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EFFECTS OF SUPPLEMENTING LAYING HENS DIETS WITH ORGANIC SELENIUM ON EGG QUALITY DURING STORAGE

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SUMMARY: A total number of 498 (450 laying hens and 48 cocks) birds of Golden Montazah (GM) and Fayoumi (F) strains at 42 wks of age were used to evaluate the effects of two dietary levels of Se as Sel-Plex (0.1 or 0.2 mg/Kg diet) on egg quality during storage. Equal numbers from each strain were divided randomly into 3 equal treatment groups of 83 birds each (75 hens and 8 cocks each). Birds were placed in 6 floor layers pens (three for each strain), the 1st group was fed the basal diet, while the 2nd and 3rd groups were fed the same diet but supplemented with one of the two levels (0.1 or 0.2 mg/Kg diet) of selenium (Se) as Sel-Plex. The experimental period lasted for 23 weeks (from 42 to 65 wks of age).The quality of 200 eggs per treatment was determined at different storage periods (50 at zero day; 50 at seven; 50 at 14 and 50 at 21d).

Results obtained could be summarized in the following:

1. Eggs from GM hens were heavier than those from F hens, with more albumen% but less shell thickness, yolk%, shell%, yolk index% and shape index%.
2. Eggs from laying hens fed diet containing 100 mg Se/ton diet as Sel-Plex had highest yolk color and albumen%. Eggs from laying hens fed diet containing 200 mg Se/ton diet as Sel-Plex had higher shape index%, while, those from layers fed the control diet had higher shell% and lower shape index%.
3. As the period of storage of eggs increased, albumen%, yolk index% and HU decreased, with the greatest increase in the percentage of the yolk. As the hens ages increased, yolk color, shell thickness and yolk% increased significantly, however, the shell%, yolk index% and HU score decreased significantly.
4. Interaction between level of addition of Se as Sel-Plex and period of storage indicated no significant differences in egg quality except, yolk color and yolk index%. Eggs from hens fed diet containing 100 and 200 mg Se/ton diet as Sel-Plex at zero d of storage had higher yolk color and yolk index%, respectively, while, eggs from hens fed diet containing 200 mg Se/ton diet as Sel-Plex at seven d of storage had lower yolk color and yolk index%.
5. The age of hens and period of storage interaction was significant for the yolk color, shell thickness, percentages of shell, yolk index% and HU. Yolk index% and HU decreased with increasing storage periods from zero to 21d at 51 wk-old birds.
6. Regardless of the strain level of addition of Se as Sel-Plex had significant positive correlation with shape index%. Age of hens had significant positive correlation with shell thickness, yolk color and yolk%, while the correlation was negative for shell%, yolk index% and HU. Period of storage had significant positive correlation only with yolk%, while the correlation was negative for albumen%, yolk index% and HU.

It could be concluded that, Se yeast as Sel-Plex (200 mg Se/ton diet) fed to Golden Montazah and Fayoumi laying hens improved egg quality during storage and may add value to market eggs.

Key words: Selenium as Sel-Plex, laying hen, egg quality, Golden Montazah, Fayoumi, storage period of egg.

INTRODUCTION

Selenium (Se) is an essential trace element for human and animal health. It was found to be an integral part of the glutathione peroxidase enzyme **(Rotruck *et al.,* 1973).** Glutathione peroxide takes part in the cellular defense against oxidative damage of cytoplasmic structures by catalyzing the reduction of hydrogen peroxide and lipid peroxides **(Watanabe *et al.,* 1997 and Payne, 2004).**

Selenium is occurring in organic and inorganic forms. The organic form is found predominantly in grains, fish, meat, poultry and dairy products **(Klein, 2004).** Traditionally, Se has been added to poultry diets via inorganic sources, such as sodium selenite (Na_2SeO_3) or selenate or as organoselenium compounds (selenoamino acids, mainly selenomethionine (SM)). Research has shown that organic Se is more bioavailable than Se in sodium selenite **(Cantor *et al.,* 1982)**, therefore, organic sources of Se, such as Se yeast, have been explored as an alternative to inorganic supplementation **(Payne *et al.,* 2005).** The use of organic Se results in less Se being transferred to the environment through feces and more Se is deposited into body tissues and eggs **(Cantor *et al.,* 2000; Patton, 2000; Payne *et al.,* 2005 and Utterback, *et al.,* 2005**)

Organic sources of Se, i.e. from Se-enriched yeast (SY) have received considerable attention **(Schrauzer, 2000, 2001**). Selenium-enriched yeast is produced by growing *Saccharomyces cerevisiae* in a Se-rich nutrient medium, under conditions of sulfur limitations. This encourages the uptake of Se to form Se analogues of organic compounds of sulfur, i.e. SM **(Reilly, 2006 and Cattaneo *et al,* 2008)**. The majority of the commercial preparations of Se-yeasts contain mainly SM. Levels of SM have been reported to range, in different preparations, from 54% to 74% of total Se **(Rayman, 2004 and Cattaneo *et al,* 2008).** In this respect, **Combs and Combs (1986)** suggested that organic Se sources, such as SM or SY, were actively absorbed and directly incorporated into protein. **Cantor and Scott (1974) ; Swanson (1987); Cantor *et al.* (2000) and Payne *et al.* (2005**) indicate that SM is deposited in the egg to a greater extent than SS. If SM is deposited into the egg directly as SM, then it is possible that the Se in SM would not be available, or at least not immediately, for incorporation into glutathione peroxidase, which could protect whole egg (shell and fluid) from free-radical damage.

The laying hens requirement for Se ranges from 0.05 to 0.08 ppm depending on daily feed intake**,** this requirement can be met by natural feedstuffs in the diet, but these feedstuffs vary widely in Se concentration depending on the region that they are grown **(NRC, 1994)**, and thus it is common practice in the poultry industry to supplement laying hens diets. The maximum allowed Se inclusion level in the United States is 0.30 ppm.

