

Effect of supplementation with organic selenium on selenium content in broilers meat

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Abstract: Consumption of poultry products in the world has increased over past years. Broilers meat is popular to eat, because of its high nutritional value and reasonable prices. This study was intended to explore the effect of selenium-enriched yeast supplemented diet on broilers and selenium (Se) content in its meat. One hundred fifty unsexed one day old of Hubbard broiler chicks were reared up to 5 weeks. Broilers diet was supplemented with selenium-enriched yeast to get different levels of organic Se (0.2, 0.3, 0.4, 0.5 and 0.6 mg/kg diet). Supplementation with 0.2 organic Se was used as control treatment (T1). The results showed that the concentration of selenium (Se) in raw breast muscles was increased along with increasing the supplementation levels of organic Se in chicken's diet. The highest value of Se content was in treatment 5 (0.48 mg/kg). The amount of Se in cooked breast muscles was increased due to cooking processes comparing with raw samples except in case of boiling process the amount of it was decreased as a result of cooking. The highest values of Se after the different cooking processes were observed in grill process. There were no significant differences in CL% accompanied by increasing organic Se in chickens diet between T1 and other treatments in boiled and fried after boiling samples. Supplementation broilers diet with organic Se resulted in increasing the activities of glutathione peroxidase (GPx), superoxide dismutase (SOD) and catalase (CAT) comparing with control treatment (T1). There were significant differences for serum malondialdehyde (MDA) levels among T1 and other treatments. Concerning to total antioxidant capacity (TAC) levels, there were no significant differences between control treatment and both T2 and T3. Meanwhile, T4 and T5 achieved significant differences between T1. Total cholesterol (TC), triglyceride (TG) as well as low-density lipoprotein (LDL-C) levels in serum were decreased in all treatments compared to T1. Meanwhile, there were significant increases in sera HDL-C levels in T4 and T5 compared to T1. The broiler meat in both raw and cooked samples was not affected by increasing Se levels in diet regarding in all sensory attributes except in case of T5 in raw and boiled samples and T4 in boiled samples when odor was tested. Also, in case of flavor, T5 differ significantly from T1 in boiled samples. By modifying broiler feeding mixtures, broiler meat is enriched with functional ingredients such as selenium. Interestingly, supplementation with 0.2, 0.3, 0.4, 0.5 and 0.6 mg organic Se/kg diet from Se-enriched yeast increased Se deposition in chicken meat muscles and improved the antioxidant status of broilers. Getting such enriched chicken meat could be considered a useful source of this vital antioxidants in the human diet. Therefore, without changing eating habits and traditions of the various populations, it is possible to solve problems related to deficiency of various nutrients, in particular selenium.

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1. Introduction

Human health may be improved with increasing intake of biologically valuable ingredients. Broiler meat is popular to eat, and the consumption is increasing. Since 1979 the consumption of poultry has increased about five hundred percent (Haug *et al.*, 2007). The meat is lean and rich in protein and nutrients. The meat nutrition quality depends largely on the composition of poultry feed. The basic broilers diet consists of cereals (wheat, corn, etc.) in general, but biological active additives are widely used in commercial broiler feed compounds for enrichment of their nutritional value.

Minerals are vital nutrients for maintenance of the homeostatic condition that exists in all living organisms. Many of the minerals are involved in

essential metabolic and physiological processes, which are critical for human and animal health and animal. (Soetan *et al.*, 2010). Advances in mineral nutrition have proven the importance of consuming adequate amounts of macro- (Ca, P, Na, Cl, Mg, K, and S) and microminerals (Co, Cu, F, I, Fe, Mn, Mo, Se, and Zn). The microminerals or trace elements function as parts of proteins, hormones, enzymes, or as cofactors that activate specific enzymes (Surai, 2002).

