International Journal of Natural and Social Sciences
Print: 2617-6637 < ISSN > Online: 2313-4461

Effects of organic selenium on productive and reproductive traits of Japanese quail vary on the length of dietary exposure

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ARTICLE INFO

Article history

Received: 27 June 2023
Accepted: 28 July 2023

Keywords

Japanese quail, Egg quality, Combined performance Index, Selenium supplementation

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ABSTRACT

An experiment was conducted with Wild Japanese quail (*Coturnix coturnix japonica)* to find out the best dose of the supplementation of dietary selenium (Se) and evaluate its effects on reproductive performance and egg quality traits. Initially, a 2-week trial of dietary Se supplementation with 0, 0.02, 0.2, 2 and 20 mg/kg feed was performed on 48 quail (36 laying females and 12 adult males). There were 3 males and 6 females under a dietary treatment group those had been housed in a pen of 1 male 2 females as a replication. Under standard management and feeding regime, 2mg/kg feed supplementation of Se was found to be the best dose of highest combined performance index (CPI). Upon selecting the best dose, the supplementation was continued to the similar birds for further 5-week period. During the extended period, an increased rate of egg production along with higher egg weight and shell weight was observed in the Se supplemented group compared to the control. A decrease in fertility rate and some other egg quality parameters were noticed at the terminal week of supplementation. However, Se supplementation during further 5-week period had no effect on yolk weight. Current findings suggested that none of the doses of the Se supplementation to laying quail for short-period excel a single trait but achieve the higher CPI, but longer period supplementation can negatively impact the reproductive trait. Therefore, the duration of a single dose of Se supplementation in laying Japanese quail needs consideration on purposes.

INTRODUCTION

Selenium (Se) is one of the vital trace elements required for the normal functioning of the body, and thought to play a significant role in the maintenance of optimal health. The symptoms of Se deficiency in poultry have been related to its role in antioxidant protection through the enzyme glutathione peroxidase (GPx). It is an important constituent of GPx involved in cellular antioxidant defence (Madkour et al., 2015). Se is linked with body weight, egg production, fertility, hatchability and immune response in poultry birds (Yoon et al., 2007; Attia et al., 2010; Waseem et al., 2016). Se sources supplemented to animal feed can be categorized into 2 forms: inorganic sodium Se (SS) and organic Se, such as selenium yeast (SY) and selenocysteine (Wang et al., 2011). Compared with SS, organic Se has greater bioavailability, such as in the aspects of Se retention ability, antioxidant defense system, and immune system, and is less toxic and more environmentally friendly (Mahan et al., 1999; Wu et al., 2011). Organic Se supplementation in commercial poultry feeds has positive impact described by (El Sheikh and Ahmed-Nagwa 2006; Baylan et al., 2010). Surai et al. (2006) observed that Se concentrations in egg yolk and albumen of quail fed SY were significantly increased in comparison with those fed SS. According to NRC (1994), selenium requirement for laying hens ranges from 0.05 to 0.08 ppm, though, AAFCO (2003) recommended 0.3 ppm maximum allowable level. However, Payne et al. (2005) used Se from sodium selenite or Se-enriched yeast up to 3.0 mg/kg in the diets. They found no negative effect of high level of Se on egg production. Recently, nutritionists realize that both the level and the source of trace elements play an important function in ration formulations and optimizing production level, product quality, health status of birds and economic returns. Supplementing feed with Se has been found to

How to cite this article: Shebli FR, Sultana F and Rahman MS (2023). Effects of organic selenium on productive and reproductive traits of Japanese quail vary on the length of dietary exposure. International Journal of Natural and Social Sciences, 10(1): 27-37. DOI: 10.5281/zenodo.10029072

enhance birds' immune systems' ability to fight off disease (Ibrahim et al., 2019; Shojadoost et al., 2019).

Additionally, there are data indicating that inadequate selenium consumption is associated with poor health, genetic defects, decreased fertility and defense against various viral and bacterial diseases (Surai, 2006). Some major ingredients of poultry feed in Bangladesh are produced locally. But, there are reports that Bangladeshi soils are deficient of Se at might results in lower carry over to these feed ingredients (Oldfield, 2002). In order to improve the overall health performance of quail dietary Se supplementation with commercially available poultry feed is urgently needed in Bangladesh condition.

Considering the health hazard, the feed manufacturer and poultry rearer's have been actively looking for an efficacious alternative. Though, farmers are using the Sel-plex or other organic form of Se in poultry diets, particularly in diet on imagination which misleads them to use over doses, resulting poor performance of the birds and financial loss. In view of the above facts, this research was undertaken to investigate the effects of dietary organic Se supplementation on body weight maintenance, feed intake, egg production performances, egg quality parameters and fertility rate in quail and to identify the best possible level and duration of feeding the organic Se to maximize the performance of quail.