Storage of eggs is common practice in commercial poultry production, both in the case of hatching eggs and those destined for human consumption. Egg storage has several benefits, such as reducing the number of individual incubations and providing flexibility to meet market demands, however, storage can alter some characteristics of the egg including loss of water, carbon dioxide, and a subsequent increase in the pH of the albumen **(Decuypere *et al.*, 2001).** On the other hand, the physical appearance of an egg makes the first impression upon the consumer. If the product does not meet perceived expectations, consumer confidence diminishes. The structural quality of the shell egg is important to the processor because eggs that are structurally sound will arrive to the consumer in the best condition. Furthermore, high interior quality is of importance to egg products manufacturers because it allows for better separation of components without crossover contamination, especially when producing albumen products **(Scott and Silversides, 2000 and Jones and Musgrove, 2005).** The conditions normally required in egg storage room is 15°C with a relative humidity of 75% **(Deeming, 1997).**

Internal egg quality is frequently assessed by measurements of the height of the inner thick albumen or a function of this such as the Haugh unit score (HU) which decreases with decreasing egg freshness, **Wakebe (1999)** has shown that addition of organic Se to laying hens diets can moderate the sharp decline in the HU of stored eggs. Changes in albumen quality during storage are described equally well by albumen height and HU **(Silversides and**

Villeneuve, 1994), HU decrease during storage (**Kahraman-Dogan *et al.*, 1994 and Jones *et al.*, 2002).** Furthermore, the age and production stage of a hens affect shell structure and consequently the rate of diffusion through the pores of the eggshell during storage **(Etches, 1996).**

Little previously conducted research has tested Sel-Plex as a method for improving the egg quality of long-term stored eggs laid by local strains. The objective of this study was to determine if Sel-Plex would improve egg quality for two local strains (Golden Montazah (GM) and Fayoumi (F) laying hens) and to investigate the importance of age, strain of the hens and the period of storage on egg quality during storage.

MATERIALS AND METHODS

This study was carried out at El Takamoly Poultry Project, Fayoum, Egypt, from December, 2007 to February, 2008 (age1) and from March to May, 2008 (age 2). A total number of 498 birds (450 hens and 48 cocks) of Golden Montazah and Fayoumi strains at forty-two weeks of age were used in this experiment to evaluate the effects of two dietary levels of Se (supplement) as Sel-Plex (0.1 or 0.2 mg/Kg diet) on egg quality during storage. Birds from each strain were wing banded and divided randomly into 3 equal treatment groups of 83 birds (having nearly similar body weight) each (75 laying hens and 8 cocks each). Birds were placed in 6 floor laying pens (three for each strain), which contain wood shaving litter (open system). The 1st group was fed the basal diet (Table1) and served as control group (unsupplemented with Se) while the 2nd and 3rd groups were fed the same diet supplemented with two levels of Se (0.1 or 0.2 mg/Kg diet, respectively) as Sel-Plex in the form of Se yeast. Selenium yeast as Sel-Plex (Alltech Inc.) contains 1000 mg Se/Kg Sel-Plex and produced by the fermentation of yeast (*Saccharomyces cerevisiae*) in a high Se medium. The experimental period was lasted for 23 weeks from 42 to 65 weeks of age. Feed and water were offered *ad libitum*. Artificial light was used beside the normal day light to provide 16-hour day photoperiod.

Table 1: Composition of the basal diets.

Item,%	Fayoumi	Golden Montazah
Yellow corn, ground	67.00	66.00
Soybean meal (44%CP)	19.50	22.00
Corn glutein meal	1.00	1.50
Wheat bran	3.22	1.22
Calcium carbonate	7.20	7.20
Sodium chloride	0.30	0.30
Vit. and Min. premix [1]	0.30	0.30
Monocalcium phosphate	1.40	1.40
DL–Methionine	0.08	0.08
Total	100.0	100.0
Calculated analysis% [2]:		
Crude protein	15.45	16.46
Ether extract	2.82	2.76
Crude fiber	3.21	3.15
Calcium	3.04	3.05
Available phosphorus	0.41	0.41
Methionine	0.34	0.36
Methionine+Cystine	0.61	0.64
Lysine	0.73	0.79
ME, kcal./Kg	2761	2776
Cost (£.E./ton) [3]	1504.0	1575.0

[1] Each 3.0 Kg of the Vit. and Min. premix contains: Vit. A, 10000000 IU; Vit. D_3 2000000 IU; Vit. E, 1000 mg; Vit. K_3, 1000 mg; Vit. B1, 1000 mg; Vit. B2, 500 mg; Vit. B6, 1500 mg; Vit. B12, 10 mg; biotin, 50 mg; folic acid, 1 mg; niacin, 3000 mg; Ca pantothenate, 1000 mg; Zn, 50 g; Cu,4 g; Fe, 30 g; Co, 0.1 g; Se, 0.1 g; I, 0.3 g; Mn, 60 g and anti-oxidant, 10 g, and complete to 3.0 Kg by calcium carbonate.
[2] According to **NRC, 1994**.
[3] According to the local market price at the experimental time.

Two batches of eggs (each of 200 eggs/treatment/strain) were collected from the 3 treatments pens for each strain at the 51th and 65th weeks of age to study the egg quality during storage. The 1st group, 50 eggs from each treatment were collected and stored for 21d; the 2nd group 50 eggs from each treatment were collected seven d after the first set of eggs (cold-stored for 14 d) and the 3rd group 50 eggs from each treatment were collected seven d after the second set of eggs (cold-stored for seven d) and the later group 50 eggs from each treatment were collected seven d after the three group (cold-stored for zero d).

The temperature during storage was monitored continuously and maintained at 15±1°C, and a humidifier kept RH constant at 78±2%. At regular intervals after collection (zero (not stored); seven; 14 and 21d) the quality of 50 eggs per treatment was determined. Eggs that were laid overnight were not used for the experiment. Fresh eggs were collected and measured within 2 h of being laid.

