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Effects of Selenium Sources and Concentrations on the Performance, Meat Quality, and Tissue Properties of Broiler Chickens.

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Abstract: ***We wanted to find out how selenium (Se) affects broiler chicken performance, meat physicochemical properties, and selenium deposition in the tissues of broilers. Each of the 96 experimental pens had 30 chickens and included a total of 2,880 one-day-old broilers (Cobb 500 strain). Factorial design of four-by-three (SY + SS) and eight-replicates (SY + SS) was used for the 12 experimental treatments, with selenium levels ranging from 0.15 to 0.60 ppm and organic (SY) or inorganic (SS) sources of selenium and their relationship (SY + SS). There were no differences in performance (P > 0.05) across Se levels or sources. 106 g/day of ADFI, 63 g/day of ADG and 1.6844 kg/kg of FCR were found to be the averaging values for these three parameters: ADFI, ADG and FCR. (P > 0.05) There were no variations in pH (5.79) or shear force between treatments (30.08 kgf). This resulted in the loss of 21.92 percent of breast flesh in the birds given 0.15 ppm Se, which was statistically significant. Adding 0.60 ppm of organic Se to the diet reduced cooking losses the most, according to the study (15.87 percent). It rose from 0.97 mg/kg (0.15 ppm) of selenium to 2.43 mg/kg (0.60 ppm) of selenium in the liver when SY was used. Se concentration in breast meat rose from 0.23 mg/kg to 1.42 mg/kg when SY intake increased. Supplementing the food with 0.15 ppm of Se from any source is thus effective in maintaining normal avian performance. As compared to the SY, the SY was more effective in depositing Se into the liver and breast muscle.***

Keywords: ***Meat, Mineral, Organic, Ant Oxidative, And Absorbed Into The Body***

1. INTRODUCTION

Antioxidant properties of Selenium (Se) make it an essential mineral for animals. Cells and cell membranes are protected from oxidation by the enzyme glutathione peroxidase, which contains Se as an essential structural component (Rotruck et al., 1987). Selenium has long been used as a dietary supplement in the poultry industry due to the wide range of Se concentrations in feed grains across the globe (Gomes et al., 2011).Soil Se deficiency in Brazil (0.02–0.05 mg/kg) necessitates supplementation in order to maintain modern broiler strains' high performance. Organic Se supplementation for poultry diets was permitted in 2000 after the feed industry had traditionally used sodium selenite as an inorganic

supplement (Food and Drug Administration, 2000). There has now been a resurgence of interest in using organic Se instead than inorganic Se, due to the latter's superior ability to accumulate in bodily tissues (Payne and Southern, 2005). As with methionine, selenium methionine may be easily absorbed by the red blood cells by an active process similar to that of methionine itself. Inorganic Se, on the other hand, is absorbed through simple diffusion, similar to sodium selenite (Surai and . Sparks, 2000). As a result, inorganic Se is eliminated at larger quantities than organic Se and is maintained at lower levels in the muscles. Protein syntheses in high-protein tissues such as the skeletal muscles, erythrocytes, pancreas, liver, kidney and the epithelium of the gastrointestinal tract absorb the ingested Se (Froning and Uijttenboogart, 1988). Dietary type and concentration of Se alter the availability of Se for tissue absorption (Payne and Southern, 2005; Choct et al., 2004 ; Skrivan et al., 2006). the meat industry is under pressure to enhance the nutritional content, quality, and shelf life of its products, and supplementing with selenium (Se) may help it do so. Customers are increasingly interested in nutrient-rich goods that are seen to be healthier (Grashorn, 2007) , therefore selenium (Se) is a popular nutrient in the food industry nowadays. Consumers often regard the amount of water lost during handling and cooking to be a sign of meat quality. Breast meat's water-holding capability is one of the most essential quality qualities. A higher intake of selenium in the diet has been shown to increase muscle water retention and oxidative stability in chicken under refrigeration (Smet et al., 2008). It has been shown that oxidation may weaken cell membranes, enabling intracellular fluids to flow out of the cells. Drip loss and cooking loss may be used to assess the quantity of water that seeps out of the tissue, which decreases the look of packed meat and diminishes the juiciness of the cooked product. Se source impacts on broiler performance and meat quality are well-documented, but little is known about where Selenium really ends up, how various Se sources affect broiler growth, or where in the gut Se actually gets absorbed. Se supplementation for broiler performance, physicochemical breast meat qualities, and Se concentration in various tissues was the focus of research in this study.

