EFFICIENCY OF ADDING ESSENTIAL MICRONUTRIENTS TO THE DIET OF BROILER CHICKENS

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Abstract: Selenium is an indispensable component for fattening broiler chickens of meat productivity. It normalizes their growth and metabolism by participating in the redox transformations of glutathione. The goal of this work was to examine the possibility of using a drug based on selenium nanoparticles and the "Ekstraselen+Vit" vitamins in the diet of broiler chickens. It is experimentally proved that supplementing the diet of poultry with a feed preventative additive leads to higher growth rates and lower mortality rates of young poultry, lower feed costs per unit of yield. During a scientific and economic experiment, we determined that there was an increase in the pre-slaughter weight, slaughter yield and the yield of certain carcass parts in accordance with anatomical butchering. Data on blood haematological parameters of broiler chickens is presented. We identified the improved chemical composition and functional-technological properties of raw meat, produced from broiler chickens, grown with the use of "Ekstraselen+Vit". The concentrations of selenium in the poultry processing products were determined. It was found that the use of the feed additive in the diet, based on selenium nanoparticles, contributes to the accumulation of this element in broiler chickens bodies. It is feasible to use enriched meat to produce medical and preventative food.

Keywords: Broiler chickens, selenium, vitamins, conversion, growth, anatomical butchering, chemical composition, microbiological parameters

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INTRODUCTION

Full feeding is an essential component that ensures high productivity of the birds, preservation of health, resistance to adverse environmental factors, quality improvement of raw meat and feather-down products. Without properly organized bird feeding, the genetic potential of poultry remains unfulfilled. Domestic and foreign experience shows that in the preparation of feed regimens for broiler chickens, a lot of attention is paid to the selection of vitamins and minerals.

Supplying poultry with the optimal amount of vitamins and minerals can improve the body's metabolism, ensure normal functioning of the immune system, and enhance the body's natural resistance.

In recent years, the research, aimed at identifying the needs of birds in certain mineral elements has become more active. Previously, these minerals were not taken into account in the preparation of food regimens; however, it is proved that they have a significant effect on the body. Selenium, which is recognized as an essential biotic ultra-microelement, also refers to these elements and their compounds that draw attention of experts and scholars in the field of poultry production.

Selenium is essential for the activity of people and animals. This biologically active microelement, which is found in a number of hormones and enzymes, is connected with all organs and systems.

The spectrum of biochemical effects of selenium in the bodies of humans and animals is quite broad, at the same time, the most studied function of selenium is the regulation of antioxidant processes in all organs and tissues, and, primarily, in the central nervous system. Selenium plays a very important role in the immune system activity; in particular, the levels of A, G and M immunoglobulin decrease in case of selenium deficiency.

It is now established that selenium deficiency is a cause of the increased risk of oncological and cardiovascular diseases, the development of arthritis, high infant mortality and various malformations in children (if women have selenium deficiency during pregnancy), cataract, coronary atherosclerosis, hypothyroidism, as well as increased risk of AIDS development. Selenium compounds are effective in preventive medicine. The introduction of selenium into a human body with the daily doses up to 200 mg during 4.5 years does not cause toxic effects. At the same time, the incidence of human skin cancer reduces

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by 50%, prostate cancer – by 69%. The development of the hepatitis B and liver cancer is prevented, the risk of developing breast, stomach, colon and lung cancer is reduced. Selenium compounds protect cell membranes from free radicals damage and prevent their generation, reducing the risk of developing tumours, heart and blood vessels diseases, at the same time.

Selenium deficiency not only reduces immunity and working efficiency, but also leads to the development of cardiovascular and oncological diseases, the accumulation of heavy metals and premature aging, diabetes and joints diseases, male infertility and female uterine inertia.

Danish scientists have shown that selenium prevents the diseases of heart and arteries, and its deficiency increases the risk of the coronary heart disease by 70%. The results of the study, conducted by the US National Cancer Institute, shocked doctors. The mortality rate from the most common types of cancer of those people, who took selenium, reduced by 49%. In Finland, after the introduction of selenium into the diet of population, the number of cardiovascular pathologies decreased by 2.5 times, the number of cancer incidence reduced by 1.8 times, endocrine system diseases – by 77%, and the overall incidence rate decreased by 47.4%.

