J. BIOL. ENVIRON. SCI.,
2018, 12(35), 51-57

Original Research Article

Effects of Zinc-L-selenomethionine on Growth Performance, Carcass Yield and Selenium Concentration of Breast Meat in Japanese Quails

Arda Sözcü[1*] and Aydın İpek [2]
[1] Ödemiş Vocational Training School, Ege University, İzmir, TURKEY
[2] Department of Animal Science, Faculty of Agriculture, Bursa Uludag University, Bursa, TURKEY

Received: 07.06.2018; Accepted: 17.07.2018; Published Online: 24.09.2018

ABSTRACT

The aim of this study was investigate the effects of dietary supplementation of organic selenium as zinc-L-selenomethionine (Zn-L-SeMet) on growth performance, carcass yield and selenium concentration of breast meat in Japanese quails (*Coturnix coturnix japonica*). A total of 300 quails were randomly divided into 5 treatment groups with 3 replicates (20 quails/each replicate), as control (0 mg/kg), dose 1 (0.1 mg/kg), dose 2 (0.2 mg/kg), dose 3 (0.3 mg/kg) and dose 4 (0.4 mg/kg) diet supplementation of Zn-L-SeMet. The supplementation was applied between 7-35 days of growing period. The quails in dose 2 and dose 3 groups were heavier with values of 179.2 g and 177.8 g, respectively, than control (152.6 g), dose 1 (163.7 g) and dose 4 (167.0 g) at 35 days of age. The highest cumulative feed consumption was observed for the quails in the control and dose 3 groups (respectively, 582.3 g and 580.7 g, $P<0.01$). Feed conversion rate was more efficient with values of 3.19 and 3.27 in dose 2 and dose 3 groups ($P<0.01$). Slaughter weight and carcass weight were found to be higher in dose 2 (respectively, 181.2 g and 131.9 g) and dose 3 (respectively, 177.0 g and 129.5 g) groups ($P<0.05$). The highest Se concentration of breast meat was observed with a value of 0.32 % in the birds fed with dose 4 diet. On the other hand, the lowest Se concentration of breast meat was found with a value of 0.20% in the control group ($P<0.01$). These findings showed that dietary supplementation of Zn-L-SeMet has a potential stimulating effect for growth performance, slaughter yield and improving of selenium concentration of breast meat in Japanese quails.

Keywords: Quail, Selenium, Growth, Feed efficiency, Breast meat

INTRODUCTION

Selenium is an important trace mineral for health status, growth performance and also meat quality for poultry (Costa *et al.*, 2008, Zhang *et al.*, 2014). It plays an important role for developing immune function, production of immunoglobulins and subsequently increasing of resistance to diseases and antioxidant defense system of birds (Spallholz *et al.*, 1973; Surai, 2002a; Avanzo *et al.*, 2002; Pappas *et al.*, 2005).

In nature, selenium exists in two forms as organic form and inorganic form (Surai, 2002b). Organic forms of selenium take part of proteins and largely known as selenomethionine and selenocysteine (Surai and Dvorska, 2002). Inorganic selenium is largely known as sodium selenium, and this form of selenium is not too effective for its biological activity (Suchý *et al.*, 2014). It is known that the pathways of organic and inorganic selenium differ from each other. Organic selenium forms have crucial functions for biological acitivites in the body, and have a higher bioavailability with a value of 75.7%, compared to the inorganic selenium forms with a value of 49.9% (Mahan *et al.*, 1999).

Previously, inorganic form of selenium as sodium selenite were largely used for animal nutrition (Payne and Southern, 2005). After that, when the detailed studies were performed, it was found that organic selenium is more available and efficient for retention of selenium in muscle tissues, compared to the inorganic forms of selenium (Mahan and Parrett, 1996; Choct *et al.*, 2004). Therefore, recently supplementation of different organic selenium forms has gained interest and importance for poultry nutrition due to its bioavailability, antioxidant effects and a stimulating effect for growth performance.

