The effect of lycopene supplementation on lipid profile and meat quality of broiler chickens

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ABSTRACT: An experiment was conducted to determine the effect of lycopene on lipid profile and quality of meat of broiler chickens Ross 308 at a different form of selenium. 540 broiler cockerels were randomly divided into 6 groups: without lycopene supplement (groups C and E3), supplemented with 50 mg/kg lycopene (groups E1 and E4), supplemented with 100 mg/kg lycopene (groups E2 and E5) while the source of selenium was sodium selenite (groups C, E1, E2) and Se-enriched yeast (groups E3, E4, E5). The experimental period was from 14 to 35 days of broiler age and was terminated by slaughter. The organic form of dietary selenium increased ($P \leq 0.05$) its content in breast meat (E3 – 174.2 μg/kg, E4 – 186.4 μg/kg, E5 – 191.9 μg/kg) compared to selenite (C – 125.4 μg/kg, E1 – 123.3 μg/kg, E2 – 128.5 μg/kg). The shear force of meat was higher ($P \leq 0.05$) in groups receiving the organic form of Se (E3 – 0.026 kN, E4 – 0.025 kN, E5 – 0.024 kN) in comparison with group C (0.017 kN), E1 (0.016 kN) and E2 (0.014 kN). Se in Se-enriched yeast reduced ($P \leq 0.05$) the concentration of malondialdehyde in breast meat after 5 days of storage. There were no significant differences in concentrations of cholesterol, LDL cholesterol and lipase in plasma. The higher content of HDL cholesterol in plasma was recorded in groups supplemented with 50 mg of lycopene, followed by groups with 100 mg of lycopene and the lowest values were measured in groups without lycopene supplementation when the difference between group E1 (1.64 mmol/l) and E3 (1.51 mmol/l) was significant ($P \leq 0.05$). Concentrations of LDL cholesterol showed an opposite trend. The lycopene supplement had a positive effect on the lipid profile of blood plasma of broiler chickens.

Keywords: broiler cockerels; selenium; lycopene; quality of meat

Lycopene is a carotenoid that is mostly present in vegetables and in some fruit species as a red pigment (pineapple, orange, grapefruit, tomato, sweet pepper, strawberry). Tomatoes and products from tomatoes are the main source of lycopene while the tomato skin is a rich source of lycopene. Lycopene is extraordinarily efficient in the control of degenerative diseases, it is a preventive against cardiovascular diseases and cancer of prostate gland, digestive tract, skin, it decreases a risk of the cancer of pancreas, uterine uvula, and it blocks the formation of noxious cholesterol. Many studies dealing with the importance of lycopene for human health and disease have been published. Blum et al. (2006) found that tomato-rich diet increased the HDL-cholesterol level. Napolitano et al. (2007) investigated the effects of lycopene on the induction of foam cell formation by modified LDL. Their findings suggest that lycopene may reduce the macrophage foam cell formation induced by modified LDL by decreasing lipid synthesis and downregulating the activity and expression of scavenger receptor activity. There exist few papers dealing with the effect of lycopene in poultry diet. The effect of lycopene on performance and quality of meat and eggs in Japanese quail was studied by

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Botsoglou et al. (2004) and Sahin et al. (2006a,b), in laying hens by Yannakopoulos et al. (1992) and Dotas et al. (1999), in broiler chicks by Leal et al. (1999). Lycopene is a potent antioxidant that provides protection against cellular damage caused by reactive oxygen species. Lycopene is known to have an effective free radical scavenging activity and this action could be beneficial to poultry because risk free radicals are formed under stress, fast growth, high reproduction rates and intensive metabolism conditions of poultry and lycopene may play an important role in the antioxidant defence system. The essential trace mineral, selenium, is of fundamental importance to human health. Selenium is known to have important roles in reproductive functions and development, immunocompetence and ageing (Arthur et al., 2003). Selenium is a component of the cell enzyme glutathione peroxidase (Mills, 1957). The Se content of animal feed ingredients is dependent on the Se concentration in soil. The Se reserve in soils was depleted in the Czech Republic (Pavlata et al., 2000) and Se intake is lower than the recommended daily allowance: 55–70 μg (Velíšek, 2002). Se is required for normal growth and maintenance in poultry and selenium in poultry nutrition was described in reviews by Surai (2002a,b), Spears et al. (2003) and Skřivan et al. (2006). The effects of selenium sources on the performance of broiler chickens, carcass characteristics and meat quality were studied by Downs et al. (2000), Ozkan et al. (2007). The utilisation and availability of the microelement depends on its concentration and form (Holovská et al., 2003; Kuricová et al., 2003; Ševčíková et al., 2006).

