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Effect of dietary organic and inorganic selenium on carcass composition and meat characteristics of broiler chickens

Jamnongtoi, P., Sivapirunthep, P. and Chaosap, C.*

Department of Agricultural Education, Faculty of Industrial Education and Technology, King Mongkut's Institute of Technology Ladkrabang, Bangkok 10520, Thailand.

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Abstract The effects of organic Zn-L-selenomethionine (Zn-L-SeMet) and inorganic sodium selenite (Na-Se) on broiler chickens'carcass composition and meat characteristics were compared. The 360 one-day-old broiler chickens subjected to a 3 phases feeding program with basal diets of corn-soy. The chickens were divided into 2 groups supplemented with 0.3 ppm of Zn-L-SeMet or Na-Se throughout 37 days of raising period. Each treatment consisted of 6 replicated with 30 male broilers. Birds were deprived of feed for 12 h and weighed prior to slaughter. Three birds from each treatment replicate were sacrificed by cervical dislocation before carcass compositions were measured. Breast muscles were collected and then determined meat characteristics. Carcass composition was not affected ($P>0.05$) by different selenium sources. Chicken fed Zn-L-SeMet had higher cooking loss and lower color of L* value compared to those fed with Na-Se. Shear force value of Zn-L-SeMet was significant lower than Na-Se at 1 day postmortem but the effect of selenium sources was not significant later than at 4 day post mortem.

Keywords: Zn-L-Selenomethionine, Sodium Selenite, Carcass Composition, Meat Characteristics, Broiler Chicken

Introduction

Selenium (Se) has been known as an important trace mineral for many biological functions that impact on animal health, growth performance and productivity (Yoon *et al.*, 2007; Surai *et al.*, 2018). It improves meat quality (Li *et al.*, 2018) and egg quality (Chantiratikul *et al.*, 2008), antioxidant activity (Jing *et al.*, 2015), activity of glutathione peroxidase (Zhou and Wang, 2011), and immune system (El-Deep *et al.*, 2016). Regarding tremendous genetic progress, modern commercial poultry has a very fast growth and high feed efficiency. However, a major drawback of such improvement in performance is that birds are often highly sensitive to various stresses. Therefore, the optimum

* **Coressponding Author:** Chaosap, C. ; **Email:** chanporn.ch@kmitl.ac.th

supplementation of selenium in diet is required to ensure the best possible production of the animals.

A primary form of Se supplemented in poultry diets is inorganic selenium such as sodium selenite (Na-Se) and sodium selenate. However, during the last decade, there has been a subsequent interest in either partly or completely replacing the inorganic Se with an organic form which is providing an improved bioavailability compared to inorganic source (Jing *et al.*, 2015; Li *et al.*, 2018; Zhou and Wang, 2011). A range of supplements that claimed to be organic Se sources should be only the products providing Selenomethionine (SeMet) or its precursor, as SeMet is the only form that allows building Se reserves in the animal body, mainly in the muscles (Surai *et al.*, 2018). The organic Se sources that can be found in the world market including Se-enriched yeast (Se-yeast), SeMet, Zn-L-selenomethionine (Zn-L-SeMet), and Hydroxy-selenomethionine (OH-SeMet). As described by the producers, a more recent organic selenium source, Zn-L-SeMet is designed to be more solubility and increase the bioavailibility and also increase more stability (Abdel-Monem and Anderson, 2005).

Several studies were conducted to compare the performance, carcass characteristics, and meat characteristics between the traditional inorganic Se and organic Se. Those studies revealed that organic Se source, mainly Se-enriched yeast, gave better performance, carcass characteristics, and meat quality (Kinal *et al.*, 2012; Yang *et al.*, 2012; Yoon *et al.*, 2007; Li *et al.*, 2018). However, there is little information on the use of Zn-L-SeMet in broiler diets and its influence on the carcass composition and meat characteristics. Therefore the aims of this study was to determine the effect of organic Zn-L-SeMet supplemented in diet compared to inorganic sodium selenite (Na-Se) on broiler chickens' carcass composition and meat characteristics.

