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Influence of Inorganic and Organic Selenium Sources on Broiler Performance and Meat Quality

Research Article

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ABSTRACT

An experiment was carried out to evaluate and compare the effects of organic and inorganic selenium (Se) sources on broiler male birds (Ross 308). Uniform broiler male chicks divided in to five groups with six replicates were fed with either normal feed (without supplemental Se, negative control), 0.25 ppm of inorganic Se, 0.5 ppm of inorganic Se, 0.25 ppm of inorganic Se + 0.25 ppm of organic Se and 0.5 ppm of organic Se. Sodium selenite and Se enriched yeast served as inorganic and organic sources of Se respectively. The birds were reared for 35 days and were analyzed for growth performance, carcass yield, and lymphoid organ yield. The meat and liver samples were also analyzed for the glutathione peroxidase (GSHPx), thio barbituric acid reactive substances (TBARS), meat pH and water holding capacity. Results showed that Se supplementation regardless of the source and levels improved the broiler performance by increasing the feed intake and body weight. No significant ($P>0.05$) difference in feed conversion ratio (FCR), survival and carcass yield was evident among the treatment groups. The organic Se at the rate of 0.5 ppm was found to be an excellent source of Se as it improved the meat quality through enhanced Se retention, higher glutathione peroxidase (GSHPx) activity and decreased lipid peroxidation rate. Further, supplemental organic Se at the rate of 0.5 ppm also improved the meat water holding capacity.

KEY WORDS carcass yield, glutathione peroxidase, selenium yeast, thiobarbituric acid reactive substances, water holding capacity.

INTRODUCTION

It is well known that the essential trace element Se improves the animal performance and production (Edens *et al.* 1996). Selenium enhances the metabolism of thyroid hormones, which are important for normal growth and development in animals (Arthur, 1991; Arthur and Beckett, 1994). The natural feed ingredients in poultry feed normally contain up to 0.26 ppm of Se in organic forms (Edens, 1996; Upton, 2008) which is sufficient for the normal broiler requirement of about 0.1 ppm (NRC, 1994). However, Se content in the feed raw materials depends on many geological and geographical factors. Edens (1996) showed that replacement of inorganic Se with either 0.1 or 0.2 ppm of organic Se in the poultry diet could increase the live body weight of broilers by ~95 g. However, this increase in live body weight of broilers could be further enhanced to 107 g by the total removal of the inorganic Se from the diet (Edens, 1996). Selenium is an essential component of the anti oxidant selenoenzyme enzyme glutathione peroxidase (GSHPx) which protects the cells against damage caused by free radicals (Combs, 1981; Flohe, 2010). Dietary Se also prevents lipid peroxidation of biological membranes as evidenced by a linear relationship between thiobarbituric acid reactive substances (TBARS) and the GSHPx activity (De Vore and Greene, 1982).

As GSHPx maintains the malondialdehydes (MDA) at low levels, the lipid oxidation tends to correlate with GSHPx activity (Maraschiello *et al.* 1999). Generally, MDA is generated from reactive oxygen species (ROS), and as such is assayed *in vivo* as a bio-marker of oxidative stress. A reduction in MDA and an increase in tissue GSH Px are the two major indicators of adequate protection of muscle tissues against oxidation which prolong the shelf-life of fresh meat (Zhan *et al.* 2007). A higher GSH-Px activity ensures an increased antioxidant status of broilers. In addition, the water holding capacity and the meat pH, could indicate the anti-oxidant status of chicken meat and therefore, may be used for the determining the meat quality and shelf life of the raw meat.

The objective of the present study was, to determine the influence of different sources Se on broiler performance, cut up yield from carcass of broilers and meat quality. Meat quality was determined by measuring the antioxidant status, pH and water holding capacity of meat.