Commercial feed mixtures for broiler production in the Czech Republic contain Se supplement in the form of sodium selenite (0.3 mg Se/kg). The objective of our experiment was to determine potential effects of dietary supplement of the antioxidant lycopene on the lipid profile of blood plasma, on some nutrition characteristics of breast meat in broiler chickens and preliminarily also on performance traits when two dietary sources of Se are compared.

MATERIAL AND METHODS

Diets and husbandry

An experiment was conducted on 540 broiler cockerels of hybrid combination ROSS 308. Broilers were obtained from a commercial hatchery on day 0 post hatching. Straight-run cockerels were randomly divided into 6 groups, each group comprised 90 chickens. Until 14 days of age all broilers received a uniform feed mixture BR1 (232.7 g of CP, 12.5 MJ of AME_N/kg). Table 1 shows the formulation and chemical composition of feed mixture. All feed mixtures were prepared specially for this experiment and represented the type of feed mixtures commonly used in Europe. The composition of vitamin-mineral supplement for feed mixture BR1 was identical with commercial supplement including the addition of 0.3 mg Se/kg in the form of sodium selenite (Na_2SO_3). An experimental period was from 14 to 35 days of broiler age when the broilers received experimental feed mixtures BR2 (214.8 g of CP, 12.5 MJ of AME_N/kg), which differed in the amount of supplemented lycopene and selenium form. Control group (C) received selenium in the form of sodium selenite (0.3 mg Se/kg) and was without lycopene supplement, two groups (E1, E2) received an addition of 50 and 100 mg lycopene/kg. One group (E3) was without lycopene supplement with 0.3 mg Se/kg selenium in the form of Se-enriched yeasts (Sel-Plex by Alltech) and other 2 groups were given lycopene supplement (E4 – 50 mg/kg; E5 – 100 mg/kg). Granular wheat-maize-soybean based feed mixtures were used. Lycopene supplement was included in the premix. Lycopene powder (Alchimica Company) was used as a lycopene source. An *ad libitum* feeding regime and automatic drinkers were used. Broiler chickens were kept in boxes 2 m × 3.3 m on bedding (wooden chips) separated with wire partitions 1 m in height. Each box was equipped with 7 nipple drinkers, 3 pan feeders and a feed hopper. Each box was heated with gas radiator with regulator, ventilation was provided with temperature-controlled fan. The broiler chickens were kept under a 24-h constant lighting schedule with the lighting intensity control according to the technological procedure. Feed consumption, live weight and mortality were examined during the experiment. Body weights were recorded at the beginning and at the end of the study. When the experiment terminated at 35 days of age, 60 birds (10 broilers from each group of average live weight of the group) were selected and blood samples were collected. Blood was taken from the *vena basilica* into a heparin stabilised test-tube, blood samples were kept on ice and subsequently used for biochemical examination. Broilers were slaughtered conventionally in a

Table 1. Composition of the diets

	Feed mixture						
	BR1	BR2					
		C	E1	E2	E3	E4	E5
Ingredients (g/kg)							
Wheat	290	340					
Maize	300	280					
Soybean meal	320	310					
Rapeseed oil	40	40					
Fish meal	20	–					
Limestone	12	12					
Dicalcium phosphate	10	10					
Sodium chloride	2	2					
DL-methionine	1	1					
Vitamin-mineral mix[1,2]	5	5	5	5	–	–	–
Vitamin-mineral mix[1,3]	–	–	–	–	5	5	5
Lycopene (mg)	–	–	50	100	–	50	100
Composition by analysis (g/kg)							
Dry matter	899.9	881.3					
Crude protein	232.7	214.8					
Fat	64.5	63.8					
Fibre	22.7	28.3					
Ash	53.0	48.5					
Calcium	90.4	85.1					
Phosphorus	69.6	63.6					
AME_N by calculation (MJ/kg)	12.5	12.5					

[1]the vitamin-mineral premix provided per kg of diets: vitamin A 12 000 IU; vitamin D_3 5 000 IU; vitamin K_3 3 mg; vitamin E 50 mg; vitamin B_1 3mg; vitamin B_2 5 mg; vitamin B_6 4 mg; vitamin B_{12} 0.02 mg; niacinamide 40 mg; Ca pantothenate 12 mg; biotin 0.15 mg; folic acid 1.5 mg; choline-Cl 250 mg; betaine 75 mg; Mn 80 mg; Zn 60 mg; Fe 50 mg; J 1 mg; Co 0.4 mg; Cu 12 mg; Se 0.3 mg; Mo 1 mg

[1,2]Se – sodium selenite

[1,3]Se – Se-enriched yeast (Sel-Plex)

slaughtering plant and the carcasses were sacrificed to carry out breast muscle analyses.

