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An improvement in productive and reproductive performance of aged broiler breeder hens by dietary supplementation of organic selenium

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ABSTRACT

This study was conducted to determine the optimum level of home-made selenium-enriched yeast (SeY) in the diet of broiler breeder hens and to compare the effects of this product with sodium selenite (SS) or Selemax (SM) on their productive and reproductive performance. A total of 150 broiler breeder hens were divided to six groups and hens in each group were received a basal diet containing no selenium (CG), 0.15, 0.30, 0.45 mg SeY/kg diet (SeY-0.15, SeY-0.30 and SeY-0.45, respectively), 0.30 mg SM/kg diet or 0.30 mg SS/kg diet for 15 successive weeks. The results showed that egg weight and production and hatchability rate were higher in SeY-0.45 compared to other groups ($P < 0.05$). Also, SeY-0.45 group led to lower embryonic mortality rate compared to CG and SS groups. Fertility rate and chick quality parameters were not affected by selenium supplementation during this period ($P > 0.05$). In conclusion, the dietary supplementation of home-made selenium, as an organic selenium source, can be used to improve the productive and reproductive performance in aged broiler breeder hens at 0.45 mg/kg feed.

1. Introduction

To extend reproductive lifespan and to reduce metabolic disorders of the birds, broiler breeder flocks are received a restricted diet during their rearing and production periods [1,2]. On the other hand, the embryonic development and pos-thatch growth of offspring can be affected by maternal nutrition in avian species because all the necessary nutrients required for developing offspring are pre-deposited inside the egg by the hen during egg formation [3,4]. Therefore, the diet of broiler breeder hens should have adequate nutrients in both quality and quantity to maintain optimal reproductive performance and to improve offspring performance.

Researchers have demonstrated that different stress conditions in poultry production, such as low nutritional quality diets, presence of different toxic compounds in the feed, environmental temperature extremes and health challenges, are associated with overproduction of free radicals and cause oxidative stress [5–7]. According to Surai findings [8], the most important reason for high level production of free radicals is the nutritional stress conditions including deficiencies of some trace minerals such as selenium (Se), zinc or manganese. The detrimental effects of oxidative stress in broiler breeder hens and their offspring range from reduced egg production and growth to decreased egg quality and the viability of hatchlings [4,9]. Therefore, it is necessary to prevent the detrimental effects of oxidative stress in poultry.

It has been shown that Se is an essential element for poultry nutrition and the growing of documents in recent years indicating that Se plays an important role in the productive and reproductive performance of both sex of birds [10]. Indeed, Se is an important component of some enzymes and has anti-oxidative, anti-inflammatory, and antiviral properties because of its presence within at least 25 selenoproteins [4].

From a nutritional point of view, Se can be up taken up in organic and inorganic forms [11]. The research findings clearly indicated that there are higher bioavailability and tissue retention rate in organic compared to inorganic form [12]. It has been shown that supplementing organic Se (Sel-Plex) into Hubbard Ultra-Yield broiler breeders' diet, at 0.30 ppm, for 33 weeks of production

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was associated with improvement of fertility (0.4–4.5%) and hatchability (1–6%) [13]. It has been found that the replacement of sodium selenite by Sel-Plex (0.3 vs. 0.3 ppm) in broiler breeder diets, is associated with an increase in egg production at 49–58 weeks and in chicks per hen housed [14]. Supplementation of Se-enriched yeast to diet of laying hens resulted in higher egg production and Se content compared to sodium selenite [15]. It has been reported that embryonic and early postnatal development and egg shell quality improved by organic Se via increasing antioxidant defense system [16].

Therefore, the aims of present study were to determine the optimum level of home-made SeY in the diet of broiler breeder hens and to compare the effects of this product with SS or Selemax on the egg weight and production, fertility, hatchability, embryonic mortality and their hatched chick quality.

2. Materials and methods

2.1. Chemical

All chemicals in the current study were purchased from Merck (Darmstadt, Germany).

2.2. Animal welfare

This study was approved by Animal Care Committee and Animal Research Ethics Board from Department of Animal Science, University of Tehran, Iran.

