EFFECTS OF DIETARY SUPPLEMENTATION WITH GREEN AND BROWN SEAWEEDS ON LAYING PERFORMANCE, EGG QUALITY, AND BLOOD LIPID PROFILE AND ANTIOXIDANT CAPACITY IN LAYING JAPANESE QUAIL

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**ABSTRACT:** The effect of green and brown seaweeds supplementation on laying performance and egg quality, serum lipid profile and antioxidant capacity was evaluated using laying Japanese quails. Five groups of Japanese quails (total n= 180, 120 laying quail hens + 60 male, 10 wks old), each in 3 replicates were used. Birds were fed either a basal diet (control) or basal diet supplemented with green (GS) and brown (BS) seaweeds each at 1.5 and 3\% for 14 weeks. Results indicated that GS and BS supplementation can significantly improve egg-laying rate (P < 0.05) and increase egg number, egg weight and egg mass and improve feed conversion ratio (FCR) (P < 0.05). However, feed consumption (FC) was insignificantly affected by the different treatments. The GS and BS supplemented groups lead to improve the eggshell thickness, also helped to improve egg yolk weight, index and color compared to the control. Supplementing dried GS and BS significantly decreased the value of Haugh unit, significantly decreased the total lipids and total cholesterol content of egg yolk (P<0.05) as well as displayed higher fertility and hatchability percentages (P<0.05) than that of the control group. Quails which had received dried GS and BS treatments had a higher slaughter percentage and a lesser percentage of abdominal fat as compared to the control group. Serum total lipids, triglycerides, cholesterol, HDL and LDL values were significantly decreased as compared to the control group. There are significant effects (P<0.05) on enzymatic antioxidant activities of blood serum. It is concluded that green and brown seaweeds supplementation can improve egg-laying performance and had a positive effect on fertility and hatchability values and resulted in a significant reduction in total lipids and total cholesterol in the serum and yolk while enhancing total antioxidant capacity in blood serum as well as positively affecting economic parameters. Thus, these results suggested that green and brown seaweeds can be used safely as a non-feed additive in diets for laying Japanese quail.

**Key words:** Seaweeds-laying performance-egg quality-antioxidant capacity-laying Japanese quails
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INTRODUCTION
Feed is generally the most expensive input in intensive poultry operations. Cheaper and most promising alternative feed ingredients and additives have been received priority in least-cost feed formulations for poultry. Seaweed, in particular, has attracted great interests because of the high content of essential amino acids, vitamins and trace minerals (Güroy et al., 2007). It is estimated that about 187 kinds of seaweed species in Egypt were listed (45 green, 35 brown and 107 red seaweeds), constituting 16\% of the Mediterranean seaweeds (Coll et al., 2010; Shabakta, 2018). Seaweeds, such as the Ulva species have become important macroalgae, which are considered valuable alternative feeds for a wide range of livestock, mostly as a source of valuable nutrients, especially chelated micro-metals, whose the availability is higher than that found in inorganic compounds; complex carbohydrates with prebiotic activities; and pigments, vitamins, and is especially rich in vitamin C and polyunsaturated fatty acids beneficial to consumer health (Evans and Critchley, 2014; Ortiz et al., 2006; Garcia-Casal et al., 2007). Makkar et al. (2015) reported that the chemical composition of Ulva sp. is as follows: 18.6\% CP, 6.9\% CF, 1.2\% EE, 26.2\% NDF, 8.7\% ADF, 3.5\% lignin, 23\% ash and 14.7 MJ/kg of gross energy on dry matter basis. In poultry, seaweeds were used to improve immune status, to reduce microbial load in the digestive tract, and to their helpful effect on the quality of poultry eggs (Abudabos et al., 2013; Wang et al., 2013a,b). Green seaweed (Ulva lactuca), and brown seaweed (Sargassum Cinereum), are considered as a potential source of nutrients (Table 1), that contain greater amounts of protein, amino acids, carbohydrate, lipid, vitamins A, B, C, (especially B12), colorants, antioxidants and antimicrobial substances (Al-Harthi and El-Deek, 2012; Wang et al., 2013a,b; Mavromichalis, 2014). Green seaweed at 1–3\% improved egg production and egg quality, weight, shell thickness, and yolk color and decreased cholesterol content of egg yolk as well as improved the feed conversion ratio (Wang et al., 2013b). Brown seaweed (Sargassum species) at 1–12\% dietary level fed to laying hens had no adverse effect on body weight, feed conversion ratio, egg production, egg weight and egg quality during 20–30 weeks (El-Deek and Al-Harthi, 2009). Most brown seaweed contains several minerals and organic acids such as alginate and fucoidan. Alginate, which has been enzymatically converted to alginate oligomers, has a stimulatory effect on the secretion of cytokine in immune cells (Iwamoto et al., 2003), and it has a positive effect on the immune system by improving the bioavailability of zinc (Baek et al., 2004). Fucoidan exists in brown seaweed, has been reported to help in blood coagulation (Koo et al., 2001), and has both anticancer (Maruyama et al., 2003) and antioxidant effects (de Souza et al., 2007). Therefore, the main objective of the current study was to evaluate the effect of green and brown seaweeds supplementation (Ulva lactuca and Sargassum Cinereum) on the laying performance, egg quality, fertility and hatchability values, blood serum lipids profile and antioxidative capacity of Japanese quail.