Analyses

Meat samples were finely ground before the analysis. Water content was determined after desiccation to constant weight at a temperature of 105°C; protein content was measured after mineralisation (Digestion System 20) and distillation with Kjeltec Auto 1030 analyser; ash content – after complete combustion in a muffle furnace at a temperature 550°C; total lipids of breast meat were extracted with 2:1 chloroform-methanol according to the method of Folch et al. (1957). Selenium was determined by atomic absorption spectrophotometry: the samples were mineralised in a closed system by microwave digestion in the presence of HNO_3 and H_2O_2 in MILESTONE ETHOS TC equipment with temperature and pressure sensors (US EPA METHOD 3052). After mineralisation Se was determined by electrothermic atomisation ET-AAS in a graphite cuvette. We used a SOLAAR M-6 atom-

ic absorption spectrometer with GF 90 Zeeman graphite cuvette and FS 95 furnace autosampler.

Shear properties of meat were measured in the left breast muscle with an Instron apparatus, model 3365, with the application of measurement according to Warner-Blatzer. The value of meat colour was measured 2 h *post mortem* in the left breast muscle with a Minolta C2500d apparatus. Lightness (L*) was measured on the medial surface of the breast muscle in an area free of obvious colour defects. The susceptibility of breast muscle to lipid oxidation in raw muscle (TBA-0) and in muscle during refrigerated storage for 3 and 5 days (TBA-3, TBA-5) was determined by measuring thiobarbituric acid-reactive substances (TBARS) using a distillation method (Tarladgis et al., 1960). A blend of 10 g of meat was homogenised for 2 min with 97.5 ml of distilled water and 2.5 ml of 4N HCl solution. The blend was distilled until 50 ml were obtained. Then, 5 ml of the distillate and 5 ml of TBA reagent (0.02M of the solution of 2-thiobarbituric acid in acetic acid) were mixed and heated in a boiling water bath for 35 min. After cooling under running tap water for 10 min, the absorbance was measured at 538 nm against a blank (CARY 50 Probe UV-Visible Spectrophotometer was used). Concentrations of cholesterol, HDL, LDL and lipase in blood plasma were measured with a biochemical analyser (HITACHI 912 analyser, Japan, commercial kit). All analyses were carried out in the Institute of Animal Science Uhříněves, Prague.

Statistical analyses

The data were analysed by one-way ANOVA. Significant treatment effects were detected by Scheffe test. Differences were considered significant at $P \leq 0.05$. The results were expressed as means with their standard errors.

RESULTS

Performance traits were evaluated and are presented due to a small number of papers in literature search dealing with the effect of lycopene in poultry diet on performance. Table 2 shows the effect of dietary lycopene supplementation with different forms of selenium on performance traits and mortality. No differences in feed conversion were determined among the groups. Chicken mortality was

Table 2. Effects of dietary lycopene supplementation and different sources of Se on broiler performance (mean ± SE)

Parameter	Group				
	C sodium selenite 0 mg lycopene	E1 sodium selenite 50 mg lycopene	E2 sodium selenite 100 mg lycopene	E3 Se-enriched yeast 0 mg lycopene	E4 Se-enriched yeast 50 mg lycopene	E5 Se-enriched yeast 100 mg lycopene
Live weight (g): at 14 days of age	405 ± 5.59	398 ± 6.13	405 ± 6.19	406 ± 6.42	402 ± 7.89	403 ± 6.62
At 35 days of age	2 258^{c} ± 20.91	2 315^{abc} ± 25.61	2 352^{ab} ± 22.51	2 282^{bc} ± 24.18	2 319^{abc} ± 27.73	2 379^{a} ± 21.93
Feed: gain (kg/kg): 14 to 35 days	1.56	1.60	1.55	1.65	1.58	1.65
Mortality (%)	0	3	2	3	2	2

^{a,b,c}means with different superscripts in lines differ at $P \leq 0.05$

Table 3. Selected nutritive characteristics of breast muscle and lipid profile in blood plasma (mean ± SE)

