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THE EFFECT OF INCREASED SELENIUM AND VITAMIN E IN THE FEEDING OF FATTENING PIGS ON THEIR GROWTH, CHEMICAL COMPOSITION OF MEAT AND SERUM BIOCHEMICAL PARAMETERS

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ABSTRACT

The aim of the study was to assess the effect of supplementing standard compound feeds for fatteners with additional amounts of selenium and vitamin E on fattening performance, meat chemical composition, serum biochemical parameters in fattening pigs. The study was carried out on 60 fatteners of the 990 Polish Synthetic Line. The animals were allocated to 4 groups: control group – receiving basal diets (grower and finisher), contain 0.3 mg inorganic Se (Na_2SeO_3) and 60 mg vitamin E · kg^{-1}. Experimental groups received additionally: SE – 0.2 mg organic Se · kg^{-1}, VE group – 60 mg vitamin E · kg^{-1}, and VE + SE group – 60 mg vitamin E · kg^{-1} and 0.2 mg organic Se · kg^{-1}. The addition of selenium contributed to the deterioration of feed conversion. Pigs receiving the additives used had a significantly lower meat content in carcass. Both selenium and vitamin E contributed to the reduction of cholesterol content in meat. Fatteners receiving the addition of vitamin E alone and in combination with selenium were characterized by significantly lower cholesterol and triglyceride concentrations in serum.

Key words: fattening pigs, selenium, vitamin E, meat, serum, cholesterol

INTRODUCTION

In recent years, in pig nutrition attention has been paid to feed additives that affect not only the production effects and quality of meat, but also to its health security, which is important from the point of view of the consumer. One of the reasons for the deterioration in meat quality is lipid oxidation. The one way of improving the quality and health security of pork is supplementation of pig diet with antioxidants [Bielli et al. 2015, Jiang and Xiong 2016].

Selenium and vitamin E, as antioxidants increasing the antioxidant stability of meat are very popular with scientists. They are part of a non-enzymatic antioxidant system providing protection of cellular lipids [Salami et al. 2016]. The main antioxidant found naturally in small amounts in pig fat is α-tocopherol. The primary function of vitamin E is to prevent lipid oxidation of cell membranes, to interrupt the already ongoing peroxidation reaction and to scavenge reactive oxygen species (ROS) and free radicals [Debier and Larondelle 2005, Zingg 2007]. The study of Boler et al. [2009] have shown that increasing the natural vitamin E feed additive decreasing lipid oxidation and extends the shelf life of pork consumption. However, in recent years, scientists' attention is focused to other than antioxidant properties of vitamin E. It also affects the expression of genes associated with lipid metabolism and cholesterol transport [Galmés et al. 2018]. Some studies have shown that vitamin E and selenium improve pork sensory and nutritional characteristics [Krska et al. 2001].

The organic form of selenium, improves the antioxidant status by increasing the activity of glutathione peroxidase, which contributes to the protection of muscle fibers and has a positive effect on meat quality [Mateo et al. 2007, Zhan et al. 2007]. Selenium deficiencies contribute to many diseases in animals [Falk et al. 2018]. According to the standards, the demand of fattening pigs for selenium, depending on the fattening phase, ranges from 0.1 to 0.3 mg · kg^{-1} of the mixture. The maximum

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amount of selenium used in animal feed should not exceed 0.5 mg · kg^{-1}. The recommended doses of vitamin E in the feed for fattening pigs are 120 mg · kg^{-1} in the first fattening phase and 90 mg · kg^{-1} in the second fattening phase. There are not many studies analyzing the supplementation of inorganic selenium with organic selenium along with an increased addition of vitamin E for the effects of fattening pigs [Chen et al. 2019]. Both selenium and vitamin E, by influencing lipid metabolism, can affect the cholesterol content in the serum and meat of pigs. The interest in the cholesterol content of meat comes from the awareness of the relationship between dietary cholesterol and cardiovascular disease. Therefore, research was carried out to determine the effect of increased amounts of selenium and vitamin E on the fattening effects and the chemical composition of pork and the development of selected biochemical parameters in serum.

MATERIAL AND METHODS

Animals and feeding

In the experiment were used 60 fatteners of the 990 Polish Synthetic Line. The experiment was conducted in the National Research Institute of Animal Production in Poland. The experiment was carried out in accordance with the applicable EU Directive 2010/63/EU. Breeding animals kept for production purposes by established methods on the farm were used. The animals from the experimental groups were slaughtered in a way that minimized pain, suffering and stress in accordance with the zootechnical procedures in force (EC NO 1099/2009, of 24 September 2009 on the protection of animals at the time of killing). The slaughter and the evaluation of the performance for slaughter were carried out at the Pigs Slaughter Utility Control Station. The same number of pigs with different sex and body weight were allocated to four dietary groups, 15 pigs in each (7 females, 8 males). The feeding experiment was carried out during the all fattening period (from 26.5 ±3.7 kg to 106.6 ±5.8 kg body weight). The animals were kept in individual pens (3 m^2 per pig). The feed was supplied ad libitum and water was provided by nipple drinkers. The pigs were given grower basal diets during the fattening period of 30 to 60 kg body weight and finisher ones during the fattening period of 60 to 107 kg body weight.