MATERIALS AND METHODS
Seaweeds preparation:
Green seaweed (GS) and Brown seaweed (BS) were handpicked and collected from the Egyptian coastal areas (the Mediterranean Sea and the Red Sea). The
green seaweed (Ulva lactuca) was collected from submerged rocks on the coast of Abu Qir Bay, Mediterranean Sea of Alexandria, Egypt. The brown seaweed (Sargassum Cinereum) was collected from the Red Sea near Hurghada with the help of the National Institute of Oceanography and Fisheries - Hurghada Branch, Egypt. The collected seaweeds were from the species U. lactuca and S. Cinereum in the division of Chlorophyta. Collected seaweeds were adequately washed with fresh water for 3 times to remove salt and sand particles, sun-dried for 7 – 10 days, and then ground into powder using Wiley mill grinder. Samples of the two types of seaweeds were performed to analysis according to AOAC (2005).

The chemical composition of U. lactuca and S. Cinereum is shown in Table 1.

**Experimental design and bird’s management:**

The experiment was performed at the Poultry Research Laboratory, Department of Animal and Fish Production, Faculty of Agriculture (Saba Basha), Alexandria University, Egypt. A hundred and eighty laying Japanese quail hens, which were in production for 10 weeks, were randomly distributed into five treatment groups (24 females and 12 males each) with equal three replicates (8 hens and 4 males each). Birds were selected on the basis of egg production rate by more than 70 % after two weeks of observation. All quails were reared in wire batteries under the same hygienic and environmental conditions throughout the entire experimental period that lasted for 14 weeks. The treatments were as follow: Quails of the control group were fed a basal diet with no supplementation; treatments 2, 3, 4 and 5 were fed the basal diet supplemented with 1.5% and 3% of GS and BS, respectively. The experimental diets were formulated to meet the recommendations of the National Research Council guidelines for laying Japanese quail (NRC, 1994). The composition and calculated analysis of the basal diet is shown in Table 2. Feed and water were available ad libitum and light regimen was of 16/8 h light /dark throughout the experimental period.

**Experimental measurements:**

**Laying performance and egg production:**

Change in body weight (CBW) and feed consumption (FC) were recorded weekly for each replicate. Feed conversion ratio was calculated (g feed / g egg mass). The number of eggs, eggs weight and mortality rate were recorded daily. Egg mass was calculated as the hen-day egg production multiplied by the average weight of eggs.

**Egg quality measurements:**

Fifteen eggs were randomly collected from each treatment every four weeks, weighed individually to determine subsequent egg quality measurements; eggshell thickness without the shell membrane was measured in three locations on the egg (air cell, equator and sharp end) in micrometers. Albumen height, Haugh unit, along with albumen height per egg weight value, was calculated using the method of (An et al., 1997). Egg yolk color was measured using a Roche yolk color fan. Yolk total lipids and yolk total cholesterol were determined by the modified method by Washburn and Nix (1974).

**Fertility and hatchability of eggs:**

All the laid eggs from each treatment replicate were collected daily over 7 days and incubated at a temperature of 37.8 °C with 55% relative humidity for 14 days. They were then transferred to hatcher trays at last 3 days of incubating and were maintained at 37.2 °C and 75% relative humidity until hatching. After hatching,
newborn chicks were counted and non-hatched eggs were broken to determine the percentages of fertility and hatchability. Fertility \% = \frac{\text{number of fertile eggs}}{\text{number of set eggs}} \times 100. Hatchability of set eggs \% = \frac{\text{number of hatched chicks}}{\text{number of set eggs}} \times 100. Hatchability of fertile eggs \% = \frac{\text{number of hatched chicks}}{\text{number of fertile eggs}} \times 100. Hatched chicks rate = \frac{\text{number of chicks hatched}}{\text{the total number of eggs set}}.

Carcass traits:
At the end of the experiment (14 wks), nine quails from each treatment (6 females and 3 males) were randomly selected, weighed individually and slaughtered. After complete bleeding, liver, heart, gizzard, spleen, abdominal fat, cecum and small intestine were separated then weighed and their relative weights were calculated as a percentage of live body weight. The lengths of caeca, small intestine and oviduct were measured.

Blood biochemical analysis and enzymatic antioxidant activity:
Blood samples were collected from slaughtered quails in non-heparinized tubes. Serum was obtained through centrifugation at 3500 r.p.m for 15 min and kept on –20°C until being analyzed. Total lipids, triglycerides, cholesterol, high density lipoprotein (HDL), low density lipoprotein (LDL), and enzymatic antioxidant activity (total antioxidant capacity (TAC), glutathione peroxidase (GPx), superoxide dismutase activity (SOD) and malondialdehyde were colorimetrically determined using a colorimetric method (UV, visible spectrophotometer (Optizen Pop, Mecasys - Korea), using the suitable commercial kits which were purchased from the Egyptian Company for Biotechnology (SPECTRUM. S.A.E, Cairo, Egypt: www.spectrum-diagnostics.com).

The economic efficiency for egg production was calculated from the input / output analysis according to the costs of the experimental diets and the selling price of one kg egg. The values of economic efficiency were calculated as the net revenue per unit of total costs.

Statistical analysis:
Obtained data were statistically analyzed using the general linear model procedure of (Proc GLM; SAS Institute, 2008), differences between treatments were subjected to Duncan’ s Multiple Range – test (Duncan, 1955). The following model was used to study the effect of treatments on the parameters investigated as follows: \( Y_{ij} = \mu + T_i + e_{ij} \) where: \( Y_{ij} \) = an observation, \( \mu \) = overall mean, \( T_i \) = effect of treatment (i=1, 2, 3…..5) and \( e_{ij} \) = experimental random error.

RESULTS AND DISCUSSION
Laying performance and egg production:
The results of laying performance and egg production parameters are shown in Table 3. The laying Japanese quail supplemented with green and brown seaweeds in the feed (1.5 and 3\%) had higher (P<0.05) CBW, laying rate \%, egg number, mean egg weight and egg mass per hen than those of the control group. The tested GS and BS treatments showed significant effects (P<0.05) on the aforementioned parameters throughout the experimental period with inconsisted trend.

