THE EFFECT OF SODIUM SELENITE, SELENIUM METHIONINE AND VITAMIN E ON PRODUCTIVITY, DIGESTIVE PROCESSES AND PHYSIOLOGIC CONDITION OF BROILER CHICKENS

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Abstract. The trial was conducted to evaluate the effects of selenite and vitamin E included in combined feed on growth performance, feed conversion and mortality, pH of gastrointestinal tract chymus, amount of dry matters and short-chain fatty acids in caecum chymus of broiler chickens. The experiment was carried out in the experimental poultry house of „Vilniaus paukštynas“ and poultry house of LUHS Veterinary Academy in 2011. Six hundred *Cobb 500* cockerels were divided into three treatment groups. Group I was control and groups II and III were experimental. Broiler chickens of the control group were fed the diet supplemented with 0.15 mg of sodium selenite (inorganic selenium) and 40 mg of vitamin E throughout the whole period of the trial (from the 1st to the 35th day of broiler chicken growth). The feed for broiler chickens of the experimental group II included 0.5 mg sodium selenite (inorganic selenium) and 40 mg of vitamin E throughout the whole period of the trial (from the 1st to the 35th day of broiler chickens growth). The feed for broiler chickens of experimental group III was supplemented with 0.15 mg of inorganic selenium and 0.35 mg of organic selenium, as well as 40 mg of vitamin E throughout the whole period of the trial (from the 1st to the 35th day of broiler chickens growth). The supplements of organic and inorganic selenium and vitamin E used in the trial had no substantial effects on the productivity, feed conversion ratio and mortality of broiler chickens. However, the latter supplements affected increase of total protein, gamma globulin, glutathione peroxidase, free thyroxine, free triiodothyronine and decrease of cholesterol and its fractions in the blood of broiler chickens. It was as well established that selenium and vitamin E have no major effects on physiological parameters of digestion of broiler chickens.

Keywords: broiler chickens, selenium, vitamin E.

Introduction. The influence of selenium on human health and prevention of free radical-related diseases was studied by many scientists (Rayman, 2009). The deficiency of this element is considered a worldwide problem. This issue can be solved not only by dietary supplements but also by production of functional food products. Selenium-supplemented eggs, poultry meat, pork or beef can be produced and used to improve human nutrition.

Selenium additives for poultry and animals were used in various forms such as yeast, algae “Chlorella”, sprouts and cabbage, though compounds of organic and non-organic selenium were used the most frequently (Seo et al., 2008; Trávníček et al., 2008; Wang, Xu, 2008; Chinrasri et al., 2009; Mikulski et al., 2009; Svoboda et al., 2009b; Upton et al., 2009). Significance of selenium and methionine in poultry nutrition is remarkable. Selenium acts synergistically with methionine and enhances selenium resorption in poultry organism. Methionine directly affects protein metabolism (Baker, 2006).

Natural antioxidants – selenium, vitamin E – have a positive impact on poultry wellness, productivity and reproductive qualities (Haug et al., 2007). Selenium supplemented feed may have positive impact on poultry quality and expiry date (Hosseini-Mansoub, 2011). Ševčíková et al. (2006) recommends maintaining selenium concentration in feed between 0.1 mg/kg to 0.15 mg/kg of body weight. On the other hand Ryu et al. (2005) states that selenium concentration, including native selenium, cannot exceed 0.5 mg/kg of feed.

Vitamins are organic low molecular weight compounds. They are included into animal fodder in small amounts, yet ensure animal productivity, normal physiological state and reproductive functions (Jeroch et al., 2004). Vitamins are included into every compound fodder and feed (Shurson et al., 2011).

Vitamin E and selenium act closely and synergistically. These two elements are essential components of anti-oxidative system and suppress oxidative processes of polyunsaturated fatty acids in cellular membranes (Skřivan et al., 2008; Yoon et al., 2007).

Poultry feed supplemented with vitamin E, improves oxidative stability in broiler meat and simultaneously is supplementary source of vitamin E for humans (Barroeta, 2007). Researches prove that larger amount of this vitamin in feed increases poultry productivity (Khan et al., 2011).

Peroxides compose in organism even though amount of vitamin E is sufficient, and glutathione peroxidase eliminates peroxides of various types. Vitamin E has a major role in most of metabolism processes. Vitamin E as antioxidant protects vitamin A, unsaturated fatty acids and other lipids from oxidation, represses production of toxic peroxides and multiplies amount of oxygen in tissue cells, improves growth of muscles and eases oxygen absorption in erythrocytes (Dlouha et al., 2008).

Selenium and vitamin E are essential in oxidation-reduction reactions. Selenium positively stimulates

activity of immune, reproductive and neurotic systems, takes part in processes of thyrone hormones and prostaglandins, and as well is antagonist for heavy metals (Choct et al., 2004).