The dietary selenium supplementations have beneficial effects on growth performance by improving body weight, feed intake, feed efficiency (Attia *et al.*, 2010; Yang *et al.*, 2012), profitability by stimulating immune system and lowering mortality (Funari *et al.*, 2012; Liao *et al.*, 2012; Rama Rao *et al.*, 2013); meat quality by improving quality and antioxidant stability of chicken meat, (Heindl *et al.* 2010; De Almeida *et al.* 2012; De Medeiros *et al.* 2012; Yang *et al.* 2012).

Supplementation amount of selenium to the diets should be adjusted according to some factors, for example, poultry species, age, yield type, age, and environmental conditions, selenium forms. The aim of this study was to determine the effects of dietary supplementation of organic selenium in the form of Zinc-L-Selenomethionine (Zn-L-SeMet) on growth performance, slaughter yield, and selenium concentration of breast meat in Japanese quails.

[*] Corresponding author: arda.sozcu@ege.edu.tr

MATERIALS AND METHODS

The care and use of animals was in accordance with the laws and regulations of Turkey and approved by the ethics committee of Uludag University (License Number 2015–06/11).

A total of 300 one-day-old Japanese quails (*Coturnix coturnix japonica*) were weighed by a digital balance with ± 0.01 g precision and then each bird was coded by a wing number. At 7th day of growing period, the birds were randomly placed to 5 experimental groups with three replicates (20 quails/each replicate). The birds were kept in a folded cage system in which each sub cage unit had a floor size as 90 x 48 cm (for 20 birds). The experimental groups were consisted of control group (no supplementation of *zinc-L-selenomethionine*) and supplementation of Zn-L-SeMet (Availa®Se, Zinpro Corporation, Eden Prairie, MN, USA) with four levels (dose 1; 0.1 mg/kg of diet, dose 2; 0.2 mg/kg of diet, dose 3; 0.3 mg/kg of diet and dose 4; 0.4 mg/kg of diet). The Zn-L-SeMet was supplemented to the ration between 7-35 days of growing period.

A maize-soybean meal based diet was considered as control diet (23.0% CP and 12.8 MJ/kg of diet) recommended by NRC (1994). Other groups were fed with basal diet supplemented with four levels of Zn-L-SeMet. The composition and calculated nutritive value of the basal diet were given in Table 1. Water and feed were supplied *ad libitum* during experimental period.

Table 1. The ingredients, chemical compositionand analysed nutrient level of experimental diet.

Ingredients, %	Diet
Maize	50.70
Soybean meal (CP 48%)	34.00
Fish meal	5.00
Vegetable oil	7.50
Dicalcium phosphate	1.33
Sodium chloride	0.11
Limestone	0.51
Calsium carbonate	0.10
DL-methionine (98%)	0.22
L-Lysine-HCl (99%)	0.10
Premix[1]	0.43
Total	100
Calculated chemical composition	
ME, MJ/kg	12.8
Analysed nutrient level	
Dry matter	93.5
CP	23.00
Ether extract	71.5
Crude fibre	88.7
Crude ash	65.1
Nitrogen free extract	544.7

[1] Vitamin and mineral premix provided per kg of diet: vitamin A 4000000 IU; vitamin D_3 800000 IU; vitamin E 8000 mg; vitamin K_3 1200 mg; vitamin B_1 800 mg; vitamin B_2 2400 mg; vitamin B_6 2000 mg; vitamin B_{12} 6 mg; vitamin C 20000 mg; niacin 8000 mg; biotin 40 mg; folic acid 400 mg; choline chlorid 80000 mg; manganese 32000 mg; iron 24000 mg; zinc 24000 mg; copper 2000 mg; iodine 400 mg; cobalt 80 mg; selenium 60 mg

The environmental conditions were equally provided for all experimental groups. Under controlled environmental conditions, room temperature was 35°C at 1 day of age and decreased gradually by 2.5-3.0° C/week, and was then maintained at 25°C and 50–60% relative humidity until the end of the experiment. A lighting schedule (23 hours light and 1 hours dark) was applied according to the standard rearing guides.

Body weights of quails and feed consumption were determined by weekly cage unit basis weighing in periods of seven days (from day 1st to day 35th). Body weight gains and cumulative feed consumption were calculated weekly, and then feed conversion ratio was estimated by weekly body weight gain and feed consumption values. Mortality was recorded daily and mortality rate was calculated at the end of the experiment.