MATERIALS AND METHODS

Experimental birds, chemicals and feeds

The experiment was conducted at Bangladesh Agricultural University, Mymensingh Poultry Farm using 3-month old 48 Wild type Japanese quail (WJQ) of which 36 were female and 12 were male which had been housed in 12 separate iron cages (1ft X 1 ft X 1ft) keeping 3 birds in each. The commercial Sel-Plex® (Donation from Avon Animal Health, Dhaka, Bangladesh) was used as the source of Se which is an organic source of Se that contained 2 g Se in 1 kg powder. Four doses; 0.0 (Control), 0.02, 0.2, 2.0 and 20.0 mg/kg of Se were used as the dietary treatments. The Se powder was mixed with standard layer quail feed having 2700 Kcal/kg ME and 19 % CP. The quails under all the experimental groups were feed on mash type iso-energetic and iso-nitrogenous feed *ad libitum* (Table 1). Safe and cool drinking water was provided to the birds at all the times.

Table 1: Proximate composition of the basal feed supplied to the experimental quail

Component	Level
Moisture (%)	13
Metabolizable energy (Kcal/kg)	2700
Crude protein (%)	19
Crude fiber (%)	8
Crude lipid (%)	5
Ash (%)	20

Performance parameters and their recording and calculations

Body weight gain or loss (BWG/BWL), feed conversion ratio (FCR), egg quality parameters and fertility rate were monitored as the target parameter. During first 2 weeks, the birds were weighed every day before morning feeding as per replication. Then, during last 5 weeks the weights were taken weekly. The amount of feed consumed by the experimental birds was calculated daily during first 2 weeks and weekly later on. Similar amount of feed was given to all the treated groups at the beginning and the residue was recorded at the end of the day/week, then the actual amount of intake was calculated by subtracting the residue from the given amount. The number of eggs laid daily in a replication were recorded and marked by marker pen after collection from the pen. After that, eggs were kept in box and weighed by an electric egg weighing balance. In every week, three eggs were selected randomly to measure the yolk weight, albumen weight and shell weight. The eggs of last 5 weeks of the experiment were subjected to fertility check after 3 days storage and 7 days incubation at 38.5°C. After 7 days incubation, the eggs are broken to see the presence of blood spot and embryonic development as evidence of fertility. To identify the best dose of Se, the combined performance index method as described by Rahman et al. (2016) was used. The combined performance index (CPI) was calculated using the following formula, $Y=A1X1 + A2X2 +$

A3X3 +A4X4; where X1, X2 and X3 were % loss/gain of the body weight, % hen-housed egg production, egg mass traits and feed intake and A1, A2, A3 and A4 were the weight of those traits respectively. The data were analyzed using one way ANOVA under the principles of CRD design of experiment. The significant difference was considered at p<0.05.

RESULTS

The trend of the responses of different parameters to Se supplementation over time (Figure 1, 2, 3 and 4) was varied by doses. The control group lost the body weight (BW) throughout the experimental period, while the 2 mg Se attributed maximum gain and the trend of gaining BW was dose-dependent (Figure 2). The 2mg Se helped to maintain higher Hen-housed egg production consistently over the experimental period (Figure 3) compared to other doses of Se. The 2mg Se also uninterruptedly produced the highest egg mass throughout the period along with consuming minimum feed, particularly during the last 6 days (Figure 1 and 4).