Poultry products supplementation with antioxidants – selenium and vitamin E – is one of the means to create functional food products, distinctive with anti-oxidative effect. There is no enough data on organic and non-organic selenium and vitamin E amount in feed and their effect on broiler chicken metabolism and physiological state.

The aim of the trial was to evaluate the effect of the different selenium amounts and forms and vitamin E on productivity, digestive processes and physiological condition of broiler chickens.

Materials and methods. The scientific investigations were made following the provisions of the Republic of Lithuania (1997-11-06) for animal welfare and handling, Law No 8-500 (Valstybės žinios, 1997-11-28, No. 108), and a sub statutory act by the State Food and Veterinary Service of Lithuanian Republic regarding the confirmation of the order on the animals for experiments, research, storage, maintenance and operating requirements (Valstybės žinios, 2009-01-22, No. 8, 287). The work was performed in accordance with EU Directive 86/609/EEC and the EC recommendation 2007/526 EC for Animal use and storage for experiments and other purposes.

The feeding trial was carried out with 1–35-days-old male Cobb 500 broiler chickens. 600 broiler chickens were divided into three groups. Each group consisted of four subgroups of 50 chickens; in total there were 200 broiler chickens in each group. The broiler chickens were kept on deep litter and had free access to water from stationary watering containers.

The feed of the control group was supplemented with 0.15 mg of sodium selenite (non-organic selenium) and with 40 mg of vitamin E throughout the whole trial period, i.e. from 1st to 35th day of age. The feed of the experimental group I was supplemented with 0.5 mg of sodium selenite (non-organic selenium) and 40 mg of vitamin E throughout the whole trial period, i.e. from 1st to 35th day of age. The feed of the experimental group II was supplemented with 0.15 mg of non-organic selenium, 0.35 mg of compound organic selenium feed additive *Alkosel® R397* and 40 mg of vitamin E throughout the whole trial period, i.e. from 1st to 35th day of age.

Alkosel® R397 (selenomethionine) is inactivated yeast (*Saccharomyces cerevisiae* NCYC R397) product containing the essential microelement selenium in its highly bioavailable natural form L(+) selenomethionine. L(+) selenomethionine is produced by growing yeast in the presence of measured amounts of selenium. Yeast cells absorb selenium and transform it into L(+) selenomethionine and proteins containing selenium. The total quantity of selenium is 2000–2400 ppm.

Sodium selenite contains 45 percent of active substance and has traces of heavy metals. White powder burns skin, dissolves in water; the solubility is 46.3 percent, the melting-point is at 710ºC, the heat of vaporization is 26.32 kJ/mol and the covalent radius is 116 pm.

Scheme of the trial is shown in Table 1.

Table 1. **Scheme of the trial**

Indexes	Control group	Experimental group I	Experimental group II
0.15* mg of sodium selenite + 40 mg of vitamin E per kg of feed from 1 to 35 day of age	+	–	–
0.5** mg of sodium selenite + 40 mg of vitamin E per kg of feed from 1 to 35 day of age	–	+	–
0.5*** mg of selenium + 40 mg of vitamin E per kg of feed from 1 to 35 day of age	–	–	+

*0.15 mg of sodium selenite (non-organic selenium); **0.5 mg of sodium selenite (non-organic selenium); ***0.5 mg of selenium = 0.15 mg of sodium selenite (non-organic selenium) + 0.35 mg of selenomethionine (organic selenium) *(Alkosell®R397)*

Broiler chickens were fed *ad libitum* with a standard wheat-soybean meal compound diet. The diet was formulated to meet the nutrient and energy requirements for broiler chickens (NRC, 2004). Qualitative parameters of the feed was as following: metabolizable energy – 12.98 (MJ/kg), crude protein – 21.00%, crude fat (analysed values) – 6.02%, crude ash – 3.95%, crude fibre – 2.36%, methionine + cysteine – 0.96%, threonine – 0.83%, tryptophan – 0.25%, calcium (analysed values) – 0.90%, phosphorus – 0.62%, available phosphorus – 0.43%, natrium – 0.18%, chlorine – 0.20%, linoleic acid – 3.01%.

The amount of the main nutrients (crude ash, total calcium) in the feed was determined according to feed research methods accredited in Lithuania (Juškienė, 2003).

During the feeding trial, body weights at the age of 1, 8, 2l and 35 days, feed conversion ratio of each subgroup at the ages of 1–8, 9–21, 22–35 days, and birds' mortality over the feeding trial were recorded.

At the end of the trial (on 35th day-of-age) five broiler chickens from each group (5 birds x 3 groups = 15 birds in total) were selected for blood serum test in order to examine:

a) the amount of total proteins – with refractometer (Tietz, 1995);

b) protein fractions – by the electrophoresis method;

c) glutathione peroxidase (analysis was made in the Environmental Health Laboratory of Institute for Biomedical Research of Kaunas University of Medicine. Samples were compared with glutathione peroxidase standard (G 6137); the standard is 25,40 mU/ml);

d) the amount of the thyroid hormones, triiodothyronine (T3) and thyroxine (T4), in the blood (Tietz, 1995).