Materials and Methods

Animals and Diets

All animal procedures were carried out following the animal welfare standards of the Department of Livestock Development, Ministry of Agriculture and Cooperatives, Royal Thai Government. A total of 360 one day old male Arbor Acres broiler chickens were reared for 37 days in floor pens in evaporate housing. Each floor pen of approximately 2x2 m^2 was giving a stocking density of 15 male-sex chickens/m^2. Continuous 24 h lighting was provided. Chickens were vaccinated against Newcastle disease and Infections Bursal disease according to commercial recommendations. They were fed ad libitum with a 3 phase of broiler industry feeding program and the basal diets for each phase were corn-soy diet. All chickens were divided into 2 groups of 180 chickens and randomly assigned to 2 treatments which were supplemented with 0.3 ppm inorganic selenium (Na-Se) or organic selenium (Zn-L-SeMet) in diets through out 37 days. In each group, chickens were divided and raised in 6 experiment pens or replication, which located 30 chickens per pen. A corn-soy base diet recommended by NRC (1994) was shown in Table 1. Three chickens from each pen or total of 36 chickens were randomly slaughtered after 37 days of age. Birds were deprived of feed for 12 h and weighed prior to slaughter. Three birds from each treatment replicate were sacrificed by cervical dislocation for measuring body and carcass compositions. Breast muscles were collected and then determined meat characteristics.

pH Measurement

The pH value was measured for 45 min, 24 hour, and 4 day postmortem at the right *Pectoralis major* with a portable pH meter equipped with a spear tip glass electrode calibrated in buffers at pH 4.01 and 7.00 at ambient temperature. (Model SG2-ELK Seven Go^{TM}, Mettler Toledo International Inc., China).

Drip Loss

Drip loss was determined as the weight loss during suspension of meat samples in a closed plastic bag filled with air and fastened to avoid evaporation and left at 4 to 6 ℃ for 48 h according to Honikel (1998). Drip loss was expressed as a percentage relative to the initial weight.

Color Measurements

Meat color was measured at 45 min postmortem with a Chroma Meter (CR-400, Minolta Co., Ltd., Suita-shi, Osaka, Japan) to measure CIE lab values (L* measures relative lightness, a* relative redness, and b* relative yellowness).

Measurement of Shear Force

The breast muscles were refrigerated for 1 day and 4 day at 4 ℃ and then brought to room temperature before cooking. The one inch thick breast muscle from each bird was cooked to an internal temperature of 70 ℃ on a digital thermostat water bath (Memmert, Germany). End point internal temperature was monitored with a thermometer. Cooked muscle was cooled to room temperature. Ten 1x2x1 cm^3 slices were removed parallel to the fiber orientation through the thickest portion of the cooked muscle. Warner-Bratzler shear force was determined by using an Texture Analyser Machine (Model EZ-SX, Shimadzu, Japan). A Warner-Bratzler apparatus was attached to a 50 kg load cell, and tests were performed at a cross head speed of 50 mm/min. Signals were processed with the Tapezium software package.

Table 1. Composition (%) of the experimental diets

Item	**Starter (0-21 day)**	**Grower (22-30 day)**	**Finisher (31-37 day)**
Ingredient			
Broken rice	28.62	34.96	38.85
Corn	30.00	30.00	30.00
Soybean meal	29.50	21.92	18.24
Fish meal	6.00	8.00	8.00
Vegetable oil	1.64	0.84	1.11
Monocalcium phosphate	1.35	1.24	1.00
Limestone	0.77	0.90	0.79
Premix[1,2]	0.60	0.60	0.60
Salt	0.42	0.39	0.39
Lysine	0.39	0.41	0.40
DL methionine	0.29	0.26	0.25
L Threonine	0.19	0.18	0.14
Cholinechloride	0.14	0.14	0.14
Antifungal	-	0.10	0.10
Maxiban	0.05	-	-
Cygro 1	-	0.05	-
Nutrient and energy level (calculated)			
Xanthophyll (ppm)	11.70	11.70	11.70
ME (kcal/kg)	3100.00	3100.00	3150.00
Protein	21.50	19.00	17.50
Ash	4.38	4.06	3.58
Fat	4.29	3.79	4.02
Fiber	2.37	2.21	2.08
Calcium	0.90	0.90	0.80
Total Phosphorus	0.72	0.67	0.60
Available Phosphorus	0.48	0.45	0.40
Salt	0.44	0.42	0.42
Lysine	1.28	1.15	1.06
Methionine	0.52	0.47	0.45
Methionine + Cystein	0.91	0.83	0.79
Threonine	0.96	0.86	0.79
Tryptophane	0.22	0.19	0.25
Sodium	0.20	0.19	0.19