2. MATERIALS AND METHODS

This experiment was carried out in one of commercial chicken farm in Iraq /Babylon. Over the course of 12 days, a total of 2,880 one-day-old Cobb 500 chicks from a local commercial hatchery were divided into 12 groups of 30 male birds each. For 24 hours, the broilers were kept in enclosures that were 2.0 meters wide and 1.11 meters long. Water and food were available at will throughout the study (Table 1). The temperature in the room where the birds were kept was maintained at 32°C. The temperature of the chamber was lowered by 3°C every week until the birds were 21 days old. ‘There were 12 treatments: a corn-soybean meal base diet supplemented with three sources of selenium (SY, SY+SS, and SS): (1) 100% selenium yeast; (2) 50% selenium yeast + 50% SS (SY+SS); and (3) 100% SS supplemented with four levels of each selenium source (0.15, 0.30, 0.45, and 0.60 ppm). Table 2 shows the assessed dietary Se content for each treatment. When it comes to inorganic Se, sodium selenite (45.6 percent) and Se yeast (Selemax 2,000 ppm) (Rodrigues et al., 2007) were employed. It was decided to split the feeding program into four distinct stages (0–7 days, 8–21 days, 22–35 days, and 36–42 days), with commercial grade meals surpassing the NRC (NRC , 1994) requirements for essential amino acids in each phase. Feed intake (FI), BW gains (BWG), and FCR were calculated by keeping track of each feeding phase's body weight growth and feed intake (FI). The ADFI and ADG were computed using this information. The FI was adjusted daily according on the number of birds who perished

Table 1. Percentage of the experimental diets' composition

	Pre starter	Starter	Grower	Finisher
Ingredient				
Yellow maize	56.274	58.700	60.608	54.950
Soybean meal	37.000	34.080	31.300	27.170
Vegetable oil	2.162	3.072	4.240	4.158
Di calcium phosphate	1.924	1.875	1.720	1.570
Limestone	0.875	0.816	0.774	0.740
Salt (NaCl)	0.470	0.460	0.440	0.420
dl-Methionine	0.373	0.273	0.245	0.241
l-Lysine HCl	0.395	0.260	0.230	0.287
l-Threonine	0.158	0.082	0.061	0.082
Vitamin[1]	0.100	0.100	1.000	0.100
Mineral[2]	0.100	0.100	0.100	0.100
Choline chloride	0.057	0.570	0.057	0.057
Nutrient and energy level				
ME kcal/kg	2,956	3,050	3,150	3,200
CP	22.35	20.98	19.80	18.32
Met + Cys	0.97	0.84	0.79	0.76
Lysine	1.36	1.19	1.10	1.05
Threonine	0.89	0.77	0.71	0.68
Tryptophan	0.25	0.24	0.22	0.20
Arginine	1.39	1.30	1.22	1.10
Isoleucine	0.86	0.81	0.76	0.69
Sodium	0.22	0.22	0.21	0.20
Calcium	0.94	0.90	0.84	0.78
Available phosphorus	0.47	0.45	0.42	0.39

There are 12,000 IU of vitamin A, 2,400 IU vitamin D3, 40 mcgs of vitamin E, 31.8 mcgs of vitamin K, 2.5 mgs of vitamin B1, 4.0 mcgs niacin and 1.5 mcgs folic acid in the vitamin premix (per kilogram of diet):The mineral premix supplied (per kilogram of diet): Fe 80 mg, Zn 70 mg, Mn 70 mg, I 1 mg, and Cu 10 mg.

Physicochemical Characteristics

Approximately six hours before slaughter, the birds had their feed withheld and were taken to the slaughterhouse in plastic crates. At the Feed Science Department processing plant, around 300 meters from the broiler house, the birds were butchered. A rotary drum picker was used to select the birds for 180 seconds, and then they were mechanically eviscerated in an automated line system. In order to gather samples, the corpses had to be freed from their restraints at this point. The bone and skin of the breast and thigh muscles were taken from the corpse after slaughter. Every replication (n = 16 per treatment) had two carcasses for testing meat quality on each of these muscle groups.