At sampling, eggs were weighed to the nearest 0.1g and broken onto a flat surface where the height of the albumen to the nearest 0.1mm was measured half way between the yolk and the edge of the inner thick albumen by using an electronic albumen height gauge. The yolk was separated from the albumen and weighed and, yolk visual color score was determined by matching the yolk with one of the 15 bands of the "1961, Roche Improved Yolk Color Fan". The same person performed all of the yolk color determinations. The shells were dried at room temperature for 3 d and weighed; egg shell thickness, including shell membranes, was measured using a micrometer at three locations on the egg (air cell, equator, and sharp end). The weight of the albumen was calculated as the difference between the weight of the egg and the weight of the yolk and shell. Haugh unit score was applied from a special chart using egg weight and albumen height which was measured by using a micrometer according to **Haugh (1937).** Egg shape index**%** (**Carter, 1968**) and yolk index**%** (**Well, 1968**) were calculated**.**

The collected data were subjected to ANOVA with the General Linear Models (GLM) procedure of SPSS software **(SPSS, 1999)** included the main effects of strain, level of addition of Se as Sel-Plex, period of storage and age of hens and the two way interactions between these factors. Treatment means indicating significant differences (P≤0.01 and P≤0.05) were tested using Duncan's multiple range test **(Duncan, 1955)**. Correlation analyses were performed using the procedure CORR of SPSS User's Guide, (**SPSS, 1999**).

RESULTS AND DISCUSSION

Data of supplementing laying hens diets with organic Se on egg quality during storage are summarized in Tables (2 to 6). Concerning the strain effect (Table 2), the eggs from GM hens were heavier than those from F hens, with more albumen% but less shell thickness, yolk%, shell%, yolk index% and shape index%.

In this respect, a number of studies have reported the major influences on albumen quality are the strain and age of laying hens, eggshell quality, and storage time and conditions **(Silversides and Scott, 2001).** The albumen height differs between strains **(Poggenpoel, 1986; Toussant *et al.*, 1995 and Scott and Silversides, 2000). Williams (1992**) reviewed factors that affect albumen height. A few nutritional factors have been implicated, but, overall, nutrition is relatively unimportant, the major influences on albumen height are the strain, age of the laying hens and storage time and conditions.

Concerning the effect of level of addition Se as Sel-Plex (Table 2), no significant effect were observed on egg quality except, yolk color, albumen%, shell% and shape index%. It is clear that laying hens fed diet containing 100 mg Se/ton diet as Sel-Plex had highest yolk color and albumen%, while, insignificant differences were detected among other level as compared to the control diet. Laying hens fed diet containing 200 mg Se/ton diet as Sel-Plex had higher shape index%, while, those fed the control diet had higher shell% and lower shape index%.

Our results also disagree with **Arnold *et al.* (1973)** and **Payne (2004)** who reported that HU were not improved by SS supplementation. While, **Wakebe (1999)** show that addition of organic Se to laying hens diets can moderate the sharp decline in the HU of stored eggs.

Concerning the effect of period of storage (Table 2). The results indicated that Sel-Plex supplementation significantly ($P \leq 0.05$ or $P \leq 0.01$) affected egg quality during all experimental storage periods studied except, shell thickness, shell% and shape index%, as the period of storage of eggs increased, albumen%, yolk index% and HU decreased, with the greatest increase in the percentage of the yolk and the change in yolk color was unclear.

Table 2: Effects of supplementing laying hens diets with organic selenium (Se) on egg quality during storage (main effect).

Items	Egg weight, g	Yolk color	Shell thickness, mm	Albumen, %	Yolk, %	Shell, %	Yolk index, %	Shape index, %	Haugh unit
Strain									
Fayoumi	47.97^{B}	6.52	0.385^{A}	55.93^{B}	33.34^{a}	10.7^{A}	42.97^{A}	77.36^{A}	60.33
Golden Montazah	53.90^{A}	6.43	0.360^{B}	57.45^{A}	32.76^{b}	9.79^{B}	41.64^{B}	75.90^{B}	59.86
±SEM[1]	0.21	0.06	0.002	0.18	0.17	0.05	0.21	0.16	0.66
Level of Se addition as Sel-Plex (mg/ton diet)									
0.00	51.04	6.33^{B}	0.373	56.51^{b}	33.09	10.42^{A}	42.42	76.15^{B}	59.02
100.00	50.74	6.69^{A}	0.371	57.17^{a}	32.67	10.16^{B}	42.47	76.79^{A}	61.28
200.00	51.03	6.42^{B}	0.374	56.40^{b}	33.38	10.20^{B}	42.02	76.96^{A}	59.99
±SEM	0.26	0.08	0.002	0.22	0.21	0.06	0.25	0.20	0.81
Period of storage (day)									
0	51.56^{a}	6.81^{A}	0.373	57.17^{A}	32.56^{b}	10.26	44.42^{A}	76.77	64.79^{A}
7	51.16^{a}	6.17^{B}	0.374	57.01^{AB}	32.83^{b}	10.17	41.46^{B}	76.58	61.73^{B}
14	50.20^{b}	6.29^{B}	0.370	56.58^{BC}	33.20^{ab}	10.22	42.55^{B}	76.27	61.21^{B}
21	50.82^{ab}	6.64^{A}	0.374	56.01^{C}	33.59^{a}	10.40	40.79^{C}	76.90	52.66^{C}
±SEM	0.30	0.09	0.002	0.26	0.24	0.07	0.29	0.23	0.94
Age of hens (wk)									
at 51	51.15	5.98^{B}	0.369^{B}	56.89	32.57^{B}	10.6^{A}	45.82^{A}	76.45	63.15^{A}
at 65	50.72	6.97^{A}	0.376^{A}	56.50	33.53^{A}	9.97^{B}	38.78^{B}	76.81	57.05^{B}
±SEM	0.23	0.07	0.002	0.20	0.19	0.06	0.23	0.18	0.72

[1]Pooled SEM

a,….b, and A,… C, values in the same column within the same item followed by different superscripts are significantly different (at P ≤0.05 for a to b ; P ≤0.01 for A to C).

Numerically, long period of storage resulted in a greater percentage of shell and shape index (the difference is not significant) and a lesser percentage of albumen, yolk index (this may be due to vitelline membrane elasticity also decreased, which could lead to yolk more easily rupturing as consumers crack the eggs, **Jones and Musgrove, 2005**) and HU when compared with those fed the control diet (Table 2). On the other hand, the HU score decreased significantly, from 64.79 in fresh eggs (zero d of storage) to 61.21 after 14 d of storage and then to 52.66 after 21 d of storage (Table 2).