Micronutrient deficiencies are a major public health problem in many developing countries, with infants and pregnant women especially at risk (Batra and Seth, 2002). Infants deserve extra concern because they need adequate micronutrients to maintain normal growth and development (Rush, 2000).

selenium (Se) has been defined as an essential dietary supplement which is important for improving health and performance of the birds and improving meat quality for human consumption (**Haug et al., 2007**). Selenium has important health promoting effect as it is one of the most active natural antioxidants. In recent years, Se research has attracted tremendous interest because of its important role in antioxidant selenoproteins for protection against oxidative stress initiated by excess reactive oxygen species (ROS) and reactive nitrogen species (NOS) (**Tinggi (2008)**). Selenium has important physiologic effects that include functioning at the catalytic centre of proteins (**Behne and Kyriakopoulos, 2001**) enhancement of immune function and reduction of cancer risk (**Beck, 2001 and Klein, 2005**).

Selenium in animal diets is supplemented primarily as inorganic sodium selenite or sodium selenate. However, there has been interest in the use of organic forms, such as selenomethionine (SeM) or Se-enriched yeast (SeY), as supplemental sources of Se (**Rayman, 2004**). Diets supplemented with either sodium selenite or Se-enriched yeast have shown that organic selenium is deposited more effectively in broiler breast muscles than inorganic selenium (**Payne and Southern, 2005**). Many studies showed that dietary supplementation with organic selenium, in the form of yeast grown on a media enriched with this trace element, decreased cancer mortality two-fold (**Clark et al., 1996**).

In addition, increasing consumer demand for healthier food products has led to the development of governmental policies regarding health claims in many developed countries. Food is the most important source of human Se intake. Results derived from various research studies conducted over the last few years have indicated that the enrichment of animal-derived foods (mainly meat, milk and eggs) with selenium via supplementation of animal feeds can be an effective way of increasing human selenium status in countries where selenium consumption falls below the Recommended Daily Allowances (RDA). The objective of this research was to investigate the effect of supplementation boiler diets with different levels of organic selenium from Se-enriched yeast on boilers and selenium contents in its raw breast muscles and cooked ones with different processes.

2. Material and Methods

Material

Organic Se in the form of a yeast source (Sel-Plexs, containing selenomethionine as the main selenocompound) was obtained from Alltech Inc, Nicholasville, KY, USA). The analytical kits were obtained from Randox Laboratories Ltd., Diamond

Road, Crumlin, Co., Antrim BT29 4QY, United Kingdom.

Methods

Experimental diets

The present study was carried out at the Poultry Nutrition Farm, Poultry Production Department, Faculty of Agriculture, Ain Shams University. One hundred fifty unsexed one day old of Hubbard broiler chicks were randomly distributed into 5 treatments. Each treatment comprised of 30 chicks which divided into 5 replicates of 6 chicks each. The chicks were reared up to 5 weeks of age in wire-floored batteries. Broilers diet were supplemented with selenium-enriched yeast to get different levels of organic Se (0.2, 0.3, 0.4, 0.5 and 0.6 mg Se/kg diet). Table (1) was used to formulate five experimental diets that meet recommended nutrient requirements of growing of broiler chickens (**NRC, 1994**) as the following:-

Treatment 1 (T1): Basal Diet (BD) supplemented with 0.2 mg organic Se/kg diet (control treatment).

Treatment 2 (T2): BD supplemented with 0.3 mg organic Se/kg diet.

Treatment 3 (T3): BD supplemented with 0.4 mg organic Se/kg diet.

Treatment 4 (T4): BD supplemented with 0.5 mg organic Se/kg diet.

Treatment 5 (T5): BD supplemented with 0.6 mg organic Se/kg diet.

At 35 days of age, five birds from each treatment having body weight around the average of treatment were selected and sacrificed by severing the carotid artery and the jugular vein and blood samples were collected. Breast muscles from each treatment were obtained. Malondialdehyde (MDA) and total antioxidant capacity (TAC) were determined in serum according to the method showed by **Meltzer et al. (1997)** and **Koracevic et al. (2001)**, respectively. Glutathione peroxidase (GPx), Superoxide dismutase (SOD) and catalase (CAT) were measured in erythrocytes calorimetrically according to methods of **Rotruck et al. (1973)**; **Nishikimi et al. (1972)** and **Aebi, (1984)**, respectively. Serum total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), Triglyceride (TG) contents were determined according to the methods of **Röschlau et al. (1974)**, **Assmann (1979)** and **Uwajima et al. (1984)**, respectively.