The composition of the basal diets (Table 1) was formulated to nutrient requirements according to standards in Poland [Pigs Nutrition Standards 1993]. The basal diet contained a supplement of 0.3 mg Se (Na_2SeO_2) and 60 mg vitamin E per 1 kg feed mixture. The pigs control group (CG) received only a basal diet, however, the pigs in the experimental groups received additionally of selenium enriched yeast (from *Saccharomyces cerevisiae*) and vitamin E (dl-α-tocopheryl acetate) in the diets (grower and finisher): SE group – basal diets + 0.2 mg Se · kg^{-1}, Vitamin VE group – basal diets + 60 mg vitamin E · kg^{-1}, VE + SE group – basal diets + 0.2 mg Se + 60 mg vitamin E · kg^{-1}.

During this experimental period (113 days), pigs were weighed individually three times: at the beginning of fattening, at a body weight 70 ±6,74 kg, and before slaughter (107 ±5.8 kg). Average daily gain (g), feed intake (kg per day) feed conversion (per 1 kg of weight gain), were determined at the end of each fattening phase for all pigs and throughout the experimented period.

Samples collection

The samples were collected from all animals in each group. At the slaughter time, at the end of the fattening period (107 ±5.8 kg body weight), blood samples were collected from jugular vein. Serum was separate by centrifugation at 4°C, 1000 × g for 10 min. Sample of serum and Longissimus dorsi muscle (between the last thoracic and first lumbar vertebra) were collected and stored at –20°C.

Carcass measurement

The evaluation of lean meat content of carcass was performed accordingly with the SEUROP grading method (The Commission of the European Communities 2005) with the use of Capteur Gras/Maigre – Sydel (CGM) apparatus (Sydel, Lorient, France). The lean meat content of carcass was calculated automatically by the CGM apparatus using the following formula:

$$Y = 50.11930 - 0.62421 \cdot X_1 + 0.26979 \cdot X_2$$

where:

Y – the estimated percentage of lean meat in the carcass,

X_1 – the thickness of the fat (including rind), between the third and fourth last ribs at 6 cm of the dorsal midline, at a trajectory perpendicular to the rind (in mm),

X_2 – the thickness of the *L. dorsi* muscle (in mm), measured at the X_1 position.

Chemical analysis

Basic chemical composition in the grower and finisher diets as well as in the M. longissimus dorsi were determined by standard AOAC methods [AOAC 2000a], while amino acids in the diet were assayed using the Beckman automatic analyzer. Phosphorus (P) was assayed by the vanadium-molybdenum photo-colorimetric method, whereas calcium (Ca) and sodium (Na) by the emission spectrometry method on a Buck Scientific spectrophotometer. Total cholesterol content in the muscle

Table 1. Ingredients and feeding value of the basal diets

Tabela 1. Skład i wartość odżywcza mieszanek pełnoporcjowych

Diet components – Składniki mieszanki	Grower, %	Finisher, %
Wheat – Pszenica	20.00	30.00
Maize – Kukurydza	–	10.00
Barley – Jęczmień	25.00	–
Triticale – Pszenżyto	30.00	35.00
Soybean meal 46% – Śruta sojowa 46%	18.00	10.00
Rapeseed meal – Śruta rzepakowa	–	6.00
Wheat bran – Otręby pszenne	2.54	5.50
Limestone – Kreda pastewna	1.00	1.10
Monocalcium phosphate – Fosforan jednowapniowy	0.80	0.30
NaCl	0.35	0.35
L-lizyne – L-lizyna	0.20	0.20
DL-methionine – L-metionina	0.04	–
L-treonine – L-treonina	0.05	0.02
Soybean oil – Olej sojowy	1.50	1.00
Porzyme 9300	0.03	0.03
Phyzyme XP TPT	–	0.01
Premix 0.5%*	0.50	0.50
Nutrients, g · kg^{-1} – Składniki odżywcze, g · kg^{-1}		
Metabolizable energy**, MJ · kg^{-1} – Energia metaboliczna**, MJ · kg^{-1}	13.00	13.00
Crude protein – Białko ogólne	175.96	162.10
Lysine – Lizyna	10.05	9.07
Methionine + cystine – Metionina + cystyna	6.20	5.91
Treonine – Treonina	6.60	5.95
Tryptophan – Tryptofan	2.10	1.88
Ca	6.60	6.10
P	5.80	5.28
Na	1.57	1.56
Se (Na_2SeO_3)	0.30	0.30