These results are in harmony with those obtained by **Pappas *et al*. (2005)** who reported that the rate of decline of HU with storage was significantly greater in the low organic Se treatments compared with high Se treatments (linear trend). Also, **Hill and Hall (1980); Silversides (1994) Scott and Silversides (2000); Niemiec *et al*. (2001); Silversides and Scott (2001) and Davis and Reeves (2002)** noted that the albumen height of all eggs is at maximum when the egg is laid and decreases with increased storage time**.** Extended cold storage led to decreases in albumen height and HU, while, shell strength was not affected (**Jones and Musgrove, 2005).** While **Vieira and Moran (1998)** indicated that with increases storage time of broiler breeder influence internal and external egg quality as egg weight and yolk percentages increase and albumen and egg shell percentages decrease and these changes effects embryo development.

These results disagree with those of **Wakebe (1999)** who show that addition of organic Se to laying hens diets can moderate the sharp decline in the HU of stored eggs. **Silva *et al*. (2008)** indicated that internal and external egg quality of broiler breeder eggs were not significantly affected by different storage time of eggs. Also, **Fasenko *et al.* (2001); Pappas *et al*. (2005) and Abdel-Azeem (2009)** reported that duration of storage did not have an effect on egg weight or on the weight of various egg components such as yolk, albumen, or shell weight. **Patton (2000)** reported that SS or SY supplementation of 0.30 ppm had no effect on HU values in eggs on d 0, 21, or 42 compared with eggs from hens fed the basal diet. **Wakebe (1998)**; **Patton**

(2000) and **(Payne, 2004)** reported that SY reduced the deterioration of the albumin after the egg is laid, which would slow carbon dioxide loss and maintain albumin quality.

Concerning age of hens, as the hens ages increased, yolk color, shell thickness and yolk% increased significantly, however, the shell%, yolk index% and HU score decreased significantly (Table 2).

These results are in harmony with those obtained by **Pappas *et al*. (2005)** who reported that the HU score of the egg albumen from 23-wk-old birds was higher than that found in the albumen of 27-wk-old birds. Also, **Hill and Hall (1980) and Silversides (1994)** reported that as the age of the hens increases, the albumen height decreases and total amount of albumen increase**.** However, **Pappas *et al*. (2005)** the weight of the egg and its components (yolk, albumen and shell) were greater at 27 wk compared with 23 wk of age.

Interaction between strain and level of addition Se as Sel-Plex presented in Table (3) indicated no significant differences in egg quality among all dietary treatments including the control group except yolk color. Fayoumi and GM hens fed diet containing 100 mg Se/ton diet as Sel-Plex had higher yolk color, while, GM hens fed control diet had lower yolk color.

The strain by period of storage interaction was significant only for the percentage of albumen, yolk and yolk index, the increase in the percentage of yolk and decrease in percentage of albumen of F eggs were greater than those of GM eggs after seven d of storage, long period of storage (21d) with GM resulted in a lesser percentage of yolk index (Table 3).

Interaction between strain and age of hens presented in Table (4) indicated no significant differences in egg quality except egg weight, yolk color and shell thickness. At 51 and 65 wk-old birds, eggs from GM hens were heavier than those from F hens. At 65 wk-old birds, eggs from F hens were higher in yolk color than those from GM hens, but as the age of the hens increased, the increase in the yolk color from GM hens was less than that of eggs from F hens.

Table 3: Effects of supplementing laying hens diets with organic selenium (Se) on egg quality during storage (interaction of strain * level of Se addition as Sel-Plex (mg/ton diet) and strain * period of storage/day).

Items		Egg weight, g	Yolk color	Shell thickness, mm	Albumen, %	Yolk, %	Shell, %	Yolk index, %	Shape index, %	Haugh unit
Strain * Level of Se addition as Sel-Plex (mg/ton diet)										
Fayoumi	0.00	48.26	6.54^{ab}	0.385	55.86	33.27	10.9	43.15	76.68	58.37
	100.00	48.02	6.65^{a}	0.385	56.40	32.93	10.7	43.09	77.62	61.22
	200.00	47.64	6.38^{ab}	0.384	55.53	33.81	10.6	42.68	77.77	61.41
Golden Montazah	0.00	53.81	6.12^{b}	0.361	57.16	32.91	9.95	41.69	75.61	59.67
	100.00	53.45	6.72^{a}	0.356	57.93	32.41	9.65	41.85	75.95	61.34
	200.00	54.43	6.46^{ab}	0.364	57.27	32.95	9.76	41.36	76.14	58.57
±SEM[1]		0.37	0.11	0.003	0.31	0.30	0.09	0.36	0.28	1.15
Strain * Period of storage (day)										
Fayoumi	0	48.06	6.86	0.388	56.65^{BCD}	32.48^{CD}	10.9	45.12^{A}	77.55	64.69
	7	47.70	6.17	0.388	55.49^{E}	33.88^{A}	10.7	41.80^{BC}	77.37	61.79
	14	47.71	6.28	0.379	56.06^{DE}	33.28^{ABC}	10.7	42.70^{BC}	76.95	61.10
	21	47.88	6.78	0.385	55.53^{E}	33.71^{AB}	10.8	42.26^{BC}	77.57	53.77
Golden Montazah	0	54.52	6.77	0.358	57.69^{AB}	32.65^{BCD}	9.66	43.72^{B}	76.00	64.90
	7	54.62	6.17	0.359	58.53^{A}	31.79^{D}	9.68	41.11^{C}	75.79	61.67
	14	52.69	6.29	0.362	57.10^{BC}	33.12^{ABC}	9.78	42.39^{BC}	75.59	61.33
	21	53.76	6.49	0.362	56.49^{CDE}	33.48^{ABC}	10.0	39.32^{D}	76.24	51.55
±SEM		0.43	0.13	0.003	0.37	0.35	0.10	0.42	0.32	1.36

[1]Pooled SEM

a,….b, and A,… C, values in the same column within the same item followed by different superscripts are significantly different (at P ≤0.05 for a to b ; P ≤0.01 for A to C).