Cooking processes

Breast samples were cooked using three different methods, (boiling only, frying after boiling and grill)

Boiling: Place samples in a pan with a enough water to cover the meat. Bring the water to boil and then reduce the heat to a gentle simmer. Cover with a lid and cook under tender for 30 min.

Frying after boiling: Samples were boiled with the previous method then were deep-fried in vegetable oil

at a temperature of 190°C for 5-7 min., until the meat is tender and crisp on the outside.

Grill: Samples were grilled in conventional electric oven at 200 °C for 25 min.

The percentage of cooking losses (CL %) of cooked chicken samples were determined according to (Kouba, 2003). The raw samples were weighed before different cooking methods. After these procedures samples were cooled at room temperature and weighed again. The percentage of cooking losses (CL %) were calculated as the following:-

Cooking loss % = [(raw weight - cooked weight) / raw weight] x 100

The selenium content in raw and cooked samples was analyzed by Inductive coupled plasma (ICP) atomic absorption spectrometry. Model ICP optima 2000 DV (perkin Elmer) according to the method described by Cantor and Tarino (1982).

Sensory evaluation

The sensory evaluation for both raw and cooked with different processes breast samples was carried out for different attributes like color, odor, flavor, tenderness and overall acceptability using 5-point scale according to Meilgaard *et al.* (2007).

Statistical analysis

Data was statistically analyzed by using one-way analysis of variance (ANOVA). For determining differences between treatments, the Duncan test was used. All *p* values of ≤ 0.05 were considered to be significant (Bouveresse *et al.*, 2011).

3. Results

As can be seen from Table (2) the concentration of selenium (Se) in raw breast muscles was increased along with increasing the supplementation levels of organic Se in chickens diet. It could be noticed that there were significant differences between all treatments. Selenium content in raw breast muscles of control treatment (T1) which was 0.2 mg organic Se /Kg diet was significantly lower than other treatments. The highest value of Se content was in treatment 5 (0.48 mg/kg). This value was nearly fourfold higher than control treatment.

Data in Table (2) also show the content of Se in breast muscles after some cooking processes (boiling, frying after boiling and grill). It was clear that the amount of Se in cooked breast muscles was increased due to cooking processes comparing with raw samples except in case of boiling process the amount of it was decreased as a result of cooking. Based on analysis of data given in Table (2), it was established that there were significant differences between raw and boiled samples in all treatments except T1 (0.11 mg/kg) and T4 (0.35 mg/kg). Concerning to samples cooked by frying after boiling, there were no significant differences between raw and cooked samples in all

treatments. On the other hand, in grill process there were significant changes due to cooking between raw and grilled samples except T4 (0.43 mg/kg) and T5 (0.52 mg/kg). In general, the highest values of Se after the different cooking processes were observed in grill process.

Effect of different supplementation levels of organic selenium in chickens diet on cooking losses percentage (CL %) in cooked samples is presented in Table (3). It was observed that there were no significant differences in CL% accompanied by increasing organic Se in chickens diet between T1 and other treatments in boiled and fried after boiling samples. In contrast, in case of grilled ones slightly significant differences were occurred in (T4) and (T5) comparing with (T1).

The data tabulated in Table (4) illustrated the effect of different levels of organic selenium on antioxidative property in broilers. It could be noticed that supplementation broilers diet with organic Se resulted in increasing the activities of glutathione peroxidase (GPx), superoxide dismutase (SOD) and catalase (CAT) comparing with control treatment (T1). Referring to GPx activities, there were significant differences between all treatments and T1 except in case of T2. The highest value was observed in (T5). It was represented 118 % relative to T1. On the other hand, there were no significant differences in SOD activities among all treatments. The values are 150.66, 151.33, 153.53, 155.26 and 157.35 U/ml, respectively.