Parameter	Group					
	C sodium selenite 0 mg lycopene	E1 sodium selenite 50 mg lycopene	E2 sodium selenite 100 mg lycopene	E3 Se-enriched yeast 0 mg lycopene	E4 Se-enriched yeast 50 mg lycopene	E5 Se-enriched yeast 100 mg lycopene
Dry matter (g/kg)	$242.5^{b} \pm 1.61$	$243.3^{b} \pm 0.86$	$244.4^{b} \pm 1.14$	$252.7^{a} \pm 1.35$	$254.1^{a} \pm 1.51$	$255.3^{a} \pm 1.91$
Crude protein (g/kg)	$210.4^{b} \pm 1.33$	$213.3^{b} \pm 0.88$	$214.5^{b} \pm 0.86$	$220.2^{a} \pm 1.43$	$221.2^{a} \pm 0.76$	$221.9^{a} \pm 1.55$
Intramuscular fat (g/kg)	10.5 ± 0.34	10.2 ± 0.42	9.7 ± 0.54	8.2 ± 0.30	9.0 ± 0.74	8.4 ± 0.56
Selenium (µg/kg)	$125.4^{b} \pm 2.98$	$123.3^{b} \pm 1.41$	$128.5^{b} \pm 3.37$	$174.2^{a} \pm 5.70$	$186.4^{a} \pm 3.85$	$191.9^{a} \pm 3.39$
Lightness value (L*)	56.6 ± 0.45	55.1 ± 1.25	53.2 ± 0.50	56.1 ± 0.50	54.6 ± 0.78	54.6 ± 0.44
Shear values (kN)	$0.017^{b} \pm 0.001$	$0.016^{b} \pm 0.001$	$0.014^{b} \pm 0.001$	$0.026^{a} \pm 0.001$	$0.025^{a} \pm 0.001$	$0.024^{a} \pm 0.001$
Blood plasma:						
– cholesterol (mmol/l)	3.39 ± 0.064	3.54 ± 0.075	3.29 ± 0.058	3.51 ± 0.048	3.48 ± 0.051	3.30 ± 0.083
– HDL cholesterol (mmol/l)	$1.52^{ab} \pm 0.029$	$1.64^{a} \pm 0.031$	$1.55^{ab} \pm 0.015$	$1.51^{b} \pm 0.020$	$1.59^{ab} \pm 0.033$	$1.54^{ab} \pm 0.021$
– LDL cholesterol (mmol/l)	1.55 ± 0.044	1.49 ± 0.076	1.46 ± 0.048	1.56 ± 0.072	1.50 ± 0.074	1.43 ± 0.061
– Lipase (ukat/l)	0.45 ± 0.064	0.51 ± 0.046	0.34 ± 0.036	0.44 ± 0.081	0.59 ± 0.068	0.35 ± 0.024

^{a,b,c}means with different superscripts in lines differ at $P \leq 0.05$

Table 4. Malondialdehyde content in raw breast meat (TBA 0), after 3 and 5 days (TBA–3; TBA–5) of storage (mean ± SE)

Parameter	Group					
	C sodium selenite 0 mg lycopene	E1 sodium selenite 50 mg lycopene	E2 sodium selenite 100 mg lycopene	E3 Se-enriched yeast 0 mg lycopene	E4 Se-enriched yeast 50 mg lycopene	E5 Se-enriched yeast 100 mg lycopene
TBA–0 (mg/kg)	0.61 ± 0.009	0.56 ± 0.009	0.59 ± 0.0005	0.60 ± 0.029	0.56 ± 0.026	0.60 ± 0.007
TBA–3 (mg/kg)	0.71 ± 0.026	0.71 ± 0.015	0.67 ± 0.009	0.65 ± 0.009	0.65 ± 0.034	0.62 ± 0.014
TBA–5 (mg/kg)	$0.96^{a} \pm 0.010$	$0.93^{a} \pm 0.019$	$0.89^{a} \pm 0.001$	$0.80^{b} \pm 0.017$	$0.80^{b} \pm 0.021$	$0.79^{b} \pm 0.001$