Table 4: Effects of supplementing laying hens diets with organic selenium (Se) on egg quality during storage (interaction of strain * age of hens (wk) and level of Se addition as Sel-Plex (mg/ton diet) * period of storage/day).

Items		Egg weight, g	Yolk color	Shell thickness, mm	Albumen ,%	Yolk, %	Shell, %	Yolk index,%	Shape index, %	Haugh unit
Strain * Age of hens (wk)										
Fayoumi	at 51	47.68^{C}	5.93^{b}	0.385^{A}	56.18	32.74	11.1	46.62	77.32	63.32
	at 65	48.27^{C}	7.11^{a}	0.385^{A}	55.69	33.94	10.4	39.32	77.39	57.35
Golden Montazah	at 51	54.61^{A}	6.02^{b}	0.353^{C}	57.59	32.40	10.0	45.02	75.58	62.97
	at 65	53.18^{B}	6.84^{a}	0.367^{B}	57.31	33.12	9.56	38.25	76.23	56.75
±SEM[1]		0.33	0.10	0.003	0.28	0.27	0.08	0.32	0.25	1.02
Level of Se addition as Sel-Plex (mg/ton diet) * Period of storage (day)										
0.00	0	52.16	6.28^{CD}	0.376	57.45	32.04	10.5	43.49^{ABC}	76.73	63.32
	7	51.12	6.52^{ABCD}	0.376	56.54	33.26	10.3	42.58^{BCD}	75.83	60.90
	14	49.68	6.29^{CD}	0.371	56.45	33.16	10.4	42.12^{BCDE}	75.68	61.24
	21	51.19	6.05^{DE}	0.371	55.60	33.91	10.5	41.49^{DE}	76.34	50.62
100.00	0	51.62	7.18^{A}	0.368	57.67	32.27	10.1	44.56^{AB}	77.10	65.52
	7	51.10	6.26^{CDE}	0.368	57.64	32.34	10.0	41.63^{CDE}	76.40	64.02
	14	50.43	6.39^{BCD}	0.371	57.21	32.62	10.2	43.13^{BCD}	76.22	61.59
	21	49.80	6.91^{AB}	0.376	56.15	33.45	10.4	40.55^{DE}	77.41	53.99
200.00	0	50.91	6.81^{ABC}	0.374	56.39	33.38	10.2	45.21^{A}	76.48	65.53
	7	51.27	5.72^{E}	0.379	56.85	32.89	10.2	40.15^{E}	77.49	60.26
	14	50.49	6.18^{CDE}	0.369	56.07	33.83	10.1	42.39^{BCDE}	76.90	60.80
	21	51.46	6.96^{AB}	0.373	56.29	33.41	10.3	40.33^{E}	76.95	53.38
±SEM		0.53	0.15	0.004	0.44	0.43	0.13	0.51	0.39	1.63

[1]Pooled SEM

a,….b, and A,… E, values in the same column within the same item followed by different superscripts are significantly different (at P ≤0.05 for a to b ; P ≤0.01 for A to E).

The shell thickness, increased for GM hens with increasing age. With increasing age, the increase in the percentage of yolk and decrease in percentage of albumen of F eggs were greater than those of GM eggs; however, the difference is not significant (Table 4).

Interaction between level of addition Se as Sel-Plex and period of storage presented in Table (4) indicated no significant differences in egg quality except, yolk color and yolk index%. It is clear that eggs from hens fed diet containing 100 and 200 mg Se/ton diet as Sel-Plex at zero d of storage had higher yolk color and yolk index%, respectively, while, eggs from hens fed diet containing 200 mg Se/ton diet as Sel-Plex at seven d of storage had lower yolk color and yolk index%.

Interaction between level of addition Se as Sel-Plex and age of hens presented in Table (5) indicated no significant differences in egg quality except, yolk color and shell%. It is clear that laying hens fed diet containing 100 mg Se/ton diet as Sel-Plex at 65 wk-old birds had higher yolk color and a lesser percentage of shell.

The age of hens and period of storage interaction (Table 5) was significant for yolk color, shell thickness, percentages of shell, yolk index and HU. Yolk index% and HU decreased with increasing storage periods from zero to 21d at 51 wk-old birds and the change in yolk index% and HU was unclear at 65 wk-old birds. In this respect, **Pappas *et al*. (2005)** found that at 23 wk of age the HU of eggs from birds fed diets supplemented with Se as Sel-Plex did not decrease after 14 d of storage; however, this was not evident in the older (27 wk of age) birds.

Correlation coefficients estimate:

The importance of the studied traits was investigated using correlation analysis for each level of addition Se as Sel-Plex, age of hens and period of storage for F, GM and both strains are presented in Table 6.

Table 5: Effects of supplementing laying hens diets with organic selenium (Se) on egg quality during storage (interaction of level of Se addition as Sel-Plex (mg/ton diet)* age of hens (wk) and age of hens (wk) * period of storage (day)).

Items		Egg weight, g	Yolk color	Shell thickness, mm	Albumen ,%	Yolk, %	Shell, %	Yolk index,%	Shape index, %	Haugh unit
Level of Se addition as Sel-Plex (mg/ton diet)* Age of hens (wk)										
0.00	at 51	50.67	5.99^{C}	0.369	56.70	32.73	10.6^{a}	46.17	75.76	61.73
	at 65	51.40	6.66^{B}	0.378	56.33	33.45	10.3^{b}	38.67	76.53	56.31
100.00	at 51	51.14	5.93^{C}	0.368	57.15	32.32	10.5^{ab}	45.59	76.83	64.38
	at 65	50.33	7.44^{A}	0.373	57.19	33.02	9.79^{c}	39.35	76.74	58.19
200.00	at 51	51.63	6.00^{C}	0.371	56.81	32.65	10.5^{ab}	45.72	76.76	63.33
	at 65	50.44	6.83^{B}	0.377	55.99	34.11	9.86^{c}	38.32	77.16	56.66
±SEM[1]		0.41	0.12	0.003	0.35	0.33	0.10	0.40	0.30	1.24
Age of hens (wk) * Period of storage (day)										
at 51	0	51.55	5.73^{F}	0.367^{C}	57.60	32.06	10.4^{AB}	47.65^{A}	76.39	71.66^{A}
	7	51.40	5.79^{EF}	0.373^{ABC}	57.03	32.41	10.6^{A}	45.57^{B}	76.28	65.37^{B}
	14	50.98	6.12^{DE}	0.372^{ABC}	56.40	32.93	10.7^{A}	45.20^{B}	76.14	61.96^{BC}
	21	50.66	6.28^{CD}	0.365^{C}	56.51	32.87	10.6^{A}	44.88^{B}	77.00	53.59^{E}
at 65	0	51.58	7.90^{A}	0.379^{AB}	56.74	33.07	10.2^{B}	41.19^{C}	77.16	57.92^{D}
	7	50.92	6.55^{C}	0.375^{ABC}	56.99	33.26	9.77^{C}	37.34^{E}	76.88	58.08^{CD}
	14	49.42	6.45^{CD}	0.368^{BC}	56.76	33.48	9.76^{C}	39.90^{D}	76.39	60.46^{CD}
	21	50.98	6.99^{B}	0.382^{A}	55.51	34.31	10.2^{B}	36.70^{E}	76.80	51.73^{E}
±SEM		0.47	0.14	0.004	0.39	0.38	0.11	0.45	0.35	1.43