The laying rate was improved by 8.79 \% 7.15 \% and 11.40 \% and 8.97 \% for hens fed diet supplemented with GS and BS by 1.5\% and 3\%, respectively compared to control group during the experiment period. The tested GS and BS treatments showed non-significant effects on the FC throughout the experiment period. The FCR for quails in GS and BS treatments were significantly (P<0.05) better than
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that of the control group (2.55, 2.68, 2.53 and 2.58 versus 2.97 g feed: g gain). The mortality did not show differences among treatments.

Seaweed contains rich polysaccharides. Complex polysaccharides in the feed are resistant to acid hydrolysis and can lead to gastrointestinal influx (O’Sullivan et al., 2010). The oligosaccharide-rich seaweed in the digestive tract improved immune status, growth performance and gut microflora (Kulshreshtha et al., 2014). For these reasons, in the present study, it was considered that seaweed rich in oligosaccharide had a positive effect on laying performance. Also, these results may be due to the beneficial components which found in seaweeds such as vitamins (A, B, B12, C), antioxidants, and antimicrobial substances and an alternative source for n-3 fatty acids microalga (Al-Harthi and El-Deek, 2012; Schiavone et al., 2007). These results are in agreement with the observations of Rizk et al. (2017) who reported that supplementing layer diets with green and brown seaweeds improved laying performance and egg production. In the present study, the addition of two types of GS and BS in the feed did not affect feed consumption in layer Japanese quails, and similar results were observed in other studies (Carrillo et al., 2008; Choi et al., 2018). However, FCR was significantly affected due to dietary GS and BS supplementations, these results may be due to that green and brown seaweeds have been improved animal immune status by decreasing microbial load in the digestive tract, which reflect on feed metabolism and improved feed conversion ratio (Wang et al., 2013a, b).

Egg quality:
There were statistically significant differences in all parameters studied for the egg quality except for the relative weights of egg shell and the membrane thickness of egg shell between the GS and BS groups (Table 4). Formation of eggshell was reported to be affected by minerals, such as Ca, P, Mg, K, and so on (NCR, 1994). In the present study, dietary supplementation with GS and BS included many minerals needed to form eggshell and this result is consistent (Makkar et al. 2016; Choi et al. 2018). However, in the current study, there was no difference in the quality of eggs due to all minerals needed to form the egg shell in all experimental feeds. The presented data also showed that, feeding diet supplemented with GS and BS significantly decreased egg yolk content of total lipids and total cholesterol as compared to control. These results are in agreement with the observations of Rizk et al. (2017) who reported that feeding GS and BS powder to laying hens had favorable effects on lowered total lipids and total cholesterol content of eggs. It is worth mention that total lipids reduced by 12.5 %, 16.26, 12.5 and 11.04 mg/g yolk and total cholesterol reduced by about 10.27, 16.43, 12.17 and 15.17 mg/g yolk, respectively in egg yolk, by supplementing GS and BS at 1.5 and 3% compared to control. This reduction in total lipids and total cholesterol content of egg yolk may be associated with their lower levels in blood serum of laying quails that fed the experimental diets. Therefore, it has been suggested that the reduction in egg yolk cholesterol depends on the reduction in cholesterol synthesized in the liver. Hence, the reduction in total lipids and total cholesterol can be attributed to the diminishing effect of herbal extracts on hepatic 3- hydroxy-3-methylglutaryl coenzyme A (HMG-CoA) reductase that is needed to synthesize

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cholesterol in the liver. This refers to the importance of dried seaweeds as natural antioxidants in hens diets as eggs are one of the most widely consumed animal food products.

**Fertility and hatchability of eggs:**
The GS and BS supplemented diets tended to significantly (P<0.05) improve the percentages of hatched chicks and both hatchability of total eggs and of fertile eggs and fertility (Table 5). The percentage of hatchability of fertile eggs of quails were superior (P<0.05) with GS at 3 % and BS at 1.5 % and 3 % supplemented diets, but quails fed GS 1.5% supplemented diet was similar to the control. The percentage of fertility was superior (P<0.05) with BS at 3 % supplemented diet compared to the other groups. The current results are in line with those obtained by (Mobarez Samia et al., 2018; Manafi, 2011; Mariey et al., 2012) who noticed that the percentages of fertility and hatchability were significantly increased for the hens received diet supplemented with Spirulina platensis compared to the control group. Such an increase may be due to the high tocopherols content in green and brown seaweeds. In this respect, El-Khimsawy, (1985) found that tocopherols had a vital role in fertility and hatchability of poultry. Also, Inborr, (1998) reported that Spirulina platensis incorporated into the broiler breeders diets resulted in improved egg fertility and reflected a 5% improvement in hatchability rates.