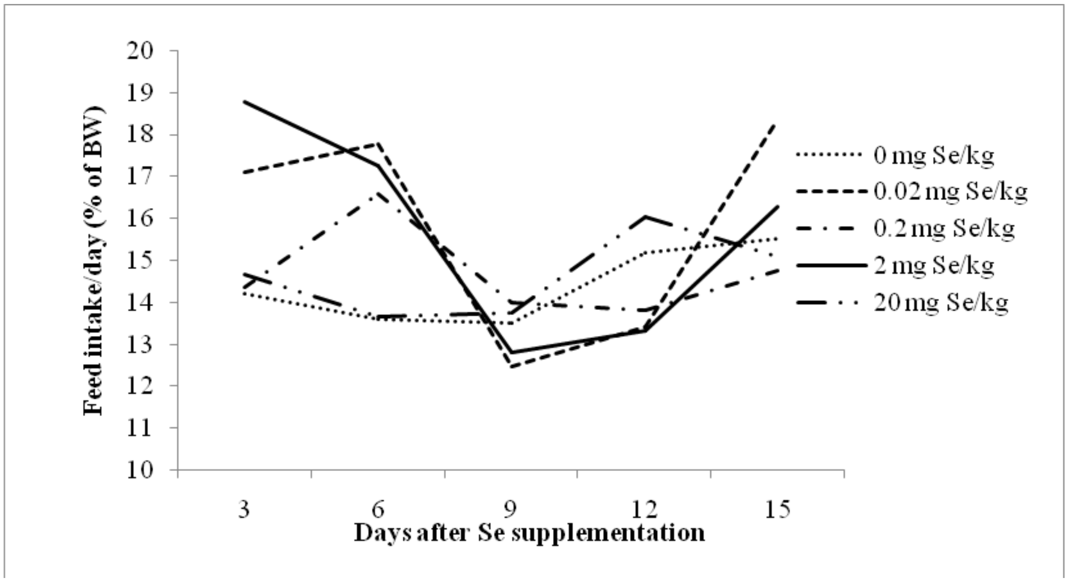

Figure 1: Daily feed intake (% of BW) of WJQ on different doses of dietary Se supplementation

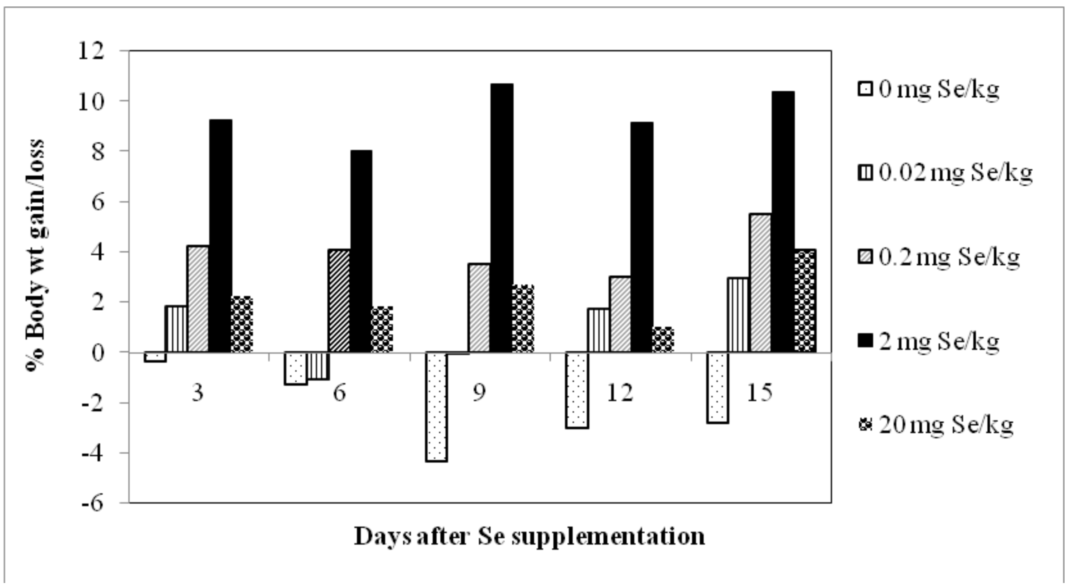

Figure 2: Body weight maintenance of the WJQ on different doses of Se supplementation in feed.

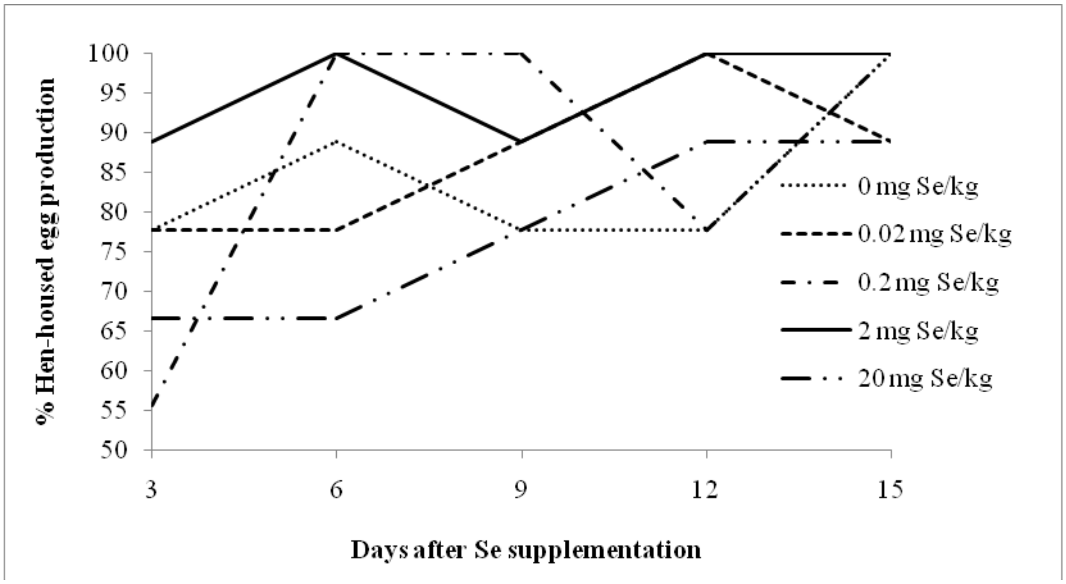

Figure 3: Hen-housed egg production of WJQ on different doses of dietary Se supplementation.