[1]/Vitamin-mineral mixture provides the following (per kg of diet): 25,000 IU of vitamin A; 5,000 IU of vitamin D3; 100 mg of vitamin E; 6 mg of vitamin K3; 4 mg of vitamin B1; 10 mg of vitamin B2; 30 mg of vitamin B3; 6 mg of vitamin B6; 60 mg of nicotinamide; 2 mg of folic acid; 0.06 mg of vitamin B12; 0.2 mg of biotin; 1,000 mg of choline chloride; 2 mg of Co, 4 mg of I, 120 mg of Mn, 40 mg of Fe, and 100 mg of Zn.
[2]/The level of Se was 0.3 ppm in each diet, provided as either organic Se (Zn-L-SeMet) or inorganic sodium selenite.

Statistical Analysis

The data were subjected to RCBD and ANOVA procedures to measure the effect of two treatments of different sources of 0.3 ppm Se in feed. The model for all response variables contained treatment as the main effect and replicate as the block. Significant was accepted at P<0.05. As live weight was significant difference between treatment therefore, the LW was used as covariate in the analysis of variance for percentage of abdominal fat, liver, gizzard, heart, spleen, head, and neck.

Results

The results of carcass characteristics and meat quality of broiler chickens fed with 0.3 ppm inorganic or organic selenium were shown in Table 2 and 3. The chickens fed with Na-Se supplemented diet had higher live weight than those fed with Zn-L-SeMet supplentation (P < 0.05). There were not significantly different between the two treatments (P>0.05) for all carcass characteristics and meat quality except at day 1 postmortem breast muscle from Zn-L-SeMet supplementation had higher cooking loss but lower L* value and lower shear force value (P < 0.05) than those supplemented with Na-Se.

Table 2. Body and carcass composition of broiler chicken fed with supplemented 0.3 ppm organic Zn-L-selenomethionine (Zn-L-SeMet) or inorganic sodium selenite (Na-Se)

Carcass Characteristics	Zn-L-SeMet	Na-Se	P-value
live weight (kg)	2.30±0.03	2.38±0.12	0.031
carcass weight (kg)	1.90±0.01	1.90±0.10	0.787
carcass weight (%)	81.33±0.56	81.13±0.54	0.806
body composition (% of live weight)			
abdominal fat	0.98±0.06	0.98±0.06	0.947
liver	2.10±0.06	2.20±0.06	0.260
gizzard	1.16±0.08	1.14±0.08	0.917
heart	0.42±0.04	0.38±0.04	0.501
spleen	0.05±0.01	0.05±0.01	0.878
head	2.53±0.08	2.61±0.08	0.498
Neck	5.02±0.24	5.15±0.23	0.969
carcass composition (% of carcass weight)			
breast	25.99±0.81	24.84±0.78	0.328
fillet	4.92±0.27	4.83±0.08	0.487
wing	9.45±0.26	9.19±0.26	0.430
leg	25.58±0.97	27.02±0.94	0.307
hook	4.59±0.11	4.28±0.01	0.054
frame	19.90±0.36	20.34±0.35	0.393
trim	0.80±0.21	0.60±0.20	0.508

Table 3. Meat quality of broiler chickens fed with supplemented 0.3 ppm organic Zn-L-selenomethionine (Zn-L-SeMet) or inorganic sodium selenite (Na-Se)