MATERIALS AND METHODS

Diet
The experimental diet consisted of corn-soya based pre broiler starter (PBS), broiler starter (BS), and broiler finisher (BF) diets (Table 1). The PBS feed fed from 0-10 days of age consisted of 3050 kcal/kg of metabolizable energy (ME) and 24-25% of crude protein. The BS feed fed from the 10-30 days of age contained 3100-3150 kcal/kg of ME and 21 – 23% of crude protein. The BF diet consisted of 3200 kcal/kg of ME and the CP of 19-20 % and fed from the age of 30 to 35 days. The background level of Se in the basal diet was found to be as less than 0.1 ppm and therefore topped Se supplements.

Experimental design
In this study, a total of one thousand five hundred male chicks (Ross 308) obtained from a commercial hatchery at Udumalpet (Tamilnadu, India) was divided in to five groups, of three hundred chicks each. The dietary treatments included in the study were: corn-soya based basal diet (BD) with no supplemental Se (negative control) (group 1), BD + 0.25 ppm of Se as sodium selenite (Na_2SeO_3) (group 2), BD + 0.5 ppm of Se as Na_2SeO_3 (group 3), BD + 0.25 ppm of Na_2SeO_3 and 0.25 ppm of Se-yeast (group 4), and BD + 0.5 ppm of Se as Se yeast (group 5). Se yeast (2000 ppm of organically bound Se) was prepared by growing the yeast in a Se rich media by fed batch fermentation (Rajashree and Muthukumar, 2013a; Rajashree and Muthukumar, 2013b). All diets were prepared and formulated to contain equal amounts of energy and crude protein to meet the minimum requirements of the chi-

cks as per the recommendations of the National Research Council (NRC, 1994).

Table 1 Nutrition composition of the basal diet

Ingredients (g/kg)	Pre starter	Starter	Finisher
Corn grain	590	655	647
Soybean meal (45%)	290	233	239
Oil	19	24	24
Fish meal	30	30	30
Bone meal	40	40	40
Calcium phosphate	5.5	1.75	2
Calcite powder	5	1	1
Salt	1.4	0.5	1
Sodium bi-carbonate	3.6	2.95	2.9
DL-methionine	2.7	2.1	2.1
Lysine H-Cl	1.9	1.45	1.3
L-threonine	0.5	0.4	0.4
Vitamin premix*	1	1	1
Mineral premix**	1	1	1
Choline chloride	1.3	1	1

* Vitamin premix (mg/kg of premix): vitamin A: 6.0 mg; vitamin D: 3.0 mg; vitamin E: 0.2 mg; vitamin K: 3.0 mg; vitamin B_1: 2.0 mg; vitamin B_2: 10.0 mg; vitamin B_5: 12.0 mg; vitamin B_3: 40.0 mg; vitamin B_6: 4.0 mg; Biotin: 0.2 mg; Folic acid: 0.75 mg and Cyanocobalamin: 0.015 mg.
** Trace mineral premix (mg/kg of premix): Copper: 24 mg; Iodine: 0.89 mg; Manganese: 281.35 mg; Zinc: 83.33 mg and Cobalt: 20.19 mg.

The experiment lasted for 35 days. One day old chicks with uniform weight (46±5 g) were randomly assigned into five treatment groups on rice husk for deep litter experiment. Each group consisted of six replicates with 50 chicks per pen. The space per 10 chicks was 1 m^2, and lighting was provided for first 7 days to maintain the chicks at 88 °F. The chicks had an easy access to water and feed at anytime. The treatment groups were fed with appropriate diets with the different Se sources for 0-35 days. All the birds were maintained under standard housing and management conditions. The feed intake, mortality and body weight were measured at 10, 20, 30 and 35th day of the treatment period. After the 35th day, six birds from each treatment were randomly selected and culled for the analysis of cut up yield from carcass weight. The meat and liver samples were collected for the determination of total Se accumulation, protein content, GSHPx activity and lipid peroxidation. The quality of meat was determined on the basis of pH and water holding capacity. The feed intake was determined by the following formula:

Feed intake= total feed (g) - (feeder weight+leftover feed weight) / total number of chicks