Table 2. Selenium analyzed (mg/kg) according to dietary source and supplementation level[1]

	Se supplementation level (ppm)			
Se source	0.15	0.30	0.45	0.60
Organic Se	0.190	0.335	0.485	0.630
Inorganic Se	0.195	0.340	0.490	0.645
Organic + inorganic Se	0.195	0.335	0.485	0.635

Se from the components differs between supplemented and analytical forms of the vitamin. The postmortem pH of selected breast muscles was evaluated after 15 minutes. After that, polyethylene bags containing the breast and thigh samples were used to transfer them to the laboratory at a temperature of 4°C. The whole breasts were divided into right and left halves 24 hours after death. Individually packaged pieces of left-side carcass were refrigerated at 4°C for five days before being utilized for pH measurements. Breasts from the right-hand side of the carcass were vacuum-sealed. The Laboratory conducted all of the meat quality tests. The breast meat was chilled overnight at 4°C in order to quantify cooking loss. The meat was taken out of the fridge and allowed to come to room temperature before serving. The samples were weighed and then wrapped in aluminum paper before being sent to the lab. During the cooking process, the samples were regularly checked. During this time, the samples were continually rotated until they achieved an internal temperature of 72 2°C (Edens,1996). At room temperature, weigh the cooked muscle to assess cooking loss. The shear force was measured by slicing a piece of cooked beef in half. Muscle fibers were sliced into 1 x 1 x 2 cm slices perpendicular to the fiber orientation of the muscle (Spears et al., 2003). With the use of a Warner-Bratzler shear tool and the Texture Expert program, we were able to analyze the texture of the material. The cross-head speed was 60 mm/min throughout the testing.

Tissue Concentration Analysis

Pre-analysis grinding of the liver, duodenum, jejunum, ileum, and breast meat samples was performed. Using a hydrate generation atomic absorption spectrophotometer (Naylor et al. ,2000), the Se concentration in the tissues was measured in accordance with the technique outlined (Deniz et al., 2005).

Statistical Analysis

Analyses of variance (ANOVA) were carried out on the data using SAS software (SAS, 2001) to examine the effects of the different levels and sources and their interaction. The Tukey test was used to examine any response variables that had a significant F-test result. P >0.05 was considered significant. The dietary Se levels in each source were put through a regression analysis.

3. RESULTS AND DISCUSSION

Treatments did not vary in any performance metric or mortality assessment during the course of the study (P > 0.05). It was shown that Se had no influence on the hens' development throughout the testing. ADFI, ADG, FCR, and mortality rates were 106 g/bird per day, 63 g/bird per day, 1.684 kg/kg, and 4.68 percent, respectively. The performance of broilers was

unaffected by the use of various amounts of SS and SY (0.0 and 0.3 ppm) or a combination of both. No variations in BW or FE were seen when broilers were given diets containing SS or SY, as reported by Edens, (1996) and Spears et al., 2003. Normal avian development seems to be maintained by supplementing Se levels. An supplemented control diet was omitted because of the low amount of Se in local maize (0.03 mg/kg). In a prior investigation, death was prevented by supplementing just 0.05 mg/kg Se (data not published). When fed diets with Se concentrations less than 0.1 mg/kg, hens may develop signs of exudative diathesis as early as 2 to 3 weeks of age and die as late as 3 to 4 weeks of age, according to the NRC, 1994. According to the findings of Deniz et al. (2005). , the yields of cut-up carcasses were not affected by the source or amount of Se in this investigation. A total of 69.50 percent of the carcass, breast, and leg yields were recorded for the pigs in this experiment. Significant increases in breast and leg yields were seen when SY was supplemented, as reported by Choct et al. (2004) Using SY as a supplement resulted in the lowest cooking loss among all sources at supplementation levels greater than 0.30 ppm (Figure 1).