2.3. Production of SeY

The strain PTCC 5209 of Saccharomyces cerevisiae used in the current study was obtained from the collection of the Industrial Microorganisms Laboratory of the Iranian Research Organization for Science and Technology (IROST). The yeast culture medium had different ingredients including KH_2PO_4 (5 g/L); Na_2HPO_4 (3.5 g/L); $MgSo_4.7H_2o$ (0.5 g/L); yeast extract (6 g/L); NH_4No_3 (3 g/L); glucose (10 g/L) and pH of the medium was adjusted to 5.8. The fermentation process was performed with basal medium (200 mL). Culture process was performed in a shaker (150 strokes/min at 28 °C for 48 h) at inclusion rate of 35 g/L. Inorganic Se in the form of sodium hydrogen selenite was added to the sterile medium after 10 h of the starting yeast culture process as a solution of $NaHSeO_3$, at a concentration of 30 mg/L. At the end of culture process, suspension was centrifuged (3000×g for 15 min at 25 °C). The supernatant was discarded and the solid phase was washed with deionized water three times in order to remove residues of the medium and surface-bound Se. Then, the cells were dried and used to measure the total selenium content [17]. The total selenium content was determined by using an optical emission spectrometer with induced coupled plasma, ICP-OES Perkin Elmer, Optima 7300 DV.

2.4. Birds and diet

A total of 150 Ross 308 broiler breeder hens were used for 15 successive weeks (from 49 to 64 week of age) at the experimental farm of department of animal science [University of Tehran, Karaj, Iran (37°47′ N, 50°55′ E)]. The birds were submitted to a photoperiod of 16 h light per day at 40 lux light intensity. All hens were received a basal diet without Se (Table 1) during a 3-week acclimation period before starting experiment. During this period, egg production and body weight (BW) were controlled in each pen and then, hens were substituted between the different groups such that each pen had a similar BW and egg production distribution. The birds were free accessed to water and were received approximately 155 g of feed/day throughout the experiment at 0830 h (2800 kcal of AMEn/kg and 14% CP).

Table 1
Ingredient and chemical composition of basal diet fed by Ros 308 broiler breeder hen.

Feed ingredient	Value (%)
Corn	71.6
Soybean meal, 42.6% CP	19
Dicalcium phosphate	1.4
Calcium carbonate (CaC03)	7
Sodium chloride	0.35
DL-Met, 99%	0.15
Vitamin premix[a]	0.25
Se-free Mineral premixes[b]	0.25
Total	100
Calculated nutrient content	
AME (kcal/kg)	2800
CP (%)	14
Available phosphorus (%)	0.35
Sodium (%)	0.16
Calcium (%)	3
Digestible Lys[c] (%)	0.72
Digestible Met[c] (%)	0.38
Digestible Met + Cys[c] (%)	0.64
Digestible Thr[c] (%)	0.55

[a] Provides (per kg of diet): vitamin A (retinyl acetate), 11 000 IU; cholecalciferol, 3500 IU; vitamin E (DL-a-tocopheryl acetate), 150 IU; vitamin K, 5 mg; thiamin, 3 mg; riboflavin, 12 mg; D-pantothenic acid, 15 mg; niacin, 55 mg; pyridoxine, 4 mg; biotin, 0.25 mg; folic acid, 2 mg; vitamin B12, 0.03 mg.
[b] Provides (per kg of diet): copper ($CuSO_4 \cdot 5H_2O$), 10 mg; iodine (KI), 2 mg; iron ($FeSO_4 \cdot 7H_2O$), 50 mg; manganese ($MnSO_4 \cdot H_2O$), 120 mg; Zn (ZnO), 110 mg. No selenium was provided by the mineral.
[c] Values are standardized ileal digestible [AMINODAT 4.0 (Evonik Industries, 2010)].