Selenium intake in most of the world is quite low, in the range of 10–70 Se micrograms per day, often in average less than 50 micrograms per day. Apparently, only the US citizens and some other countries in the Americas, take selenium in a higher range of 70–120 μg/day. The problem is that in some parts of the world the status of selenium decreases – there is a trend, which aggravates selenium deficiency.

With intensive cultivation technologies, under industrial conditions, modern high efficiency crosses have vitamins deficiency quite often. Vitamins act as catalysts for many metabolic reactions in birds, though they do not serve as a source of energy. They are necessary for normal functioning of tissues, organs and body as a whole in small doses.

Based on the above, we consider it expedient to enrich the diet of broiler chickens with the feed preventative additive "Ekstraselen+Vit", synthesized by a group of authors led by the Professor of NCFU, Serov A.V. This drug consists of selenium nanoparticles and vitamins E, A, B_1, B_2, B_6, B_{12}, PP, K.

A distinctive feature of the new product is its full compatibility with conventional feeds, vitamins and essential microelements, and high digestibility, as well as the retention in the body due to manifestations of a nano effect and synergistically low toxicity due to the zero oxidation degree.

"Ekstraselen+Vit" complex drug to the level of 100 micrograms of selenium per 1 litre of drinking water, in order to determine the level of its effectiveness when administered orally.

We consider it expedient to discuss the possibility of enriching drinking water of broiler chickens with the

The goal of our work is to improve the technology of producing raw meat with a high content of micronutrients and improved functional and technological properties.

OBJECTS AND METHODS OF STUDY

The experimental part of the work was carried out under the conditions of a private farm by the method of the All-Russian Institute of Scientific Research and Technologies of poultry farming (2008) on the broiler chickens of the "Ross 308" cross without gender division. Main research was conducted on the basis of the department "Technology of meat and conservation" of the North Caucasus Federal University in the laboratory of the Stavropol State Agrarian University, the ANO – Centre for Biotic Medicine (Moscow) and others specialized laboratories.

To carry out a scientific and economic experiment by the analogue method, we formed 2 groups of 18 days old chicks – control (C) and experimental (E) with 14 chicks in each group.

Breeding of hybrid meat young broiler chickens was carried out in the areas without pasture on deep litter in compliance with the necessary microclimate parameters (fan) and incandescent lighting with adjustable brightness. The main parameters of the microclimate were maintained according to the recommendations of the ARISRTPF (Table 1).

The "Ekstraselen+Vit" preparation was added to the drinking water of chickens. Water was changed daily. The control group drank regular water. For an experimental group, we used the drinking water with the concentration of selenium 125 μg/l. 1 ml of the drug was dissolved in 10 litres of water. Water was supplied in equal amounts to each group, with a subsequent increase [1].

Feeding of the birds was carried out to appetite with granulated and ground mixed feed ("Start", "Rost", "Finish"), produced at the feed plants of the Stavropol region, in accordance with the recommendations of the ARISRTPF.

RESULTS AND DISCUSSION

Feed was served in the equal amount of identical composition for each group.

During the experimental studies, we took into account the live weight of poultry, its liveability and food intake.

During the experiment, we accounted for the dynamics (Fig. 1) of live weight and the liveability of broilers. In the process of growing, the birds were weighed every 3 days individually on the electronic scales accurate to 0.5 g.