**Carcass traits:**
The slaughter percentage and relative weights and lengths of different organs are presented in Table 6. The feeding GS and BS treatments did not show significant differences on the relative weights of internal organs; including the heart, spleen, empty intestinal weight, cecum weight. Similarly, there was no significant (P>0.05) difference among treatments in the length of the oviduct. The highest slaughter percentage (%) and the highest relative weights of gizzard, cecum, ovary and testes, and the shortest lengths of the caeca and small intestine were observed in the GS and BS treatment groups as compared to the control group. The BS group at 1.5 and 3% had significantly (P<0.05) lower relative weights of liver and pancreas than the others, and it was followed by the GS at 1.5 and 3% group, but there was no significant difference between the GS group and the control. A lower percentage (%) of abdominal fat (P<0.05) was observed in the GS and BS treatment groups compared to the control group. Previously, Zhou et al. (2009) found that the liver weight increased in broiler, as the oligosaccharide level increased in the experimental diet. The increase in the relative weight of liver might be explained by the synthesis of fat content (Carew et al., 2003). However, in the present study, there was a consistent decrease in the relative weights of liver and abdominal fat resulting in the use of GS and BS at 1.5 and 3% in the laying quail’s diet. However, in the current study, there was no consistent association between intestinal weight and cecum. This obtained result can be explained by the difference of oligosaccharides magnitude among all treatments, the oligosaccharide-rich in cecum improved immune status, growth performance and gut microflora (O’Sullivan et al., 2010). It was considered that increasing cecum influx polysaccharide had an effect on increasing microbial population. It could be noticed that there was a significant increase in the intestinal length by 6.79%, 7.61%, 8.13%, and 5.45% and in the cecum length by 11.21%, 9.30%, 16.82% and 16.82%.
Seaweeds-laying performance-egg quality-antioxidant capacity-laying Japanese quails

respectively, above the control value for groups fed diet supplemented with green and brown seaweed by 1.5 and 3 % compared to the control. These results may be due to seaweeds that used in poultry to improve animal immune status and to reduce microbial load in the gastrointestinal tract (Wang et al., 2013a, b).

Blood biochemical analysis and enzymatic antioxidant activity:
The diet supplemented groups with GS and BS at different levels had the lowest serum total lipids, triglycerides, total cholesterol, HDL and LDL than the control group (p<0.05) (Table 7). Diet supplemented with GS and BS had an increasingly significant effect on TAC, CAT, GPX and SOD activities and the effects of decreasing the MDA contents were more obvious. The results of the present study are inconsistent with the result of Choi et al. (2018) who found that total triglycerides and cholesterol were significantly higher in laying hens had received BS compared to the control. Abouelezz, (2017) reported that the quails supplemented with Spirulina platensis powder at 1% in the feed and at 0.25% in the drinking water did not display significant changes in the serum total antioxidant capacity. The findings of Wang et al. (2013a,b) indicated that there were no significant differences of MDA levels in liver between the normal and the Sargassum fusiforme-fed groups (P>0.05). Seaweed is generally considered a promising source of bioactive peptides have been identified with beneficial properties for human health, including antioxidants (Fan et al., 2014).

Economic efficiency:
The present results indicated that the diet containing green and brown seaweeds as a feed additive result the best net revenue and relative efficiency compared to the control group as shown in Table 8.

CONCLUSION
Dietary supplementation with 1.5% and 3% of green and brown seaweeds is concluded to improve laying performance, egg production, egg quality, hatchability and hatched chicks’ numbers. In addition, up to 3% green and brown seaweeds in the laying Japanese quail’s diet resulted in a significant decrease in serum and yolk total lipids and cholesterol, while enhancing total antioxidant capacity.
Table (1): Chemical composition of Ulva lactuca and Sargassum Cinereum.

<table>
<thead>
<tr>
<th>Items</th>
<th>Ulva lactuca (GS)</th>
<th>Sargassum Cinereum (BS)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chemical analysis (% on DM basis)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OM</td>
<td>81.67</td>
<td>77.46</td>
</tr>
<tr>
<td>CP</td>
<td>21.05</td>
<td>17.66</td>
</tr>
<tr>
<td>CF</td>
<td>9.88</td>
<td>16.87</td>
</tr>
<tr>
<td>EE</td>
<td>3.18</td>
<td>2.78</td>
</tr>
<tr>
<td>NFE</td>
<td>47.56</td>
<td>40.15</td>
</tr>
<tr>
<td>Ash</td>
<td>18.33</td>
<td>22.54</td>
</tr>
<tr>
<td>NDF</td>
<td>38.44</td>
<td>40.33</td>
</tr>
<tr>
<td>ADF</td>
<td>24.28</td>
<td>25.95</td>
</tr>
<tr>
<td>ADL</td>
<td>7.36</td>
<td>7.93</td>
</tr>
<tr>
<td>Hemicellulose</td>
<td>14.16</td>
<td>14.38</td>
</tr>
<tr>
<td>Cellulose</td>
<td>16.92</td>
<td>18.02</td>
</tr>
<tr>
<td><strong>Minerals composition, mg/kg:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium</td>
<td>193.8</td>
<td>203.9</td>
</tr>
<tr>
<td>Potassium</td>
<td>96.9</td>
<td>92.1</td>
</tr>
<tr>
<td>Calcium</td>
<td>72.4</td>
<td>68.3</td>
</tr>
<tr>
<td>Magnesium</td>
<td>200.1</td>
<td>190.3</td>
</tr>
<tr>
<td><strong>Major Anions, mg/kg:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphorus</td>
<td>306.4</td>
<td>292.9</td>
</tr>
<tr>
<td>Iodine</td>
<td>188.9</td>
<td>162.7</td>
</tr>
<tr>
<td><strong>Minor Cations, mg/kg:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lead</td>
<td>0.052</td>
<td>0.09</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.029</td>
<td>0.041</td>
</tr>
<tr>
<td>Iron</td>
<td>2.06</td>
<td>2.43</td>
</tr>
<tr>
<td>Cupper</td>
<td>0.10</td>
<td>0.14</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.08</td>
<td>0.09</td>
</tr>
<tr>
<td>Selenium</td>
<td>1.11</td>
<td>1.02</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.84</td>
<td>0.58</td>
</tr>
</tbody>
</table>
Seaweeds-laying performance-egg quality-antioxidant capacity-laying Japanese quails

Table (2): Composition and calculated analysis of the basal diet.

