova et al., 2004). At the same time, they note that this norm is indicative and can be adjusted to meet the recommendations for a specific ducks breed or ducks cross.

There are reports in the literature that the optimal selenium content in the diet of ducklings can be considered of 0.25 ± 0.05 mg/kg (Kasumov, 1981).

Italian scientists claim that selenium should be introduced into compound feed for ducklings meat at a dose of 0.3 mg/kg (Bonomi et al., 2001).

Domestic scientists recommend introducing selenium at a dose of 0.1 mg/kg in compound feed for ducklings (Bratishko et al., 2013). However, this dose corresponds only to the minimum physiological poultry need in this trace element.

At the same time, further studies conducted by Ukrainian scientists have shown that ducklings have the best productive qualities at the rate of selenium introduction into compound feed of 0.4 mg/kg (Sobolev, 2012).

In developing and scientifically justifying the optimal rate of selenium introduction into compound feed for ducklings, the assessment system should include a set of

indicators that characterize not only the productivity of young animals, but also the quality of their meat. Duck meat is tender, juicy, and has a specific taste. It contains all substances necessary for human nutrition: proteins, fats, mineral elements, vitamins and extractives.

Analysis of available literature sources shows that scientists who have studied the effect of selenium on the ducklings body have paid relatively little attention to meat quality. For researchers, the criteria of selenium nutrition fullness were primarily the growth rate of young animals, their safety, the cost of feed per unit of production, individual morphological and biochemical parameters of blood. The qualitative composition of poultry meat interested them only from the point of view of selenium deposition in muscle tissue and internal organs.

Due to the lack of scientific work on the effect of selenium on the chemical composition, energy and biological value of duckling meat, when feeding it as part of mixed feeds, there was a need for additional research.

Material and methods

The research was conducted on Ukrainian white ducklings breed (line UB-7), raised for meat. To conduct a scientific and economic experiment, groups of daily young animals were formed according to the principle of analogues. Four groups of 100 ducklings in each were formed. The duration of the experiment was 56 days and corresponded to the period of raising ducklings for meat.

According to existing standards, the ducklings were fed with dry complete mixed feeds during the growing period, which is balanced by the main nutrients and biologically active substances. The poultry of the first control group did not receive selenium supplementation in mixed feed. The ducklings of the experimental groups were additionally introduced into compound feed with different amounts of selenium according to the experiment scheme (Table 1).

Table 1
Scheme of scientific experience

Group	Number of poultry in the group	Selenium supplement in compound feed, mg/kg
1 control group	100	Compound feed - CF
2 experimental group	100	CF + 0.2
3 experimental group	100	CF + 0.4
4 experimental group	100	CF +0.6

Selenium was introduced as part of a mineral premix in compound feed for ducklings. Sodium selenite was used as a source of selenium.

According to existing standards, the ducklings were raised on a deep litter, with free access to feed and water, in compliance with the technological parameters of amount of floor space per bird, microclimate and lighting (Galibarenko et al., 2005).

At the end of the scientific and economic experiment, at 56 days of age, 4 poultry were selected from each group according to technical specifications (DSTU 3136-95, 1996) and their control slaughter was carried out. During the control slaughter, the condition of poultry internal organs and tissues was assessed. After the control slaughter of ducklings, a complete anatomical disassembly and collapse of their carcasses was carried out in accordance with the existing methodological recommendations (Lukashenko, 2013).

During anatomical disassembly and collapse of duckling carcasses, average samples of muscle tissue (thigh, drumstick and pectoral muscles) were taken for chemical analysis (GOST 7702.2.0-95, 2009).

The following methods and techniques were used to study the chemical composition of duckling muscle tissue:

– mass fraction of moisture-by drying the sample in a drying oven at a temperature of 100–105 °C to a constant mass (DSTU ISO 1442:2005, 2008);

– mass fraction of nitrogen and protein by Kjeldahl method (DSTU ISO 937:2005, 2007);

– mass fraction of fat – extraction with ethyl alcohol in Soxhlet apparatus (DSTU ISO 1443:2005, 2007);

– mass fraction of ash – by burning the sample in a muffle furnace at a temperature of 525–550 °C (DSTU ISO 936:2008, 2010).