Table 1. Microclimate indicators during chicken broilers breeding

Age, weeks	Temperature, °C	Relative humidity,%	Duration of daylight hours	Intensity of the light, lux
3	27.0–26.0	60.0–65.0	23	15–17
4	26.0–24.0	60.0–65.0	23	10–12
5–6	18.0–22.0	60.0–65.0	23	20–25

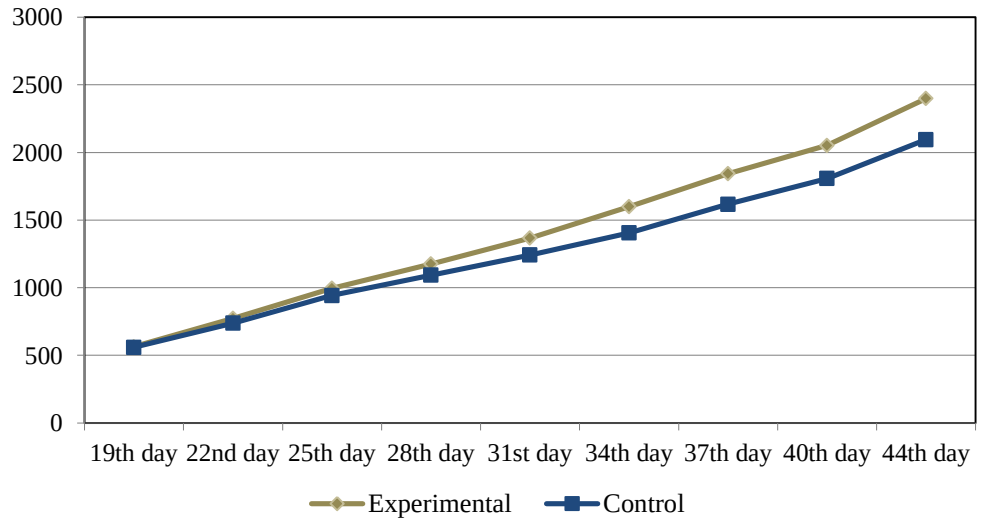

Fig. 1. Dynamics of broiler chickens' live weight gain in the control and experimental groups.

The data shows that by the end of breeding, the live weight of broiler chickens in the experimental group is 14.5% higher than the live weight of broiler chickens in the control group.

In order to give a comprehensive assessment of the broiler chickens' productive qualities, we determined such integrated value as the European Production Efficiency Factor (EPEF), calculated by the formula:

$$\text{EPEF} = \frac{L \times W}{\tau \times C} \times 100, \% \qquad (1)$$

where L is the liveability, %; W is the live weight of chicken broilers, kg; τ is the breeding period, days; C is the feed conversion ratio.

The results of the breeding effectiveness are shown in Table 2.

The experimental results showed that the youngsters who were given the "Ekstraselen+Vit" preventative additive with drinking water had the highest productivity rates.

Livestock mortality rate of both groups was equal to 0%.

The actual mixed feed intake during breeding was similar for both groups during the first four weeks,

Table 2. Indicators of the live weight gain of the broiler chickens in the control and experimental groups

24-hour period	Live weight, kg	Feed intake, g/24 hours	The average weight gain over the period to the next weighing, g	Feed conversion, kg/kg of live weight	EPEF
Control group					
19	0.559	98.1	–	–	–
22	0.738	128.6	179	1.652	203
25	0.943	136.3	205	1.879	201
28	1.093	142.1	150	2.720	144
31	1.242	144.3	149	2.876	139
34	1.406	156.3	164	2.628	157.4
37	1.617	151.3	211	2.153	203
40	1.808	170.0	191	2.669	169
44	2.096	158.6	288	2.202	216
Experimental group					
19	0.564	114.4	–	–	–
22	0.773	136.7	209	1.640	214
25	0.996	145.3	223	1.844	216
28	1.176	169.1	180	2.416	174
31	1.368	189.1	192	2.648	167
34	1.599	186.5	231	2.420	194
37	1.843	204.8	244	2.518	198
40	2.053	184.3	210	2.334	220
44	2.400	184.4	347.3	1.592	343

then there was a tendency to the increased intake in the experimental group. Therefore, by the end of breeding, young broiler chickens in the experimental group consumed 13.99% more feed than the birds in the control group, in which this indicator amounted to 158.6 g/day. It should be noted that the efficiency of feed use in the groups was different. Due to the high growth rate of chickens in the experimental group, the feed cost per 1 kg of live weight gain was lower by 27.7% and amounted to 1.592 and 2.202 kg/kg of live weight respectively. EPEF calculation showed that the birds of the experimental group compare favourably with the control group. Its value in the control group amounted to 216 units versus 343 units in the youngsters of the experimental group.