As shown in Table (4), there were significant increase in CAT activities in T3, T4 and T5 comparing with T1. It could also be seen that there were significant differences for serum malondialdehyde (MDA) levels among T1 and other treatments. The lowest value of MDA level was found in T5 and the highest one was for control treatment. Concerning to total antioxidant capacity (TAC) levels, there were no significant differences between control treatment and both T2 and T3. Meanwhile, T4 and T5 achieved significant differences between T1 being 135.2% and 139%, respectively relative to T1

The lipid profile of broilers fed on different levels of organic Se were shown in Table (5). It was observed that total cholesterol (TC), triglyceride (TG) as well as low-density lipoprotein (LDL-C) levels in serum was decreased in all study treatments compared to T1. The lowest values of previous parameters were taken place in T5. These values were 135.28, 89.44 and 87.83 mg/dl, respectively. On the other hand, supplementation with organic Se resulted in significant increases in sera HDL-C levels in T4 and T5 compared to T1. The values were 88.12 and 87.83 mg/dl, respectively.

As shown in Table (6), the sensory evaluation indicated no significant differences among treatments in both raw and cooked with different processes breast samples, when samples were tested for color, tenderness and overall acceptability. In terms of odor there were significant differences between T1 and T5 in raw samples moreover, there were significant differences between T1 and T4 in boiled samples. On the other hand, in case of flavor, T5 differ significantly from T1 in boiled samples.

4. Discussion

Selenium is one of the trace elements most studied because of its particular properties. Like some other trace elements, Se is bimodal in nature whereby its beneficial properties occur in a limited range of daily intake below which it cannot perform its essential functions. Selenium deficiency is recognized as a global problem which urgently needs resolution (Valdiglesias *et al.*, 2010). Because soils are becoming depleted and the foods grown on them are therefore lower in selenium. A deficiency of selenium can cause Keshan's disease, a heart ailment in the young and cognitive decline in adults. Enriched poultry meat could help alleviate this condition.

Broiler meat, in particular breasts have long been carrying a label of dietetic food because of high portion of protein and low amount of fat, and as such it is recommended in the diet of children and elderly people, as well as of all who are concerned about their health. Selenium content in raw breast muscles was increased by increasing the supplementation levels of organic Se in chickens diet. These results are in good agreement with the findings of Mikulski *et al.* (2009) who reported that supplementation turkey diet with 0.3 mg organic Se /kg feed resulted in a significant increase in selenium concentrations in turkey meat and the most striking response to Se was noted in the selenium content of breast muscles.

Moreover, Yu *et al.* (2008) showed that by adding 0.24 mg of selenium (as organic selenium) per kilogram of feed, the selenium content of breast meat was increased from 8.6 µg to 41 µg/100g, which is more than 65 % of Recommended Daily Allowances (RDA) of selenium. The RDA of selenium is 55 µg per day. The same amount of selenium in the form of inorganic sodium selenite also increased selenium in the breast meat, but only to 16 µg/100g. It may be due to that the bioavailability of organic Se is more than inorganic one. Bioavailability is the amount or percentage of a substance that passes from the gastrointestinal tract to the plasma under normal physiologic conditions (Wolffram, 1999). From previous it be observed that breast meat of broiler chickens is a good source of organic Se. It could be

used to improve human Se status especially in Se-deficient areas of the world.

Cooked samples should be examined, because consumers eat them cooked. In the present study, when different cooking processes were studied, it could be thought that the amount of Se in cooked breast muscles by boiling was decreased comparing with raw samples. On the other hand, it was increased in both fried after boiling and grilled samples. These findings are consistent with those of Martins *et al.* (2011) who cited that the major exception of Se occurred when boiling was the method of cooking meanwhile, fried and grilled cooked samples showed higher selenium contents than uncooked ones. Also, Bognár (1998) found that minerals are easily lost in cooking water when plant and animal foods are boiled and dropping when meat was roasted and the losses of minerals in deep fried meat were significantly lower than in boiled ones. Martins *et al.* (2011) illustrated that the higher Se contents in cooked samples than the raw ones could be attributed to the losses of water content and concentration of selenium in cooked samples. The results from our study showed that grill process seems to be more appropriate as concerning selenium content. The same pattern was reported by Gokoglu *et al.* (2004) who found that baking and grilling were considered appropriate concerning minerals and proximate composition.

There were no significant differences in cooking losses (CL%) when the levels of organic Se in chickens diet were increased boiled and fried after boiling samples while, slightly significant differences were carried out in some grilled treatments. The present data are in accordance with those stated by Miezele *et al.* (2011) who reported that cooking losses for the breast or thigh samples were not significantly affected by increasing the content of organic Se in the chicken diet. On the other side, Bradley (2002) found that supplementation cows diet with Se-enriched yeast resulted in significant decrease in cooking loss of their carcasses.