On the 35th day-of-age, broiler chickens were killed according to the recommendations for euthanasia of experimental animals (Close et al., 1997), and pH were determined in the content of duodenum *(Duodenum)*, small intestine *(Intestinum tenue)*, caeca *(Caecum)* and colon *(Intestinum crassum)* by pHmeter "730 Inolab". Dry matter content in the same part of guts chymus was determined by the difference between wet weight and dry weight (dried at 105ºC for 3 hours).

The concentration of short-chain fatty acids was estimated with gas chromatograph (Shimadzu GC-2010 with 2.5 mm x 2.6 mm glass tube filled with 10 percent of SP -1200/ 1 percent of HPO on 80/100 Chromosorb WAW, tube temperature was 110ºC, detector FID temperature was 108ºC and injector temperature was 195ºC). The caecal pool sizes of short-chain fatty acids were calculated as concentrations of short-chain fatty acids in digesta (Ziołecki, Kwiatkowska, 1973).

Statistical data evaluation. Analysis of variance (ANOVA) was applied to the descriptors tested individually with significance level at $P<0.05$ to determine differences between the groups. Sample comparisons were determined using the statistical program SAS (2001). Statements of statistical significance were based on $P<0.05$.

Results and discussion. The analysis of broiler chicken weight gain dynamics (Table 2) showed that the maximum variation during 8 days-of-age was determined in experimental group II. The weight of broiler chickens in this group was by 8% higher than that of broiler chickens in the control group ($P>0.05$). The results of weight gain on the 21st day-of-age indicated that selenium and vitamin E in the combined feed for experimental group I reduced the weight of broiler chickens by 1% ($P>0.05$), whereas this index in experimental group II was by 2% higher compared with control group ($P>0.05$). During the last growing period (on the 35th day-of-age), the weight of broiler chickens in both experimental groups was by 2% lower than in the control group ($P>0.05$). Similar results were obtained by Payne and Southern (2005), as well as Upton et al. (2008). They reported that broiler chickens fed with selenium supplements of two types (organic and nonorganic) had an increasing tendency of weight gain compared with the control group.

Many researches proved that weight of broiler chickens increased when their ration was supplemented with organic selenium. Sefton and Edens (2004) also ascertained that chickens of parents that were fed with greater amount of selenium had larger weight. Chickens of parent flocks fed with smaller amount of selenium had lower weight gain (Hanafy et al., 2009).

Table 2. **Influence of selenium and vitamin E on broiler chickens weight,** g

Chickens age in days	Control Group	Experimental Group I	Experimental Group II
Chicken body weight, g			
1	47.49±0.10	47.51±0.22	47.49±0.16
8	162.31±1.28	163.88±1.21	174.54±1.44
21	988.35±8.31	980.03±8.11	1004.76±8.81*
35	2496.15±18.20	2438.08±18.05*	2438.74±20.88*

* Data statistically significant ($P<0.05$)

Table 3. **Influence of selenium and vitamin E on broiler chickens feed conversion ratio,** kg/kg

Chickens age in days	Control group	Experimental group I	Experimental group II
Feed conversion ratio, kg/kg			
1–8	1.51±0.07	1.49±0.10	1.57±0.05
9–21	1.58±0.03	1.55±0.09	1.43±0.07*
22–35	2.03±0.11	1.99±0.09	2.16±0.11
1–35	1.88±0.08	1.84±0.09	1.92±0.10

* Data statistically significant ($P<0.05$)

Feed conversion ratio (FCR) (Table 3) during the first growing period was by 1% lower in experimental group I and by 4% higher in experimental group II compared with the control group ($P>0.05$). On the 9-21 days-of-age, this index in experimental groups I and II was by 2% ($P>0.05$) and 9% ($P<0.05$), respectively, lower than in the control group. During the last growing period (on the 22–35 days-of-age), FCR was by 2% lower in experimental group I and by 6% higher in experimental group II than in the control group ($P>0.05$).

Throughout the whole trial (on the 1-35 days-of-age), this index was by 2% lower in experimental group I and by 2% higher in experimental group II, when compared with the control group ($P>0.05$).

The results of this trial corresponded with trial data provided by M. Choct et al. (2004), which indicated that organic selenium in the feed had no influence on the final weight of broiler chickens. Ševčíková et al. (2006) and Dlouha et al. (2008) determined that organic selenium intensified broiler chicken growth; however, non-organic selenium had no such impact.