2.5. Experimental design

2.5.1. Treatment groups

The birds were allotted to the six groups with five replicates of five hens each. The birds of each groups were received one of the following treatment: 1) basal diet with no Se supplement (control group, CG), 2) basal diet with 0.15 mg SeY/kg diet (SeY-0.15), 3) basal diet with 0.3 mg SeY/kg diet (SeY-0.3), 4) basal diet with 0.45 mg SeY/kg diet (SeY-0.45), 5) basal diet with 0.3 mg Selemax/kg diet (SM), and 6) basal diet with 0.3 mg sodium selenite (SS) as inorganic Se source/kg diet. Sodium selenite, SM and SeY used in this study contained 10000, 2000 and 2500 ppm or mg Se per kg of product, respectively (Table 2). The supplementation levels of Se in the diets were calculated as proportion of each Se source in diet. For example, 150 g of Selemax was added to 1000 kg of diet to provide 0.3 mg Se/kg of diet.

2.5.2. Egg weight and production

The number of produced eggs and their weight were daily recorded from 49 to 62 week of age. The laying rate in each group was calculated as the ratio between total egg production and number of females, and expressed as a percentage.

2.5.3. Artificial insemination

Semen samples were collected from 30 sexually mature Ross 308 broiler breeder males. The roosters were received a common male diet with 2760 kcal of AMEn/kg and 12% CP according to the parent stock management manual for Ross 308 [18]. After collection of semen by abdominal massage, semen concentration was determined by Neubauer hemocytometer. Thereafter, semen samples were pooled and diluted by skim milk to final concentration of

Table 2
The levels of selenium (mg/kg or ppm) in home-made selenium-enriched yeast (SeY), commercial Selemax (SM) and sodium selenite (SS) and supplementation levels in per Kg diet.

Sample	Selenium level in products (mg/kg or ppm)	Supplementation level of selenium products in diet (mg/kg or ppm)
SeY	2500	60 mg SeY/kg to supply 0.15 mg Se/kg 120 mg SeY/kg to supply 0.30 mg Se/kg 180 mg SeY/kg to supply 0.45 mg Se/kg
SM	2000	150 mg SM/kg to supply 0.3 mg Se/kg
SS	10000	30 mg SS/Kg to supply 0.3 mg Se/Kg

The selenium content was determined by using an optical emission spectrometer with induced coupled plasma, ICP-OES Perkin Elmer, Optima 7300 DV.

400×10^6 spermatozoa/mL and then used for artificial insemination of hens. All hens were inseminated once a week with diluted semen (250 μL) at the 63rd and 64th weeks of the experiment. All produced eggs were collected from the second day after first insemination to five days after second insemination (720 settable eggs). Thereafter, all eggs incubated in an automatic incubator at 37.5 °C and 55% RH.

2.5.4. Fertility and hatchability

Fertility (fertile/incubated eggs), hatchability of fertile (hatched/fertile eggs) and total egg (hatched/total incubated eggs) egg were calculated at the end of the incubation period. In order to calculate fertility, the unhatched eggs on day 21 were counted and broken to differentiate infertile eggs from those containing dead embryos (embryonic mortality). All hatchlings were counted and classified as A-grade (of good quality) or culls.

2.6. Statistical analysis

Normal distribution of data were checked by UNIVARIATE procedure and Shapiro–Wilk test of SAS 9.4 (SAS Institute Inc., Cary, North Carolina, USA), and all percentage data were normalized through ArcSin$\sqrt{x}$ transformation when appropriate. The repeated measurements data were analyzed by MIXED procedure. Non parametric data including fertility, hatchability and embryonic mortality rate and chick quality data were analyzed by GENMOD procedure. Results were presented as Lsmean ± SEM and the Tukey test was applied to compare Lsmeans.

3. Results

3.1. Egg weight and production

Egg production was increased in SeY-0.3 and SeY-0.45, SM and SS compared to CG and SeY-0.15 groups ($P < 0.05$) (Table 3). Also, the highest value of egg production was observed in the SeY-0.45 group in comparison with other groups ($P < 0.05$). The results showed that weekly laying rate was not affected by different groups in the first four weeks of experiment ($P > 0.05$), however this parameter was significantly ($P < 0.05$) higher in SeY-0.45 group compared to control group at 53rd, 55th and 58th week of egg production. At 64th week of egg production, SeY-0.45 group led to significantly higher percent of laying rate compared to SeY-0.15 group. Also, weekly egg production was decreased with increasing broiler breeder age ($P < 0.05$). Average egg weight was increased in SeY-0.15, SeY-0.45, SM and SS groups compared to CG group (Table 4; $P < 0.05$). Also, no significant difference was observed in average egg weight between SeY-0.45 and SM or between SeY-0.30 and CG groups. The results showed that SeY-0.45 group was resulted in higher weekly egg weight compared to CG group in some weeks of experiment ($P < 0.05$).