The economic and nutritional demands of food from poultry necessitate the raising of large number of birds in relatively small areas with high rates of productivity. During this intensive system of production birds are exposed to considerable stress which leads to overproduction of free radicals. The free radical generation and lipid peroxidation are responsible for the development of disease conditions leading to poor performance and product quality (Panda and Cherian., 2013).

In Addition, poultry meat is relatively more susceptible to oxidative deterioration due to its high polyunsaturated fatty acids content. One approach to enhance the oxidative stability of meat is to add antioxidants either into the diet of the animal or

directly during meat processing. Selenium is an essential trace element for humans, animals, and some bacteria. It is important for many cellular processes, because it is a component of several selenoproteins with essential biological functions (**Letavayová et al., 2008**).

In the current investigation, supplementation with different levels of organic Se resulted in improvement of antioxidant enzyme status in broilers. The antioxidant system includes both enzymatic and non enzymatic defenses (**Surai, 2000**). The principal enzymatic systems include superoxide dismutase, glutathione peroxidase, glutathione reductase, and catalase (**Fang et al., 2002**). Non enzymatic antioxidants defense systems include molecules (e.g., glutathione, vitamin A and E, and carotenoids) and other elements such as selenium.

The observation that the activity of GPx increased by increasing organic Se levels in broilers diet is in agreement with that reported by **Pilarczyk et al. (2012)** who found that GPx activity depends on the selenium content and lot of animal diseases and dysfunction are caused by GPx activity change aroused by selenium deficiency. Our results are in the same line with **Sirichakwal et al., 2005** who reported that the best known biochemical role of selenium is its function as part of the enzyme glutathione peroxidase which protects vital components of cells against oxidative damage.

In addition, **Devore and Greene (1982)** reported that the antioxidant functions of Se, via GSH-Px activity, have been shown to persist post mortem in poultry muscle tissue, delaying the onset of oxidation reactions. Also, **Morrissey et al. (1998)** cited that oxidation will reduce the nutritive value and flavor of meat products so, supplementation with organic Se can maintain the good quality of broilers meat through the improved antioxidant capacity.

The present study investigated the effect of different levels of organic Se on MDA levels which one of the oxidative stress indicators in broilers. The MDA is formed as an end product of lipid peroxidation. By increasing Se concentration in chickens diet the levels of MDA were decreased. This finding indicate that lipid peroxidation was reduced by increasing organic Se levels via enhancing antioxidative action, which is in agreement with the results of **Kim et al. (2010)** who indicated that selenium plays an important role in antioxidative system efficiency. Whereas in poultry the fortification of diets with 0.3 ppm of Se increased lipid oxidative stability and delayed microbial growth in the thigh muscle.

In this study, the activities of superoxide dismutase (SOD), catalase (CAT) as well as total antioxidant capacity (TAC) levels were increased with

increasing Se levels. These findings coincided with **Chen et al. (2013)** who provided a strong evidence that broiler oxidation resistance was significantly increased with selenium additive level.

The chicken is an important model organism that bridges the evolutionary gap between mammals and other vertebrates and provides a major protein source from meat and eggs throughout the world. **Ayala et al. (2005)** indicated that chicken is a good animal model for the study of atherosclerosis research, since it presents lipoprotein levels similar to those in humans. As regard to lipid profile in Table (5), the current study showed that supplementation with organic Se resulted in improvement in lipid profile in broilers serum. In comparison to the T1 and other treatments, TC, TG and LDL levels were decreased. Meanwhile, in case of HDL, increase organic Se concentrations in broilers diet led to increase serum HDL levels. These findings coincided with **Kanchana and Jeyanthi., 2010** who reported that combination of vitamin E at a level of 200mg and Se at 0.4 of mg/kg diet are good for improving growth rate of layer chickens. Moreover, **Kang et al. (2000)** cited that selenium seems to have a hypocholesterolemic effect where supplementation with Se decreased total cholesterol and triglyceride levels in rabbits. Also, **Dhingra and Bansal (2006)** reported that Se deficiency has been shown to down regulate the LDL-receptor which is important in regulating the cholesterol level in plasma.