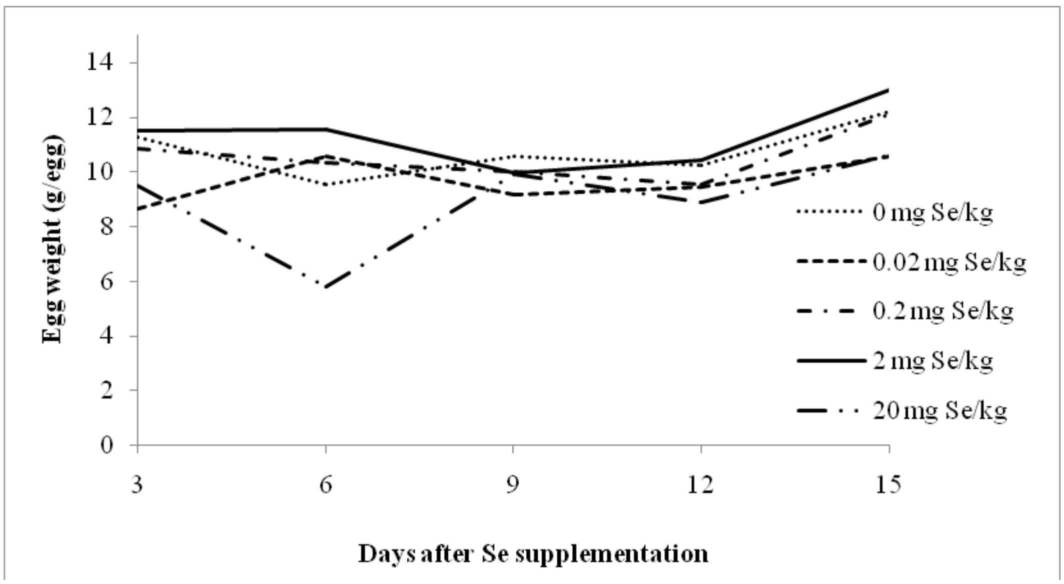

Figure 4: Egg mass production of WJQ on different doses of dietary Se supplementation

Combined performance indexes under different doses of selenium

The results depicted in Figures 1 to 4 indicate that no single dose excels in all the measured traits. But there was a noticeable trend where supplementing with selenium up to 2 mg/kg in the feed yielded better results across all parameters compared to both the control group and the 20 mg dose. When considering the combined performance index, it became evident that the 2 mg Se supplementation outperformed all other doses, with the control group exhibiting the poorest performance. The combined performance index values are presented in (Table 2).

Table 2: Average values of 14 days performance parameters of the Wild type laying Japanese quail fed diet supplemented with different doses of Se

Doses of Se (mg/kg feed)	Performance traits				
	BW gain or loss (%)	Hen-housed Egg Production (%)	Egg Mass (g/egg)	Feed Intake (% of Body Weight)	Combined Performance Index
0 (Control)	-5	84	11	14	49
0.02	5	87	10	16	53
0.2	10	87	11	15	57
2	17	96	11	17	66
20	7	78	10	15	50