The energy value of duckling meat was determined according to the existing methodology (Pro, 2018) and calculated by the formula:

$$E = [D – (F + A)] \times 4.0 + (F \times 9.0),$$

where E is the energy value of meat, kcal/100 g; D is the dry matter content in meat, %; F is the fat content in meat, %; A is the ash content in meat, %.

The relative biological value of meat was determined by a micrometode using the test-organism of the infusoria Tetrahymene pyriformis, strain WH14 (Mikitjuk et al., 2004).

Statistical processing of research results was performed using Excel spreadsheets. The probability of difference between the groups was evaluated by Student's test.

Results and discussion

A comparison the commercial type of duckling carcasses, no significant differences between the control and experimental groups were found. In ducklings of the experimental groups, the carcass muscles were generally well developed, slightly moist, pink, and elastic on the cut. The keel of the sternum did not prominent. Subcutaneous fat deposition was observed on the sternum and abdomen. The carcass muscles of young animals of the control group were developed satisfactorily, although the keel of the sternum bone was not prominent. There were minor deposits of subcutaneous fat on the sternum

and abdomen. All the carcasses had a specific smell inherent to fresh poultry meat.

During the anatomical disassembly and collapse of duckling carcasses of experimental groups, no pathological changes in organs and tissues or deviations from the control were noted.

Analysis of the research results of duckling muscle tissue revealed some differences between the control and experimental groups, which, in our opinion, are caused by the introduction of different selenium doses into the composition of mixed feeds. Although the difference in most indicators was unlikely, the ducklings of the experimental groups had slightly better meat quality (Table 2).

Table 2

Chemical composition, energy and biological value of meat at 56 days of age ducklings, ($\overline{X} \pm S_{\overline{X}}$, n = 4)

Indicator	Group			
	1 control	2 experimental	3 experimental	4 experimental
	Pectoral muscles			
The content of , %:				
dry matter	23.7 ± 0.23	24.0 ± 0.40	23.9 ± 0.57	23.8 ± 0.02
protein	20.0 ± 0.07	20.1 ± 0.62	20.1 ± 0.37	20.2 ± 0.18
fat	2.3 ± 0.25	1.8 ± 0.11	2.0 ± 0.26	1.9 ± 0.18
ashes	1.1 ± 0.10	1.3 ± 0.24	1.2 ± 0.16	1.2 ± 0.16
Energy value, kcal/100 g	101.9 ± 2.37	99.7 ± 1.72	100.9 ± 3.69	100.2 ± 1.34
The number of grown ciliates, units/ml	5.69 ± 0.125 ×10⁴	5.74 ± 0.228 ×10⁴	6.01 ± 0.094 ×10⁴	6.02 ± 0.140 ×10⁴
Relative biological value, %	100.0	100.9	105.6	105.8
	Thigh and drumstick muscles			
The content of, %:				
dry matter	27.6 ± 0.26	29.1 ± 0.19**	29.1 ± 0.32*	28.4 ± 0.44
protein	19.4 ± 0.24	19.0 ± 0.09	19.4 ± 0.40	19.5 ± 0.18
fat	6.9 ± 0.24	8.3 ± 0.10**	7.8 ± 0.63	7.0 ± 0.56
ashes	0.9 ± 0.08	1.0 ± 0.05	1.1 ± 0.06	1.1 ± 0.06
Energy value, kcal/100 g	141.2 ± 1.30	153.9 ± 0.99***	151.1 ± 4.36	144.1 ± 4.66
The number of grown ciliates, units/ml	7.62 ± 0.100 ×10⁴	7.60 ± 0.227 ×10⁴	7.88 ± 0.110 ×10⁴	7.82 ± 0.111 ×10⁴
Relative biological value, %	100.0	99.7	103.4	102.6

Note: the probability of difference between the control and experimental groups: * – P < 0.05; ** – P < 0.01; *** – P < 0.001

The data from chemical analysis showed that in the ducklings pectoral muscles of the experimental groups, the dry matter content slightly increased compared to the control group (by 0.1–0.3 %) and amounted to: in the second by 24.0 %, the third by 23.9 and the fourth by 23.8 %. It should be noted that with increasing selenium concentration in the diet, the dry matter content in the pectoral muscles decreased and approached to the level of the control group.

In the thigh and drumstick muscles, this pattern also persisted, but the differences in dry matter content between the groups were more significant. Thus, in the second and third experimental groups, the difference was 1.5 % in compared to the control group and was statistically significant (P < 0.01 and P < 0.05, respectively), in the fourth was 0.8 %.