*Vitamin – mineral premix provide (per kg basal diet): vitamin A – 8000 IU; vitamin, D3 – 1000 IU; vitamin E – 60 mg; vitamin K3 – 2 mg; vitamin B1 – 2 mg; vitamin B2 – 4 mg; vitamin B6 – 4 mg; vitamin B12 – 25 µg; biotin – 100 µg; pantothenic acid – 10 mg; niacin – 20 mg; folic acid – 400 µg; choline chloride – 600 mg; Fe – 80 mg; Mg – 400 mg; Mn – 40 mg; Zn – 100 mg; Cu – 10 mg; I – 0.8 mg; Co – 0.4 mg, Se – 0.3 mg.
**Calculated from Polish Standards of Pig Nutrition (1993).
Addition to basal diets for experimental groups: selenium enriched yeast from *S. cerevisiae* CNCM I-3399 /2000 mg Se kg – 1 – Lesaffre Feed Additives (France); Vitamin E 50% Powder Feed Grade (dl – α – tocopheryl acetate) – Zhejiang Medicine Co. Ltd Vitamin Factory (China).
*Premiks witaminowo – mineralny wprowadza (do 1 kg mieszanki): witamina A – 8000 IU; witamina D3 – 1000 IU; witamina E – 60 mg; witamina K3 – 2 mg; witamina B1 – 2 mg; witamina B2 – 4 mg; witamina B6 – 4 mg; witamina B12 – 25 µg; biotyna – 100 µg; kwas pantotenowy – 10 mg; niancyna – 20 mg; kwas foliowy – 400 µg; chlorek choliny – 600 mg; Fe – 80 mg; Mg – 400 mg; Mn – 40 mg; Zn – 100 mg; Cu – 10 mg; I – 0.8 mg; Co – 0.4 mg, Se – 0.3 mg.
**Obliczone na podstawie Polskich Norm Żywienia Świń (1993).
Dodatek do diet podstawowych dla grup eksperymentalnych: drożdże *S. cerevisiae* wzbogacone w selen CNCM I-3399 /2000 mg Se · kg^{-1} – Lesaffre Feed Additives (France); witamina E 50% proszek do paszy – Zhejiang Medicine Co. Ltd Vitamin Factory (China).

was determined using the AOAC [2000] method. The determination of cholesterol content in pig meat was performed by means of gas chromatography with mass spectrometry (GCMS) on a CLARUS 600 system from Perkin Elmer (USA).

Serum biochemical traits analysis

Blood samples were collected on slaughter from all porkers from the jugular vein to obtain serum. After centrifugation, serum was frozen at –20°C. In the thawed serum, the following indices were determined: total protein, glucose, total cholesterol, HDL fraction, LDL fraction, triglycerides. To measure the level of respective biochemical parameters in the blood serum (total protein, cholesterol, HDL cholesterol, glucose, triglycerides), BioMaxima reagent kits (Poland) were used. The absorbance measurement was made using a Marcel® PRO (Bio, Poland) spectrophotometer. LDL cholesterol levels were calculated using the Friedewald formula [Friedewald et al. 1972].

Statistical analysis

An animal represented the experimental unit. The grouping factor was the type of additive used. The normal distribution of obtained data was evaluated by the Shapiro-Wilk test, and the variance of homogeneity was assessed by the Levene's test. The obtained data was analyzed statistically by means of the STATISTICA 10.0 PL computer software using one-way analysis of variance (ANOVA). The significance of differences between the groups was evaluated with the Duncan test. The obtained data are expressed throughout as an arithmetic means and standard error of the mean and p-Value.

RESULTS

The increased amounts of selenium and vitamin E used in the nutrition of fattening pigs applied in this study did not significantly affect the final body weight and growth rate of the animals examined (Table 2). Considering the entire fattening period, pigs receiving an increased amount of selenium and vitamin E per 1 kg of feed were characterised by a similar, though slightly lower growth rate and feed utilization compared to control animals. It was observed that the addition of organic selenium contributed to a significant deterioration of feed utilization per 1 kg of weight gain in the first stage of fattening ($P \leq 0.05$). The other experimental groups of fatteners (SE and SE + VE) were also characterised by slightly worse feed utilization in the first stage of fattening compared to the control group. Considering the entire fattening period, the SE groups were characterised by significantly worse feed utilization than the CG and VE group ($P \leq 0.05$).

As indicated in Table 3, control animals had a significantly higher meat content in carcass compared to animals SE and VE groups ($P \leq 0.05$). The lowest meat content in carcasses was found in animals VE + SE group ($P \leq 0.01$). Fresh half-carcass weight and carcass dressing percentage were similar in all examined groups. The meat of animals VE and VE + SE groups contained significantly more dry matter ($P \leq 0.05$) compared to the CG animals. In addition, the meat of fatteners VE group contained significantly more total protein ($P \leq 0.05$) compared to the CG. Selenium and vitamin E given to the feed contributed to the reduction of cholesterol content in the L. dorsi muscle of the fatteners examined. The best effect was obtained for combined administration of selenium and vitamin E, where the cholesterol content in meat was the lowest ($P \leq 0.05$).