The results of broiler chicken liveability (Table 4) showed that during the growing period (1–8 days-of-age) selenium and vitamin E had no major influence. During the later period (9–21 days-of-age), broiler chicken liveability in experimental group I was by 0.5% lower and in experimental group II was by 1% higher than in the control group. During the last period of the trial, additives increased this index by 0.5% compared with the control group.

Table 4. **Influence of selenium and vitamin E on broiler chickens liveability,** %

Chickens age in days	Control group	Experimental group I	Experimental group II
1–8	100.0	100.0	99.0
9–21	99.0	99.5	98.0
22–35	100.0	99.5	99.5
1–35	99.0	98.5	96.5

Data statistically insignificant (P>0.05)

During the analysis of selenium and vitamin E influence on broiler chicken liveability throughout the whole trial, it was noticed that additives in the feed had no vital influence. Broiler chicken liveability in experimental groups I and II increased by 0.5% and 2.5%, respectively, when compared with the control group. Statistically significant differences were not determined.

Blood plasma proteins are high molecular weight organic compounds of colloidal nature. When concentration of proteins in blood plasma decreases, it also decreases in tissue (Praškevičius et al., 2003). This, consequently, may have influence on general functions and productivity of broiler chickens. The results of the amount of total protein in broiler chicken blood plasma (Table 5) showed that this index in experimental groups I and II was by 5–10% higher than in the control group (P>0.05).

Albumin in organism regulates osmotic pressure, transports fatty acids, bilirubin, aldosterone, anions and cations; additionally albumins are a source of amino acids (Ahmed, Ahmed, 2009). According to the results of our trial, vitamin E and selenium in feed decreased the amount of albumins in broiler chicken organism by 7–10% compared with the control group (P>0.05).

The total increase of the amount of alpha-1 globulins is determined during various inflammations of infectious or allergic origin, when liver is affected and tissues are decaying or due to cellular malignant tumours (Adugna et al., 2004). The concentration of alpha-1 globulins in the blood of broiler chickens in the control group and experimental group I was equal, however, this index in blood broiler chickens in experimental group II had a tendency of increasing.

The concentration of alpha-2 globulins increases during inflammatory processes, during diseases, when pathological process involves connective tissue or in the case of malignant tumours (Praškevičius et al., 2003). The results of trial showed that the amount of alpha-2 globulins in blood of broiler chickens in experimental groups had a tendency of increasing from 0.26% to 0.80% (P>0.05).

Alterations of the beta-globulins are usually related to alterations of lipoproteins and transferrin. The concentration of beta-globulins increases in case of fat metabolism disorders: hyperlipoproteinemia, hepatic diseases, nephrotic syndromes, inflammatory diseases (Praškevičius et al., 2003). The concentration of serum beta-globulins of broiler chickens in experimental groups I and II was 2.64% and 0.58%, respectively, lower than in the control group (P>0.05).

Table 5. **Influence of selenium and vitamin E on concentration of broiler chickens blood plasma proteins**

Parameters	Control group	Experimental group I	Experimental group II
Total proteins, g/l	31.88±0.97	35.08±1.90	33.32±2.96
Albumins, %	53.78±1.51	46.78±5.87	44.28±8.80
Alpha-1 globulins, %	3.40±0.51	3.40±0.49	3.90±0.77
Alpha-2 globulins, %	7.14±0.59	7.40±0.98	7.94±0.74
Beta-globulins, %	24.52±1.19	21.88±3.59	23.94±3.38
Gamma-globulins, %	11.14±0.43	20.48±9.29	19.88±10.78

Data statistically insignificant (P>0.05)

The gamma-globulins fraction is composed of immunoglobulin. Increase of the gamma-globulins is influenced by intensification of immunoglobulin production (Praškevičius et al., 2003). The results of trial showed that the amount of serum gamma-globulins in experimental groups increased by 8.74–9.34% in comparison with the control group (P>0.05).

The analysis of the results of cholesterol concentration

in broiler chicken blood (Table 6) defined that combined feed for experimental group I supplemented with 0.5 mg of natrium selenite and 40 mg of vitamin E for increased this index by 3%, and combined feed for experimental group II supplemented with 0.15 mg of natrium selenite, 0.35 mg of selenium methionine and 40 mg of vitamin E decreased cholesterol concentration by 13% in comparison with control group (P>0.05).

According to the results of our trial, DTL cholesterol concentration in broiler chickens blood of experimental groups were by 4–13% lower than in the control group (P>0.05).

During the analysis of MTL cholesterol and triglycerides concentration in blood, it was determined that broiler chickens in experimental group I had by 3% and 33%, respectively, higher values of such indexes, while broiler chickens in experimental group II demonstrated by 12% and 6%, respectively, lower values than in the control group. Statistically significant differences were not determined.