Broiler performance and productivity
The broiler performance was calculated based on the body

weight, and feed conversion ratio and mortality during the study. At 10, 20, 30 and 35th day of experiment, the individual birds from each treatment were weighed and the average feed intake was noted. The mean body weight and total feed intake were calculated for the analysis of feed conversion ratio (FCR), European efficiency factor (EEF) and day gain and livability (Singh and Panda, 1990). The advantage of using EEF is that all of the factors mentioned above are considered simultaneously and it provides a reasonable idea of overall technical efficiency. The performance of the birds was evaluated on the basis of FCR and EEF. The FCR and EEF were calculated using the following formulas:

FCR= feed consumed (g) / weight gain (g)
EEF= [survivability (%) × live weight (kg)] / [age (days) × feed conversion ratio] × 100
Survivability %= 100 - (% dead+% rejected)

Carcass yield
At the end of trail, six chicks from each treatment were randomly selected for assessing yield.

Chickens were slaughtered after five hours of feed and water deprivation, to eliminate the influence of external factors on body weight (Jokic *et al.* 2009). Broilers were then scalded, defeathered, and eviscerated. Carcasses (without head, feet, intestine, and lungs) were cut into parts to obtain breast, legs, wings and neck weights (with skin and bones). Weight of gizzard, liver, heart and abdominal fat were measured. Abdominal fat included all the adipose tissues surrounding the cloaca and adhering to the gizzard. Lymphoid organs such as spleen and thymus were removed and weighed separately to determine the lymphoid organs weight (Giamborne and Closser, 1990). The chicken parts were weighed on a digital balance with ±0.25 g accuracy.

Determination of Se content in meat and liver
A total of six breast meat and liver samples collected from each treatment was analysed for total Se content using inductively coupled plasma atomic emission spectroscopy (ICP-AES) by AOAC (2006) using Na_2SeO_3 (Sigma) as a standard.

Measurement of GSHPx activity
Glutathione peroxidase was assayed according to the method of Rotruck *et al.* (1973) with some modifications. The meat and liver samples were homogenized with phosphate buffer saline (pH 7.0) to which 0.4 mL of 0.4 M sodium phosphate buffer, 0.1 mL of 10 mM sodium azide and 0.2 mL of 4 mM reduced glutathione, were added and the volume was made upto 2 mL. The reaction mixture was incubated at 37 ˚C for 10 min. The reaction was terminated by

the adding of 0.5 mL trichloro acetic acid. The reaction mixture was then centrifuged at 8000 *g* for 5 min., and the supernatant was collected. To the supernatant, 3 ml of buffer and one mL of 5,5'-dithiobis-2-nitrobenzoic acid (DTNB) was added and the color developed was read at 412 nm. A blank was prepared with disodium hydrogen phosphate solution and 1 ml of the DTNB reagent. Suitable aliquots of the standard were taken and treated in the same manner. The GSHPx activity was expressed in terms of μg of reduced glutathione utilized / min (Sharmila and Vasundra, 2011).

Measurement of lipid oxidation
Lipid oxidation (LPO) in the tissue homogenates was measured by estimating the formation of thiobarbituric acid reactive substances (TBARS) (Okhawa *et al.* 1979). The meat samples were homogenized with 50 mM phosphate buffer (pH 7.4) to which 0.02 *M* tris buffer (1 mL, pH 7.5), 10% (w/v) of tricholoacetic acid (1 mL) and 1.5% w/v thiobarbituric acid (1.5 mL) were added sequentially. The reaction mixture was placed in a boiling water bath at 100 ˚C for 15 minutes and cooled to room temperature (30 ˚C). The contents were centrifuged at 1000 *g* for 20 min., and the supernatant was collected and the absorbance was read at 535 nm against the blank reagent. Melanaldehyde was used a standard for TBARS and was expressed as μ moles of MDA / mg of meat.

Water holding capacity (WHC)
After slaughter, de-feathering, evisceration and chilling, the meat samples were stored at 4 ˚C. The WHC of the samples were determined 24 hours after slaughter. A slice of one cm[3] was taken from the anterior part and another slice from posterior part of a breast muscle, weighed and placed on a non-absorbing mesh cloth and hung for 48 hours. The muscle sample was then wiped off with a paper towel and weighed again. Water holding capacity is expressed as relative weight loss (Henckel *et al.* 2006).