Selenium supplements to compound feed didn't have a significant effect on protein deposition in the meat of experimental ducklings. However, in the poultry' pectoral muscles of the experimental groups, its content was slightly higher by 20.1–20.2 % against 20.0 % in the control group.

In the thigh and drumstick muscles of ducklings in the control and third experimental groups, the amount of protein was the same and amounted to 19.4 %, while in their peers from the second experimental group it was 0.4 % lower, and in the fourth was 0.1 % higher.

At the same time, the nature of fat deposition in research muscles significantly changed. Its content in the poultry' pectoral muscles of the experimental groups decreased by 0.3–0.5 %, and in the thigh and drumstick muscles it increased by 0.1–1.4 %, compared to the control group, where similar indicators were 2.3 and 6.9 %, respectively. At the same time, the differences in this indicator in the pectoral muscles didn't have a certain natural relationship with selenium level in mixed feeds.

If we consider that the ability to deposit fat depends on the amount of inter-bundle connective tissue, then we can assume that selenium supplements have different effects on its development in individual muscles.

It was also established that the ash content of meat increased in ducklings of experimental groups. In the pectoral muscles of young animals of the third and fourth experimental groups, the ash content was the same and was equal to 1.2 %, and in the thigh and drumstick muscles were 1.1 %. Compared to the control group, the difference was 0.1 and 0.2 %, respectively. In contrast, the poultry of the second experimental group had 0.2 % more ash in pectoral muscles and in thigh and drumstick muscles only 0.1 %.

The amount of basic nutrients in meat, in particular protein and fat, also depended on its caloric content. Determination of the chemical composition of the energy value of pectoral muscles showed that the young animals

of the experimental groups were slightly inferior in this indicator to their peers from the control group (99.7–100.9 kcal/100 g vs. 101.9 kcal/100 g).

More significant differences, but already in favor of the experimental groups, were found in the thigh and drumstick muscles. Thus, the energy value of 100 g of ducklings' thigh and drumstick muscles of the second experimental group was 153.9 kcal, the third was 151.1 and the fourth was 144.1 kcal, which was 9.0 % ($P < 0.001$), 7.0 and 2.0 %, respectively, more than in young animals of the control group. It should be noted that the caloric content of the studied muscles was largely determined by the fat content in them.

It is known that the high nutritional and energy value of a product is not always a guarantee of its high quality. The real value of a product depends not only on its chemical composition, but also on the degree of assimilation and harmlessness to the body.

Today, for a more complete assessment quality of animal products, including poultry meat, biological methods are increasingly used in scientific research and practice, which will allow us to make a conclusion about the biological value of the product, that is, its physiological usefulness in accordance with the body's needs. For rapid methods in determining the biological value of product, one of the most convenient and promising test objects is considered to be infusoria Tetrahymena pyriformis. A conclusion is made about its biological value according to the intensity of ciliates reproduction in meat samples, and in the presence of dead ciliates and altered forms about the toxicity of studied samples.

The results of the research showed that the biological value of ducklings meat of the third and fourth experimental groups was higher, compared with the control group. Thus, the ducklings' pectoral muscles of these groups had a relative biological value of 105.6 and 105.8 %, and the thigh and drumstick muscles had 103.4 and 102.6 %, respectively. The difference between the control and second experimental groups in this indicator was insignificant: in the pectoral muscles was 0.9 % in favor of the latter and in the thigh muscles was 0.3 % in favor of the former.

The evidence of non-toxicity of duck meat was the absence of dead ciliates and any pathological changes in the Tetrahymena pyriformis in all the studied samples during the incubation period.

The lack of data in the scientific literature on qualitative changes in the muscle tissue of ducklings under the influence of selenium-containing drugs does not allow us to compare the data obtained by us. At the same time, they are consistent with similar data obtained on other poultry species.

Conclusions

It was established that the introduction selenium into compound feed in the studied dose didn't significantly affect the quality of ducklings' meat, although it had a positive effect on some indicators that characterize its chemical composition, nutritional and biological value. Among the experimental groups, ducklings of the third and fourth groups, which were injected selenium into compound feed at the rate of 0.4 and 0.6 mg/kg, stood out in terms of meat quality.

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