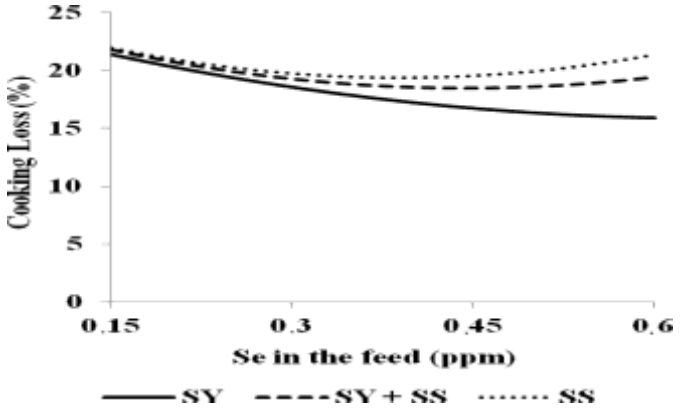

Figure 1 In the case of 42-day-old broiler chicken breast meat, the effect of Se source (selenium yeast (SY) or sodium selenite (SS)) and amount on cooking loss (percent) can be shown in Figure 1. The R2 for SY is 99.53 percent, for SY+SS it is 84.88 percent, and for SS it is 91.86 percent. SY+SS: y = 25.997792 – 33.941205x + 38.274514x2, for SY+SS it is 84.88 percent, and for SS it is 91.86 percent.

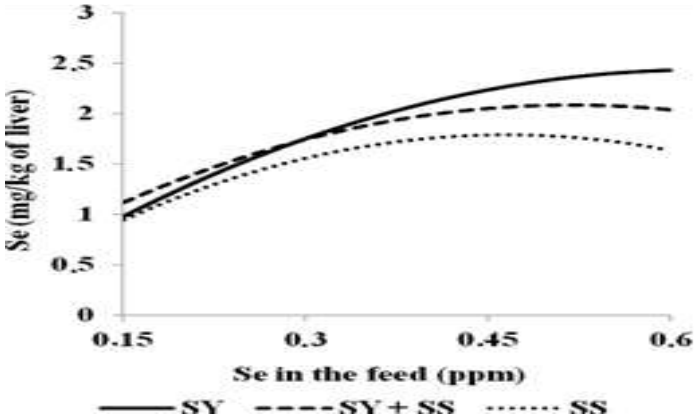

Figure 2. Se (mg/kg) deposition in the liver of 42-day-old broiler chickens was influenced by the source of Se (organic or inorganic) and the amount of Se (mg/kg). To summarize, the R2

for the SY model is around 96.5 percent; for the SY+SS model, the R2 is approximately 92.0 percent; and for the SS model, the R2 is approximately 98.1 percent.

The predicted intermediate findings were obtained by combining the two data sets (SY+SS). Increasing the amount of Se in the diet and relying on SY as the primary source may enhance several meat physicochemical properties. pH and shear force were unaffected; their average values were 5.79 kgf and 30.08 kgf correspondingly. As Naylor et al. (2000) discovered, supplementing with 0.30 and 0.40 ppm of SY improved cooking loss. There were no significant variations in cooking loss in the breast meat of broiler chickens and turkeys, according to Miezeliene et al. (2001) and Mikulski et al. (2009). This microelement is observed in the liver tissue of hens given various quantities and types in Figure 2. Except for the birds given SS, which had the lowest Se concentrations, the greatest levels were discovered in birds fed the highest quantities of Se. After six weeks, significant variations in the effects of SY, SY+SS, and SS were seen. Because selenium methionine, which is not employed in the production of sialoproteins, is highly maintained in tissues, including the liver, it may explain the increased Se concentration seen in birds who were given SY compared to those that weren't. For the most part, the leftover sodium selenite is eliminated in the urine (Yoon et al., 2007). Similarly, Wang and Xu (2008) discovered improvements in the deposition of Se in the liver in broilers fed SY, which is consistent with these findings Baowei et al. (2011) revealed that the Se deposition increased with increasing dietary SY concentrations in geese (0.0, 0.1, 0.3, and 0.5 ppm). For birds with a Se deficit, it's noteworthy to note that the liver may mobilize Se to satisfy the body's essential activities without suffering any performance degradations. It didn't matter where the Se came from or how much was investigated; the duodenum consistently had the highest Se concentrations, followed by the jejunum and ileum. This is consistent with previous investigations on rats and cocks, which found that absorption reduced in the duodenum, jejunum, and ileum. For broilers, Yoon et al. (2007) and Gomes et al. (2011) observed that SY seems to retain more Se. These authors' findings corroborate ours, showing that SY absorbs more energy than SS. The simple diffusion absorption method of sodium selenite (Figures 3 and 4) keeps it in the jejunum and ileum at greater concentrations than the active mechanism of SY. Birds fed SS had the highest Se concentration in their duodenums, but this finding cannot be explained physiologically. For birds given SS, the breast Se concentration stayed steady as the dietary Se level increased. Figure 5 shows that supplementation with SY and SY+SS enhanced the concentration of Se in the breast. The Se deposited in the breasts of birds fed SY was 68.15% greater than that of birds given SY+SS and 246.66% higher than that of birds fed SS. 150 grams of breast meat from broilers fed diets supplemented with 0.30 ppm of SY, SY+SS or SS would meet the daily Se requirements for males and women, respectively, if they ate 150 grams of breast meat per day. Using the same quantity of breast meat from broilers treated with SY or SY+SS at 0.45 or 0.60 parts per million (ppm) would supply more selenium than the FAO recommends. The FAO [38] recommends a daily intake of Se of 0.065 mg for males and 0.055 mg for women aged 19 to 65 years. Se was preferentially deposited in the breasts of birds that received nutritional supplementation, perhaps because of the great potential of Se to be integrated into muscle. Muscles metabolize selenium yeast, which is mostly made of selenium methionine, in the same manner as methionine. As a result, in tissues like muscles, where protein turnover is modest, SY is more readily deposited than SS.