^{a,b,c}means with different superscripts in lines differ at $P \leq 0.05$

low in all groups. The average live weight of broilers at the beginning of experiment was balanced in all groups (398–406 g). The supplement of 100 mg/kg lycopene increased ($P \leq 0.05$) the final live weight of broilers (E2, E5) by 9.5 and 9.7% compared to group C and E3. The content of selected basic nutrients in breast muscle – dry matter, proteins, intramuscular fat, selenium content, lightness value, shear values and lipid profile of broiler sera are shown in Table 3. In the breast muscle of broilers that received selenium in an organic form (E3, E4, E5) higher ($P \leq 0.05$) values of proteins and dry matter were determined compared to groups C, E1, E2. The effect of lycopene on the microelement content in muscle was not observed. With an increasing dietary supplement of lycopene the content of dry matter and proteins increased, without statistical significance. There were no significant differences in the content of intramuscular fat (IF) while lower values of IF were measured in Sel-Plex groups and the lycopene supplement also reduced the content of this fat. The organic form of Se in broiler diet increased ($P \leq 0.05$) the microelement concentration in breast muscle (groups E3, E4, E5) compared to selenite (C, E1, E2). The effect of lycopene on the microelement content in muscle was not significant. The highest concentrations of Se were measured in groups that received 100 mg dietary lycopene, both in the inorganic and organic form of selenium. In many experiments the Warner and Bratzler method of measuring the shear force is used to evaluate meat tenderness as one of the traits of its quality. In our experiment the effect of selenium form was significant. We recorded a higher ($P \leq 0.05$) shear force of muscle in groups receiving Se in an organic form (E3, E4, E5) compared to the control group C, group E1 and E2. Lycopene was not found to influence the meat colour. The average L* (lightness) value was 55.0 and the meat was lighter than the meat of normal colour. In the groups with a higher concentration of dietary lycopene the breast muscle was of insignificantly darker colour and L* values approached the meat of normal colour.

Although we did not prove a significant effect of lycopene in broiler diet on the concentration of total cholesterol, LDL cholesterol and lipase in plasma, the lowest values of total cholesterol were measured in the groups with dietary lycopene supplement of 100 mg/kg. In the present paper groups supplemented with 50 mg of lycopene had a higher content of HDL cholesterol, followed by groups receiving 100 mg of lycopene, and the lowest values were recorded in groups without lycopene. A significant difference ($P \leq 0.05$) in the content of HDL cholesterol was only in group E1 with 50 mg lycopene in comparison with group E3 without lycopene. The concentrations of LDL cholesterol showed an opposite trend. The susceptibility of breast muscle to lipid oxidation in raw muscle (TBA-0) and in muscle during refrigerated storage for 3 and 5 days (TBA-3, TBA-5) was determined by measuring thiobarbituric acid-reactive substances (TBARS) and it is shown in Table 4. The values of malondialdehyde were higher after 3 and 5 days of storage compared to raw muscle. In the groups receiving selenium in the form of Se-enriched yeasts lower values of malondialdehyde were recorded after 3 days of storage and after 5 days of storage this reduction was significant ($P \leq 0.05$) compared to groups with selenite. The lycopene supplement insignificantly reduced the concentration of MDA also after 3 and 5 days of storage.

DISCUSSION

Few papers have been published that describe the effect of dietary lycopene on poultry performance. The effect of lycopene on live weight of animals tends to be insignificant but lycopene has positive effects on egg quality from the aspect of their weight and yolk colour. Leal et al. (1999) reported that the broilers exposed to mycotoxins showed a decrease in body weight, feed intake and feed efficiency and these decreases were partly alleviated by lycopene supplementation. Sahin et al. (2006a) investigated how dietary lycopene supplementation at different doses (50, 100 and 200 mg/kg of diet) would influence performance, carcass characteristics, oxidative stress markers, cholesterol, triglyceride, and glucose in growing Japanese quails reared at a high ambient temperature (34°C). Lycopene supplementation linearly increased feed intake ($P \leq 0.05$), live weight gain ($P \leq 0.01$), feed efficiency ($P \leq 0.01$) under heat stress conditions (34°C), but the performance of birds reared at a thermoneutral temperature (22°C) was not affected by lycopene supplementation. Jain et al. (1999) reported that live weight and feed intake were not affected by lycopene supplementation in rat in thermoneutral conditions. The effect of different selenium forms on live weight of broilers, feed consumption and mortality was not recorded, neither did Downs et al. (2000) observe a significant effect

of the addition of 0.3 mg/kg Se in the form of selenite and Se-enriched yeast on performance traits of broiler chickens. On the other hand, Ševčíková et al. (2006) reported the higher final live weight of broiler chickens supplemented with 0.3 mg/kg dietary selenium in the form of Se-enriched yeast and Se-enriched alga *Chlorella*. In poults at the age of 28 days Cantor et al. (1982) recorded higher live weight and increased feed intake after dietary Se supplementation in the form of sodium selenite or selenomethionine (0.04 to 0.12 ppm Se).

The broilers that received the organic form of selenium had higher content of proteins and lower content of fat in muscle in comparison with the inorganic form of the element in which selenium is contained in commercial feed mixtures. Lonergan et al. (2003) also reported that the breast from commercial broilers who were fed commercial maize-soybean-based diets contained lower percentages of protein ($P \leq 0.05$) and higher percentages of lipids ($P \leq 0.05$).