Table 6. **Influence of selenium and vitamin E on concentration of lipids in broiler chickens blood, mmol/l**

Parameters	Control group	Experimental group I	Experimental group II
Cholesterol	3.77±0.09	3.87±0.42	3.28±0.42
DTL cholesterol	2.66±0.10	2.56±0.11	2.31±0.27
MTL cholesterol	0.67±0.04	0.71±0.21	0.59±0.22
Triglycerides	0.98±0.11	1.30±0.35	0.92±0.21

Data statistically insignificant (P>0.05)

Glutathione peroxidase is a natural anti-oxidative enzyme containing selenium. Glutathione peroxidase protects cells and whole organism from harmful impact of oxidation and free radicals (Arthur, 2000). The result analysis of glutathione peroxidase activity in broiler chicken blood (Table 7) showed that this index in experimental groups was by 35% higher than in the control group (P<0.05).

Glucose is the most important carbohydrate. During the digestive process, all the other carbohydrates are transformed into glucose. One of the most important functions of glucose in living organisms is to provide them with energy (Adugna et al., 2004). Glucose level in blood of broiler chickens of experimental groups decreased by 3–11% in comparison with the control group, and the index of glutathione peroxidase increased by 21–40% (P>0.05).

The level of GOT (glutamate oxaloacetate transaminase) in blood of broiler chickens in experimental group I increased by 20% (P>0.05), and decreased by 2% in experimental group II, if compared with the control group (P>0.05).

Thyrotropin stimulates thyroid gland growth and biosynthesis of thyroid hormones; it also activates biosynthesis of proteins, phospolips and nucleic acids, increases the number and size of thyrocytes and influences catabolism of carbohydrate (Postiglione et al., 2002). Thyrotropin concentration in blood of broiler chickens in experimental group I and II decreased by 0.005 mlU/l and 0.003 mlU/l, respectively, compared with the control group (P>0.05).

Thyroxin is a hormone secreted by the thyroid gland. If the thyroid gland secretes overly thyroxin, metabolism accelerates, thus weight reduces. If there is a lack of thyroxin, metabolism processes are slower (Postiglione et al., 2002). The blood of broiler chickens in experimental groups contained by 0.4–15.65 pmol/l more free thyroxin than in the control group.

One of the main functions of triiodothyronine is to maintain general synthesis of proteins and positive balance of nitrogen. Biological effect of triiodothyronine is important for physiological functions of the most systems in organism (nervous and muscular, digestive, cardiac and vascular systems), as well as for state of skin (Adugna et al., 2004). The result analysis of triiodothyronine level in blood of broiler chickens showed that this index in experimental groups increased by 0.40-6.67 pmol/l compared with the control group (P>0.05).

Table 7. **Influence of selenium and vitamin E on concentration of enzymes in broiler chickens blood**

Parameters	Control group	Experimental group I	Experimental group II
GPx activity, mU/ml	19.51±0.22	26.37±0.64*	26.37±0.00**
Glucose, mmol/l	14.14±0.82	13.97±0.52	14.09±0.73
GPT, U/l	1.36±0.43	1.90±0.93	1.64±0.34
GOT, U/l	248.24±19.53	297.71±70.31	242.48±8.13
Thyrotropin, mlU/l	0.011±0.00	0.006±0.00	0.008±0.00
Free thyroxine, pmol/l	6.58±2.59	6.98±2.01	22.23±19.70
Free triiodothyronine, pmol/l	6.58±2.59	6.98±2.01	13.25±10.29

* Data statistically significant (P<0.005); ** Data statistically significant (P<0.001)

Analysis of the pH of the chymus in the separate gastrointestinal tract segments (Table 8) showed that supplements of selenium and vitamin E had influence on this particular index. Duodenum pH of broiler chickens in experimental groups increases by 0.01–0.43 points compared with the control group (P>0.05). Ileum pH of broiler chickens in experimental group I decreased by 0.14 points, whereas in experimental group it II increased by 0.69 points compared with the control group (P>0.05). Dynamics of microorganisms' population in separate segments of the digestive tract depends on pH value; this value also highly influences how nutrients are digested and converted. Growth of most pathogens is permitted, when pH value is 7 and higher. Acidic environment of pH value 5.8–6.2 is beneficial for positive population of microorganisms. This environment allows optimal conditions to reproduce and compete with pathogenic micro flora (Rahmani, Speer, 2005). A reduced pH value creates acidic environment, in which most pathological microorganisms, capable of infecting, die (Conway, 2001; Gibson, 2004).