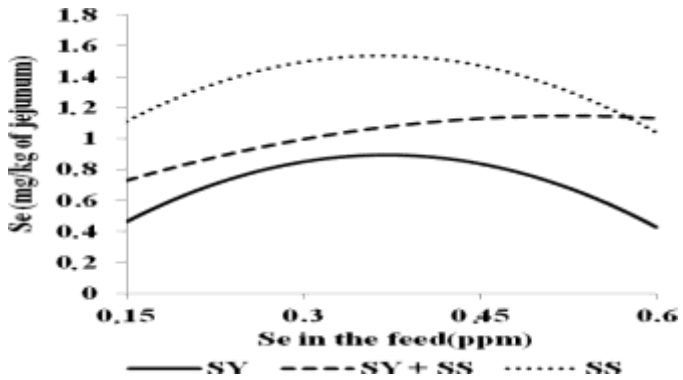

Figure 3 shows the impact of Se source and amount on the deposition of Se (mg/kg) in the jejunum of 42-day-old broiler hens fed either selenium yeast (SY) or sodium selenite (SS). A R2 value of 99.18 percent is obtained using the SY model, whereas the SY+SS model yields an R2 value of 83.66 percent when using the SY+SS model, and an R2 value of 99.99 percent when using the SY model when using the SY+SS model.

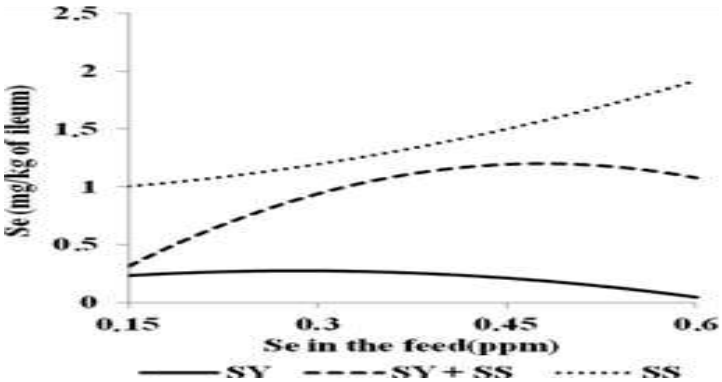

Figure 4 shows the impact of Se source and amount on the deposition of Se (mg/kg) in the ileum of 42-day-old broiler hens fed either selenium yeast (SY) or sodium selenite (SS). The R2 for the SY model is 73.13 percent; for the SY+SS model, the R2 is 94.91 percent; and for the SS model, the R2 is 73.20 percent: y = 0.9225 + 0.1462 + 2.5305x2.

4. CONCLUSIONS AND APPLICATIONS

1. A Se-deficient baseline food supplied with the NRC (NRC, 1994) recommended amount of 0.15 ppm Se maintained normal performance in the birds, regardless of the source.
2. In the case of Se shortage, selenium yeast was shown to be a more effective selenium depositor in the liver.
3. SY enhanced the Se content in breast meat, however supplementation with 0.30 ppm of SY+SS supplied the Se necessary for an adult person to consume 150 g of breast meat per day, when the birds were given SY instead of SY+SS. a hen that eats 150 grams of chicken breasts per day.