Fatteners receiving increased addition of vitamin E and selenium and vitamin E combined had significantly lower serum cholesterol (Table 4.) compared to the control group ($P \leq 0.01$). However animals of the group receiving additionally organic selenium, obtained higher cholesterol levels than the groups receiving more vitamin E ($P \leq 0.05$). The HDL cholesterol fraction remained at a similar level in all examined groups. However, when it comes to the LDL cholesterol fraction, it was significantly lower ($P \leq 0.05$) in the serum of fatteners receiving vitamin E and selenium and vitamin E combined. The additions used significantly reduced ($P \leq 0.05$, $P \leq 0.01$) triglyceride concentration in the serum of fatteners. Their lowest concentration in relation to the control group was recorded in the group receiving vitamin E as well as selenium and vitamin E ($P \leq 0.05$). Fatteners receiving selenium addition also contained significantly less triglycerides in serum ($P \leq 0.05$). The addition of vitamin E also contributed to the reduction of protein concentration in relation to the control group of animals and the group receiving selenium addition ($P \leq 0.01$) as well as to the group receiving vitamin E and selenium combined ($P \leq 0.05$).

DISCUSSION

This study did not show a beneficial effect of the tested supplements on the growth rate of fattening pigs. In the first stage of fattening, deterioration of daily weight gain in pigs receiving selenium and vitamin E supplements was found; animals of these groups also gained lower body weight than in the control group. Also in the study by Boler et al. [2009] the addition of 200 mg · kg^{-1} of synthetic vitamin E contributed to the reduction of daily gains and the lower body weight of fattening pigs. Other authors [Guo et al. 2006, Huang et al. 2019] also did not obtain a beneficial effect of increased vitamin E supplementation on the growth rate of fattening pigs. However, Niculita et al. [2007] obtained a higher daily weight gain with an increase in vitamin E content in the feed to 300 mg · kg^{-1}, which was administered for a period of 30 days. It follows that the length of vitamin E administration period in pigs may be important, and in this study vitamin E supplementation was used throughout the whole fattening period.

Increasing the addition of selenium in the form of selenium-enriched yeast did not significantly affect the growth rate of the examined fatteners and their final body weight. Similar results were obtained in other studies on fattening pigs [Mateo et al. 2007, Chen et al. 2019], in which the addition of organic selenium in the amount of 0.3 mg · kg^{-1} of compound feed was used. Also studies on guinea pigs showed no effect of selenium on nutrient conversion [Chaudhary et al. 2010]. According to some authors [Mahan et al. 1999, Tian et al. 2006], both the dose and the form of selenium have no effect on the growth rate of fattening pigs. Increasing the amount of selenium in feed for fatteners to 0.5 mg · kg^{-1} of compound mixture, by supplementing the standard compound feed with 0.2 mg organic Se, contributed to a significant deterioration of feed utilization in the first stage of fattening, as well as throughout the whole fattening period. Similar results were obtained in other studies [Schwarz et al. 2017], where the addition of 0.5 mg of inorganic selenium reduced feed utilization. In studies by other authors

Table 2. Results of fattening performance

Tabela 2. Wyniki użytkowości tucznej

Item – Wyszczególnienie	CG	Se and vitamin E addition, mg · kg^{-1} Dodatek Se i witaminy E, mg · kg^{-1}			SEM	p
		SE	VE	SE + VE		
Body weight, kg – Masa ciała, kg						
Initial – Początkowa	26.6	26.0	25.1	26.0	0.434	0.672
Average – Średnia	72.9	69.5	69.0	69.6	0.880	0.390
Final – Końcowa	107.5	106	107	106.5	0.684	0.882
Average daily gains, g – Średni dzienny przyrost, g						
I fattening period – I faza tuczu	734	690	699	691	10.57	0.407
II fattening period – II faza tuczu	690	737	762	738	13.86	0.320
Whole fattening period – Cały okres tuczu	715	711	728	712	6.64	0.810
Feed intake, g · day^{-1} – Pobranie paszy, g · day^{-1}						
I fattening period – I faza tuczu	1941	2042	1899	1989	19.4	0.075
II fattening period – II faza tuczu	2443	2524	2540	2572	33.17	0.422
Whole fattening period – Cały okres tuczu	2159	2250	2178	2243	16.69	0.063
Feed conversion (kg) per 1 kg of weight gain – Wykorzystanie paszy (kg) na 1 kg przyrostu masy ciała						
I fattening period – I faza tuczu	2.66^{a}	2.97^{b}	2.77	2.92	0.048	0.035
II fattening period – II faza tuczu	3.58	3.46	3.38	3.50	0.071	0.807
Whole fattening period – Cały okres tuczu	3.02^{a}	3.17^{b}	2.99^{a}	3.16^{b}	0.025	0.016

^{a}, ^{b} – means marked with different letters differ significantly at P ≤ 0.05.
^{a}, ^{b} – średnie oznaczone różnymi literami różnią się istotnie przy P ≤ 0,05.