3.2. Fertility and hatchability

The different sources of Se did not significantly influence on fertility (Table 5). On the contrary, hatchability of total eggs was improved in SeY-0.30 and SeY-0.45 compared to CG and SS groups ($P < 0.05$). Also, no significant difference was observed in hatchability of total eggs between SeY-0.15, SeY-0.3, SeY-0.45 and SM

Table 3
The effects of supplementing diet with sodium selenite, Selemax and different levels of produced selenium-enriched yeast on the weekly and average laying rate (%) of broiler breeder hen (Lsmean ± SEM).

Breeder age (week)	Treatment Groups						SEM
	CG	SeY0.15	SeY0.30	SeY0.45	SM	SS	
49	61.37	62.50	64.11	64.68	64.03	65.89	1.33
50	61.15	60.38	61.16	65.35	64.24	64.95	1.33
51	57.82	59.82	62.55	65.34	63.46	62.17	1.33
52	59.61	59.08	63.66	66.23	63.88	60.70	1.33
53	57.45^{b}	58.51^{b}	63.02^{ab}	69.24^{a}	62.36^{ab}	61.20^{ab}	1.33
54	58.34^{ab}	57.88^{b}	63.68^{ab}	66.11^{a}	58.57^{ab}	58.66^{ab}	1.33
55	56.20^{b}	56.32^{b}	61.43^{ab}	65.41^{a}	61.37^{ab}	57.50^{ab}	1.33
56	56.20	58.78	59.58	65.62	60.01	57.07	1.33
57	55.43	57.44	58.41	64.57	57.37	56.09	1.33
58	54.78^{b}	54.28^{b}	57.00^{ab}	63.85^{a}	54.72^{b}	55.57^{b}	1.33
59	52.08	53.44	54.92	61.39	56.68	54.11	1.33
60	51.30	50.20	54.63	60.13	54.06	53.57	1.33
61	49.55	51.93	53.65	59.03	52.18	52.43	1.33
62	48.47	49.60	53.58	57.56	49.03	52.72	1.33
Average (49–62 weeks)	55.70^{c}	56.44^{c}	59.38^{b}	63.89^{a}	58.71^{b}	58.04^{b}	0.35

$^{a-c}$ values within a raw with different superscripts differ at $P < 0.05$. CG: the control group which was the basal diet with no supplemental Se; SeY0.15: the basal diet supplemented with 0.15 mg of organic Se/kg in the form of produced SeY; SeY0.30: the basal diet supplemented with 0.30 mg of organic Se/kg in the form of produced SeY; SeY0.45: the basal diet supplemented with 0.45 mg of organic Se/kg in the form of produced SeY; SM: the basal diet supplemented with 0.30 mg of organic Se/kg in the form of Selemax and SS: the basal diet supplemented with 0.30 mg of inorganic Se/kg in the form of SS.

Table 4
The effects of supplementing diet with sodium selenite, Selemax and different levels of produced selenium-enriched yeast on the weekly and average egg weigh (g) of broiler breeder hen (Lsmean ± SEM).