The development of new food products by modification of ingredients or processing conditions, cost reduction and quality control, often employs sensory evaluation techniques to determine the acceptability of food. (**Anjum et al., 2013**).

In this experiment, the broiler meat in both raw and cooked samples was not affected by increasing Se levels in diet regarding color, tenderness and overall acceptability. Conversely, in case of odor there were significant differences between T1 and T5 in raw samples and between T1 and T4 in boiled samples. Also, T5 differ significantly from T1 in boiled samples when flavor was tested. These differences may due to the odor and the flavor of the yeast that may be more pronounced in the highest level of Se in T5 but in other cooking samples there were no significant differences between this highest level and control treatment (T1) when odor and flavor were tested. Our results are in the same line with **Miezeliene et al. (2011)** who reported that addition of Se and vitamin E or their combination on chicken feed had no significant impact on perceived intensities of sensory and texture profiles of the chicken breasts or thigh muscle in general. On the other hand, **Hussain et al. (2012)** cited that the odor, flavor and overall acceptability were not changed due to different Se

sources, levels, and storage days in chicken breast meat but showed significant influence on color and

juiciness during the 12 days of storage.

Table (1). Feed ingredients and chemical composition of basal diets.

Ingredients	Starter (0-2 weeks of age)	Grower (3-5 weeks of age)
Yellow corn	56.00	59.93
SBM 44 %	28.85	26.42
Corn gluten 60 %	8.95	6.90
Soybean oil	1.50	2.50
Ca carbonate	1.60	1.45
MCP	1.85	1.60
L-Lysine	0.40	0.35
MHA	0.25	0.25
Salt (NaCl)	0.30	0.30
Premix	0.30	0.30
Total	100.00	100.00
CP%	23.00	21.00
ME Kcal/Kg diet	3000	3100
Lysine	1.41	1.29
Methionine	0.66	0.62
Methionine + Cysteine	1.05	0.98
Ca%	1.00	0.90
NPP%	0.51	0.45

SBM: soybean meal, MCP: mono-calcium phosphate MHA: methionine hydroxy-analogue
NPP: non-phytate phosphorus.

The premix contains: Vitamins: A (12000000 IU); Vit. D3 (2000000 IU); Vit. E (10000 mg); Vit. K₃ (2000 mg); B₁ (1000 mg); B₂ (5000 mg); B₆ (1500 mg); B₁₂ (10 mg); Biotin (50 mg); Coline chloride (250000 mg); Pantothenic acid (10000 mg); Nicotinic acid (30000 mg); Folic acid (1000 mg); Minerals: Mn: (60000 mg); Zn: (50000 mg); Fe (30000 mg); Cu 10000 mg; I (1000 mg); and Co: (100 mg).

Table (2). Effect of supplementation broilers diet with different levels of organic selenium on Se content (mg/kg) in raw and cooked breast samples.

Samples	Organic selenium levels in diet (mg/kg diet)				
	0.2 (T1)	0.3 (T2)	0.4 (T3)	0.5 (T4)	0.6 (T5)
Raw	0.13 ± 0.009 ^{BCe}	0.20 ± 0.015 ^{Bd}	0.28 ± 0.015 ^{Bc}	0.38 ± 0.020 ^{ABb}	0.48 ± 0.020 ^{ABa}
Boiling	0.11 ± 0.006 ^C	0.17 ± 0.009 ^C	0.23 ± 0.012 ^C	0.35 ± 0.012 ^B	0.42 ± 0.015 ^C
Frying after Boiling	0.15 ± 0.015 ^B	0.21 ± 0.009 ^B	0.25 ± 0.009 ^{BC}	0.40 ± 0.009 ^A	0.45 ± 0.009 ^{BC}
Grill	0.18 ± 0.009 ^A	0.27 ± 0.012 ^A	0.32 ± 0.009 ^A	0.43 ± 0.009 ^A	0.52 ± 0.006 ^A

Each value represents the mean ± SE. Different capital letters indicate significant difference at ($P \leq 0.05$) among means in the same column. Different small letters indicate significant difference at ($P \leq 0.05$) among means in the same row.