A total of 45 quails (9 quails per each experimental group) were randomly selected at 35th day for slaughter. Before slaughter, feed was withdrawn for 12 hours. Birds were individually weighed to determine slaughter weight, and then were slaughtered. After the slaughter process, evisceration and chilling were performed and the carcass weight was determined by weighing of quail carcasses. The carcass yield was then calculated as a ratio between carcass weight and slaughter weight.

Breast meat samples (5 samples per each experimental group) were stored in plastic bags at a storage temperature of -18 ºC for further Se analysis. Se concentration of breast samples were analysed by using an inductively coupled plasma-mass spectrometry (ICP-MS) (Agilent 7500a Series Shield Torch System instrument; Agilent Technologies Inc., USA) and ASX 520 autosampler (CETAC, USA). Each breast sample was washed with distilled water. Breast samples were cut into small pieces then these samples were homogenized. The 0.5 g sample was weighed for analysis. The method parameters and instrument conditions for ICP-MS are given in Table 2.

Table 2. Method parameters and instrument conditions for ICP-MS.

ICP-MS	**Settings**
RF power	1400 W
RF Matching	1.68 V
Sample Depth	7.5 mm
Torch –H	-1 mm
Torch – V	0 mm
Carrier Gas	1.16 mm/min
Nebulizer Pump:	0.1 rps
S/C temp	0 °C
Acquisition Parameters	
Mass Range	7-205 amu
Dwell Time	0.1 sn
Acquistion Time	22.76 sn

The data of growth performance, slaughter and carcass yield and selenium concentration of breast meat were analysed by one way ANOVA program of Statistical Analysis Software (version 9.1.3; SAS Institute Inc., Cary, NC) using Duncan’s multiple range test (SAS, 2010). Analyses for percentage data were conducted after a square root of arc sine transformation of the data. Mortality data were analysed using chi-square. All results were presented as mean ± SD at significant $P \leq 0.05$.

RESULTS AND DISCUSSION

The effects of dietary Zn-L-SeMet supplementation on body weight of quails are given on Table 3. The body weight on days 1, 7 and 21 was similar among the experimental groups ($P>0.05$). Birds fed with dose 4 diet were found to be heavier compared the other groups on day 14 of growing period (54.5 g, $P<0.05$). At 28 and 35 days of age, body weight of birds fed with dose 2 and dose 3 diets were found to be higher when compared to control, dose 1 and dose 4 groups ($P<0.01$). The birds in dose 2 and dose 3 groups were heavier with values of 179.2 g and 177.8 g, respectively, than control (152.6 g), dose 1 (163.7 g) and dose 4 (167.0 g) at the end of the growing period.

Table 3. The effects of dietary Zn-L-SeMet supplementation on body weight in Japanese quails.

Days	Experimental groups					
	Control	Dose 1	Dose 2	Dose 3	Dose 4	P-Value
Day 1	10.3 ± 0.1	10.3 ± 0.2	10.2 ± 0.2	10.4 ± 0.2	10.3 ± 0.2	NS
Day 7	29.1 ± 0.5	28.8 ± 0.8	29.0 ± 0.7	29.0 ± 0.7	28.8 ± 0.7	NS
Day 14	48.9 ± 1.0 ^{c}	51.3 ± 1.4 ^{b}	52.3 ± 1.4 ^{b}	49.5 ± 1.1 ^{c}	54.5 ± 1.1 ^{a}	*
Day 21	77.1 ± 1.5	78.0 ± 2.0	78.6 ± 1.5	77.5 ± 1.2	77.8 ± 1.6	NS
Day 28	104.5 ± 1.6 ^{c}	109.3 ± 2.1 ^{b}	118.8 ± 1.9 ^{a}	118.0 ± 1.8 ^{a}	108.2 ± 1.8 ^{b}	**
Day 35	152.6 ± 5.5 ^{c}	163.7 ± 5.0 ^{b}	179.2 ± 4.2 ^{a}	177.8 ± 5.2 ^{a}	167.0 ± 4.5 ^{b}	**