[1]Pooled SEM

a,….b, and A,… F, values in the same column within the same item followed by different superscripts are significantly different (at P ≤0.05 for a to b ; P ≤0.01 for A to F).

Table 6: Correlation coefficients between egg components and level of selenium (Se) addition as Sel-Plex (mg/ton diet), age of hens (wk) and period of storage/day.

Items	Egg weight, g	Yolk color	Shell thickness, mm	Albumen, %	Yolk, %	Shell, %	Yolk index,%	Shape Index%	Haugh unit
Effect of level of Se addition as Sel-Plex (mg/ton diet)									
Fayoumi	-0.080	-0.057	-0.020	-0.031	0.055	-0.097	-0.029	0.166**	0.096
Golden Montazah	0.092	0.100	0.048	0.006	0.007	-0.067	-0.022	0.085	-0.037
Regardless of the strain	0.014	0.018	0.013	-0.010	0.030	-0.072	-0.026	0.124**	0.028
Effect of age of hens (wk)									
Fayoumi	0.091	0.440**	-0.007	-0.085	0.210**	-0.365**	-0.682**	0.013	-0.249**
Golden Montazah	-0.161**	0.336**	0.231**	-0.040	0.117	-0.242**	-0.681**	0.126*	-0.248**
Regardless of the strain	-0.041	0.390**	0.102*	-0.058	0.160**	-0.270**	-0.675**	0.063	-0.249**
Effect of period of storage (day)									
Fayoumi	-0.102	0.026	-0.068	-0.125*	0.133*	-0.009	-0.177**	-0.008	-0.337**
Golden Montazah	-0.098	-0.016	0.049	-0.166**	0.132*	0.139*	-0.260**	0.037	-0.369**
Regardless of the strain	-0.077	0.006	-0.007	-0.147**	0.134**	0.058	-0.213**	0.013	-0.353**

** Correlation is significant at the 0.01 level.

* Correlation is significant at the 0.05 level.

As shown in Table 6, in F and regardless of the strain, level of Se addition as Sel-Plex had significant positive correlation with shape index% (P≤0.01). In F strain, age of hens had significant positive correlation with yolk color and yolk% (P≤0.01), while the correlation was negative for shell%, yolk index% and HU (P≤0.01). In GM strain, age of hens had significant positive correlation with yolk color, shell thickness (P≤0.01) and shape index% (P≤0.05), whereas significant negative correlations were found between age of hens and each of EW, shell%, yolk index% and HU (P≤0.01). Regardless of the strain, age of hens had significant positive correlation with shell thickness (P≤0.05), yolk color and yolk% (P≤0.01), while the correlation was negative for shell%, yolk index% and HU (P≤0.01).

From Table 6 it is also shown that in F strain, period of storage had significant positive correlation with yolk% (P≤0.05), while the correlation was negative for albumen% (P≤0.05), yolk index% and HU (P≤0.01). In GM strain, period of storage had significant positive correlation with yolk and shell% (P≤0.05), whereas significant negative correlations were found between period of storage and each of albumen%, yolk index% and HU (P≤0.01). Regardless of the strain, period of storage had significant positive correlation only with yolk% (P≤0.01), while the correlation was negative for albumen%, yolk index% and HU (P≤0.01).

In conclusion, the results of this study indicated that feeding laying hens diets containing Se as Sel-Plex improved egg quality of laying hens during storage, on the other hand, Se yeast fed to laying hens may add value to market eggs.

REFERENCES

Abdel-Azeem, F. A. (2009). Effect of using different pre-storage incubation warming times and storage periods on hatchability of Japanese quail eggs and subsequent growth of chicks. *Egypt. Poult. Sci.* 29: 761-775.

Arnold, R. L., O. E. Olson, and C. W. Carlson (1973). Dietary selenium and arsenic additions and their effects on tissue and egg selenium. *Poult. Sci*. 52:847–854.

Cantor, A. H., and M. L. Scott (1974). The effect of selenium in the hen’s diet on egg production, hatchability, performance of progeny and selenium concentration in eggs. *Poult. Sci.* 53:1870–1880.

Cantor, A. H., P. D. Moorehead, and M. A. Musser (1982). Comparative effects of sodium selenite and selenomethionine upon nutritional muscular dystrophy, selenium-dependent glutathione peroxidase, and tissue selenium concentrations of turkey poults. *Poult. Sci.* 61:478–484.

Cantor, A. H., M. L. Straw, M. J. Ford, A. J. Pescatore, and M. K. Dunlap (2000). Effect of feeding organic selenium in diets of laying hens on egg selenium content. Page 473 in Egg Nutrition and Biotechnology. J. S. Sim, S. Nakai, and W. Guenter, ed. CABI Publishing, New York.

Carter, T.C. (1968). The hen egg. A mathematical model with three parameters. *Br. Poult. Sci.* 9: 165-171.