The above data shows that the method of growing broiler chickens using the "Ekstraselen+Vit" is significantly more efficient than the traditional one.

At the end of fattening, in order to determine the morphological, anatomical indicators of carcasses, physical and chemical parameters and functional-technological properties of raw meat, the control slaughter of 3 broiler chickens from each group was carried out.

Theeffect of the "Ekstraselen+ Vit" on haematological blood parameters of broiler chickens was studied.

Blood sampling was carried out after the experiment completion, 27 days after introducing the drug into drinking water. Blood in a test tube was stabilized with heparin and used for haematological studies.

As one of the most important physiological body systems, blood plays an important role in the body's vital functions. According to Stepanov V.I. et al. (1999), blood parameters are changed under the influence of internal and external factors. Since, body protective functions are regulated through blood, the intensity of metabolic processes in animals and their economically useful signs directly depend on it [3].

Haematological blood parameters of birds characterize its state (Table 3). Thus, haemoglobin, which is a blood pigment, acts as an oxygen carrier from the lungs to the tissues. The increased content of haemoglobin over the physiological norms occurs if blood thickens, during fluid loss due to diarrhoea, vomiting, oedemas, physiological stress, if animals are moved to mountains at high altitude, and the decreased content is observed in case of starvation, anaemia, blood loss, lack of iron, cobalt, vitamins in the feed and in case of chronic intoxications.

The analysis of the morphological composition of broiler chickens' blood showed that after the drug treatment in the experimental group haemoglobin increased by 1.1 times. We identified that the erythrocyte count in the experimental group increased 1.14 times, it indicates the presence of body compensatory mechanisms on the background of a balanced diet.

It is known that selenium promotes the synthesis of glutathione and the glutathione reductase enzyme, which constantly form in erythrocytes and protect the erythrocytes' components that protect from damage by the oxidation products of unsaturated fatty acids.

Established fluctuations in the erythrocytes count and haemoglobin content did not go beyond the physiological norm for broiler chickens.

A significant increase in erythrocytes, haemoglobin and total protein in the blood of the experimental birds suggests that essential microelements positively influence the protein metabolism in the body.

We took the carcass weight without blood and feathers as a weight of the non-eviscerated carcass. The slaughter yield was calculated as a ratio of the non eviscerated carcass to the pre-slaughter weight, expressed in percent.

The results of the slaughter are shown in Table 4.

The analysis of slaughter results indicates that the use "Extraselen+Vit" in the diet of chicken broilers contributes to the yield of an eviscerated carcass, and this complies with the data on an eviscerated carcass weight. In particular, the average yield of eviscerated carcasses of the control samples – 74.49%, the experimental ones – 75.15%.

Eviscerated carcasses from each group were butchered in the laboratory of the NCFU Department of

Table 3. Hematologic and biochemical blood parameters of broiler chickens

Indicators	Norm	Control group	Experimental group
Erythrocyte count, ×1012/l	3.2–4.5	3.15	3.59
Leucocyte count, ×109/l	20–40	36.9	29.7
Haemoglobin, g/l	100–135	115.4	126.5
Total protein, g/l	30–60	35.4	39.9
Glucose, mmol/l	11.0–27.5	12.86	12.82
Cholesterol, mmol/l	2.6–3.6	3.1	3.6

Table 4. The results of the poultry slaughter in the experimental and control groups

The studied sample / Indicator	Control group	Experimental group
Pre-slaughter weight, g	1 976 ± 200	2 370 ± 100
Weight of a non-eviscerated carcass, g	1 805 ± 200	2 193 ± 100
Slaughter yield of a non-eviscerated carcass,	91.35 ± 5.00	92.53 ± 2.00
Weight of an eviscerated carcass, g	1 472 ± 180	1 781 ± 90
Slaughter yield of an eviscerated carcass, %	74.49 ± 5.00	75.15 ± 2.00

meat and canning technologies. Wings were cut on the glenohumeral joint, legs on the hip joint and breasts parts on the coracoid line of ribs. Then, legs were divided into two components – drumstick and thigh [2].