Selenium content in muscle was influenced by its dietary form. The organic form of selenium increased ($P \leq 0.05$) the microelement concentration in breast muscle compared to selenite and the results are consistent with the findings of other authors (Choct et al., 2004; Payne and Southern, 2005). The results of an experiment of Kuricová et al. (2003) demonstrated the evident advantage of supplementation of poultry feed with Se-enriched yeast due to more effective Se utilization and formation of body deposits of Se than in the case of supplementation with selenite. Ševčíková et al. (2006) also reported that the supplement of selenium from Se-enriched yeast and alga *Chlorella* in the diet of broiler chickens increased ($P \leq 0.05$) the microelement concentration in breast and thigh muscle. Spears et al. (2003) reported that broiler chickens fed 0.15 ppm Se-Met had increased breast Se concentrations compared with those fed sodium selenite. The content of selenium in muscle may be influenced by the method of its determination. The utilisation efficiency of selenium from organic compounds is likely to be influenced by the content of selenomethionine. Selenomethionine (Se-Met) can be the major selenocompound in selenium-enriched yeast (Whanger, 2002).

In many experiments the Warner and Bratzler method of measuring the shear force is used for the evaluation of meat tenderness that may be considered as the most important trait from the aspect of quality (Northcutt et al., 2001; Schilling et al., 2003). Our experiment proved a significant effect of selenium form. It is possible to suppose that the higher shear force of muscle and lower content of intramuscular fat in groups that received the organic form of dietary selenium will influence meat quality from the aspect of consumers. The results are consistent with Fortin et al. (2005), who reported that the average shear force in muscles of pigs (*m. longissimus lumborum and thoracis*), an instrumental measure of tenderness (Warner-Bratzler shear force), was higher ($P \leq 0.05$) at less than 1% intramuscular fat. From the aspect of consumers meat colour is also important. Nikolakakis et al. (2004) reported that dietary incorporation up to a level 10% of dried tomato pulp improved carcass colour significantly. Qiao et al. (2001) gave these values for breast meat lightness (L*): lighter than normal (light, $L^* > 53$), normal ($48 < L^* < 53$), and darker than normal (dark, $L^* < 46$). Although in our experiment the groups with a higher intake of dietary lycopene had darker meat, this difference was not significant. The measured L* value in group E2 with supplement of 100 mg lycopene was 53.2, approaching the values of meat of normal colour. Barbut (1997) concluded that the value of breast meat colour $L^* > 49$ may indicate PSE meat in poultry. Yannakopoulos et al. (1992) and Dotas et al. (1999) reported that dried tomato pulp in the diet of laying hens up to the levels of 12 and 15% did not affect laying performance but significantly improved yolk colour.

In the present study a positive effect of lycopene on cholesterol concentration in the blood plasma of broiler cockerels was observed. Similar results were reported by Sahin et al. (2006a) in Japanese quail when the supplementation of lycopene increased HDL concentration whereas VLDL and LDL concentrations were reduced by lycopene supplementation ($P \leq 0.01$), particularly at a dietary concentration of 200 mg lycopene/kg. Blum et al. (2006) also found that tomato-rich diet – 300 g daily for one month – increased the HDL-cholesterol level significantly by 15.2%. Rao and Shen (2002) reported that the plasma level of total cholesterol was reduced by lycopene supplementation. On the contrary, Frederiksen et al. (2007) stated that dietary supplementation with an extract of lycopene-rich tomatoes had no effect on cholesterol and triacylglycerol levels measured in total plasma in rabbits. Sahin et al. (2006b) reported that supplementing with a combination of dietary lycopene and vitamin E reduced serum and yolk cholesterol concentrations ($P \leq 0.05$).

In the groups that received selenium in Se-enriched yeast lower values of malondialdehyde were

recorded after 3 days of meat storage and after 5 days of storage this reduction was significant ($P \leq 0.05$) compared to selenite groups. On the contrary, Holovská et al. (2003) reported that the lipid peroxide formation in liver tissue measured as the appearance of thiobarbituric acid-reactive substances (TBARS) showed no dependence on the amount or form of Se supplemented (sodium selenite and Se-enriched yeast) to the diet of chickens. The lycopene supplement insignificantly decreased the concentration of MDA after 3 and 5 days of storage. The results are consistent with Leal et al. (1999), who reported that the broilers exposed to lycopene showed a reduction in MDA production. Lycopene could reduce the cytotoxicity induced by T-2 toxin, mainly by reducing lipid peroxidation. The male broiler chicks receiving dietary lycopene and mycotoxin showed a reduction in malondialdehyde production (24, 54 and 67% for 7, 14 and 21 days of treatment, respectively) when compared with animals exposed to T-2. Chicks receiving lycopene alone showed similar responses like the control animals ($P \leq 0.05$). Sahin et al. (2006b) also stated that lycopene and vitamin E in the diet of Japanese quail reduced serum and liver malondialdehyde. Botsoglou et al. (2004) studied the effect of 5 and 10% of dried tomato pulp (DTP) in Japanese quail diet on the oxidative stability of raw and cooked breast meat during storage. After 6 and 9 days of raw meat storage the levels of MDA increased ($P \leq 0.05$) in the group with 10% of dietary DTP but they decreased ($P \leq 0.05$) at 5% DTP. The results indicated that dried tomato pulp showed antioxidative properties when incorporated in quail diet at the level of 5%. The incorporation of DTP at the level of 10% caused higher MDA values than in the control exerting a prooxidant effect. Sahin et al. (2006a) indicated that malondialdehyde (MDA) levels in serum, liver, and heart ($P \leq 0.001$) linearly decreased in all thermoneutral and heat stress groups as dietary lycopene supplementation increased. Similarly to the results of the current study, Jain et al. (1999) reported that dietary lycopene decreased serum TBARS concentration in rats by 14%.