<table>
<thead>
<tr>
<th>Ingredients (%)</th>
<th>Layer basal diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow corn</td>
<td>50.20</td>
</tr>
<tr>
<td>Soybean meal (48%)</td>
<td>31.42</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>7.56</td>
</tr>
<tr>
<td>Di-calcium phosphate</td>
<td>1.16</td>
</tr>
<tr>
<td>Limestone</td>
<td>5.00</td>
</tr>
<tr>
<td>Sunflower oil</td>
<td>3.80</td>
</tr>
<tr>
<td>Vit. and min. mix. ¹</td>
<td>0.46</td>
</tr>
<tr>
<td>Salt (NaCl)</td>
<td>0.40</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

**Calculated analysis:**

<table>
<thead>
<tr>
<th></th>
<th>Layer basal diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude protein, %</td>
<td>20.05</td>
</tr>
<tr>
<td>ME (Kcal/kg diet)</td>
<td>2889</td>
</tr>
<tr>
<td>Ether extract, %</td>
<td>2.43</td>
</tr>
<tr>
<td>Crude fiber, %</td>
<td>3.00</td>
</tr>
<tr>
<td>Methionine, %</td>
<td>0.45</td>
</tr>
<tr>
<td>Methionine + cystine, %</td>
<td>0.74</td>
</tr>
<tr>
<td>Lysine, %</td>
<td>1.01</td>
</tr>
<tr>
<td>Calcium, %</td>
<td>2.63</td>
</tr>
<tr>
<td>Av. Phosphorus</td>
<td>0.33</td>
</tr>
</tbody>
</table>

¹ Each kg of vitamin and minerals mixture contained: Vit. A, 10,000,000 IU; Vit. D3, 3,000,000 IU; Vit. E, 2500 mg., Vit. K3, 4000 mg., Vit. B1, 5000 mg., Vit. B2, 500 mg., Vit. B6, 2500 mg., Vit. B12, 5 mg., Vit. C, 10,000 mg., Nicotinamide, 20,000 mg., Pantothenic acid, 5000 mg., Biotin, 5 mg., Folic acid, 250 mg., D.L Methionine, 10,000 mg., L. Lysine, 5,000 mg., Fe, 70 mg., CuSO₄, 120 mg., ZnSO₄, 60 mg., MnSO₄, 160 mg., CoSO₄, 16.2 mg., MgSO₄, 70 mg., Calcium iodate, 50 mg., NaCl, 7,000 mg., KCl, 15,000 mg., Antioxidant. D.H.D, 5,000 mg.
Table (3): Effect of dietary supplementation with green and brown seaweeds on productive performance of laying Japanese quail.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Control</th>
<th>GS</th>
<th>BS</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.5 %</td>
<td>3 %</td>
<td>1.5 %</td>
<td>3 %</td>
</tr>
<tr>
<td>Change in body weight, g</td>
<td>16.85±4.94</td>
<td>28.66±3.64</td>
<td>21.07±2.82</td>
<td>22.17±3.47</td>
</tr>
<tr>
<td>Egg laying rate %</td>
<td>78.35±1.98</td>
<td>85.24bc±1.29</td>
<td>83.95b±1.29</td>
<td>87.28ab±0.20</td>
</tr>
<tr>
<td>Egg number, hen/day</td>
<td>0.78±0.02</td>
<td>0.88±0.04</td>
<td>0.84±0.01</td>
<td>0.87ab±0.00</td>
</tr>
<tr>
<td>Mean egg weight, g</td>
<td>13.22±0.07</td>
<td>13.74±0.15</td>
<td>13.56b±0.08</td>
<td>13.74ab±0.06</td>
</tr>
<tr>
<td>Egg mass/hen/day, g</td>
<td>10.35±0.24</td>
<td>12.11±0.15</td>
<td>11.39b±0.12</td>
<td>11.99±0.06</td>
</tr>
<tr>
<td>Feed consumed /hen /day, g</td>
<td>30.54±0.28</td>
<td>31.56±0.20</td>
<td>30.82±1.03</td>
<td>30.13±0.34</td>
</tr>
<tr>
<td>Feed conversion ratio</td>
<td>2.97±0.07</td>
<td>2.55b±0.13</td>
<td>2.68b±0.11</td>
<td>2.53b±0.03</td>
</tr>
<tr>
<td>Mortality rate %</td>
<td>8.33±0.11</td>
<td>8.33b±0.09</td>
<td>2.78b±0.05</td>
<td>2.78b±0.02</td>
</tr>
</tbody>
</table>

a-c Means in the same row having different letters are significantly different (P≤0.05).
Table (4): Effect of dietary supplementation with green and brown seaweeds on egg quality of laying Japanese quails.