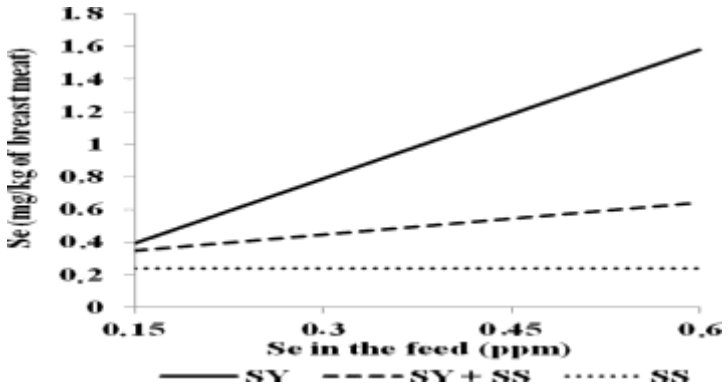

Figure 5 shows the effect of Se source [selenium yeast (SY, organic) or sodium selenite (SS, inorganic)] and amount on the deposition of Se (mg/kg) in the breast meat of 42-day-old broiler chickens. In SY, y = 0.156750 + 2.629667x, R2 = 97.13 percent; in SY+SS, y = 0.247625 + 0.653833x, R2 = 91.81 percent; in SS, y = 0.239 percent.

5.REFERENCES

[1] Baowei, W., H. Guoqing, W. Qiaoli, and Y. Bin.2011. Effects of yeast selenium supplementation on the growth performance, meat quality, immunity, and antioxidant capacity of goose. J. Anim. Physiol. Anim. Nutr. (Berl.) 95:440–448.

[2] Choct, M., A. J. Naylor, and N. Reinke. 2004. Sele- nium supplementation affects broiler growth performance, meat yield and feather coverage. Br. Poult. Sci. 45:677–683.

[3] Deniz, G., S. S. Genzen, and I. I. Turkmen. 2005. Ef- fects of two supplemental dietary selenium sources (mineral and organic) on broiler performance and drip-loss. Rev. Med. Vet. (Toulouse) 156:423–426.

[4] Edens, F. W. 1996. Organic selenium: From feathers to muscle integrity to drip loss. Five years onward: No more selenite! Pages 165–185 in Proc. Alltech's 12th Ann. Symp., Nottingham, UK.

[5] FAO. 2002. Human Vitamin and Mineral Requirements. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy.

[6] Food and Drug Administration. 2000. FDA approves food additive petition for selenium yeast. Page 10 in FDA Veterinarian Newsletter (July/August). Food and Drug Administration, Washington, DC.

[7] Froning, G. W., and T. G. Uijttenboogart. 1988. Ef- fect of postmortem electrical stimulation on color, texture, pH, and cooking losses of hot and cold deboned chicken broiler breast meat. Poult. Sci. 67:1536–1544.

[8] Gomes, F. A., A. G. Bertechini, R. L. Dari, J. A. G. Brito, E. J. Fassani, P. B. Rodrigues, and L. A. Silva. 2011. Effect of sources and levels of selenium on physiological traits in broilers. Arq. Bras. Med. Vet. Zool. 63:633–640.

[9] Grashorn, M. A. 2007. Functionality of poultry meat. J. Appl. Poult. Res. 16:99–106.

[10] Humaloja, T., and H. M. Mykkanen. 1986. Intestinal-absorption of Se-75 labeled sodium selenite and selenomethionine in chicks—Effects of time, segment, selenium concentration and method of measurement. J. Nutr. 116:142–148.

[11] Kim, Y. Y., and D. C. Mahan. 2003. Biological as- pects of selenium in farm animals. Asian-australas. J. Anim. Sci. 16:435–444.

[12] Kuricova, S., K. Boldizarova, L. Gresakova, R. Bob- cek, M. Levkut, and L. Leng.