Meat pH
The pH of breast meat samples were measured after 45 min. The meat samples were homogenized with 1: 2, meat sample: water (v/v) in a mortar and pestle and the pH was measured using a portable pH meter (Hanna Instruments, Scientific Industries, Haryana, India). Three samples were measured for each treatment and the pH was measured always at almost the same place in breast muscle for all the groups (Dou *et al.* 2009).

Statistical analysis
All the data were subjected to analysis of variance (ANOVA) using SPSS software (version 9.2). The means were

separated using Duncan's multiple range test (DMRT) when the result of one way ANOVA was significant ($P<0.05$).

RESULTS AND DISCUSSION

Broiler performance and productivity

The feed intake by birds ranged between 3244 g and 3437 g and the feed intake by birds in groups 2 to 5 were 4.92%, 5.59%, 5.54% and 5.37% higher compared to the control birds. Similarly, the average body weight of birds ranged from 1759 g to 1884 g and the average body weight in groups 2 to 5 were 3.01%, 6.63%, 5.77% and 5.22% higher compared to the control group (Table 2). The feed intake ($F_{4, 25}=58.60$) and body weight ($F_{4, 25}=15.62$) were significantly ($P<0.001$) lower in control than in Se supplemented groups. Very less deviation was observed in FCR ($F_{4, 25}=2.54$; $P>0.05$) and no significant variation in survivability ($F_{4, 25}=0.335$; $P>0.05$) was observed among groups. The lowest EEF occurred in negative control and inorganic Se supplemented treatment (group 2), but was higher for groups 3, 4 and 5 ($F_{4, 25}=27.98$; $P<0.001$). The results of the present study clearly shows that supplementation of Se in feed significantly improves the average feed intake and body weight of the broilers contrary to the observations of Miller *et al*. (1972) and Deniz *et al*. (2005) who found no difference in live weight gain of broilers fed with different sources and levels of Se. But, Choct *et al*. (2004) and Upton *et al*. (2008) also found improvements in body weight of broilers fed with Se in accordance with the present study. In spite of increased feed intake and higher body weight, the calculated FCR values for birds fed with Se supplemental diet was almost similar to the control birds except for those fed with 0.25 ppm sodium selenite. In contrast, Deniz *et al*. (2005) found that the FCR values of broilers fed organic Se supplemented diet was higher than those fed with either inorganic or no supplemental Se diet in spite of indifferences in growth. Other studies have also found that Se supplementation in feed could increase the FCR values in broilers (Choct *et al*. 2004; Upton *et al*. 2008; Payne and Southern 2005; Yoon *et al*. 2007).

In contrast with the above all reports, there was a significant difference in feed intake and body weight of birds with Se supplementation over birds without Se supplementation in the present study. The feed intake of birds without any Se supplementation was 168 g to 184 g lower than the birds in group 2 to 5. Likewise, the average body weight of group 1 was also less by 54 to 124 g compared to birds in group 2 to 5. We did not observe any difference in survivability due to the level and source of Se supplementation in broiler chickens which is in agreement with Miller *et al*. (1972), Cantor *et al*. (1975), Edens *et al*. (2001) and Payne and

Southern (2005). The Se supplementation improved the FCR and thereby improved the EEF values also.

Carcass yield

Table 3 shows the carcass yield of the five treatment groups. There was no significant ($P>0.05$) difference between the mean average values of live weight ($F_{4, 25}=1.85$), dressing weight ($F_{4, 25}=0.93$), breast meat ($F_{4, 25}=0.89$), legs ($F_{4, 25}=1.85$), wings ($F_{4, 25}=2.0$), neck ($F_{4, 25}=1.68$), liver ($F_{4, 25}=0.483$), heart ($F_{4, 25}=0.40$), gizzard ($F_{4, 25}=1.10$) and abdominal fat ($F_{4, 25}=1.2$) among treatments. Nevertheless, there was a significant ($P<0.001$) improvement in mean lymphoid organ weights in group 5: spleen, 2.77 ± 0.15 ($F_{4, 25}=18.6$) and thymus, 9.89 ± 0.22 ($F_{4, 25}=131.9$).