Table 3. Carcass traits and chemical composition of longissimus muscle

Tabela 3. Jakość tuszy i skład chemiczny mięśnia najdłuższego grzbietu

Item – Wyszczególnienie	CG	Se and vitamin E addition, mg · kg^{-1} Dodatek Se i witaminy E, mg · kg^{-1}			SEM	p
		SE	VE	SE + VE		
Meatiness, % – Mięsność, %	60.2^{Aa}	58.8^{b}	59.0^{b}	57.7^{B}	0.204	0.002
Hot carcass weight, kg – Masa tuszy ciepłej, kg	88.6	87.9	87.8	88.0	0.590	0.978
Dressing, % – Wydajność rzeźna, %	80.0	79.7	79.9	80.0	1.107	0.870
Dry matter, % – Sucha masa, %	25.5^{a}	26.2^{b}	26.4^{b}	26.5^{b}	0.142	0.028
Crude protein, % – Białko surowe %	22.4^{a}	22.6	23.2^{b}	22.8	0.106	0.043
Intramuscular fat, % – Tłuszcz śródmięśniowy, %	2.26	1.99	1.94	2.22	0.100	0.864
Cholesterol, mg · 100 g^{-1} – Cholesterol, mg · 100 g^{-1}	89.5^{Aa}	82.7^{b}	71.1^{B}	59.8^{B}	0.142	0.000

^{a}, ^{b} – means marked with different lower-case letters differ significantly at P ≤ 0.05.
^{A}, ^{B} – means marked with different capital letters differ significantly at P ≤ 0.01.
^{a}, ^{b} – średnie oznaczone różnymi małymi literami różnią się istotnie przy P ≤ 0,05.
^{A}, ^{B} – średnie oznaczone różnymi dużymi literami różnią się istotnie przy P ≤ 0,01.

Table 4. Biochemical indices in pigs serum

Tabela 4. Wskaźniki biochemiczne surowicy świń

Item – Wyszczególnienie	CG	Se and vitamin E addition, mg · kg^{-1} Dodatek Se i witaminy E, mg · kg^{-1}			SEM	p
		SE	VE	SE + VE		
Total cholesterol, mmol · l^{-1} – Cholesterol ogólny, mmol · l^{-1}	2.77^{A}	2.68^{a}	2.28^{Bb}	2.36^{Bb}	0.054	0.001
HDL cholesterol, mmol · l^{-1} – Cholesterol HLD, mmol · l^{-1}	0.94	0.92	0.89	0.96	0.019	0.611
LDL cholesterol, mmol · l^{-1} – Cholesterol LDL, mmol · l^{-1}	1.58^{a}	1.56^{a}	1.22^{b}	1.23^{b}	0.051	0.007
Triglicerydes, mmol · l^{-1} – Triglicerydy, mmol · l^{-1}	0.56^{Aa}	0.452^{b}	0.39	0.38^{B}	0.020	0.007
Glucose, mmol · l^{-1} – Glukoza, mmol · l^{-1}	5.11	4.92	4.84	4.89	0.193	0.074
Protein, mg · dl^{-1} – Białko, mg · dl^{-1}	8.05^{A}	8.12^{A}	6.87^{Ba}	7.55^{b}	0.120	0.000

^{a}, ^{b} – means marked with different lower-case letters differ significantly at P ≤ 0.05.
^{A}, ^{B} – means marked with different capital letters differ significantly at P ≤ 0.01.
^{a}, ^{b} – średnie oznaczone różnymi małymi literami różnią się istotnie przy P ≤ 0,05.
^{A}, ^{B} – średnie oznaczone różnymi dużymi literami różnią się istotnie przy P ≤ 0,01.

[Chen et al. 2019], in which the combined addition of organic and inorganic selenium was used in the amount of 0.5 mg · kg^{-1} in the feed for fattening pigs for 45 days, no significant effect on feed utilization was shown. This may be due to the fact that the addition of selenium in an amount of 0.5 mg · kg^{-1} in organic or inorganic form does not increase the digestibility of nutrients [Tian et al. 2006].

Increasing the selenium addition contributed to the reduction of carcass meat content, although the total amount of the additive used did not exceed the standards recommended by the European Union. In the study by Calvo et al. [2016], increasing the selenium dose in organic and inorganic form to 0.4 mg · kg^{-1} of the feed ration did not contribute to the reduction of carcass muscling, however the period of this ration application was much shorter and amounted to 26 days. Also the use of increased amounts of vitamin E [Boler et al. 2009] did not contribute to a reduction in carcass meat content.

The addition of selenium and vitamin E in pig nutrition is also considered in the aspect of meat chemical composition. The meat of animals in groups receiving an increased amount of vitamin E was characterised by a significantly higher content of dry matter ($P = 0.028$), which was not confirmed by studies of other authors [Lahucky et al. 2005]. No effect of the addition of this vitamin on the intramuscular fat content was observed, which was confirmed in other studies [Lahucky et al. 2005, Boler et al. 2009]. The addition of selenium did not significantly affect the chemical composition of pig meat. Also in the studies of other authors [Zhan et al. 2007, Lisiak et al. 2014] no significant effect of the additive on the protein and fat content in pig meat was found. The increased amount of selenium and vitamin E used in this study significantly reduced the cholesterol content compared to the control group. The addition of organic selenium in the amount of 0.3 mg to 1 kg of compound feed in pig nutrition analysed in the study by Štefanka et al. [2014] did not significantly affect the cholesterol content in meat, though slightly reduced it. Currently, a significant relationship between vitamin E and lipoprotein uptake as well as cholesterol transport and storage is suggested [Wallert et al. 2014].