Table (3). Effect of supplementation broilers diet with different levels of organic selenium on cooking losses (%).

Samples	Organic selenium levels in diet (mg/kg diet)				
	0.2 (T1)	0.3 (T2)	0.4 (T3)	0.5 (T4)	0.6 (T5)
Boiling	22.42 ± 0.12 ^a	22.22 ± 0.09 ^a	22.00 ± 0.06 ^a	21.58 ± 0.12 ^a	21.58 ± 0.11 ^a
Frying after Boiling	25.27 ± 0.06 ^a	25.24 ± 0.09 ^a	25.20 ± 0.15 ^a	25.20 ± 0.15 ^a	25.18 ± 0.09 ^a
Grill	32.47 ± 0.06 ^a	32.47 ± 0.06 ^a	32.44 ± 0.09 ^{ab}	32.42 ± 0.09 ^b	32.39 ± 0.10 ^b

Each value represents the mean ± SE. Different superscript letters indicate significant difference at ($P \leq 0.05$) among means in the same row.

Table (4). Antioxidative property of broilers fed on different levels of organic selenium.

Treatments	Organic selenium levels in diet (mg/kg diet)				
	0.2 (T1)	0.3 (T2)	0.4 (T3)	0.5 (T4)	0.6 (T5)
GPx (U/g Hb)	274.33 ± 4.63 ^c	280.83 ± 4.05 ^c	303.10 ± 4.24 ^b	315.60 ± 3.04 ^a	323.77 ± 2.71 ^a
SOD (U/ml)	150.66 ± 1.45 ^a	151.33 ± 2.60 ^a	153.53 ± 2.03 ^a	155.26 ± 2.83 ^a	157.35 ± 2.82 ^a
Catalase (U/ml)	42.63 ± 0.060 ^b	43.28 ± 0.023 ^b	45.61 ± 0.055 ^a	46.52 ± 0.075 ^a	47.74 ± 0.046 ^a
MDA (nmol/ml)	4.25 ± 0.017 ^a	4.17 ± 0.015 ^b	4.12 ± 0.017 ^b	4.09 ± 0.012 ^b	4.00 ± 0.040 ^c
TAC (U/ml)	18.35 ± 0.87 ^c	19.16 ± 1.01 ^c	21.30 ± 1.18 ^{bc}	24.81 ± 1.22 ^{ab}	25.52 ± 1.23 ^a

Each value represents the mean ± SE. Different superscript letters indicate significant difference at ($P \leq 0.05$) among means in the same row.

MDA: Malondialdehyde

GPx: Glutathione peroxidase,
TAC: Total Antioxidant Capacity

SOD: Superoxide dismutase

Table (5). Lipid profile of broilers fed on different levels of organic selenium.

Treatments	Organic selenium levels in diet (mg/kg diet)				
	0.2 (T1)	0.3 (T2)	0.4 (T3)	0.5 (T4)	0.6 (T5)
Total cholesterol (mg/dl)	142.73 ± 1.29 ^a	140.23 ± 0.99 ^{ab}	138.91 ± 1.23 ^{ab}	138.50 ± 0.95 ^{bc}	135.28 ± 0.65 ^c
Triglycerides (mg/dl)	95.42 ± 0.40 ^a	94.70 ± 0.89 ^a	94.21 ± 0.37 ^{ab}	92.28 ± 0.87 ^b	89.44 ± 0.60 ^c
HDL- C (mg/dl)	26.31 ± 0.61 ^c	27.64 ± 0.49 ^{bc}	28.21 ± 0.77 ^{bc}	29.68 ± 0.55 ^{ab}	31.82 ± 0.94 ^a
LDL- C (mg/dl)	92.31 ± 0.42 ^a	91.52 ± 0.56 ^a	90.70 ± 0.59 ^a	88.12 ± 0.65 ^b	87.83 ± 0.97 ^b

Each value represents the mean ± SE. Different superscript letters indicate significant difference at ($P \leq 0.05$) among means in the same row.