Breeder age (week)	Treatment Groups						SEM
	CG	SeY0.15	SeY0.30	SeY0.45	SM	SS	
49	65.18^{b}	68.52^{a}	66.54^{ab}	69.56^{a}	68.77^{a}	66.93^{ab}	1.13
50	65.79^{b}	67.32^{ab}	66.96^{ab}	69.02^{a}	66.73^{ab}	69.19^{a}	1.13
51	65.30^{b}	66.75^{ab}	66.40^{b}	69.62^{a}	67.86^{ab}	67.84^{ab}	1.13
52	65.66	66.63	66.42	68.59	67.21	66.16	1.13
53	65.26	67.50	66.91	68.08	67.11	67.70	1.13
54	65.70	66.78	67.02	68.83	68.23	65.73	1.13
55	66.41	67.86	66.27	69.08	68.74	68.03	1.13
56	66.29^{c}	67.86^{bc}	67.10^{c}	70.28^{ab}	71.31^{a}	69.35^{abc}	1.13
57	66.19	68.31	66.70	68.70	68.92	67.64	1.13
58	65.86^{b}	67.00^{ab}	65.91^{b}	69.51^{a}	66.57^{ab}	67.57^{ab}	1.13
59	66.92	66.70	66.77	69.14	69.03	67.83	1.13
60	62.95^{b}	66.21^{a}	64.50^{ab}	67.17^{a}	66.21^{a}	64.63^{ab}	1.13
61	64.92^{b}	67.67^{ab}	63.54^{c}	68.72^{a}	68.28^{a}	66.66^{abc}	1.13
62	66.01^{c}	67.44^{abc}	66.87^{abc}	69.19^{ab}	69.69^{a}	66.30^{bc}	1.13
Average (49–62 weeks)	65.60^{c}	67.32^{b}	66.28^{bc}	68.98^{a}	68.19^{ab}	67.25^{b}	0.30

$^{a\text{-}c}$ values within a raw with different superscripts differ at $P < 0.05$. CG: the control group which was the basal diet with no supplemental Se; SeY0.15: the basal diet supplemented with 0.15 mg of organic Se/kg in the form of produced SeY; SeY0.30: the basal diet supplemented with 0.30 mg of organic Se/kg in the form of produced SeY; SeY0.45: the basal diet supplemented with 0.45 mg of organic Se/kg in the form of produced SeY; SM: the basal diet supplemented with 0.30 mg of organic Se/kg in the form of Selemax and SS: the basal diet supplemented with 0.30 mg of inorganic Se/kg in the form of SS.

Table 5
The effects of supplementing basal diet with sodium selenite, Selemax and different levels of produced selenium-enriched yeast on fertility, hatchability of total eggs and hatchability of fertile eggs of broiler breeder hen (63–65 weeks; Lsmean±SEM).

Parameters	Treatment Groups						SEM	P value[a]
	CG	SeY0.15	SeY0.30	SeY0.45	SM	SS		
Fertility[¥] (%)	62.50	64.16	68.33	72.50	65.83	65	0.47	0.62
Hatchability of total egg[€] (%)	45.83^{b}	51.66^{ab}	60^{a}	60.83^{a}	55^{ab}	44.16^{b}	0.49	0.03
Hatchability of fertile egg[≠] (%)	73.33^{b}	75.32^{b}	76.82^{b}	88.50^{a}	77.21^{ab}	75.64^{b}	0.41	0.15

^{a,b} values within a raw with different superscripts differ at $P < 0.05$. CG: the control group which was the basal diet with no supplemental Se; SeY0.15: the basal diet supplemented with 0.15 mg of organic Se/kg in the form of produced SeY; SeY0.30: the basal diet supplemented with 0.30 mg of organic Se/kg in the form of produced SeY; SeY0.45: the basal diet supplemented with 0.45 mg of organic Se/kg in the form of produced SeY; SM: the basal diet supplemented with 0.30 mg of organic Se/kg in the form of Selemax and SS: the basal diet supplemented with 0.30 mg of inorganic Se/kg in the form of SS. All produced eggs were collected from the second day after first insemination to five days after second insemination (720 settable eggs). [¥]fertile/incubated eggs, [€]hatched/total incubated eggs and [≠]hatched/fertile eggs.
[a] Likelihood ratio Statistics for Type 3 Analysis.

groups. The results showed that SeY-0.45 was led to significantly higher hatchability of fertile eggs compared to other groups, except SM group. The embryonic mortality rate was lower ($P < 0.05$) in SeY-0.45 compared to CG and SS groups (Fig. 1). Also, no significant difference was observed in embryonic mortality rate between SeY-0.15, SeY-0.3, SeY-0.45 and SM groups. The results showed that rate