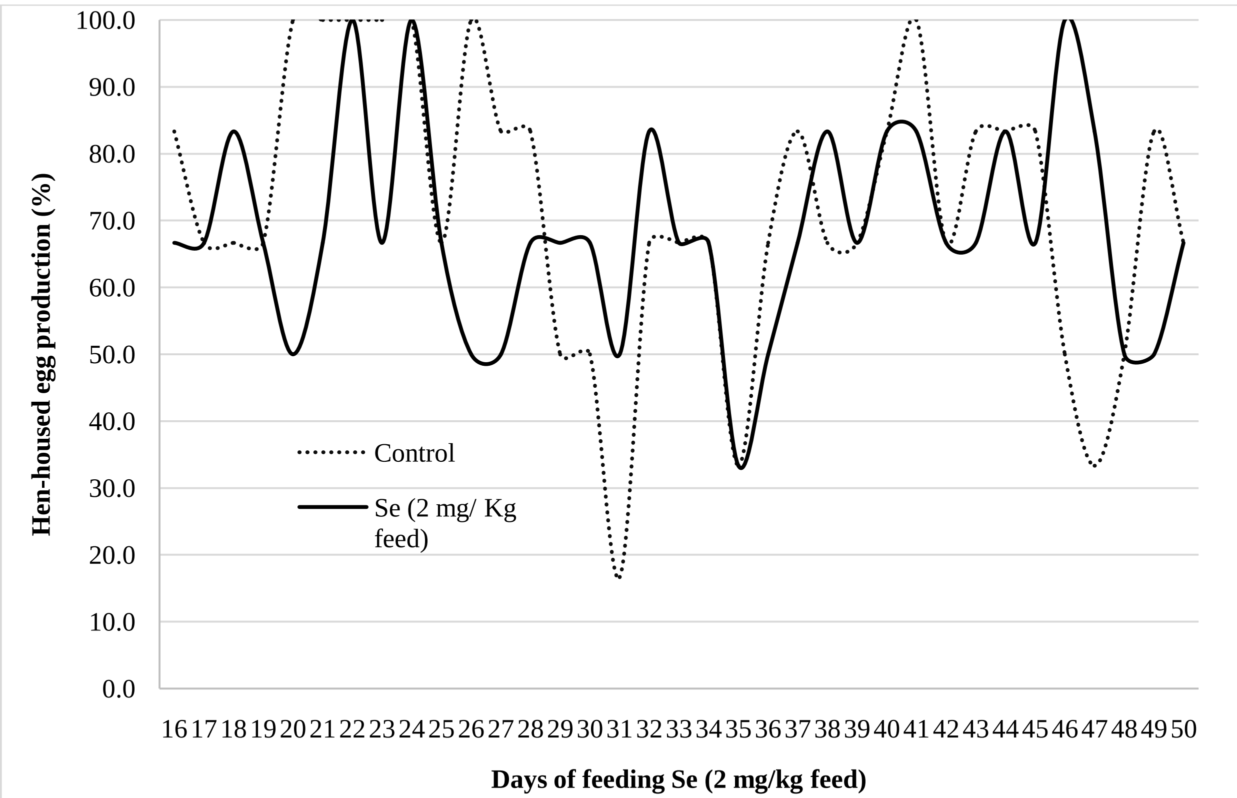

Figure 5: Trend of egg production in Wild Japanese quail over different period of Se supplementation

Performance of the birds during the extended period of dietary Se supplementation

The egg production percentage was not significantly impacted by longer-term selenium supplementation. But, results indicated that there was a declining trend of egg production rate at control group from 3rd to 5th week period, while in the Se supplemented group that was almost unchanged (Figure 5).