HDL-C: High-density lipoprotein cholesterol

LDL-C: low-density lipoprotein cholesterol

Table (6). Sensory evaluation for raw and cooked chicken breast samples.

sensory trait	Organic selenium levels in diet (mg/kg diet)				
	0.2 (T1)	0.3 (T2)	0.4 (T3)	0.5 (T4)	0.6 (T5)
Color					
Raw	4.12 ± 0.19 ^a	4.49 ± 0.28 ^a	4.36 ± 0.14 ^a	4.32 ± 0.26 ^a	4.84 ± 0.20 ^a
Odor					
Raw	4.32 ± 0.13 ^a	4.16 ± 0.22 ^a	4.04 ± 0.18 ^{ab}	3.90 ± 0.19 ^{ab}	3.49 ± 0.16 ^b
Boiling	4.00 ± 0.10 ^a	3.85 ± 0.20 ^{ab}	3.68 ± 0.12 ^{ab}	3.39 ± 0.16 ^b	3.34 ± 0.21 ^b
Frying after Boiling	3.89 ± 0.22 ^a	3.87 ± 0.21 ^a	3.76 ± 0.17 ^a	3.69 ± 0.20 ^a	3.55 ± 0.23 ^a
Grill	4.09 ± 0.19 ^a	3.92 ± 0.14 ^a	3.85 ± 0.14 ^a	3.85 ± 0.20 ^a	3.84 ± 0.14 ^a
Flavor					
Boiling	4.14 ± 0.18 ^a	3.70 ± 0.19 ^{ab}	3.74 ± 0.14 ^{ab}	3.78 ± 0.21 ^{ab}	3.33 ± 0.16 ^b
Frying after Boiling	4.29 ± 0.15 ^a	4.24 ± 0.15 ^a	4.04 ± 0.11 ^a	4.02 ± 0.14 ^a	3.80 ± 0.16 ^a
Grill	3.93 ± 0.24 ^a	3.90 ± 0.19 ^a	3.69 ± 0.18 ^a	3.58 ± 0.19 ^a	3.32 ± 0.19 ^a
Tenderness					
Boiling	4.45 ± 0.13 ^a	4.56 ± 0.21 ^a	4.64 ± 0.14 ^a	4.59 ± 0.16 ^a	4.72 ± 0.19 ^a
Frying after Boiling	4.48 ± 0.15 ^a	4.61 ± 0.12 ^a	4.57 ± 0.15 ^a	4.64 ± 0.17 ^a	4.73 ± 0.15 ^a
Grill	4.18 ± 0.18 ^a	4.29 ± 0.11 ^a	4.31 ± 0.15 ^a	4.35 ± 0.09 ^a	4.43 ± 0.10 ^a
Overall acceptability					
Raw	3.46 ± 0.26 ^a	3.58 ± 0.20 ^a	3.73 ± 0.18 ^a	4.11 ± 0.15 ^a	3.88 ± 0.19 ^a
Boiling	3.45 ± 0.15 ^a	3.76 ± 0.23 ^a	3.65 ± 0.11 ^a	3.62 ± 0.21 ^a	4.04 ± 0.17 ^a
Frying after Boiling	3.44 ± 0.25 ^{ab}	3.35 ± 0.19 ^b	3.80 ± 0.13 ^{ab}	4.11 ± 0.14 ^a	3.94 ± 0.30 ^{ab}
Grill	3.72 ± 0.16 ^a	4.05 ± 0.24 ^a	3.93 ± 0.12 ^a	3.90 ± 0.23 ^a	4.36 ± 0.18 ^a

Each value represents the mean ± SE. Different superscript letters indicate significant difference at ($P \leq 0.05$) among means in the same row.

Conclusions

Due to high quality nutritional content and lower prices than of other meat, broiler meat is often used in human nutrition. As an affordable foodstuff, broiler meat represents an excellent means for transferring active substances to human organism without having to make any changes in food habits. The consumer will go to the same supermarket to buy the same products and then cook and consume them as usual. The only difference will be in the amount of specific nutrients delivered with such products. Supplementation broilers diet with 0.2, 0.3, 0.4, 0.5 and 0.6 mg organic Se/kg diet from Se-enriched yeast resulted in Se deposition in breast muscles and improved the antioxidant status of broilers

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