CONCLUSION

The dietary supplement of 100 mg/kg lycopene increased ($P \leq 0.05$) the final live weight of broilers. The effect of lycopene and different selenium forms in broiler diet on feed consumption per kg of production and mortality was not proved. We determined higher ($P \leq 0.05$) concentration of Se in breast muscle and higher shear force in the meat of broilers with the organic form of dietary selenium. Selenium in Se-enriched yeast reduced the content of malondialdehyde in breast muscle after 5 days of storage. The dietary supplementation of lycopene positively affected the lipid profile of blood plasma.

REFERENCES

Arthur J.R., McKenzie R.C., Beckett G.J. (2003): Selenium in the immune system. Journal of Nutrition, 133, 1457–1459.

Barbut S. (1997): Problem of pale soft exudative meat in broiler chickens. British Poultry Science, 38, 355–358.

Blum A., Merei M., Karem A. et al. (2006): Effects of tomatoes on the lipid profile. Clinical and Investigative Medicine, 29, 298–300.

Botsoglou N., Papageorgiou G., Nikolakakis I. et al. (2004): Effect of dietary dried tomato pulp on oxidative stability of Japanese quail meat. Journal of Agricultural and Food Chemistry, 52, 2982–2988.

Cantor A.H., Moorehead P.D., Musser M.A. (1982): Comparative effects of sodium selenite and selenomethionine upon nutritional muscular dystrophy, selenium-dependent glutathione peroxidase, and tissue selenium concentrations of turkey poults. Poultry Science, 61, 478–484.

Choct M., Naylor A.J., Reinke N. (2004): Selenium supplementation affects broiler growth performance, meat yield and feather coverage. British Poultry Science, 45, 677–683.

Dotas D., Zamanidis S., Balios J. (1999): Effect of dried tomato pulp on the performance and egg traits of laying hens. British Poultry Science, 40, 695–697.

Downs K.M., Hess J.B., Bilgili S.F. (2000): Selenium source effect on broiler carcass characteristics, meat quality and drip loss. Journal of Applied Animal Research, 18, 61–71.

Folch J.M., Lees M., Sloane-Stanley G.H. (1957): A simple method for the isolation and purification of total lipids from animal tissues. Journal of Biological Chemistry, 226, 497–509.

Fortin A., Robertson W.M., Tong A.K.W (2005): The eating quality of Canadian pork and its relationship with intramuscular fat. Meat Science, 69, 297–305.

Frederiksen H., Rasmussen S.E., Schroder M. et al. (2007): Dietary supplementation with an extract of lycopene-rich tomatoes does not reduce atherosclerosis in Watanabe Heritable Hyperlipidemic rabbits. British Journal of Nutrition, 97, 6–10.

Holovská K., Boldizarová K., Cekonová S. et al. (2003): Antioxidant enzyme activities in liver tissue of chickens fed diets supplemented with various forms and amounts of selenium. Journal of Animal and Feed Sciences, 12, 143–152.

Jain C.K., Agarwal S., Rao A.V. (1999): The effect of dietary lycopene on bioavailability, tissue distribution, in-vivo antioxidant properties and colonic preneoplasia in rats. Nutrition Research, 19, 383–1391.

Kuricová S., Boldizarová K., Gresaková L. et al. (2003): Chicken selenium status when fed a diet supplemented with Se-yeast. Acta Veterinaria Brno, 72, 339–346.

Leal M., Shimada A., Ruiz F. et al. (1999): Effect of lycopene on lipid peroxidation and glutathione-dependent enzymes induced by T-2 toxin *in vivo*. Toxicology Letters, 109, 1–10.