Vitamin E caused a decrease in cholesterol and triglycerides in pig serum ($P \leq 0.01$). Similar trends were observed in other studies conducted in pigs [Huang et al. 2019]. Despite the differences in the chemical structure between cholesterol and vitamin E, their transport processes are very similar [Yamanashi et al. 2017]. Vitamin E transport depends on lipoproteins, which include triglycerides. Vitamin E is bound by chylomicrons and thus transported into tissues, where it accumulates [Jiang 2014]. Valastyan et al. [2008] report the unusual properties of vitamin E reducing cholesterol synthesis. Vitamin E plays a regulatory role in relation to cholesterol, contributing to the reduction of its endogenous synthesis by affecting the expression of genes that regulate the secretion of enzymes involved in oxysterol biosynthesis pathways [Landrier et al. 2010].

There are few studies showing the effect of selenium on serum lipid levels and their results are still not conclusive. Amer et al. [2019] in the study in rabbits showed the hypolipidaemic effect of the addition of selenium regardless of the administered form (organic and inorganic). This study has shown a significant effect of organic selenium on the reduction of serum triglycerides. Similar results were obtained in the study out on chickens receiving selenium increased to 0.45 mg · kg^{-1} (0.15 mg sodium selenite and 0.3 mg selenomethionine) [Beer-Ljubić et al. 2012]. Reduction of the total level of cholesterol and triglycerides was obtained in the blood of rabbits receiving a high-fat diet using 1 ppm sodium selenite [Kang et al. 2000]. However, in the study in piglets, Yu et al. [2004], using 0.3 ppm organic selenium, showed a trend to lower total cholesterol and increase HDL cholesterol, which was not confirmed in this study. Guo et al. [2020] in the study carried out on mice suggest that selenium in the form of nanoparticles can significantly alleviate hyperlipidemia. This is due to the effect of selenium in this form on the regulation of expression of key genes associated with cholesterol metabolism in liver.

CONCLUSIONS

The obtained results indicate that the combined use of selenium in inorganic (0.3 mg) and organic (0.2 mg) form in the nutrition of fattening pigs in the highest allowable dose (0.5 mg · kg^{-1} of feed) throughout the whole fattening period deteriorates significantly feed conversion. Fatteners receiving the increased amount selenium and vitamin E together (SE + VE) and separately (SE, VE) had a significantly lower meat content in carcass. The meat of pigs receiving an increased addition of vitamin E by 60 mg in 1 kg diet mixture, is characterized by a higher dry matter content. The results of this study have shown that an increased vitamin E used in combination with selenium in the feeding of fatteners contributed to the significantly reduction of cholesterol content in meat. Fattening pigs receiving an increased addition of vitamin E alone and in combination with selenium were characterized by significantly lower serum cholesterol (total and LDL) and triglyceride concentrations.

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REFERENCES

Amer, S.A., Omar, A.E., Abd El-Hack, M.E. (2019). Effects of selenium- and chromium-enriched diets on growth performance, lipid profile, and mineral concentration in different tissues of growing rabbits. Biol. Trace Elem. Res., 187, 92–99. DOI: 10.1007/s12011-018-1356-4.

AOAC (2000a). Official Methods of Analysis of the Association of Official Analytical Chemists, International 17th edition; Gaithersburg, MD, USA Association of Analytical Communities.

AOAC (2000). Official Method 994.10: Cholesterol in foods. Official Methods of Analysis of the Association of Official Analytical Chemists, International 17th edition; Gaithersburg, MD, USA Association of Analytical Communities.

Beer-Ljubić, B., Aladrović, J., Milinković-Tur, S., Lazarus, M., Pušić I. (2012). Effect of fasting on lipid metabolism and oxidative stability in fattening chicken fed a diet supplemented with organic selenium. Arch. Tierz., 55(5), 485–495. DOI: 10.5194/aab-55-485-2012.

Bielli, A., Scioli, M.G., Mazzaglia, D., Doldo EOrlandi, A. (2015). Antioxidants and vascular health. Life Sci., 143, 209–216. DOI: 10.1016/j.lfs.2015.11.012.

Boler, D.D., Gabriel, S. R., Yang, H., Balsbaugh, R., Mahan, D.C., Brewer, M.S., Mc Keith, F.K.; Killefer J. (2009). Effect of different dietary levels of natural-source vitamin E in grow-finish pigs on pork quality and shelf life. Meat Sci., 83, 723–730. DOI: 10.1016/j.meatsci.2009.08.012.

Calvo, L., Toldrá, F., Aristoy, M.C., López-Bote, C.J., Rey, A.I. (2016). Effect of dietary organic selenium on muscle proteolytic activity and water-holding capacity in pork. Meat Sci., 121, 1–11. DOI: 10.1016/j.meatsci.2016.05.006.

Chaudhary, M., Garg, A.K., Mittal, G.K., Mudgal, V. (2010). Effect of organic selenium supplementation on growth, Se uptake and nutrient utilization in guinea pigs. Biol. Trace Elem. Res., 133, 217–226. DOI: 10.1007/s12011-009-8420-z.

Chen, J., Tian, M., Guan, W., Wen, T., Yang, F., Chen, F., Zhang, S., Song, J., Ren, C., Zhang, Y. (2019). Increasing selenium supplementation to a moderately-reduced energy and protein diet improves antioxidant status and meat quality without affecting growth performance in finishing pigs. J. Trace Elem. Med. Biol., 56, 38–45. DOI: 10.1016/j.jtemb.2019.07.004.