Table 8. **Influence of selenium and vitamin E on pH value in the gastrointestinal tract of broiler chickens**

Different part of gastrointestinal tract	Control group	Experimental group I	Experimental group II
Duodenum (*duodenum*)	4.63±0.26	5.06±0.22	4.64±0.23
Small intestine (*intestinum tenue*)	4.97±0.11	4.83±0.22	5.66±0.59
Caecum (*cecum*)	6.20±0.17	6.20±0.36	6.62±0.10
Colon (*intestinum crassum*)	5.24±0.33	5.08±0.23	4.99±0.19

Data statistically insignificant (P>0.05)

Analysis of the influence of selenium and vitamin E on the amount of dry matter in digesta (Table 9) showed that these additives reduced the amount of dry matter in the small intestine (0.86-1.41%), the colon (by 0.42% in experimental group I, P>0.05; by 5.8% in experimental group II, P<0.05) and in the caecum (by 1.09% in experimental group II) compared with the control group. The amount of dry matter increased in the duodenum (0.76–1.65%) and the caecum (by 5.98% in experimental group I, P<0.05), compared with the control group.

Excrements of birds are drier, if the amount of dry matter in the digestive tract is higher, therefore qualitative parameters of litter and microclimate are increased and wellness of chickens is positively impacted.

Table 9. **Influence of selenium and vitamin E on dry matter concentration in the gastrointestinal tract of broiler chickens,** %

Different part of gastrointestinal tract	Control group	Experimental group I	Experimental group II
Duodenum (*duodenum*)	15.38±0.77	16.14±1.28	17.03±0.80
Small intestine (*intestinum tenue*)	20.08±0.96	19.22±0.78	18.67±0.97
Caecum (*cecum*)	13.46±1.15	19.44±1.04*	12.37±1.31
Colon (*intestinum crassum*)	19.87±0.97	19.45±1.75	14.49±1.05*

* Data statistically significant (P<0.05)

Large concentration of short-chain fatty acids (SCFA) reduces intestines pH, thus the growth of certain pathogenic microorganisms is suppressed. Acetic acid is an energy source for peripheral tissues, and butyric acid not only provides epithelial cells of the large intestine with energy, but also has a major role in reproductions and differentiation of cells. Propionic acid together with blood is transported to liver and takes part in glucogenesis process (Priebe et al., 2002).

Different amount of natrium selenite, vitamin E and selenium methionine in the caecum of broiler chickens increased the amount of acetic acid (Table 10) (experimental group II – 2.47 µmol/g), butyric acid (experimental group I – 7.72 µmol/g) compared with the control group (P>0.05). The aforesaid supplements decreased the amount of acetic acid (experimental group I – 6.45 µmol/g), propionic acid (1.27-1.73 µmol/g) and butyric acid (experimental group II – 0.74 µmol/g) compared with the control group (P>0.05).

Table 10. **Influence of selenium and vitamin E on the amount of short-chain fatty acids (SCFA) in caecum of broiler chickens, µmol/g**

Organic acids	Control group	Experimental group I	Experimental group II
Acetic	70.49±3.01	64.04±3.42	72.96±1.80
Propionic	18.72±2.77	17.45±2.40	16.99±2.36
Butyric	10.79±4.50	18.51±3.48	10.05±2.62

Data statistically insignificant (P>0.05)

Supplements of organic and nonorganic selenium and vitamin E had no major influence on broiler chickens productivity, feed conversion ratio and liveability. However, these supplements had influence on the increase of total protein, gamma-globulin, glutathione peroxidase, free thyroxine and free triiodothyronine, as well as on reduction of cholesterol and its fractions in broiler chicken blood. Major influence of selenium and vitamin E on physiological parameters was not determined.

Conclusions

1. Supplements of organic and nonorganic selenium and vitamin E in compound feed had no significant influence on broiler chicken productivity, feed conversion ratio and liveability; however, on the 35th day-of-age broiler chickens in experimental groups weighed by 2% less than broiler chickens in the control group ($P<0.05$).

2. Analysis of the composition of broiler chickens' serum proteins showed that selenium and vitamin E additives increased the concentration of total protein and gamma-globulin. Significant influence on the other indexes of serum plasma was not determined ($P>0.05$).

3. During the analysis of lipids concentration in broiler chicken blood, it was determined that selenium and vitamin E additives decreased DTL cholesterol concentration by 0.1-0.35 mmol/l ($P>0.05$). Other parameters met physiological standard and vital alterations were not determined.

4. Supplementation of broiler chickens' feed with nonorganic selenium and vitamin E increased only glucoperoxidase activity in blood serum by 6.86 mU/ml ($P<0.005$), whereas application of nonorganic and organic selenium and vitamin E glucoperoxidase activity increased by 6.86 mU/ml ($P<0.001$), free thyroxine by 15.65 pmol/l and free triiodothyronine by 6.67 pmol/l ($P>0.05$) compared with the control group.

5. The analysis of the results showed that there is no great influence of selenium supplements and vitamin E on the pH dynamics in separate segments of the digestive tract, as well as on the concentration of dry matter and short-chain fatty acids. The results were different only in a few segments of digestive tract: concentration of dry matter increased by 5.98% ($P<0.05$) in the digesta of caecum (*cecum*) of broiler chickens in experimental group I, and decreases by 5.38% ($P<0.05$) in the digesta of rectum (*intestinum crassum*) of broiler chickens in experimental group II.