Selected parts were boned manually with the anatomical clean-up of bones. The ratio of muscle and bone tissue, as well as the skin was determined by weighing (Table 5).

Table 5. The results of the anatomical butchering of broiler chickens

Indicators	Control group			Experimental group		
	Weight of carcass parts, g	% from the eviscerated carcass weight	% from live weight	Weight of carcass parts, g	% from the eviscerated carcass weight	% from live weight
Pre-slaughter (live) weight	1976			2370		
Weight of an eviscerated carcass	1472			1781		
Slaughter yield	74.49			75.15		
Breast:						
muscles	472.61	32.11	23.92	584.81	32.84	24.68
including fillet	343.00	23.30	17.36	457.22	25.67	19.29
skin	28.74	1.95	1.45	34.81	1.95	1.47
bones	52.13	3.54	2.64	61.50	3.45	2.59
Total	553.48	37.60	28.01	681.12	38.81	28.74
Thigh:						
muscles	270.13	18.35	13.67	351.28	19.72	14.82
skin	52.72	3.58	2.67	65.12	3.66	2.75
bones	84.72	5.76	4.29	101.76	5.71	4.29
Total	407.57	28.43	20.63	518.16	29.09	21.86
Drumstick:						
muscles	119.03	8.09	6.02	144.04	8.09	6.08
skin	21.71	1.47	1.10	17.65	0.99	0.74
bones	60.04	4.08	3.04	57.11	3.21	2.41
Total	200.78	13.64	10.16	218.80	12.29	9.23
Wing:						
muscles	68.17	4.08	3.45	83.87	4.71	3.54
skin	37.18	2.53	1.88	39.22	2.20	1.65
bones	45.23	3.07	2.29	55.31	3.11	2.33
Total	150.58	10.23	7.62	178.4	10.02	7.53
Back:						
muscles	22.31	1.52	0.79	28.37	1.59	1.20
skin	15.13	1.03	0.77	19.87	1.12	0.84
bones	84.09	5.71	4.26	91.76	5.15	3.87
Total	128.65	8.74	6.51	146.75	8.24	6.20
Internal fat	13.24	0.90	0.67	15.37	0.86	0.65
Kidneys	10.92	0.74	0.55	13.12	0.74	0.55
Lungs	6.78	0.46	0.34	9.28	0.52	0.39
Wastes	7.12	0.48	0.36	6.75	0.38	0.28
Edible parts						
muscles	952.25	65.17	48.55	1192.37	66.95	50.32
skin	155.48	10.56	7.87	176.67	9.92	7.45
Kidney + fat + lungs	30.94	2.10	1.57	37.77	2.12	1.59
Total	1138.67	77.36	57.63	1406.81	78.99	59.36
Inedible parts						
bones	326.21	22.16	16.51	367.44	20.63	15.50
wastes	7.12	0.48	0.36	6.75	0.38	0.28
Total	333.33	22.64	16.87	374.19	21.01	15.78
The ratio of the weight of edible parts to the weight inedible parts	3.42			3.76		
The ratio of muscle weight to bones weight	2.92			3.19		

As a result of the experiment, it was established that a live weight of the chickens in the experimental group was 16.63% higher than in the control group.

The anatomical butchering of carcasses showed an increase in the yield of the most valuable parts, from a technological point of view – breasts and thighs in the experimental chickens, of 18.8 and 21.3%, respectively.

Total content of muscle tissue in the test samples is significantly higher than in the control samples. In addition, the ratio of muscle weight to the weight of the eviscerated carcass amounts to 66.95%. This indicator exceeds the standard values for the species and the age groups of birds significantly.