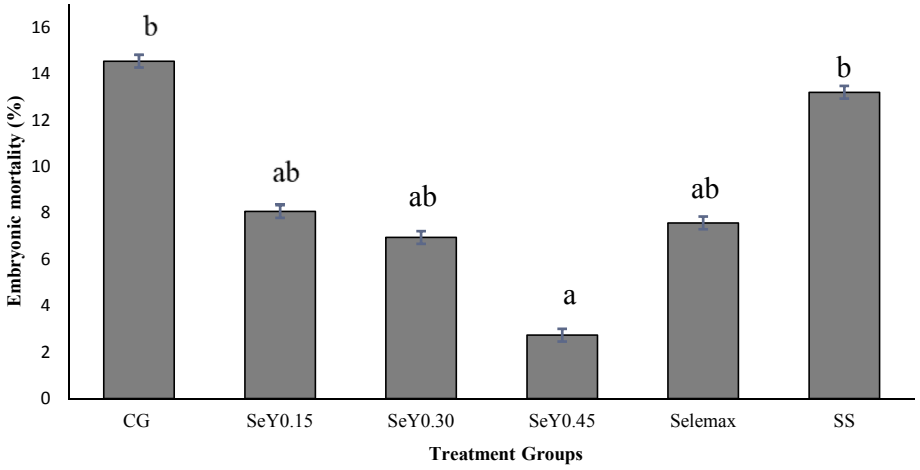

Fig. 1. The effects of supplementing diet with sodium selenite, Selemax and different levels of produced selenium-enriched yeast on the embryonic mortality rate of incubated fertile egg (63 and 64 weeks; Lsmean). Different letters (a, b) represent significant differences among treatment groups ($p < 0.05$). CG: the control group which was the basal diet with no supplemental Se; SeY0.15: the basal diet supplemented with 0.15 mg of organic Se/kg in the form of SeY; SeY0.30: the basal diet supplemented with 0.30 mg of organic Se/kg in the form of SeY; SeY0.45: the basal diet supplemented with 0.45 mg of organic Se/kg in the form of SeY; SM: the basal diet supplemented with 0.30 mg of organic Se/kg in the form of Selemax and SS: the basal diet supplemented with 0.30 mg of inorganic Se/kg in the form of sodium selenite.