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References

1. Ahmed K., Ahmed R. Biochemistry II. *General Medicine*. 2009. P. 1–52.

2. Adugna S., Alemu L. A. M., Kelemu T., Tekola H., Kibret B., Genet S. Medical Biochemistry. *EPHTI J.* 2004. P. 1–253.

3. Arthur J. R. The glutathione peroxidases. *Cell. Mol. Life Sci.* 2000. Vol. 57. P. 1825–1835.

4. Baker D. H. Comparative species utilization and toxicity of sulfur amino acids. *J Nutr.* 2006. 136(6). P. 1670S–1675S.

5. Barroeta A. C. Nutritive value of poultry meat: relationship between vitamin E and PUFA. *World's Poultry Science Journal.* 2007. 63. N. 2. P. 277–284.

6. Chinrasri O., Chantiratikul P., Thosaikham W., Atiwetin P., Chumpawadee S., Saenthaweesuk S., Chantiratikul A. Effect of selenium-enriched bean sprout and other selenium sources on productivity and selenium concentration in eggs of laying hens. *Asian-Australasian Journal of Animal Science.* 2009. 22. P. 1661–1666.

7. Choct M., Naylor A. J., Reinke N. Selenium supplementation affects broiler growth performance, meat yield and feather coverage. *Brit. Poult. Sci.* 2004. 45. P. 677–683.

8. Close B., Banister K., Baumans Bernoth E. M. Laboratory animals. 1997. Vol. 2. P. 1–32.

9. Conway P. L. Prebiotics and human health: The state-of-the-art and future perspectives. *Scandinavian Journal of Nutrition*. 2001. 45. P. 13–21.

10.Dlouhá G., Ševčíková S., Dokoupilová A., Zita L., Heindl J., Skřivan M. Effect of dietary selenium sources on growth performance, breast muscle selenium, glutathione peroxidase activity and oxidative stability in broilers. *Czech. J. Anim. Sci.* 2008. 53 (6). P. 265–269.

11.Gibson G. R. Prebiotics. Best Practise and Research Clinical Gastroenterology. 2004. 18(2). P. 287–298.

12.Hanafy M. M.; El-Sheikh A. M. H., Abdalla E. A. The effect of organic selenium supplementation on productive and physiological performance in a local strain of chicken. 1-The effect of organic selenium (sel-plex™) on productive, reproductive and physiological traits of bandarah local strain. Egypt. *Poult. Sci.* 2009. 29. P. 1061–1084.

13.Haug A., Eich-Greatorex S., Bernhoft A., Wold Jens P., Hetland H., Christophersen O. A., Sogn T. Effect of dietary selenium and omega-3 fatty acids on muscle composition and quality in broilers. Lipids in Health and Disease. 2007. 6. P. 29

14.Hosseini-Mansoub N. Influence of organic selenium source on performance and selenium and vitamin E contents in male broilers. *Scholars Research Library*. 2011. P. 497.

15.Jeroch H., Šeškevičienė J., Kulpys J. Žemės ūkio gyvulių ir paukščių mitybos fiziologinės reikmės. Kaunas. 2004. P. 158.

16.Juškienė V. Pašarų tyrimo metodai. Normatyvinių aktų rinkinys. Lietuvos Respublikos Žemės ūkio ministerija. ISBN 9955-9428-5-1. 2003. 305 p.

17.Khan R. U., Naz S., Nikousefat Z., Tufarelli V., Javdani M., Rana N., Laudadio V. Effect of vitaminE in heat-stressed poultry. *World's Poultry Science Journal.* 2011. 67. P. 471–474.

18.Lietuvos Respublikos gyvūnų globos, laikymo ir

naudojimo įstatymas Nr. 8-500. Valstybės žinios. 1997. Nr. 108.

19.Lietuvos Respublikos valstybinės maisto ir veterinarijos tarnybos įsakymas „Dėl gyvūnų, skirtų eksperimentiniams ir kitiems mokslo tyrimams, laikymo, priežiūros ir naudojimo reikalavimų patvirtinimo“. Valstybės žinios. 2009. Nr. 8-287.

20.Mikulski D., Jankowski J., Zdunczyk Z., Wroblewska M., Sartowska K., Majewska T. The effect of selenium source on performance, carcass traits, oxidative status of the organism, and meat quality of turkeys. *Journal of Animal and Feed Scinces.* 2009. 18. P. 518–530.

21.National Research Council. Nutrient requirements of poultry. 10th ed. National Academy Press Washington, D. C., USA. 2004.

22.Payne R. L., Southern L. L. Comparison of inorganic and organic selenium sources for broilers. *Poult. Sci.* 2005. 84 (6). P. 898–902.