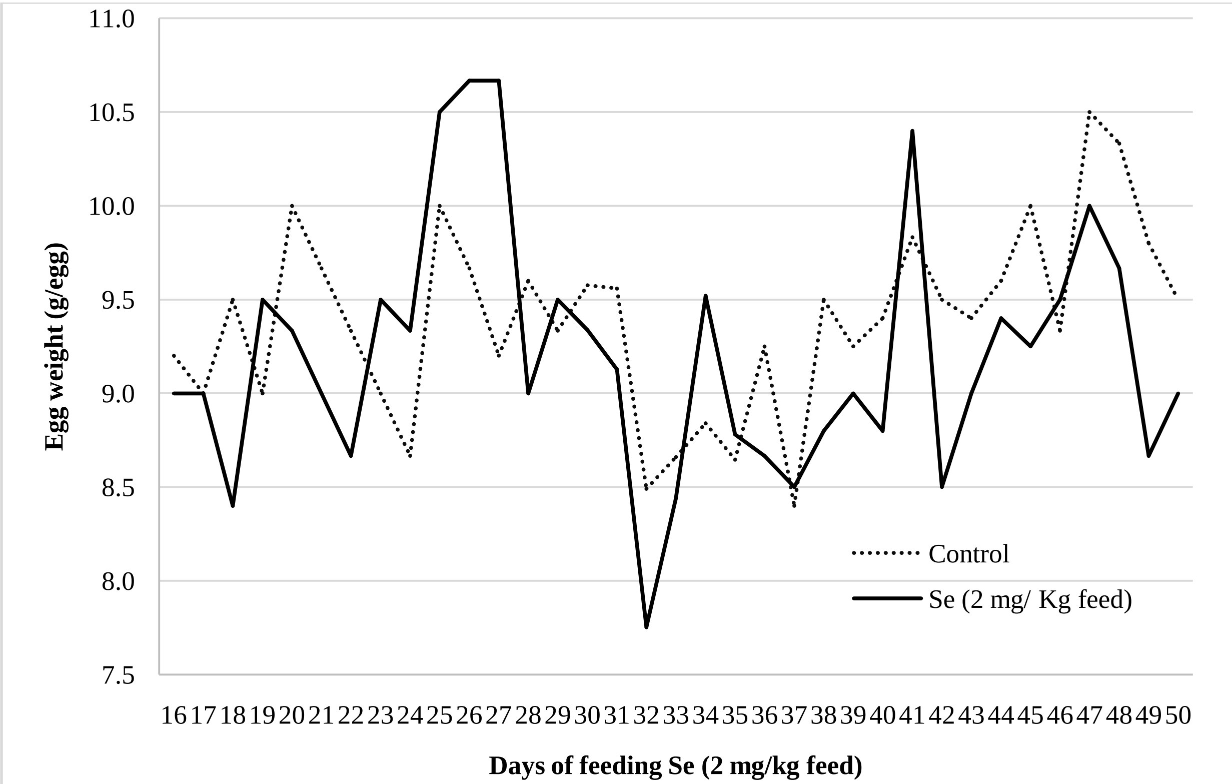

Figure 6: Trend of egg weights in Wild Japanese quail over different period of Se supplementation

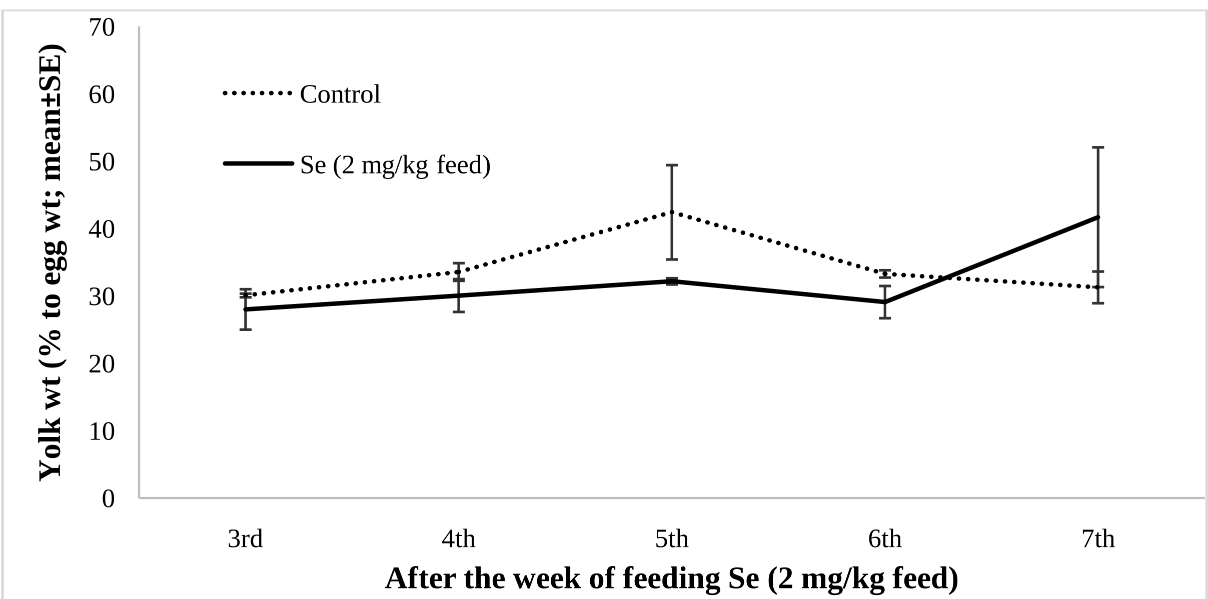

Figure 7: Trend of yolk weights in Wild Japanese quail over different period of Se supplementation