Information on the carcass traits of broiler in response to Se supplementation is limited. As observed by Payne and Southern (2005), we also did not find any significant difference in the carcass trait among level and source of Se supplementation. Whereas, Upton *et al*. (2008) showed that Se supplementation of feed could influence the cut up yield of carcass. Supplementation of feed with organic Se has been shown to improve the yield of the feet, neck, leg and thighs of poultry birds (Upton *et al*. 2008). Other studies have also shown that the yield of legs, thighs and feathers was higher for poultry birds fed with organic Se without any compromise on breast meat yield (Edens 1996; Naylor *et al*. 2000; Choct *et al*. 2004). The weight of lymphoid organs (spleen and thymus) of birds fed with either organic or inorganic Se sources was significantly higher than the birds without supplemental Se. This is in accordance with Hegazy and Adachi (2000) who showed that Se supplementation improves the relative weight and development of spleen. Hussain *et al*. (2004) also reported that supplementation of the poultry diet with organic Se improved the mean lymphoid organ weight than the birds fed on diet with inorganic Se. In line with the above studies, the mean weight of lymphoid organs of the spleen and thymus of the birds fed on organic Se was significantly higher than those without supplemental Se or supplemented with inorganic Se.

Analysis of meat and liver

Selenium accumulation in the breast meat was significantly higher in group 5 followed by group 3, group 4, group 2 and group 1 ($F_{4, 15}=18.96$; $P<0.001$). Selenium accumulation was significantly more in the liver of both organic and inorganic Se supplemented birds ($F_{4,15}=13.32$; $P<0.001$), but less Se accumulation was observed in control group. The low concentrations of Se in breast meat of group 1 (without supplemental Se) birds, and its increase with inorganic Se supplementation (0.25 ppm and 0.5 ppm Se) by 22-56% suggests that inorganic Se supplementation could increase the Se content of meat.

Table 2 Influence of different sources and levels of selenium supplementation on broiler performance and production

Parameters	Treatments				
	Group 1	Group 2	Group 3	Group 4	Group 5
Feed intake (g)	3244.8±10.38[b]	3412±14.18[a]	3437.0±12.92[a]	3435.0±6.69[a]	3428.83±7.85[a]
Body weight (g)	1759.3±12.37[c]	1814±10.54[b]	1884.17±17.19[a]	1867.0±7.79[a]	1856.17±13.56[a]
FCR	1.84±0.01[b]	1.88±0.01[a]	1.84±0.01[b]	1.84±0.01[b]	1.85±0.01[ab]
Survivability %	95.58±0.42[a]	95.38±0.77[a]	95.18±1.08[a]	95.38±0.77[a]	96.39±0.89[a]
EEF	261.0±1.44[b]	262.0±1.21[b]	279.0±2.89[a]	277.0±1.03[a]	276.0±0.86[a]

Group 1: basal diet (BD) with no supplemental Se (negative control); Group 2: BD + 0.25 ppm of Se as sodium selenite; Group 3: BD + 0.5 ppm of Se as sodium selenite; Group 4: BD + 0.25 ppm of sodium selenite and 0.25 ppm of Se yeast and Group 5: BD + 0.5 ppm of Se as Se-yeast.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
FCR: feed conversion ratio and EEF: european efficacy factor.