Meat quality	Zn-L-SeMet	Na-Se	P-value
drip loss (%)	1.69±0.59	2.01±0.69	0.767
shrinkage loss (%)			
1 day	0.76±0.33	0.92±0.44	0.191
4 day	1.91±0.59	2.17±0.54	0.336
cooking loss (%)			
1 day	14.05±2.79 [a]	10.89±1.92 [b]	0.004
4 day	11.79±2.65	12.24±1.25	0.072
color			
L* 1 day	50.11±3.03[b]	52.29±2.41[a]	0.022
a* 1 day	1.82±0.52	1.83±0.74	0.967
b* 1 day	7.29±0.98	7.71±1.79	0.288
L* 4 day	53.11±3.11	52.67±2.11	0.451
a* 4 day	1.82±0.52	1.83±0.74	0.554
b* 4 day	7.29±0.98	7.71±1.79	0.563
pH			
pH 45 min	6.50±0.20	6.50±0.23	0.725
pH 1 day	6.01±0.15	5.91±0.27	0.435
pH 4 day	6.01±0.15	5.95±0.19	0.095
shear force (kg)			
1 day	2.94±0.75[b]	3.40±0.62[a]	0.005
4 day	2.20±0.28	2.31±0.36	0.116

There were no effect on drip loss and shrinkage loss at day 1 and day 4 postmortem except cooking loss at day 1 postmortem of chicken meat from in organic Zn-L-SeMet or inorganic Se sources in diets. The cooking loss at day 1 postmortem of chicken fed organic Se was higher than that fed with inorganic Se ($P<0.01$).

Chicken fed with inorganic Se had higher L* value at day 1 postmortem than that fed with organic Zn-L-SeMet ($P<0.05$). While, a* and b* value at day 1 postmortem was not significantly different. There were no effect of Se sources on L*, a*, and b* values measuring at day 4 postmortem. The sources of Se did not affect pH at 45 min, day 1, and day 4 postmortem in this study.

Shear force value at day 1 postmortem of chicken breast fed with inorganic Se was higher than that fed with Zn-L-SeMet ($P<0.05$). Whereas there was no effect of Se source on shear force value of day 4 postmortem ($P > 0.05$).

Discussion

According to the NRC (1994), the recommended supplement of 0.3 ppm Se in broiler diet is sufficient to maintain normal growth and production. Suchy *et al.* (2014) explained that inorganic Se (sodium selenite) is biologically less active than organic Se. However, the finding of this study showed that the carcass characteristics of broiler chickens were not much influenced by the different sources of Se which in agreement with the reports of Deniz *et al.* (2005). But Choct *et al.* (2004) and Payne and Sonthern (2005) found that birds receiving organic Se in their diet had improved eviscerated weight, breast yield, and reduced drip loss. However, Navid *et al.* (2010) reported that when the organic Se in combination with vitamin E were supplemented in diets compared to inorganic Se diets, the organic Se supplemented diets gave better carcass characteristics and increased breast weight (P<0.05).

In this study there was no effect of Se source in diet on drip loss while Choct *et al.* (2004) found that Se-Met caused less drip loss but higher pH value than Na-Se. Jiang *et al.* (2009) found that supplemented organic Se and inorganic Se in diet caused lower drip loss value than unsupplemented Se. When supplemented with organic Se, chicken meat tended to have lower drip loss. The lower drip loss might be caused by the higher pH in chicken fed with organic Se (Choct *et al.*, 2004).

The L* value at day 1 postmortem of breast meat from supplemented with organic Zn-L-Se was lower than supplemented with inorganic Se in the present study which similar result as Boiago *et al.* (2014) study. They explained that the L* value decreased probably because of better water holding capacity causing less moisture on the surface.

Supplemented with organic Zn-L-SeMet had lower shear force value in the present study. In agreement with Li *et al.* (2018) who found that Se-Met, Se-enriched Yeast, and Nano-Se supplementation had lower shear force value than Na-Se supplementation. This is explained by Yoon *et al.* (2007) who found a significant higher intramuscular fat content in broiler breast muscle supplemented with Se-enriched Yeast could be having lower shear force value. However, the results from Jiang *et al.* (2009) reported that the shear force value was not significant different between unsupplemented and supplemented with organic or inorganic Se. There was not significantly different shear force value at day 4 postmortem between the treatments in this study. The similar shear force value at day 4 postmortem between treatments might be associated with the effect of proteolysis during postmortem storage which more impacts on protein degradation resulting in lower shear force value than the effect of Se sources.

It is concluded that the broiler receiving inorganic selenium had higher live weight, body and carcass composition were not affected by selenium sources. Meat quality in terms of cooking loss, L* value, and SF value at day 1 postmortem were significantly different because of selenium sources which organic selenium giving better tenderness.

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