It is noted that the internal fat content is at a quite low level, which suggests the dietary properties of the broiler chickens carcasses.

Thus, due to the conducted research, it is determined that the meat of broiler chickens, grown with the use of the "Ekstraselen+Vit" preventative feed additive, has better quality characteristics compared to the control chickens.

The chemical composition of the most valuable parts of carcasses from a technological point of view – skinless breast and thigh (Table 6).

To meet the needs of the population in poultry meat, its nutrition value, which depends on the chemical composition, is of great importance. The table above shows that the protein content in the test samples is higher than in the control samples. We identified a decrease of fat content in the thoracic and femoral muscles of test samples, which suggests the dietary properties of the raw meat.

Functional and technological properties of raw meat are shown in Table 7.

The value of active acidity (pH) is in the range of 6.3–6.5 for the control and test samples, which indicates a fairly high stability of the protein system.

Water binding capacity (BCC) is the most important functional characteristic, which determines the quality of minced meat and organoleptic, structural and mechanical properties, as well as the yield of finished products. The data analysis shows an increase in BCC of the test samples: BCC increase in breast – 7.11%, skinless thigh – 4.3%, drumstick – 0.55%. Due to the fact that from a technological point of view, the most valuable parts are breast (white meat) and thigh (red meat), in our opinion, the use of the "Ekstraselen+Vit" is quite effective.

The fact that the plasticity indicators of the test samples are increased, is also worth mentioning. This is due to a high protein content and decreased fat content in the test samples.

Based on the study of functional-technological properties of meat, we determined that is feasible to use this type of raw material in the production of meat products.

In the ANO centre for biotic medicine, the studies were conducted to determine the concentration of selenium in poultry processing products, obtained after slaughter of the control and test samples. The results of the study are presented in Table 8.

The data shows that the concentration of selenium in the muscles of the experimental chickens was significantly higher than in the control chickens. The difference in the selenium content in chickens' femoral muscles of the experimental and control groups amounted to 28.57%, and in the thoracic

Table 6. Chemical composition of raw meat

Studied indicators	Experimental group		Control group	
	breast	skinless thigh	breast	skinless thigh
Fat content, %	1.62	3.56	2.34	4.37
Water content, %	74.7	74.41	75.72	74.54
Salt content, %	2.45	1.99	2.19	1.93
Protein content, %	21.23	20.04	19.75	19.16

Table 7. Functional and technological properties of raw meat

Studied indicators	Experimental group			Control group		
	breast	skinless thigh	skinless drumstick	breast	skinless thigh	skinless drumstick
$pH_{\text{of the studied sample}}$ ($pH_{\text{of distilled water}}$ – 6.62)	6.53	6.39	6.37	6.42	6.36	6.29
WBC, % to the sample weight	60.48	56.55	54.90	56.18	54.12	54.60
Plasticity, cm2/g	3.57	2.59	2.06	2.46	2.14	1.95

Table 8. The concentration of selenium in poultry processing products

Name of the sample	Control group	Experimental group
Liver, mg/g	0.54 ± 0.100	0.84 ± 0.101
Heart, mg/g	0.36 ± 0.043	0.50 ± 0.059
Thigh, mg/g	0.28 ± 0.033	0.36 ± 0.043
Breast, mg/g	0.24 ± 0.028	0.26 ± 0.031

muscles – 8.33%. In the liver and heart, the selenium content increased significantly – by 55.56% and 38.89%, respectively.

Thus, the meat of broiler chickens, grown using the preventative feed additive, is a good source of selenium for humans. Consumption of the meat, enriched within the physiological range, will meet the daily needs of an adult in this microelement, which is 70 mg/day.

CONCLUSION

The studies determined that the introduction of the "Ekstraselen+Vit" feed preventative additive into the diet of broiler chickens increases the pre-slaughter weight and slaughter yield. Thanks to good feed bioconversion, it is possible obtain raw materials at reduced cost, but with high quality indicators.

The technology of growing broiler chickens under development can be used by farms as well as by small and medium-sized poultry processing businesses.

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