Table 3 Influence of different sources and levels of selenium supplementation on carcass yield of chicken

Parameters (in grams)	Treatments				
	Group 1	Group 2	Group 3	Group 4	Group 5
Live weight	1769.67±12.54[a]	1729.08±7.41[a]	1770.25±15.26[a]	1764.33±20.44[a]	1734.75±14.82[a]
Dressing wt	1230.67±13.58[a]	1199.33±11.28[a]	1238.41±13.18[a]	1219.58±20.27[a]	1210.91±19.83[a]
Breast meat	485.0±9.45[a]	467.33±13.03[a]	497.66±20.28[a]	476.92±30.5[a]	465.91±12.38[a]
Legs	344.25±3.71[a]	336.25±3.45[a]	344.33±3.80[a]	343.25±12.45[a]	351.33±3.26[a]
Wings	101.58±2.61[a]	98.25±1.78[a]	95.5±2.02[a]	93.33±5.17[a]	95.33±2.11[a]
Neck	46.50±3.56[a]	54.66±3.12[a]	53.41±2.65[a]	53.42±2.55[a]	56.25±2.26[a]
Liver	40.17±2.33[a]	40.41±4.3[a]	43.25±1.99[a]	41.67±1.57[a]	40.08±1.99[a]
Heart	10.92±0.70[a]	11.83±1.07[a]	10.58±0.52[a]	11.25±0.67[a]	11.08±0.58[a]
Gizzard	33.67±3.4[a]	35.33±1.94[a]	34.1±2.39[a]	37.33±1.31[a]	37.41±0.93[a]
Fat	20.50±1.38[a]	22.16±3.68[a]	26.08±3.22[a]	24.08±2.00[a]	18.41±2.22[a]
Spleen	1.50±0.08[a]	1.79±0.17[ab]	1.84±0.12[b]	1.90±0.10[b]	2.77±0.06[c]
Thymus	6.18±0.11[a]	6.11±0.16[a]	6.50±0.08[a]	7.89±0.22[b]	9.89±0.09[c]

Group 1: basal diet (BD) with no supplemental Se (negative control); Group 2: BD + 0.25 ppm of Se as sodium selenite; Group 3: BD + 0.5 ppm of Se as sodium selenite; Group 4: BD + 0.25 ppm of sodium selenite and 0.25 ppm of Se yeast and Group 5: BD + 0.5 ppm of Se as Se yeast.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).

However, supplementation of organic Se increased the Se concentration in meat by 97% compared to control and by 27%-61% over inorganic Se supplementation suggesting better uptake and accumulation of organic Se. These results are in agreement with Cantor *et al.* (1982), Shan and Davis (1994), Spears *et al.* (2003) and Payne and Southern (2005) who also found high concentrations of Se in breast meat of poultry fed with organic Se compared to the unfed control or those fed with inorganic Se fed birds. Birds fed with inorganic Se accumulate more Se in their liver tissues rather than in meat tissues. This may be attributed to the detoxification process of liver.

The GSHPx activity for the meat tissues ranged between 1605 and 1686 among Se supplemented group, and the variations were significant ($F_{4, 15}$=4.092; P<0.05). The GSHPx activity of meat in group 1 (negative control without any Se supplementation) was 7-12% lower than Se supplemented groups. Selenium supplementation also significantly ($F_{4, 15}$=13.33; P<0.001) improved the GSHPx activity of the liver tissues of group 5 and 2 birds. Moderate GSHPx activity was evident in group 1 and least GSHPx activity occurred in group 3 and 4. However, the GSHPx values for meat were higher in Se fed broiler than the negative control regardless of the level and source. This is in agreement with the observations of Cantor *et al.* (1982), Hassan *et al.* (1988), Spears *et al.* (2003) and Yoon *et al.* (2007) where

supplementation of broiler diets with Se increased the GSHPx values of meat. In the present study, we found an increased Se accumulation in the tissues of organic Se fed broilers as indicated by the increased GSHPx activity.

The TBARS value of meat, indicative of the oxidative damage to the tissues significantly ($F_{4, 10}$=115.5; P<0.001) decreased by 41-69% in Se fed broilers which is in agreement with Dlouha *et al.* (2008) who reported that a reduction in lipid oxidation in breast meat of broilers in response to supplementation of feed with Se enriched *Chlorella.* Similarly, there was also a small, but a significant difference ($F_{4, 15}$=5.52; P<0.01) in the liver TBARS values among treatments. Contrary to the meat, Se supplementation increased the TBARS values for liver tissue by 5-13%. The meat pH was significantly ($F_{4, 10}$=21.78; P<0.001) altered in response to Se supplementation with the control recording a pH of 5.8 (Table 4). Selenium supplementation reduced the meat pH by 0.3 to 0.6 and ranged between 5.2-5.5 for Se supplemented groups. As a high muscle pH results in shorter shelf life of meat due to microbial growth (Dou *et al.* 2009), a reduction of pH in response to Se supplementation indicate the longer shelf life of the meat and its quality. Selenium supplementation also significantly ($F_{4, 10}$=237.58; P<0.001) increased the WHC of meat by 2-97% which ranged between 13.49% (group 2) and 26.10% (group 5) for Se supplemental groups (Table 4).