$^{a-c}$ Means within a row with different letter are significantly different.
*P<0.05, **P<0.01, NS: not significant.
Dose 1; 0.1 Zn-L-SeMet mg/kg of diet, dose 2; 0.2 Zn-L-SeMet mg/kg of diet, dose 3; 0.3 Zn-L-SeMet mg/kg of diet and dose 4; 0.4 Zn-L-SeMet mg/kg of diet

The effects of dietary Zn-L-SeMet supplementation on body weight gain of quails are presented on Table 4. The body weight gain was only found to be significantly between 22-28 days and 29-35 days of growing period ($P<0.05$). A higher body weight gain between 22-28 days was observed in birds fed with dose 2 and dose 3 diets, whereas it was higher between 29-35 days of growing period for the birds in dose 2, dose 3 and dose 4 groups (respectively, 60.5 g, 59.8 g and 58.8 g).

Table 4. The effects of dietary Zn-L-SeMet supplementation on body weight gain in Japanese quails.

Periods	Experimental groups					
	Control	Dose 1	Dose 2	Dose 3	Dose 4	P-Value
1-7 d	18.8 ± 0.9	18.6 ± 1.0	18.8 ± 0.9	18.7 ± 0.9	18.5 ± 0.9	NS
8-14 d	19.8 ± 1.5	22.5 ± 1.7	23.3 ± 1.8	20.4 ± 1.7	25.7 ± 1.8	NS
15-21 d	28.2 ± 2.1	26.7 ± 1.8	26.3 ± 1.9	28.1 ± 2.0	23.4 ± 2.0	NS
22-28 d	27.4 ± 2.0 ^{bc}	31.3 ± 2.1 ^{b}	40.2 ± 2.1 ^{a}	40.4 ± 2.0 ^{a}	30.4 ± 2.3 ^{b}	*
29-35 d	48.0 ± 2.8 ^{b}	54.3 ± 2.4 ^{ab}	60.5 ± 3.5 ^{a}	59.8 ± 3.9 ^{a}	58.8 ± 4.1 ^{a}	*

$^{a-c}$ Means within a row with different letter are significantly different.
*P<0.05, **P<0.01, NS: not significant
Dose 1; 0.1 Zn-L-SeMet mg/kg of diet, dose 2; 0.2 Zn-L-SeMet mg/kg of diet, dose 3; 0.3 Zn-L-SeMet mg/kg of diet and dose 4; 0.4 Zn-L-SeMet mg/kg of diet

Results showed that the supplementation of Zn-L-SeMet improved the growth performance in the quails, by stimulating of body weight gain during growing period. The increment of body weight was affected by supplementation amount of Zn-L-SeMet in the study. These results are consistent with Payne and Southern (2005), Mansoub *et al.* (2010), Zancanela *et al.* (2017) who concluded that supplementation of Se caused an improvement for growing performance of broilers compared to the control group. This stimulating effect could be attributed to improvement of antioxidant defense due to increased levels of Se levels in the diets (Łukaszewicz *et al.*, 2011).

In another study performed by Funari *et al.* (2010), it was stated that broilers treated with 0.45 mg Se/kg of feed (both organic and inorganic form of Se) resulted with a higher body weight and body weight gain, compared to other birds treated with 0.15 mg Se/kg of feed during growing period (between 1-42 days). Contrarily, Yoon *et al.* (2007) stated that supplementation of selenium in different forms (selenium with different yeast types) did not affect the growth performance of broilers during the growing period.

The effects of dietary Zn-L-SeMet supplementation on the cumulative feed intake, feed conversion rate and mortality were shown on Table 5. The highest cumulative feed consumption was observed for the birds in the control and dose 3 groups (respectively, 582.3 g and 580.7 g, P<0.01). Feed conversion rate was more efficient with values of 3.19 and 3.27 in dose 2 and dose 3 groups (P<0.01). The total mortality (1-35 days) was similar among the experimental groups (Chi-square = 9.327; P>0.05).

Table 5. The effects of dietary Zn-L-SeMet supplenmentation on cumulative feed consumption, feed conversion ratio and mortality in Japanese quails.