2003. Chicken selenium sta- tus when fed a diet supplemented with Se-yeast. Acta Vet. (Brno) 72:339–346.
[13] Miezeliene, A., G. Alencikiene, R. Gruzauskas, and T. Barstys. 2011. The effect of dietary selenium supplementation on meat quality of broiler chickens. Biotechnol. Agron. Soc. Environ. 15:61–69.
[14] Mikulski, D., J. Jankowski, Z. Zdunczyk, M. Wro- blewska, K. Sartowska, and T. Majewska. 2009. The effect of selenium source on performance, carcass traits, oxidative status of the organism, and meat quality of turkeys. J. Anim. Feed Sci. 18:518–530.
[15] Naylor, A. J., M. Choct, and K. A. Jacques. 2000. Effect of feeding Sel-Plex TM organic selenium in diets of broiler chickens on liver selenium. In Proc. Concent. South- ern Poult. Sci., Atlanta, GA.
[16] NRC. 1994. Nutrient Requirements of Poultry. 9th ed. National Academy Press, Washington, DC.
[17] Payne, R. L., and L. L Southern.. 2005. Compari- son of inorganic and organic selenium sources for broilers. Poult. Sci. 84:898–902.
[18] Perić, L., N. Milošević, D. Žikić, Z. Kanački, N. Džinić, L. Nollet, and P. Spring. 2009. Effect of selenium sources on performance and meat characteristics of broiler chickens. J. Appl. Poult. Res. 18:403–409.
[19] Rodrigues, E. C., E. M. Ramos, L. V. Rossato, A. G. Beterchini, L. M. G. Botega, and F. A. Gomes. 2007. Quali- dade da carne do peito de frangos suplementados com diferentes fontes e concentrações de selênio. Pages 327–329 in Proc. IV Congr. Bras. Ciênc. Tecn. Carnes, Campinas, Bra- zil. Colégio Brasileiro de Nutrição Animal, Campinas, SP, Brazil.
[20] Rotruck, J. T., A. L. Pope, H. E. Ganther, A. B. Swan- son, D. G. Hafeman, and W. G. Hoekstra. 1973. Selenium: Biochemical role as a component of glutathione peroxidase. Science 179:588–590.
[21] SAS Institute. 2001. SAS User's Guide: Statistics. Version 8.02 ed. SAS Institute Inc., Cary, NC.
[22] Schrauzer, G. N. 2001. Commentary: Nutrition sele- nium supplements: Product types, quality, and safety. J. Am. Coll. Nutr. 20:1–4.
[23] Skrivan, M., J. Simáne, and G. Dlouhá. 2006. Ef- fect of dietary sodium selenite, Se-enriched yeast and Se- enriched Chlorella on egg Se concentration, physical parameters of eggs and laying hens production. Czech J. Anim. Sci. 51:163–67.
[24] Smet, K., K. Raes, G. Huyghebaert, L. Haak, S. Ar- nouts, and S. De Smet. 2008. Lipid and protein oxidation of broiler meat as influenced by dietary natural antioxidant supplementation. Poult. Sci. 87:1682–1688.
[25] Spears, J. W., J. Grimes, K. Lloyd, and T. L. Ward.2003. Efficacy of a novel organic selenium compound (zinc-1.selenomethionine, available Se) in broiler chicks. Pages 197–198 in Proc. 1st Latin Am. Congr. Anim. Nutr., Cancun, Mexico.
[26] Stable Micro Systems Ltd., Godalming, UK.
[27] Surai, P. F., and N. H. C. Sparks. 2000. Tissue-specif- ic fatty acid and α-tocopherol profiles in male chickens de- pending on dietary tuna oil and vitamin E provision. Poult. Sci. 79:1132–1142.
[28] Tinggi, U. 2003. Essentiality and toxicity of selenium and its status in Australia: A review. Toxicol. Lett. 137:103–110.
[29] Wang, Y. B., and B. H. Xu. 2008. Effect of differ- ent selenium source (sodium selenite and selenium yeast) on broiler chickens. Anim. Feed Sci. Technol. 144:306–314.

[30] Whanger, P. D., P. H. Weswig, J. A. Schmitz, and J. E. Oldfield. 1976. Effects of selenium, cadmium, mercury, tellurium, arsenic, silver and cobalt on white muscle disease in lambs and effect of dietary forms of arsenic on its accumulation in tissues. Nutr. Rep. Int. 14:63–72.
[31] Yoon, I., T. M. Werner, and J. M. Butler. 2007. Effect of source and concentration of selenium on growth perfor- mance and selenium retention in broiler chickens. Poult. Sci. 86:727–730.