Cattaneo, D., G. Invernizzi, M. Ferroni, A. Agazzi, R. Rebucci, A. Baldi, V. Dell’orto, and G. Savoini (2008). Selenium and poultry products: nutritional and safety implications. *Impact of Pollution on Animal Products.* 133-141.

Combs, G. F., and S. B. Combs (1986). The Role of Selenium in Nutrition. Academic Press, Orlando, FL.

Davis, C., and R. Reeves (2002). High value opportunities from the chicken egg. A Report for the Rural Industries Research and Development Corporation. Australian Government, Kingston, Australia.

Decuypere, E., K. Tona, V. Bruggeman, and F. Bamelis (2001). The day-old chick: A crucial hinge between breeders and broilers. *World’s Poult. Sci.* 57:127–139.

Deeming, D. C. (1997). Ratite egg incubation; A practical guide. Pages 23–24, 60–61. in: Ratite Conference. High Wycombe, Buckinghamshire, UK.

Duncan, D. B. (1955). Multiple range and multiple F tests. Biometrics, 11: 1-42.

Etches, R. J. (1996). Monitoring reproductive success. Pages 298–309 in Reproduction in Poultry. CAB International, Oxon, UK.

Fasenko, G. M., V. L. Christensen, M. J. Wineland, and J. N. Petitte (2001). Examining the effects of pre-storage incubation of turkey breeder eggs on embryonic development and hatchability of eggs stored for four or fourteen days. *Poult. Sci.* 80:132–138.

Haugh, R. R. (1937). The Haugh unit for measuring egg quality. *US Egg Poult. Mag*. 43: 552-555.

Hill, A. T., and J. W. Hall (1980). Effects of various combinations of oil spraying, washing, sanitizing, storage time, strain, and age upon albumen quality changes in storage and minimum sample sizes required for their measurement. *Poult. Sci.* 59:2237–2242.

Jones, D. R., and M. T. Musgrove (2005). Effects of extended storage on egg quality factors. *Poult. Sci.* 84: 1774–1777.

Jones, D. R., J. B. Tharrington, P. A. Curtis, K. E. Anderson, K. M. Keener, and F. T. Jones (2002). Effects of cryogenic cooling of shell eggs on egg quality. *Poult. Sci.* 81: 727–733.

Kahraman-Dogan, H., L. Bayindirli, and M. Ozilgen (1994). Quality control charts for storage of eggs. *Food Qual.* 17:495–501.

Klein, E. A. (2004). Selenium: Epidemiology and basic science. J. Urol. 171:S50–S53.

National Research Council, NRC (1994). Nutrient Requirements of Poultry. 9th revised edition. National Academy Press. Washington, D.C., USA.

Niemiec, J., M. Pinska, E. Swierczewska, J. Riedel, and A. Boruta (2001). The effect of storage on egg quality and fatty acid content in PUFA-enriched eggs. *J. Anim. Feed Sci.* 10:267–272.

Pappas, A. C., T. Acamovic, N. H. C. Sparks, P. F. Surai, and R. M. McDevitt (2005). Effects of supplementing broiler breeder diets with organic selenium and polyunsaturated fatty acids on egg quality during storage. *Poult. Sci.* 84:865–874.

Patton, N. D. (2000). Organic selenium in the nutrition of laying hens: Effects on egg selenium content, egg quality and transfer to developing chick embryos. Ph. D. Diss., Univ. Kentucky, Lexington, KY, USA.

Payne, R. L. (2004). The effects of inorganic and organic selenium sources on growth performance, carcass traits, tissue mineral concentrations, and enzyme activity in poultry. Ph.D. Thesis, Faculty of the Louisiana State University and Agricultural and Mechanical College, UK.

Payne, R. L., T. K. Lavergne, and L. L. Southern (2005). Effect of inorganic versus organic selenium on hen production and selenium concentration. *Poult. Sci.* 84:232–237.

Poggenpoel, D. G. (1986). Correlated response in shell and albumen quality with selection for increased egg production. *Poult. Sci.* 65:1633–1641.

Rayman, M. P. (2004). The use of high selenium yeast to raise selenium status: how does it measure up?. *Brit. J. Nutr.*, 92: 557–573.

Reilly, C. (2006). Selenium in food and health, 2nd ed. Springer, New York, p. 206.

Rotruck, J. T., A. L. Pope, H. E. Ganther, A. B. Swanson, D. G. Hafeman, and W. G. Hoekstra (1973). Selenium: biochemical role as a component of glutathione peroxidase. *Science* 179:588–590.

Schrauzer, G. N. (2000). Selenomethionine: a review of its nutritional significance, metabolism and toxicity, *J. Nutr.*, 130: 1653–1656.

Schrauzer, G. N. (2001). Nutritional selenium supplements: product types, quality, safety, *J. Am. Coll. Nutr.*, 20: 1–4.

Scott, T. A., and F. G. Silversides (2000). The effect of storage and strain of hen on egg quality. *Poult. Sci.* 79:1725–1729.

Silva, F. H. A., D. E. Faria, K. A. A. Torres, D. E. Faria Filho, A. D. D. Coelho, and V. J. M. Savino (2008). Influence of egg pre-storage heating period and storage length on incubation results. *Brazilian J. of Poul. Sci.* 10 :17-22.

Silversides, F. G. (1994). The Haugh unit correction for egg weight is not adequate for comparing eggs from chickens of different lines and ages. *J. Appl. Poult. Res.* 3:120–126.

Silversides, F. G., and P. Villeneuve (1994). Is the Haugh unit correction for egg weight valid for eggs stored at room temperature?. *Poult. Sci.* 73:50–55.

Silversides, F. G., and T. A. Scott (2001). Effect of storage and layer age on quality of eggs from two lines of hens. *Poult. Sci.* 80:1240-1245.

SPSS (1999). User’s Guide: Statistics. Version 10. SPSS Inc. Chicago, IL, USA.

Swanson, C. A. (1987). Comparative utilization of selenite, selenomethionine, and selenized yeast by the laying hen. *Nutr. Res.* 7:529–537.

Toussant, M. J., D. E. Swayne, and J. D. Latshaw (1995). Morphologic characteristics of oviducts from hens producing eggs of different Haugh units induced by genetics and by feeding vanadium as determined with computer software-integrated digitizing technology. *Poult. Sci.* 74:1671–1676.