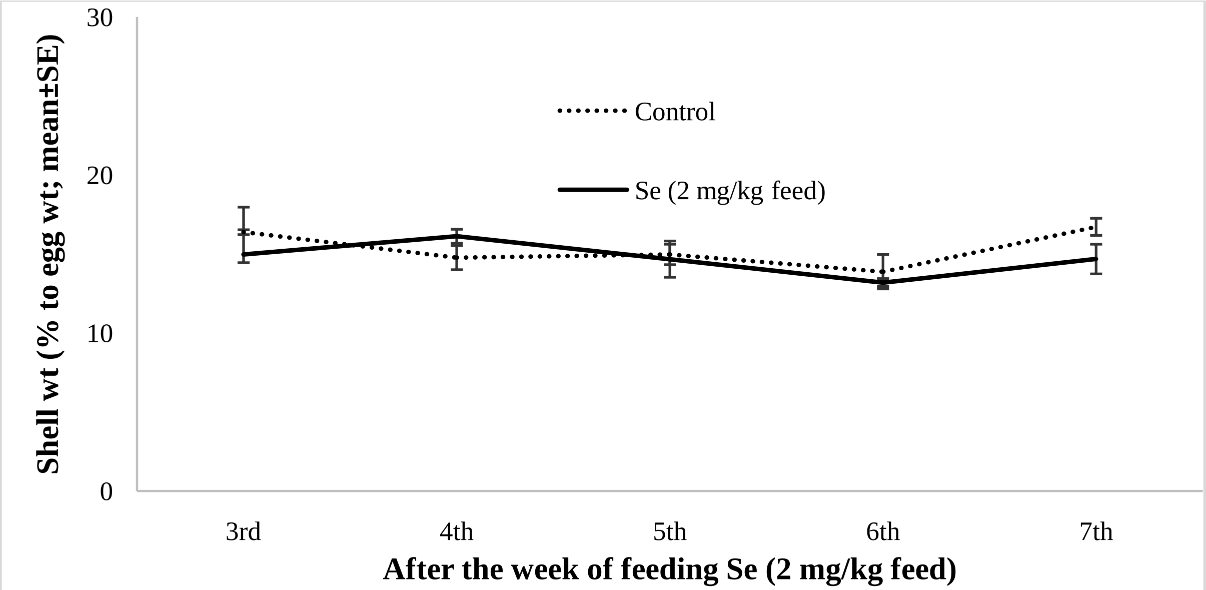

Figure 8: Trend of shell weights in Wild Japanese quail over different period of Se supplementation. *, $p<0.05$

The results of the effects of supplementing Se on egg weight have been cataloged in Table 4 and Figure 6. Results demonstrated a trend of lower egg weight in the Se fed group was than the control from 3rd to 7th week feeding (Figure 6).

Results of the yolk weight at 3rd and 7th week of feeding revealed that supplementation of Se have no significant effect on yolk weight (Figure 7).

The results of the effects of supplementing Se in regular quail diet have shown in figure 8. Results indicated that Se supplementation showed a tendency of lowering the shell weight after the 4th week and at 7th week of feeding it was significantly lower than that of the control.

The fertility rate (Table 5) was found to be unaffected by selenium administration until 3rd week, but by the 7thweek, the addition of selenium drastically reduced the fertility rate ($p<0.05$).

Table 3: Egg production (%; mean ± SD) of Wild Japanese quail at 3rd and 7th week of feeding diet supplemented with/ without selenium (Se)

Treatments	3rd week	7th week	Significance
Control	83.3 ± 16.7	64.3± 20.2	NS
Se	71.4 ± 15.8	71.4± 18.5	NS

SD, Standard deviation. NS, $p>0.05$ when compared in the same row.

Table 4: Egg weight g/egg; mean ± SD) of Wild Japanese quail at 3rd and 7th week of feeding diet supplemented with/ without selenium (Se)

Treatments	3rd week	7th week	Significance
Control	9.39± 0.37	9.86 ± 0.44	NS
Se	8.99 ± 0.36	8.37± 0.43	NS

SD, Standard deviation. NS, $p>0.05$ when compared in the same row.

Table 5: Fertility rate (%) on the basis of total number of eggs set (Fertile egg/Total egg set)$^{\$}$ of Wild Japanese quail

Treatments	3rd week	4th week	5th week	6th week	7th week
Control	82.35 (14/17)	82.35 (25/26)	82.35 (8/12)	72.0 (18/25)	77.78 (14/18)
Se	87.50 (14/16)	87.50 (25/29)	87.50 (7/17)	50.0 (11/22)	52.63 (10/19)
Significance	NS	NS	NS	**	**

**, p<0.01 and NS, p>0.05 when compared with the values of the control presented in similar column; $^{\$}$ the ratios shown within the bracket after each values indicate the number of fertile eggs out of total eggs set.

DISCUSSION

Dose responses of Se supplementation

Dose-dependent increase of the CPI up to 2 mg/kg feed Se supplementation revealed two reasons; i) basal diet was deficient in Se level compared to optimum requirement, or, alternatively, ii) the birds were suffering from stress that demanded extra anti-stressors to maintain optimum performances. The first hypothesis might be supported by the poor performance of control group. However, the beneficial effect of Se supplementation in array of living organisms including all poultry species is well documented (Messarah et al., 2012), which was strongly in agreement with the results of current study. But, the poor performance of the experimental quail on 20mg Se supplementation indicated that the maximum supplementation level should be limited to or less than the 20mg/kg feed.