Traits	Experimental groups					
	Control	Dose 1	Dose 2	Dose 3	Dose 4	P-Value
CFC, g	582.3 ± 9.8 ^{a}	555.6 ± 10.4 ^{c}	572.3 ± 10.0 ^{ab}	580.7 ± 8.3 ^{a}	568.0 ± 9.4 ^{b}	**
FCR	3.82 ± 0.17 ^{a}	3.40 ± 0.12 ^{b}	3.19 ± 0.15 ^{c}	3.27 ± 0.18 ^{c}	3.40 ± 0.21 ^{b}	**
Mortality, %	10 (6/60)	1.66 (1/60)	0 (0/60)	3.33 (2/60)	6.66 (4/60)	NS
					Chi-square value: 9.327	

$^{a-c}$ Means within a row with different letter are significantly different.
*P<0.05, **P<0.01, NS: not significant
Dose 1; 0.1 Zn-L-SeMet mg/kg of diet, dose 2; 0.2 Zn-L-SeMet mg/kg of diet, dose 3; 0.3 Zn-L-SeMet mg/kg of diet and dose 4; 0.4 Zn-L-SeMet mg/kg of diet
CFC: Cumulative feed consumption
FCR: Feed conversion rate

Results showed that supplementation of Zn-L-SeMet caused an improvement for cumulative feed consumption and feed conversion rate. This effect was clearly observed in dose 2 and dose 3 groups. Similar results are also reported by Wang and Xu (2008) and Naylor *et al.* (2009) for these parameters. It is known that the selenium has function as an antioxidant and also takes part in some important enzymes, for examples thioredoxin reductase and glutathione peroxidase. These enzymes have crucial importance for the pancreatic activities (Combs and Combs, 1986), especially for secretion of the digestive enzymes (Lagana *et al.*, 2007). A special stimulating effect for digestive enzymes by selenium supplementation could be resulted with increment of nutrient digestibility and subsequently improvement of feed efficiency. Similar results were also reported by Zancanela *et al.* (2017) who found more efficient feed conversion rate when the broilers fed with 0.29 mg Se/kg of feed. In contrast to our findings, Selle *et al.* (2013) found any significant effect of 0.3 mg/kg selenomethioine suplementation for feed conversion rate for broilers. Similarly, Ryu *et al.* (2005) reported that body weight and feed efficiency were not affected by dietary selenium levels. In the study, a higher mortality rate was numerically observed in the control group compared other group with Se supplementation. This could be related with stimulating effect for immune system and antioxidant capacity of cells by Se supplementation (Jokic *et al.*, 2009).

The effects of dietary Zn-L-SeMet supplementation on slaughter and carcass yield were given on Table 6. Slaughter weight and carcass weight were found to be higher in dose 2 (respectively, 181.2 g and 131.9 g) and dose 3 (respectively, 177.0 g and 129.5 g) groups (P<0.05). However, carcass yield was similar at the end of the experiment (P>0.05). It changed within a range of 72.4-73.2% among the experiemental groups. These findings are consistent with other studies performed by Choct *et al.* (2004) and Mansoub *et al.* (2010) who concluded that supplementation of organic Se improved slaughter and carcass weight in broilers.

Table 6. The effects dietary Zn-L-SeMet supplementation on slaughter and carcass yield in Japanese quails.

Traits	Experimental groups					
	Control	Dose 1	Dose 2	Dose 3	Dose 4	P-Value
SW (g)	151.8 ± 4.9 [c]	164.3 ± 4.7 [b]	181.2 ± 4.0 [a]	177.0 ± 5.1 [a]	165.9 ± 4.9 [b]	*
CW (g)	110.0 ± 5.3 [c]	120.0 ± 3.6 [b]	131.9 ± 5.7 [a]	129.5 ± 4.9 [a]	120.1 ± 3.8 [b]	*
CY (%)	72.5 ± 1.4	73.0 ± 1.2	72.8 ± 1.6	73.2 ± 1.5	72.4 ± 1.3	NS

[a-c] Means within a row with different letter are significantly different.
*P<0.05, **P<0.01, NS: not significant
Dose 1; 0.1 Zn-L-SeMet mg/kg of diet, dose 2; 0.2 Zn-L-SeMet mg/kg of diet, dose 3; 0.3 Zn-L-SeMet mg/kg of diet and dose 4; 0.4 Zn-L-SeMet mg/kg of diet
SW: Slaughter weight
CW: Carcass weight
CY: Carcass yield