<table>
<thead>
<tr>
<th>Treats</th>
<th>Control</th>
<th>1.5 %</th>
<th>3 %</th>
<th>1.5 %</th>
<th>3 %</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg shape index, (%)</td>
<td>78.470±1.099</td>
<td>80.419±0.484</td>
<td>79.170b±0.372</td>
<td>81.003a±0.515</td>
<td>79.688ab±0.432</td>
<td>0.037</td>
</tr>
<tr>
<td>Egg shell weight (%)</td>
<td>10.459±0.182</td>
<td>10.166±0.319</td>
<td>10.330±0.064</td>
<td>10.161±0.368</td>
<td>10.151±0.268</td>
<td>0.741</td>
</tr>
<tr>
<td>Shell thickness, (mm)</td>
<td>0.197b±0.006</td>
<td>0.204ab±0.004</td>
<td>0.205±0.003</td>
<td>0.206±0.002</td>
<td>0.207±0.003</td>
<td>0.016</td>
</tr>
<tr>
<td>Membrane thickness of egg shell (mm)</td>
<td>0.015±0.003</td>
<td>0.019±0.002</td>
<td>0.019±0.005</td>
<td>0.016±0.002</td>
<td>0.014±0.004</td>
<td>0.844</td>
</tr>
<tr>
<td>Haugh unit, (%)</td>
<td>81.254a±0.414</td>
<td>79.370b±0.555</td>
<td>79.412b±1.522</td>
<td>79.188b±0.685</td>
<td>78.761b±1.069</td>
<td>0.007</td>
</tr>
<tr>
<td>Yolk weight, (%)</td>
<td>28.512c±0.174</td>
<td>31.148b±0.292</td>
<td>29.698b±0.168</td>
<td>31.325b±0.150</td>
<td>30.748ab±0.447</td>
<td>0.003</td>
</tr>
<tr>
<td>Yolk index, (%)</td>
<td>45.427c±0.259</td>
<td>47.711ab±0.149</td>
<td>46.485b±0.528</td>
<td>48.273b±0.556</td>
<td>46.666b±0.472</td>
<td>0.001</td>
</tr>
<tr>
<td>Yolk color</td>
<td>2.889c±0.222</td>
<td>3.889ab±0.294</td>
<td>4.222a±0.111</td>
<td>3.556b±0.111</td>
<td>3.556b±0.401</td>
<td>0.001</td>
</tr>
<tr>
<td>Albumen weight, (%)</td>
<td>42.657a±0.202</td>
<td>41.435b±0.425</td>
<td>41.171b±0.860</td>
<td>41.857b±0.371</td>
<td>41.457b±0.001</td>
<td>0.039</td>
</tr>
<tr>
<td>Egg yolk total lipids, (mg/g yolk)</td>
<td>434.67±12.47</td>
<td>380.33b±5.93</td>
<td>364.00±2.65</td>
<td>380.33b±4.10</td>
<td>386.67b±5.49</td>
<td>0.001</td>
</tr>
<tr>
<td>Egg yolk total cholesterol, (mg/g yolk)</td>
<td>211.00a±9.07</td>
<td>189.33b±4.84</td>
<td>176.33±7.84</td>
<td>185.33bc±5.81</td>
<td>179.00c±9.07</td>
<td>0.001</td>
</tr>
</tbody>
</table>

a-c Means in the same row having different letters are significantly different (P≤0.05).
Table (5): Effect of dietary supplementation with green and brown seaweeds on fertility and hatchability of laying Japanese quails.

<table>
<thead>
<tr>
<th>Items</th>
<th>Dietary treatments</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>GS</td>
</tr>
<tr>
<td>Fertility, (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.5 %</td>
<td>3 %</td>
</tr>
<tr>
<td></td>
<td>83.60 ± 0.31</td>
<td>85.30 ± 0.72</td>
</tr>
<tr>
<td>Hatchability of total eggs(%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>51.40 ± 1.40</td>
<td>58.23 ± 3.36</td>
</tr>
<tr>
<td>Hatchability of fertile eggs(%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>65.77 ± 0.28</td>
<td>65.46 ± 0.34</td>
</tr>
<tr>
<td>Hatched chicks No.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19.00 ± 0.37</td>
<td>20.22 ± 0.56</td>
</tr>
</tbody>
</table>

Means in the same row having different letters are significantly different (P≤0.05).
Table (6): Effect of dietary supplementation with green and brown seaweeds on carcass characteristics of laying Japanese quails.