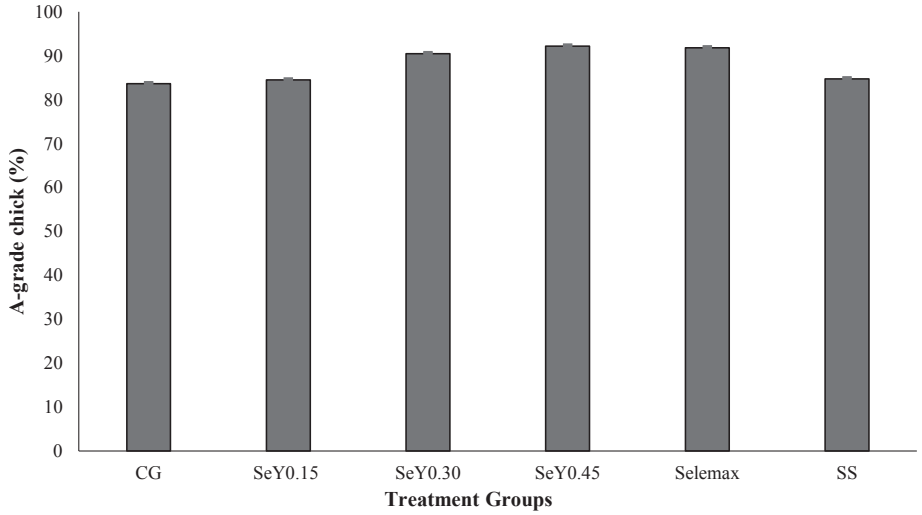

Fig. 2. The effects of supplementing diet with sodium selenite, Selemax and different levels of produced selenium-enriched yeast on the hatched chick quality (63 and 64 weeks; Lsmean). CG: the control group which was the basal diet with no supplemental Se; SeY0.15: the basal diet supplemented with 0.15 mg of organic Se/kg in the form of SeY; SeY0.30: the basal diet supplemented with 0.30 mg of organic Se/kg in the form of SeY; SeY0.45: the basal diet supplemented with 0.45 mg of organic Se/kg in the form of SeY; SM: the basal diet supplemented with 0.30 mg of organic Se/kg in the form of Selemax and SS: the basal diet supplemented with 0.30 mg of inorganic Se/kg in the form of sodium selenite.

of A-grade hatched chicks was not affected by supplementing basal diet with different forms of Se (Fig. 2; $P > 0.05$).

4. Discussion

As the results of the current study showed that SeY-0.45 group resulted in higher egg weight and production, hatchability of fertile and total eggs and lower embryonic mortality rate. Also, there were no significant differences in the most parameters between SeY-0.45 and SM groups. In comparison with SS, SeY-0.45 resulted in an increase in egg weight and production, hatchability of fertile and total eggs and a decrease in embryonic mortality rate.

Genetic and environmental factors, more likely their interaction, affect egg production in female birds. Also, it is clear that the rate of weekly egg production was reduced with increasing bird age after peak production [20]. In the current study, weekly laying rate was decreased with increasing broiler breeder age. After 13 weeks of Se supplementation, laying rate was increased in SeY-0.45 group by 13% compared to CG group. It has been reported that genes associated with energy production and protein synthesis pathways were affected by organic Se supplementation in reproductive tissue of broiler breeder hens [21]. Therefore, it is possible that these changes are responsible for increasing egg production at 49–62 weeks of age. In addition to the hen age, it has been demonstrated that source and level of Se and length of supplementation can affect reproductive performance in poultry [21]. There was no measurable impact on the reproductive performance of hen when the length of Se supplementation was less than 8 weeks [22–24]. However, egg production was improved in broilers [25] and layers [15,26] after more than 12 weeks of Se supplementation. This effect of Se on egg production was also seen in both mid-lay [26] and late-lay birds [25]. Our result agree with the findings of Renema et al. [14] who reported an increase in egg production during late lay period when 24 week old hens were received a basal diet supplemented with 0.30 mg/kg feed SeY. The better egg production was also reported in quail breeders due to the supplementation of SeY compared to SS [27]. On the contrary, other studies on laying [15,23,28], layer breeder [22,29,30] and broiler breeder hens [9,31] reported that neither source nor level of dietary Se had no effect on egg production, which is not agreement with our results. This discrepancy may be due to differences in the bird management procedures, source and level of Se and length of supplementation.

In the current study, egg weight was heavier in the all treated compared to CG group. However, hens in SeY-0.45 group produced eggs with heavier weight. It is believed that organic Se is more bioavailable and retains in greater concentration in body tissues, because of its better absorption and form [9]. The absorbed Se behaves as seleno-amino acids in body tissues [32]. It has been suggested that deposition of selenomethionine relative to inorganic Se is high because it replaces methionine in body protein [33]. With consideration of direct relation between sulfur amino acids and egg weight [34], an increase in weight of the eggs laid by the hens fed the basal diets supplemented with SM and SeY may be due to the higher deposition of seleno-sulfur amino acids in the egg. The influence of Se on the egg weight is contradictory. It has shown that supplementing Se into the diet leads to increase egg weight [23,35,36]. Maysa et al. [37] observed an increase in egg weight when dietary organic selenium increased from 0 to 0.3 mg/kg feed. However, Leeson, et al. [38] reported that supplementing inorganic or organic Se into diet had no effect on egg weight of broiler breeders and layers hens, which is in contrast to the results of our study.