Role of Se on body weight, feed intake, egg production and egg weight

Se, which is considered as an essential dietary micro-mineral for poultry, is reported to have negative or positive impacts on production performance. A study on dual purpose breeding hens (Attia et al., 2010) as well as on quail breeders (Cruz and Fernandez, 2011) revealed an increase in feed intake due to addition of the Se-Y in feed. The results of the present study contradicted with researchers who reported no significant influences of organic Se on feed intake (Payne et al., 2005; Hanafy et al., 2009). Similarly, it has been observed that the feed intake remained same in the broiler chickens (Spears et al., 2003; Niu et al., 2009) or laying hens (Pavlovic et al., 2009) where Se could not establish its effect on average daily feed intake (Invernizzi et al., 2013). On the contrary, most of the researchers have different point of view and reported the higher daily feed intake in the birds fed organic Se supplemented diets compared to inorganic and control (Papazyan et al., 2006). Chinrasri et al. (2009) detected that different selenium sources had no effect on feed intake; however, feed intake was increased in hens fed diets supplemented with selenomethionine compared with the basal diet. Naylor et al. (2004) also noted that adding Se to the diet reduces feed intake and feed conversion ratio.

Dietary supplementation with the different levels of Vitamin E and Se significantly improved body weight, better feed efficiency and livability in Japanese quail compared to unsupplemented group observed by Chitra et al. (2012). For body weight gain, the findings of this study are corresponding to the results of (Vara Prasad Reddy et al., 2007; Yoon et al., 2007) who reported that there was no significant (p>0.05) effect of Se on final body weight in layers as well as in broilers. Biswas et al. (2006) also observed that body weight gain, feed intake was not affected by Se supplementation in Japanese quail. In the present study, comparatively lower egg production observed in the Se supplemented group in contrast to control. Adebiyi et al. (2014) found that vitamin E and Se supplementation in the diet of laying eggs resulted in significant differences among the groups with regard to egg production. However, many studies failed to find a significant impact of dietary Se supplementation on daily egg production and egg weight (Chantiratikul et al., 2008; Mohiti-Asli et al., 2010). Zdunczyk et al. (2013) observed that using different levels of Se and vitamin E in dietary laying hens had no significant impact on the total egg weight and daily egg production.

Role of Se on egg quality traits and fertility rate

The 7-week dietary Se supplementation reduced the weight of the egg relative to the control. The findings of the current study for egg weight and egg production mismatch with the results of Sara et al. (2008) who indicated that the use of organic Se improved egg production and egg weight. Gjorgovska et al. (2012) demonstrated that the dietary supplementation of organic Se in laying hens had a significant effect on egg weight. Moreover, like the findings of current study, Malek Mohammadi et al. (2009) did not find any significant impact on egg yolk weight.

Eggshell quality is an important factor in the table-egg industry. Cracked eggs give significant economic losses and allow microbiological contamination of the inside of the eggs. The supplementation of the combination of organic Mn, Zn and Se to Isa Brown layer diets tended to promote higher eggshell weight (Rutz et al., 2008). According to these authors, the dietary supplementation of layer diets with organic trace minerals improves eggshell quality, provided organic Mn and Zn are added in combination. Our results were in agreement with the reports of Pavlovi et al. (2010) that revealed neither the source nor the level of Se affected eggshell quality although, Renema (2004), found Se supplementation, particularly Se-Yeast, resulted in the greatest positive changes in egg shell quality.

In the current research, the reduced fertility rate at 6^{th} and 7^{th} week on dietary Se supplementation group indicated that the supplementing agents impacted the male fertility. These results are mis-match with the findings of Madkour et al. (2015) who reported that diet containing (Se 1mg/kg) significantly increased egg fertility. In addition, these data are also harmony with the observation of Osman *et al.* (2010) who illustrated supplementation of laying hen diets with organic selenium increased fertility and hatchability %. However, the findings of the present research work was not in agreement with those of others might be due to differences in doses, duration of feeding, environmental factors and genetical differences of the experimental quail.

From the current findings, it is clear that the locally made compound layer feed is needed to be supplemented with Se to use in breeder ration for ensuring higher egg production for a shorter period. Under standard management procedure and feeding, the 2mg/kg feed was found to be the best dose of supplementation to achieve the highest combined performance index. Se supplementation in spite of unchanged feed intake and body weight indicated that the Se effect was mostly oriented to the axis of reproduction than the growth and body maintenance of quails. Extended period of Se supplementation with a constant dose have negative impact on fertility and egg shell weight. Therefore, a prolonged duration of Se supplementation with a constant dose may not be advised.

Conflict of interest: There is no conflict of interest among the authors.

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