<table>
<thead>
<tr>
<th>Items</th>
<th>Control</th>
<th>GS 1.5%</th>
<th>GS 3%</th>
<th>BS 1.5%</th>
<th>BS 3%</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live weight (g)</td>
<td>257.78±8.32</td>
<td>254.07±3.49</td>
<td>256.87±4.42</td>
<td>252.67±4.66</td>
<td>255.03±11.34</td>
<td>0.897</td>
</tr>
<tr>
<td>Slaughter weight (%)</td>
<td>66.89±0.65</td>
<td>69.41±0.80</td>
<td>68.79±0.26</td>
<td>71.30±0.44</td>
<td>70.49±1.01</td>
<td>0.007</td>
</tr>
<tr>
<td>Liver weight (%)</td>
<td>1.876±0.225</td>
<td>1.631±0.175</td>
<td>1.630±0.252</td>
<td>1.566±0.199</td>
<td>1.599±0.257</td>
<td>0.039</td>
</tr>
<tr>
<td>Heart weight (%)</td>
<td>0.835±0.052</td>
<td>0.840±0.047</td>
<td>0.840±0.030</td>
<td>0.803±0.073</td>
<td>0.832±0.085</td>
<td>0.788</td>
</tr>
<tr>
<td>Gizzard weight (%)</td>
<td>1.265±0.037</td>
<td>1.591±0.241</td>
<td>1.571±0.064</td>
<td>1.739±0.126</td>
<td>1.515±0.094</td>
<td>0.004</td>
</tr>
<tr>
<td>Spleen weight (%)</td>
<td>0.067±0.003</td>
<td>0.063±0.005</td>
<td>0.053±0.005</td>
<td>0.056±0.010</td>
<td>0.047±0.011</td>
<td>0.846</td>
</tr>
<tr>
<td>Pancreas weight (%)</td>
<td>0.159±0.028</td>
<td>0.153±0.011</td>
<td>0.146±0.009</td>
<td>0.134±0.025</td>
<td>0.132±0.025</td>
<td>0.029</td>
</tr>
<tr>
<td>Abdominal fat weight(%)</td>
<td>3.264±0.151</td>
<td>2.677±0.076</td>
<td>2.586±0.139</td>
<td>2.545±0.178</td>
<td>2.594±0.148</td>
<td>0.002</td>
</tr>
<tr>
<td>Empty intestinal weight(%)</td>
<td>1.683±0.185</td>
<td>1.998±0.263</td>
<td>2.091±0.302</td>
<td>1.901±0.134</td>
<td>1.876±0.308</td>
<td>0.688</td>
</tr>
<tr>
<td>Intestinal length (cm)</td>
<td>61.33±2.49</td>
<td>65.50±2.43</td>
<td>66.00±3.43</td>
<td>66.32±1.91</td>
<td>64.67±2.12</td>
<td>0.007</td>
</tr>
<tr>
<td>Cecum weight (%)</td>
<td>0.599±0.042</td>
<td>0.592±0.068</td>
<td>0.612±0.041</td>
<td>0.584±0.055</td>
<td>0.547±0.058</td>
<td>0.866</td>
</tr>
<tr>
<td>Cecum length (cm)</td>
<td>8.92±0.27</td>
<td>9.92±0.47</td>
<td>9.75±0.36</td>
<td>10.42±0.32</td>
<td>10.42±0.64</td>
<td>0.003</td>
</tr>
<tr>
<td>Ovary weight (%)</td>
<td>0.451±0.007</td>
<td>0.588±0.016</td>
<td>0.543±0.015</td>
<td>0.561±0.035</td>
<td>0.527±0.059</td>
<td>0.011</td>
</tr>
<tr>
<td>Oviduct weight (%)</td>
<td>2.911±0.021</td>
<td>3.332±0.111</td>
<td>3.071±0.050</td>
<td>3.278±0.071</td>
<td>3.109±0.047</td>
<td>0.037</td>
</tr>
<tr>
<td>Oviduct length (cm)</td>
<td>41.00±0.82</td>
<td>40.67±1.25</td>
<td>40.50±1.06</td>
<td>40.50±0.54</td>
<td>40.00±0.41</td>
<td>0.735</td>
</tr>
<tr>
<td>Testes weight (%)</td>
<td>3.167±0.090</td>
<td>3.756±0.062</td>
<td>3.303±0.055</td>
<td>3.708±0.022</td>
<td>3.848±0.033</td>
<td>0.014</td>
</tr>
</tbody>
</table>

a-c Means in the same row having different letters are significantly different (P≤0.05).
Table (7): Effect of dietary supplementation with green and brown seaweeds on blood biochemical parameters and enzymatic antioxidant activity of laying Japanese quails.

<table>
<thead>
<tr>
<th>Items</th>
<th>Dietary treatments</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>GS 1.5%</td>
</tr>
<tr>
<td><strong>Biochemical blood parameters:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total lipids (mg/dl)</td>
<td>460.43±5.70</td>
<td>377.98±4.19</td>
</tr>
<tr>
<td>Triglycerides (mg/dl)</td>
<td>110.39±0.99</td>
<td>78.26±2.49</td>
</tr>
<tr>
<td>Total Cholesterol (mg/dl)</td>
<td>177.92±5.97</td>
<td>132.13±3.81</td>
</tr>
<tr>
<td>LDL (mg/dl)</td>
<td>83.59±1.17</td>
<td>46.63±0.47</td>
</tr>
<tr>
<td>HDL (mg/dl)</td>
<td>73.52±1.56</td>
<td>62.95±0.96</td>
</tr>
<tr>
<td><strong>Enzymatic antioxidant activity:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MDA (mg/dl)</td>
<td>37.52±0.46</td>
<td>30.56±0.35</td>
</tr>
<tr>
<td>TAC (U/mL)</td>
<td>184.68±2.03</td>
<td>212.53±2.32</td>
</tr>
<tr>
<td>CAT (U/L)</td>
<td>7.70±0.08</td>
<td>9.10±0.23</td>
</tr>
<tr>
<td>GPx (U/L)</td>
<td>3.64±0.12</td>
<td>5.40±0.34</td>
</tr>
<tr>
<td>SOD (U/L)</td>
<td>9.94±0.26</td>
<td>11.92±0.27</td>
</tr>
</tbody>
</table>

Means in the same row having different letters are significantly different (P≤0.05).
AG ratio = Albumin/ Globulin ratio; HDL-c = High density lipoprotein concentration; LDL-c = Low density lipoprotein concentration.
MDA = Malondialdehyde; TAC = Total antioxidant capacity; CAT = Catalase; GPx = glutathione peroxidase; SOD = Superoxide dis-mutase.
**Table (8):** Effect of dietary supplementation with green and brown seaweeds during laying period on economic efficiency of Japanese quails.

<table>
<thead>
<tr>
<th>Items</th>
<th>control</th>
<th>1.5 %</th>
<th>3 %</th>
<th>1.5 %</th>
<th>3 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total feed intake (kg/bird/14weeks)</td>
<td>2.993</td>
<td>3.093</td>
<td>3.020</td>
<td>2.953</td>
<td>2.948</td>
</tr>
<tr>
<td>Feed cost/kg (L.E)*</td>
<td>4.34</td>
<td>4.37</td>
<td>5.00</td>
<td>4.37</td>
<td>5.00</td>
</tr>
<tr>
<td>Total feed cost (L.E)</td>
<td>12.99</td>
<td>13.52</td>
<td>15.10</td>
<td>12.91</td>
<td>14.74</td>
</tr>
<tr>
<td>Egg number (hen/14 weeks)</td>
<td>77.48</td>
<td>79.10</td>
<td>83.54</td>
<td>81.15</td>
<td>81.26</td>
</tr>
<tr>
<td>Total revenue</td>
<td>42.61</td>
<td>43.51</td>
<td>45.95</td>
<td>44.63</td>
<td>44.69</td>
</tr>
<tr>
<td>Net revenue</td>
<td>29.62</td>
<td>29.99</td>
<td>30.85</td>
<td>31.72</td>
<td>29.95</td>
</tr>
<tr>
<td>Economic efficiency %</td>
<td>2.28</td>
<td>2.22</td>
<td>2.04</td>
<td>2.46</td>
<td>2.03</td>
</tr>
<tr>
<td>Relative efficiency</td>
<td>100</td>
<td>10.25</td>
<td>104.15</td>
<td>107.09</td>
<td>101.11</td>
</tr>
</tbody>
</table>