Selenium concentration of breast meat was shown on Figure 1. The highest Se concentration of breast meat was observed with a value of 0.32 % in the birds fed with dose 4 diet. On the other hand, the lowest Se concentration of breast meat was found with a value of 0.20% in the control group (P<0.01). This findings are supported by other studies indicated that when birds received Se supplementation to the basal diets, the Se retention of breast muscle showed an increment compared to the control group. Habibian *et al.* (2016) indicated that when broiler feeds supplemented with different levels of Se, the selenium concentration of breast meat showed an increment (0.176, 0.341 and 0.546 µg/g wet tissue when broiler feeds supplemented with 0, 125 and 250 mg/kg Se, respevtively. In another study performed by Sevcikova *et al.* (2006), it was found that the selenium concentration breast meat of broilers increased from 0.521 mg/kg to 2.174 mg/kg when broilers received 0.3 mg/kg Se supplementation, compared to broilers fed with basal diet. Similar increment of breast Se concentration was also reported by Choct *et al.* (2004) and Payne and Southern (2005).

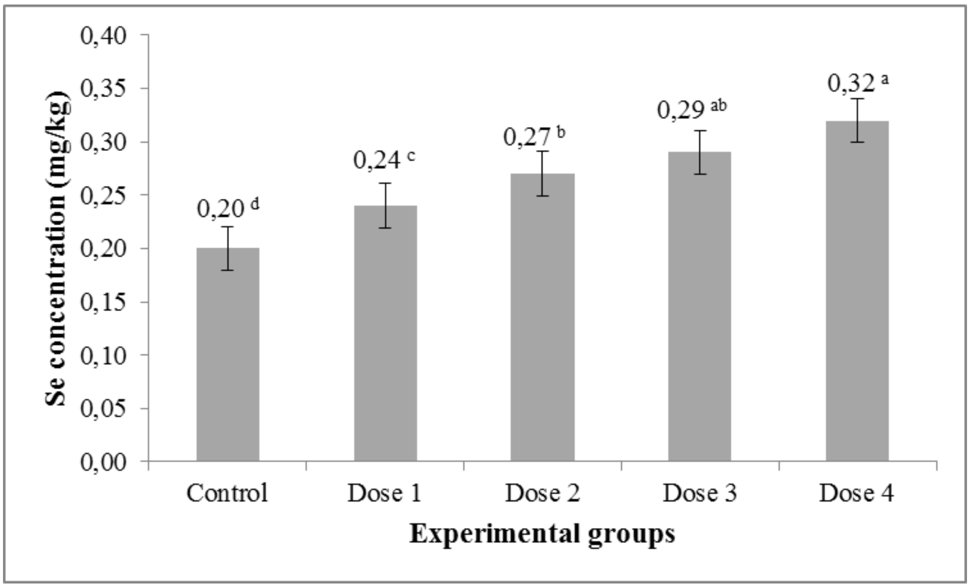

Figure 1. Se concentration of breast meat in Japanese quails. Dose 1; 0.1 Zn-L-SeMet mg/kg of diet, dose 2; 0.2 Zn-L-SeMet mg/kg of diet, dose 3; 0.3 Zn-L-SeMet mg/kg of diet and dose 4; 0.4 Zn-L-SeMet mg/kg of diet
Each point represents mean ± SEM [a,b,c,d] indicate significant differences at P < 0.01

CONCLUSIONS

As a conclusion, the present results showed that supplementation of Zn-L-SeMet caused an improvement growth performance, slaughter yield and also Se concentration of breast muscle. But this improvement depends on the Se form and Se supplementation amount to the basal diet. Results showed that the effective dose of Zn-L-SeMet for Japanese quails is 0,2 and 0,3 mg Zn-L-SeMet/kg of basal diet for an optimum growth performance.

ACKNOWLEDGEMENTS

This work was supported by the Research Fund of The University of Uludağ (Project Number: HDP-Z 2013/7).

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