Debier, C., Larondelle, Y. (2005). Vitamins A and E: metabolism, roles and transfer to offspring. Brit. J. Nutr., 93, 153–174. DOI: 10.1079/BJN20041308.

Falk, M., Bernhoft, A., Framstad, T., Salbu, B., Wisloff, H., Kortner, T.M., Kristoffersen, A.B., Oropeza-Moe, M. (2018). Effects of dietary sodium selenite and organic selenium sources on immune and inflamatory responses and selenium deposition in growing pigs. J. Trace Elem. Med. Biol., 50, 527–536. DOI: 10.1016/j.jtemb.2018.03.003.

Friedewald, W.T., Levy, R.I., Fredrickson, D.S. (1972). Estimationof the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin. Chem., 18, 499–502. DOI: 10.1093/clinchem/18.6.499.

Galmés, S., Serra, F., Palou, A. (2018). Vitamin E Metabolic Effects and Genetic Variants: A Challenge for Precision Nutrition in Obesity and Associated Disturbances. Nutrients, 10, 1919. DOI: 10.3390/nu10121919.

Guo, L., Xiao, J., Liu, H., Liu, H. (2020). Selenium nanoparticles alleviate hyperlipidemia and vascular injury in ApoE-deficient mice by regulating cholesterol metabolism and reducing oxidative stress. Metallomics, 1, 204–217. DOI: 10.1039/C9MT00215D.

Guo, Q., Richert, B.T., Burgess, J. R., Webel, D.M., Orr, D.E., Blair, M., Fitzner, G.E., Hall, D.D., Grant, A.L., Gerrard, D.E. (2006). Effects of dietary vitamin E and fat supplementation on pork quality. J. Anim. Sci., 84, 3089–3099. DOI: 10.2527/jas.2005-456.

Huang, C., Chiba, L.I., Magee, W.E., Wang, Y., Griffing, D.A., Torres, I.M., Rodning, S.P., Bratcher, C.L., Bergen, W.G., Spangler, E.A. (2019). Effect of flaxseed oil, animal fat, and vitamin E supplementation on growth performance, serum metabolites, and carcass characteristics of finisher pig and physical characteristics of pork. Livestock Sci., 220, 143–151. DOI: 10.1016/j.livsci.2018.11.011.

Jiang, Q. (2014). Natural forms of vitamin E: metabolism, antioxidant, and anti-inflammatory activities and their role in disease prevention and therapy. Free Radic. Biol. Med., 72, 76–90. DOI: 10.1016/j.freeradbiomed.2014.03.035.

Jiang, J., Xiong, Y.L. (2016). Natural antioxidants as food and feed additives to promote health benefits and quality of meat products: A review. Meat Sci., 120, 107–117. DOI: 10.1016/j.meatsci.2016.04.005.

Krska, P., Lahucky, R., Küchenmeister, U., Nürnberg, K., Palanska, O., Bahelka, I., Kuhn, G., Ender K. (2001). Influence of vitamin E supplementation on anti-oxidative status in muscle and meat quality of pig. Arch. Tierz., 43, 487–497.

Lahucky, R., Kuechenmeister, U., Bahelka, I., Novotna, K., Vasickova, K., Ender, K. (2005). Effects of Vitamin E by dietary supplementation and of Calcium Ascorbate by post mortem Injection in Muscle on the Antioxidative status and on Meat quality of Pigs Arch. Tierz., 48, 592–600. DOI: 10.5194/aab-48-592-2005.

Landrier, J.-F., Gouranton, E., Reboul, E., Cardinault, N., El Yazidi, C., Malezet-Desmoulins, C., André, M., Nowicki, M., Souidi, M., Borel, P. (2010). Vitamin E decreases endogenous cholesterol synthesis and apo-AI-mediated cholesterol secretion in Caco-2 cells. J. Nutr. Biochem., 2, 1207–1213. DOI: 10.1016/j.jnutbio.2009.10.008.

Lisiak, D., Janiszewski, P., Blicharski, T., Borzuta, K., Grześkowiak, E., Lisiak, B., Powałowski, K., Samardakiewicz, Ł., Szymowska, K., Batorska, M., Hammermeister, A. (2014). Effect of selenium supplementation in pig feed on slaughter value and physicochemical and sensory characteristics of meat. Ann. Anim. Sci., (14), 213–222. DOI: 10.2478/aoas-2013-0063.

Mahan, D.C., Cline, T.R., Richert, B. (1999). Effects of dietary levels of selenium-enriched yeast and sodium selenite as selenium sources fed to growing-finishing pigs on performance, tissue selenium, serum glutathione peroxidase activity, carcass characteristics, and loin quality. J. Anim. Sci., 77, 2172–2179. DOI: 10.2527/1999.7782172x.

Mateo, R.D., Spallholz, J.E., Elder, R., Yoon, I., Kim, S. W. (2007). Efficacy of dietary selenium sources on growth and carcass characteristics of growing-finishing pigs fed diets containing high endogenous selenium. J. Anim. Sci., 85, 1177–1183. DOI: 10.2527/jas.2006-067.