*Based on average price of diets during the experimental time.
Price / one egg (55 PT) according to the local market price at the experimental time.
REFERENCES


Seaweeds-laying performance-egg quality-antioxidant capacity-laying Japanese quails


تأثير إضاف الأعشاب البحرية الخضراء والبنية على الأداء الإنتاجي، وجودة البيض، والدهون والمضادات الأكسدة في الدم في السمان الياباني اليماني
حسن زويل1، سامح هاشم أبو حفص2، سليمان زهرا3، محمد حسن أحمد4، وليد دسوقى1
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2 قسم بحوث الحيوانات المرضية - معهد بحوث الأراضي الفلاحية - مدينه الأبحاث العلميه والتطبيقات التكنولوجيه - مدينه برج العرب - مصر.

يجريت هذه التجربة لتقييم تأثير إضاف الأعشاب البحرية الخضراء والبنية المجهفه إلى علاق السمان الياباني اليماني على الأداء الإنتاجي وتحقيق الوزن النسيب لبعض الأعشاب. وتحقيق جودة البيض وتحديد محتوي الصفار من الدهون والكوليسترول الكلي. تم توزيع عدد 180 طائر من السمان الياباني اليماني عمر 10 أسابيع وزناً توزعوا عشوائياً على مجموعتا سمان متساوية في كل مجموعة ثلاث مكررات متساوية. كل مجموعة (120 سمان، بıyor عدد 60 ذكر). وتكرار تكوين 4 مجموعات: المجموعة الأولى ب(dummy) وهي الكنترول. ثم اخذت هذه المجموعة كالمراجعة. وتم إختبارها على النتائج الأساسية بدون أي إضافات، بينما تم إعطاء المجموعات الثانية والثالثة والرابعة والخامسة مضافاً الـ 1/5 من الفيبرة المجهفه (BS) وفريكة (GS) في المائة ومعدل 1.5% و3% على التوالي لمدة أسبوعين. وكانت النتائج المحصل عليها كالتالي:

أوضح النتائج أن مكملات الفيبرة من الأعشاب البحرية الخضراء والبنية من معدل 1.5% و3% أدى إلى تحسن ملحوظ في معدلات وضع البيض وزائدة عدد وزن وكثافة البيض مقارنة بمجملة الكنترول. لم يتأثر استهلاك الطيور بشكل معنوي من المعدلات المختلفة، بينما تزداد محتويات الفيبرة في معدل التوسع الغذائي أثناء فترة التجربة الكلية مقارنة بالمجملة الكنترول. أما في معدل السمن البائي على علاقة مع مقدمة الـ 1.5% و3% من الأعشاب البحرية الخضراء والبنية (BS) والإعدادي معروض الصفار بـ 1.11 مقارنة بالمجملة الكنترول. أما الأعشاب البحرية الخضراء والبنية المجهفه (GS) في زيادة متميزة في معدلات وضع البيض. كما ساعد في تحسين كميات وزن صفر البيض، في تحسين حالة إضافة الصفر من الدهون الكلي، وانخفاض في معنوي معدل السمن البائي (GS) والكوليسترول الكلي، بينما كانت هذه الإضافات من مكملات الفيبرة، في معدل 1.5% و3% نسبة تضاعف من مقدمة الـ 1.11 مقارنة بالمجملة الكنترول. حيث أن النتائج سجلت مجموعات السمان التي تتناقص على معاملات مضفاة إضافة الأعشاب البحرية الخضراء والبنية المجهفه. بدلاً من وضع البيض، بينما كانت النسب أقل من دهون من طبق اضافة البائي مقارنة بالمجملة الكنترول. كما تظهرت تأثيرات إيجابية على الفيبرة من السمن البائي. والكوليسترول الكلي، والدهون في تركيب الـ (LDL) والدهون بنية الكولسترول. وكان هناك تأثير إيجابي على الأنشطة المضادة للأكسدة، والمستويات من الـ (HDL) مرتفعات الكولسترول. للكبد، والمجهفه في معدل 1.5% و3% نسبة تضاعف من مقدمة الـ 1.11 مقارنة بالمجملة الكنترول. أظهرت إضافات الأعشاب البحرية الخضراء والبنية المجهفه إفادة في علاج السمن اليماني اليماني وضع البيض، مما أدى إلى تحسين في معدلات وضع البيض. كما أن لها تأثير إيجابي على جودة البيض وخفض محتوى الصفر من الدهون الكلي، وزائدة تركيب الـ (LDL) والكوليسترول الكلي، وزيادة الفيبرة مثبط الدهون للكبد. وكذلك تأثر إيجابياً على الكفاءة الاقتصادية. وبالتالي فإن هذه النتائج تشير إلى أن سمح الأعشاب البحرية الخضراء والبنية يمكن استخدامها كمضافات أمينة في علاج السمن الياباني اليماني.