Table 4 Effect of inorganic and organic selenium (Se) sources on total Se accumulation, glutathione peroxidase (GSHPx), thiobarbituric acid reactive substances (TBARS), pH and water holding capacity (WHC) of meat and liver

Parameters	Treatments				
	Group 1	Group 2	Group 3	Group 4	Group 5
Se content (μg/kg)					
Meat	0.315±0.02[d]	0.385±0.01[cd]	0.490±0.03[b]	0.413±0.11[bc]	0.620±0.04[a]
Liver	0.400±0.01[c]	0.658±0.02[a]	0.625±0.02[a]	0.495±0.02[b]	0.638±0.06[a]
GSHPx (μm/g)					
Meat	1503.6±37.99[b]	1605.1±33.9[a]	1631.7±21.37[a]	1613.1±39.79[a]	1686.1±27.2[a]
Liver	1464.6±6.79[b]	1558.2±24.5[a]	1421.6±24.51[bc]	1354.5±36.2[c]	1539.4±23.1[a]
TBARS (μm/g)					
Meat	75.2±1.5[a]	54.1±1.5[b]	44.4±1.4[c]	45.4±1.3[c]	23.5±1.2[d]
Liver	42.6±0.53[b]	45.3±0.8[b]	44.8±0.8[b]	45.0±1.3[b]	48.3±0.58[a]
pH of meat	5.80±0.03[a]	5.3±0.4[c]	5.5±0.1[b]	5.3±0.06[c]	5.2±0.04[c]
WHC of meat (%)	13.27±0.34[c]	13.49±0.2[c]	15.17±0.4[b]	15.87±0.42[b]	26.10±0.26[a]

[1]Group 1- Basal diet with no supplemental Se (negative control); Group 2- 0.25 ppm of Se as sodium selenite; Group 3- 0.5 ppm of Se as sodium selenite; Group 4 - 0.25 ppm of sodium selenite + 0.25 ppm of Se-yeast; Group 5: 0.5 ppm of Se as Se-yeast.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).

There was a significant increase in WHC of the broiler meat fed on organic Se which is in line with the Downs *et al.* (2000) who reported reduced water loss by organic Se addition.

CONCLUSION

Based on the broiler trail and *in vitro* analysis with the negative control (without supplemental Se), 0.25 ppm of inorganic Se, 0.5 ppm of inorganic Se, 0.25 ppm inorganic Se +0.25 ppm organic Se from Se yeast and 0.5 ppm of organic Se from Se yeast, we have come to the following conclusions:

(i) Selenium supplementation is essential, without which the feed intake and average body weight of broilers drastically reduces.
(ii) Selenium supplementation does not affect on survivability of birds or the carcass yield.
(iii) The weight of lymphoid organs like spleen and thymus increases in response to organic Se supplementation.
(iv) Selenium retention was high in organic Se fed broiler meat than the other treatment groups.
(v) Regardless of the source and levels, Se supplementation enhanced the GSHPx activity of meat.
(vi) The lipid peroxidase activity for broiler meat measured as MDA values was significantly lowered by Se supplementation.
(vii) Supplementation of broiler diet with organic Se increased the WHC and lowered the meat pH.

Therefore, the overall results of the study suggests that the 0.5 ppm of organic Se supplementation generally improve the chicken meat quality by improving Se bioavailability, Se retention, improved GSHPx activity and reduce the thiobarbituric acid reactive substance.

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