Selenium sources had no influence on fertility in the present study. This results is consistent with the findings of Urso et al. [9] who reported that feeding of Cobb 500 broiler breeders with SS or zinc- L-selenomethionine (0.40 mg/kg) from 22 to 53 weeks of age had no effects on fertility rate. Also, another study showed that supplementing diet with SS or SeY or selenomethionine had no effect on fertility of 48 week of age Lingnan Yellow broiler breeder hens [31]. In contrast, increased fertility was observed in Egyptian layer hens fed diet supplemented Sel-plex (0.2 mg/kg) at 42 week of age [39]. It is quite possible that the genetic variations may be the reason for this discrepancy. It has been shown that genotypes, different strains, and local breeds respond differently to fertility [40]. As confirmed by Peters et al. [41], fertility was prominently affected by strain of the dam.

Lipid fraction of chick embryo tissues contain a high proportion of highly polyunsaturated fatty acids [42]. Therefore, these tissues are sensitive to lipid peroxidation and need antioxidant defense [43]. On the other hand, it is generally accepted that hatching

process is an oxidative stress and increased hatchability can be achieved by improving antioxidant defenses [10]. In the present study, hatchability of total egg was affected by supplementing organic Se and was higher in SeY-0.30 and SeY-0.45 groups. The hatchability of fertile egg was only improved in SeY-0.45. Also, this level of SeY let to lower embryonic mortality compared to CG and SS groups. It was also shown that the heavier weight of the eggs produced by breeders fed diet supplemented SeY may indicate an accumulation of Se in the eggs. It has been reported that the concentration of Se in the egg depends on its dietary level and the form of Se in the diet, and Se accumulated in the egg is transferred to the developing embryo and subsequently delivered to different tissues during embryonic development [31]. Since Se is an important component of antioxidant enzymes, it is possible that improvements in egg hatchability and chick survivability might be due to enhance body antioxidant capacity, and consequently lower oxidative stress on the developing embryo during embryogenesis and in particular hatching [10]. These results agree well with the finding of Yuan et al. [31], Rajashree et al. [44] and Khan et al. [40] who observed an improvement in the hatchability rate using supplementation of diet with organic Se in Ross 308, Lingnan Yellow and Aseel broiler breeder hens, respectively. However, Urso et al. [9] reported that the different sources of Se had no effect on hatchability of fertile or total eggs in Cobb 500 broiler breeders. A possible reason for this discrepancy can be attributed to strain differences. It has been reported that supplementation of organic Se in the diet of Aseel hens reduces embryonic mortality [40], which is in agreement with the results of present study. Our findings are also in agreement with those of other authors [7,31] who observed embryonic mortality can be reduced with supplementing organic Se. In contrast, Attia et al. [45] did not find any effects of Se sources (selenomethionine, SeY and SS) on embryonic mortality. Similar findings have been obtained in breeding hens fed organic Se (Sel-Plex) [46]. In contrast, Stepinska et al. [47] observed more dead embryos in the turkey breeders fed organic selenium (0.30 mg/kg). Despite supplementation of organic Se at a higher level (0.45 mg/kg in the form SeY) in breeding hens, we did not find any embryotoxic effects of organic Se.

In the present study, A-grade hatched chicks, classified by macroscopically evaluation, was not affected by Se supplementation. This result, however, is not consistent with the finding of Pappas et al. [46] and Urso et al. [9] who reported that A-grade chicks can be increased with supplementing organic Se. Our finding is in contrast to findings of Khan et al. [40] who showed that the percentage of A-grade chicks decreased in Aseel hens treated SS (0.30 mg/kg) and concluded that the negative effect of inorganic Se on chick quality may be due to the pro-oxidant and toxic effect of inorganic Se. As explained above, different strains may respond differently to Se supplementation.

In conclusion, optimum level of our home-made SeY was 0.45 mg/kg in aged broiler breeder hens' diet that led to higher egg weight and production, hatchability of fertile and total eggs and lower embryonic mortality. Also, the results of this study showed that egg production decrease with increasing broiler breeder age. In comparison with SM, SeY-0.45 resulted in an increase in egg production, but no significant differences were observed in other parameters. Therefore, the dietary supplementation of home-made SeY, as an organic selenium source, can be used to improve the productive and reproductive performance in aged broiler breeder hens at 0.45 mg/kg diet.

Conflicts of interest

The authors have no conflict of interest to disclose for this study.

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