Lonergan S.M., Deeb N., Fedler C.A. et al. (2003): Breast meat quality and composition in unique chicken populations. Poultry Science, 82, 1990–1994.

Mills G.C. (1957): Hemoglobin metabolism I. Glutathione peroxidase, an erythrocyte enzyme which protect hemoglobin from oxidative damage. Journal of Biological Chemistry, 229, 189–197.

Napolitano M., De Pascale C., Wheeler-Jones C. et al. (2007): Effects of lycopene on the induction of foam cell formation by modified LDL. American Journal of Physiology-Endocrinology and Metabolism, 293, E1820–E1827.

Nikolakakis I., Banakis D., Florou-Paneri P. et al. (2004): Effect of dried tomato pulp on performance and carcass characteristics of growing quails. Archiv für Geflugelkunde, 68, 34–38.

Northcutt J.K., Buhr R.J., Young L.L. et al. (2001): Influence of age and post-chill carcass aging duration on chicken breast fillet quality. Poultry Science, 80, 808–812.

Ozkan S., Malayoglu H.B., Yalcin S. et al. (2007): Dietary vitamin E (alpha-tocopherol acetate) and selenium supplementation from different sources: performance, ascites-related variables and antioxidant status in broilers reared at low and optimum temperatures. British Poultry Science, 48, 580–593.

Pavlata L., Pechová A., Illek J. (2000): Direct and indirect assessment of selenium status in cattle – a comparison. Acta Veterinaria Brno, 69, 281–287.

Payne R.L., Southern L.L. (2005): Comparison of inorganic and organic selenium sources for broilers. Poultry Science, 84, 898–902.

Qiao M., Fletcher D.L., Smith D.P. et al. (2001): The effect of broiler breast meat colour on pH, moisture, water-holding capacity, and emulsification capacity. Poultry Science, 80, 676–680.

Rao A., Shen H. (2002): Effect of low dose lycopene intake or lycopene bioavailability and oxidative stress. Nutrition Research, 22, 1125–1131.

Sahin K., Onderci M.C., Sahin N. et al. (2006a): Effects of lycopene supplementation on antioxidant status, oxidative stress, performance and carcass characteristics in heat-stressed Japanese quail. Journal of Thermal Biology, 31, 307–312.

Sahin N., Sahin K., Onderci M.C. et al. (2006b): Effects of dietary lycopene and vitamin E on egg production, antioxidant status and cholesterol levels in Japanese quail. Asian-Australian Journal of Animal Science, 19, 224–230.

Schilling M.W., Schilling J.K., Claus J.R. et al. (2003): Instrumental texture assessment and consumer acceptability of cooked broilers breasts evaluated using a geometrically uniform-shaped sample. Journal of Muscle Foods, 14, 11–23.

Skřivan M., Šimáně J., Dlouhá G., Doucha J. (2006): Effect of dietary sodium selenite, Se-enriched yeast and Se-enriched alga *Chlorella* on egg Se concentration, physical parameters of eggs and laying hens production. Czech Journal of Animal Science, 51, 163–167.

Spears J.W., Grimes J., Lloyd K., Ward T.L. (2003): Efficacy of a novel organic selenium compound (zinc-l-selenomethionine, Availa Se) in broiler chicks. In: Proceedings of the 1st Latin American Congress of Animal Nutrition, Cancun, Mexico, 197–198

Surai P.F. (2002a): Selenium in poultry nutrition 1. Antioxidant properties, deficiency and toxicity. World's Poultry Science Journal, 58, 333–347.

Surai P.F. (2002b): Selenium in poultry nutrition 2. Reproduction, egg and meat quality and practical applications. World's Poultry Science Journal, 58, 431–450.

Ševčíková S., Skřivan M., Dlouhá G. et al (2006): The effect of selenium source on the performance and meat quality of broiler chickens. Czech Journal of Animal Science, 51, 449–457.

Tarlagdis B.G., Wats B.M., Younathan M.T., Dugan Jr. L.R. (1960): A distillation method for quantitative determination of malonaldehyde in rancid foods. Journal of the American Oil Chemists Society, 37, 44–48.

Velíšek J. (2002): Essential elements. Food Chemistry II. Ossis, Tábor, CR, 97 pp. (in Czech)

Whanger P.D. (2002): Selenocompounds in plants and animals and their biological significance. Journal of the American College of Nutrition, 21, 223–232.

Yannakopoulos A.L., Tservenigousi A.S., Christaki E.V. (1992): Effect of locally produced tomato meal on the performance and the egg quality of laying hens. Animal Feed Science and Technology, 36, 53–57.

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