Utterback, P. L., C. M. Parsons, I. Yoon, and J. Butler (2005). Effect of supplementing selenium yeast in diets of laying hens on egg selenium content. *Poult. Sci.* 84: 1900-1901.

Vieira, S. L., and E. T. Moran (1998). Eggs and chicks from broiler breeders of extremely different age. *J. Appl. Poultry. Res.* 7:372-376.

Wakebe, M. (1998). Feed for chicken and for hen. Japanese Patent Office, Patent number JP10023864A2. Jan 27.

Wakebe, M. (1999). Organic selenium and egg freshness. Feed for meat chickens and feed for laying hens. Japanese Patent Office, Application Heisei 8-179629. Patent 10-23864. Assignee: Fujisawa Chemical Company.

Watanabe T., V. Kiron, and S. Satoh (1997). Trace minerals in fish nutrition. *Aquaculture*. 151:185-207.

Well, R. J. (1968). The measurement of certain egg quality: A study of the hens egg. Ed. By T.C. Carter Pub. Oliver and Boyd Edinbrugh pp. 220-226 and 235-236.

Williams, K. C. (1992). Some factors affecting albumen quality with particular reference to Haugh unit score. *World's Poult. Sci.* 48:5–16.

"تأثير إضافة السلنيوم العضوي إلي علائق الدجاج البياض علي جودة البيض أثناء التخزين".

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أجريت هذه التجربة لمدة ٢٣ أسبوع من عمر ٤٢ إلي عمر ٦٥ أسبوع. كان العدد المستخدم ٤٩٨ طائر(٤٥٠ دجاجة بياضة و٤٨ ديك) من سلالتي المنتزة الذهبي والفيومي عمر ٤٢ أسبوع لتقيم مستويين من السلنيوم في صورة سلبلكس (٠,١ ، ٠,٢ ملليجرام لكل كجم عليقة) علي جودة البيض أثناء التخزين، قسمت الطيور عشوائياً إلي ٣ معاملات بكل معاملة ٨٣ طائر (٧٥ أنثي و ٨ ذكر). وزعت الطيور عشوائيا في ٦ حظائر أمهات تم تغذية المجموعة الأولي علي العليقة الأساسية (الضابطة) بينما المجموعة الثانية والثالثة غذيت علي نفس العليقة مضاف إليها مستويين من السلنيوم في صورة سلبلكس ٠,١ ، ٠,٢ ملليجرام لكل كجم عليقة. تم تخزين البيض بعد تجميع ٢٠٠ بيضة لكل معاملة وتخزين ٥٠ منها لمدة صفر يوم (طازج) ،٥٠ لمدة ٧ و٥٠ لمدة ١٤ و٥٠ لمدة ٢١ يوم ثم تم قياس جودة البيض بعد التخزين.

وتتلخص أهم النتائج المتحصل عليها فيما يلي:-

١- كان وزن البيض الناتج من دجاج المنتزة الذهبي أعلي في وزن البيضة ونسبة البياض عن الفيومي وأقل في سمك القشرة ونسبة كل من الصفار والقشرة ودليل الصفار ودليل الشكل.

٢- كان البيض الناتج من الدجاج المغذي علي عليقة تحتوي علي ١٠٠ ملليجرام سلنيوم للطن في صورة سلبلكس اعلي لون للصفار ونسبة بياض، كان البيض الناتج من الدجاج المغذي علي عليقة تحتوي علي

٢٠٠ ملليجرام سلنيوم للطن في صورة سلبلكس أعلي نسبة لدليل الشكل، بينما كان البيض الناتج من الدجاج المغذي علي عليقة الكنترول أعلي نسبة للقشرة واقل نسبة لدليل الشكل.

٣- بزيادة مدة التخزين تقل معنوياً نسبة البياض ودليل الصفار ووحدات هاو مع أعلي زيادة في نسبة الصفار. بزيادة عمر الدجاجات يزداد لون الصفار وسمك القشرة ونسبة الصفار بينما تقل معنوياً نسبة القشرة و الصفار ووحدات هاو.

٤- لم يكن هناك أي فرق معنوي بالنسبة للتداخل بين نسبة إضافة السلنيوم ومدة التخزين علي جودة البيض فيما عدا لون الصفار ودليل الشكل%. كان البيض الناتج من الدجاج المغذي علي عليقة تحتوي علي ١٠٠ أو ٢٠٠ ملليجرام سلنيوم للطن في صورة سلبلكس والمخزن لمدة صفر يوم أعلي لون ودليل للصفار % علي التوالي، بينما كان البيض الناتج من الدجاج المغذي علي عليقة تحتوي علي ٢٠٠ ملليجرام سلنيوم للطن في صورة سلبلكس والمخزن لمدة سبعة أيام أقل لون ودليل للصفار%.

٥- كان هناك فرق معنوي بالنسبة للتداخل بين عمر الدجاجات ومدة التخزين علي لون الصفار وسمك القشرة ونسبة القشرة ودليل الصفار ووحدات هاو. ينخفض دليل الصفار ووحدات هاو مع زيادة مدة التخزين من صفر إلي ٢١ يوم وذلك علي عمر ٥١ أسبوع.

٦- بغض النظر عن السلالة ارتبط مستوي إضافة السلنيوم ارتباط موجب ومعنويا مع دليل الصفار. أرتبط عمر الدجاجات ارتباط موجب و معنويا مع كلا من سمك القشرة ولون القشرة ونسبة الصفار، بينما كان الارتباط سالب مع كلا من نسبة القشرة ودليل الصفار ووحدات هاو. ارتبطت مدة التخزين ارتباط موجب و معنويا مع نسبة الصفار، بينما كان الارتباط سالب مع كلا من نسبة البياض ودليل الصفار ووحدات هاو.

ومن ذلك يمكن استنتاج أنه يمكن تحسين جودة البيض المخزن لدجاج المنتزة الذهبي أو الفيومي بالتغذية علي عليقة تحتوي علي السلنيوم في صورة سلبلكس (٢٠٠ ملليجرام للطن) وبالتالي يمكن أن يحسن من القيمة التسويقية للبيض.