23.Postiglione M. P., Parlato R., Rodriguez-Mallon A., Rosica A., Mithbaokar P., Maresca M., Marians R. C., Davies T. F., Zannini M. S., De Felice M., di Lauro R. Role of the thyroid-stimulating hormone receptor signaling in development and differentiation of the thyroid gland. *Proceedings of the National Academy of Sciences USA.* 2002. 99 (24). P. 15462–15467.

24.Praškevičius A., Ivanovienė L., Stasiūnienė N., Burneckienė J., Rodovičius H., Lukoševičius L., Kondratas D. Biochemija. 2003. P. 726–753.

25.Priebe M. G., Vonk R. J., Sun X. The physiology of colonic metabolism. Possibilities for interventions with pre- and probiotics. *European Journal of Nutrition*. 2002. 1. P. 2–10.

26.Rahmani H. R., Speer W. Natural additives influence the performance and humoral immunity of broilers. *Int. J. Poult. Sci*. 2005. 4. P. 713–717.

27.Rayman M. P. Selenoproteins and human health: Insights from epidemiological data. *Biochimica et Biophysica Acta.* 2009. 1790. P. 1533–1540.

28.Ryu Y. C., Rhee M. S., Lee K. M., Kim B. C. Effects of different levels of dietary supplementation selenium on performance, lipid oxidation, and colour stability of broiler chicks. *Poult. Sci.* 2005. 84. P. 809–815.

29.Sefton A. E., Edens F. W. Sel-Plex improves broiler breeder performance. *Nutritional Biotechnology in the Feed and Food Industry*. Proceedings of the 20th Annual Symposium (Suppl. 1), Lexington, Kentucky, USA. May 22–26, 2004. P. 32.

30.Seo T. C., Spallholz J. E., Yun H. K., Kim S. W. Selenium- enriched garlic and cabbage as a dietary selenium source for broilers. *Journal of Medicinal Food*. 2008. 11. P. 687–692.

31.Shurson G. C., Salzer T. M., Koehler D. D., Whitney M. H. Effect of metal specific amino acid complexes and inorganic trace minerals on vitamin stability in premixes. *Animal feed science and technology.* 2011. 163. P. 201.

32.Skřivan M., Dlouhá G., Mašata O., Ševčíková S. Effect of dietary selenium on lipid oxidation, selenium and vitamin E content in the meat of broiler chickens. *Czech Journal of Animal Science*. 2008. 53. P. 306–311.

33.Smet K., Raes K., Huyghebaert G., Haak L., Arnouts S., de Smet S. Lipid and protein oxidation of broiler meat as influenced by dietary natural antioxidant supplementation. *Poult. Sci.* 2008. 87. P. 1682–1688.

34.Svoboda M., Saláková A., Fajt Z., Kotrbáček V., Ficek R., Drábek J. Efficacy of Se-enriched alga *Chlorella* spp. and Se-enriched yeast on tissue selenium retention and carcass characteristics in finisher pigs. *Acta Veterinaria Brno.* 2009b. 78. P. 579–587.

35.Ševčíková S., Skřivan M., Dlouhá G., Koucký M. The effect of selenium source on the performance and meat quality of broiler chickens. *Czech. J. Anim. Sci.* 2006. 51. P. 449–457.

36.Tietz N. W. Clinical Guide to Laboratory Tests 3rd ed AACC. 1995.

37.Trávníček J., Racek J., Trefil L., Rodinová H., Kroupová V., Illek J., Doucha J., Písek L. Activity of glutathione peroxidase (GSH-Px) in the blood of ewes and their lambs receiving the selenium-enriched unicellular alga *Chlorella*. *Czech Journal of Animal Science.* 2008. 53. P. 292–298.

38.Upton R., Edens F. W., Ferket P. R. Selenium Yeast Effect on Broiler Performance. *Int. J. Poult. Sci.* 2008. 7. P. 798–805.

39.Upton J. R., Edens F. W., Ferket P. R. The effects of dietary oxidized fat and selenium source on performance, glutathione peroxidase, and glutathione reductase activity in broiler chickens. *Journal of Applied Poultry Research.* 2009. 18. P. 193–202.

40.Wang Y. B., Xu B. H. Effect of different selenium source (sodium selenite and selenium yeast) on broiler chickens. *Animal Feed Science and Technology.* 2008. 144. P. 306–314.

41.Yoon L., Werner T. M., Butler J. M. Effect of source and concentration of selenium on growth performance and selenium retention in broiler chickens. *Poultry Science*. 2007. 86. P. 727–730.

42.Ziołecki A., Kwiatkowska E. Gas chromatography of C1 to C5 fatty acids in rumen fluid and fermentation media. *Journal of Chromatography.* 1973. 80. P 250–254.

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