Niculita, P., Popa, M.E., Ghidurus, M., Turtoi, M. (2007). Effect of vitamin E in swine diet on animal growth performance and meat quality parameters. Pol. J. Food Nutr. Sci., 57, 125–130.

Pigs Nutrition Standards (1993). Nutritional value of feed. Omnitech Press, Warszawa.

Salami, S.A., Guinguina, A., Agboola, J.O., Omede, A.A., Agbonlahor, E.M., Tayyab U. (2016). Review: In vivo and postmortem effects of feed antioxidants in livestock: A review of the implications on authorization of antioxidant feed additives. Animal, 10, 1375–1390. DOI: 10.1017/S1751731115002967.

Schwarz, C., Ebner, K., Furtner, F., Duller, S., Wetscherek, W., Wernert, W., Kandler, W., Schedle, K. (2017). Influence of high inorganic selenium and manganese diets for fattening pigs on oxidative stability and pork quality parameters. Animal, 11, 345–353. DOI: 10.1017/S1751731116001518.

Štefanka, P., Bučko, O., Gálik, B., Čanigová, M., Debrecéni, O. (2014). The analysis of the carcass characteristics and physical-technological quality of pork after using diet with the addition of organic chromium and selenium. J. Centr. Europ. Agric., 14, 1039–1049. DOI: 10.5513/JCEA01/14.3.1302.

Tian, J.Z., Yun, M.S., Ju, W.S., Long, H.F., Kim, J.H., Kil, D.Y., Chang, J.S., Cho, S.B., Kim, Y.Y., Han, I.K. (2006). Effects of dietary selenium supplementation on growth performance, selenium retention in tissues and nutrient digestibility in growing-finishing pigs. Asian-Aust. J. Anim. Sci., 19, 55–60. DOI: 10.5713/ajas.2006.55.

Valastyan, S., Thakur, V., Johnson, A., Kumar, K., Manor, D. (2008). Novel transcriptional activities of vitamin E: inhibition of cholesterol biosynthesis. Biochemistry, 47, 744–752. DOI: 10.1021/bi701432q.

Wallert, M., Schmölz, L., Galli, F., Birringer, M., Lorkowski, S. (2014). Regulatory metabolites of vitamin E and their putative relevance for atherogenesis. Redox Biol., 2, 495–503. DOI: 10.1016/j.redox.2014.02.002.

Yamanashi, Y., Takada, T., Kurauchi, R., Tanaka, Y., Komine, T., Suzuki, H. (2017). Transporters for the intestinal absorption of cholesterol, vitamin E, and vitamin K. J. Atheroscler. Thromb., 24, 347–359. DOI: 10.5551/jat.RV16007.

Yu, I-T., Ju, C-C., Lin, J., Wu, H-L., Yen, H-T. (2004). Effects of probiotics and selenium combination on the immune and blood cholesterol concentration of pigs. J. Anim. Feed Sci., 13, 625–634. DOI: 10.22358/jafs/67630/2004.

Zhan, X., Wang, M., Zhao, R., Li, W., Xu, Z. (2007). Effects of different selenium source on selenium distribution, loin quality and antioxidant status in finishing pigs. Anim. Feed Sci. Tech., 132, 202–211. DOI: 10.1016/j.anifeedsci.2006.03.020.

Zingg, J-M. (2007). Vitamin E: An overview of major Research directions. Mol. Aspects Med., 28, 400–422. DOI: 10.1016/j.mam.2007.05.004.

WPŁYW ZWIĘKSZONEGO POZIOMU SELENU I WITAMINY E W ŻYWIENIU TUCZNIKÓW NA ICH WZROST, SKŁAD CHEMICZNY MIĘSA ORAZ PARAMETRY BIOCHEMICZNE SUROWICY

STRESZCZENIE

Celem pracy była ocena wpływu uzupełniania standardowych mieszanek paszowych dla tuczników dodatkową ilością selenu i witaminy E na wyniki tuczu, skład chemiczny mięsa i parametry biochemiczne surowicy tuczników. Badania przeprowadzono na 60 tucznikach linii 990. Zwierzęta podzielono na 4 grupy: grupa kontrolna (CG), otrzymująca mieszankę pełnoporcjową zawierającą 0,3 mg Se (Na_2SeO_3) i 60 mg witaminy E · kg^{-1}, grupa SE, otrzymująca dodatek 0,2 mg organicznego Se · kg^{-1}, grupa VE, otrzymująca 60 mg witaminy E · kg^{-1}, oraz grupa VE + SE, otrzymująca dodatkowo 60 mg witaminy E · kg^{-1} i 0,2 mg organicznej Se · kg^{-1}. Badania wykazały, iż żywienie tuczników zwiększoną ilością selenu i witaminy E może nieznacznie pogorszyć wykorzystanie paszy i mięsność, ale obniża zawartość cholesterolu w surowicy oraz mięsie tuczników.

Słowa kluczowe: tuczniki, selen, witamina E, mięso, surowica, cholesterol

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