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

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ABSTRACT: The effect of green and brown seaweeds supplementation on laying performance, egg quality, serum lipid profile and antioxidant capacity was evaluated in Japanese quails. Five groups of Japanese quails (total = 180; 120 hens + 60 males) of 10 wks old were fed on diets without or with green (GS) and brown (BS) seaweeds, each at 1.5 and 3% for 14 weeks. Results indicate that GS and BS supplementation significantly improved egg-laying rate and increase egg number, egg weight and egg mass and decrease feed conversion ratio (FCR). However, feed consumption (FC) was not significantly affected by experimental treatments. The GS and BS supplemented groups led to improve the eggshell thickness, also helped to improve the egg yolk weight, index and color compared to the control. Supplementing dried GS and BS significantly decreased the value of Haugh unit, total lipids and total cholesterol content of egg yolk as well as displayed higher fertility and hatchability percentages than those of the control group. Quails received dried GS and BS treatments had a higher dressing percentage and a lesser percentage of abdominal fat compared to the control group. Serum total lipids, triglycerides, total cholesterol, HDL and LDL values were significantly decreased compared to the control. There were significant effects on enzymatic antioxidant activity of blood serum (malondialdehyde, total antioxidant capacity, catalase, glutathione peroxidase and superoxide dismutase). 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 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 feed additive in diets for laying Japanese quail.

Key words: Laying quail – seaweeds – performance - egg quality - antioxidant capacity

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; Shabaka, 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; pigments, vitamins, and are 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 spp*. is as follow: 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 have been 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 which contain greater amounts of protein, amino acids, carbohydrate, lipid, vitamins A, B, B12 and C, colorants, antioxidants and antimicrobial substances (Al-Harthi and El-Deek, 2012; Wang et al., 2013a,b; Mavromichalis, 2014). Green seaweed at 1–3% of the feed 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 Fasciata* 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 and Brown seaweed were handpicked and collected from the

Egyptian coastal areas (the Mediterranean Sea and the Red Sea). The green seaweed (*Ulva Fasciata;* GS) was collected from submerged rocks on the coast of Abu Qir Bay, Mediterranean Sea of Alexandria, Egypt. The brown seaweed (*Sargassum Cinereum;* BS) 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. Fasciata* 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 analyzed according to AOAC (2005). The chemical composition of *U. Fasciata* 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 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: control group fed a basal diet with no seaweeds supplementation; treatments 2, 3, 4 and 5 were fed the basal diet supplemented with 1.5% and 3% GS or 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 are shown in Table 2. Feed and water were available *ad libitium* and light regimen was of 16/8 h light /dark throughout the experimental period.

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 were collected daily over 7 days (during 15^{th}, 19^{th} and 22^{th} weeks of age) and were 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 incubation and were maintained at 37.2 °C and 75% relative humidity until hatching. After being hatched, chicks were counted and non-hatched eggs were broken to determine the percentages of fertility and hatchability. Fertility % = (number of fertile eggs / number of set eggs) × 100. Hatchability of set eggs % = (number of hatched chicks / number of set eggs) × 100. Hatchability of fertile eggs % = (number of hatched chicks / number of fertile eggs) ×100. Hatched chicks rate = the number of chicks hatched / the total number of eggs set.

Carcass traits:

At the end of the experiment, 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 in cm^2.

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, μ = 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 at 1.5 and 3% in the diet had higher 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 on the aforementioned parameters throughout the experimental period with inconsistant 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 effect on the FC throughout the experiment period. The FCR for quails in GS and BS treatments were significantly better than that of the control group (2.55, 2.68, 2.53 and 2.58 versus 2.97 g feed: g gain). The mortality rate was within acceptable range for all 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, B_{12}, 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 FC 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 traits 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 (NRC, 1994). In current study, dietary supplementation with GS and BS included many minerals necessary for eggshell formation (Makkar *et al*. 2016; Choi *et al*. 2018). However, in this study, there was no difference in the quality of eggs due to all the minerals needed to form eggshell were provided 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 compared to the control (Table 4).

These results are in agreement with those reported by Rizk *et al*. (2017) who showed that feeding GS and BS powder to laying hens had favorable effects on lowering 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 cholesterol in the liver. This refers to the importance of dried seaweeds as natural antioxidant in the hen diets that eggs are one the most widely consumed animal food products.

Fertility and hatchability of eggs:

The current results confirmed a positive effect of both GS and BS at levels 1.5% and 3%, which increased the hatching rate significantly by 13.29 %, 16.10 %, 7.16 % and 15.23 % of total eggs compared to the control group. This positive effect resulted from a significant increase in the fertility percentage (2.03 %, 3.96 %, 3.62 % and 5.84 %), respectively, compared with control group. Supplementing both GS and BS in diet of Japanese laying quails can be an effective tool to increase the weight of newly-hatched chicks, and this effective improvement was significant compared to control group. Newly hatched chicks for GS and BS at 1.5% and 3% surpassed the control one by 6.42 %, 14.05 %, 9.95 % and 12.84 %, respectively.

The current results are in line with those obtained by Mobarez *et al*. (2018); Manafi (2011); Mariey *et al.* (2012) who reported 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 dressing percentage and relative weights and lengths of different organs are presented in Table 6. Feeding GS and BS diets 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 between treatments in the length of the oviduct.

Dressing percentage and relative weight of gizzard, ovary and testes were higher and lengths of the caeca and small intestine were longer in GS and BS groups compared to the control group. The BS group at 1.5 and 3% had significantly 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 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 upon using of GS and BS at 1.5 and 3% in the laying quail’s diet. In current study, there was no consistent association between intestinal and cecum weight. 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 %, respectively, above the control value for groups fed diet supplemented with GS and BS by 1.5 and 3 % compared to the control. These results may be due to that seaweeds could improve 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 (Table 7). Similar results were obtained by Abouelezz (2017) who indicated that serum total cholesterol was significantly lowered in Japanese quails fed *Spirulina platensis* in diets than those in the control. Rizk *et al*. (2017) found that the lowest value of triglycerides and total cholesterol were recorded for laying hens fed on diet supplemented with brown seaweed by 0.2. Similarly, Selim *et al*. (2018) showed that the concentration of serum cholesterol decreased significantly in laying hens as dietary *Spirulina platensis* increased. However, Choi *et al.* (2018) found that triglycerides and total cholesterol were significantly higher in laying hens had received 0.5 % brown seaweed compared to the control.

Diet supplemented with GS and BS had an increasingly significant effect on TAC, CAT, GPX and SOD activities and the effect in decreasing the MDA concentration were obvious (Table 7). Seaweeds are considered a promising source of bioactive peptides and have demonstrated various beneficial properties such as antioxidant potential (Chandini *et al.,* 2008; Fan *et al.,* 2014). Similar results were reported by Li *et al*. (2018) who reported that the concentration of TAC and SOD in 0.5 to 1% groups supplemented with Ulvan extracted from green seaweed was significantly higher than that the control group ($P<0.05$), and MDA was significantly decreased. However, Abouelezz (2017) reported that the quails supplemented with *Spirulina platensis* powder at 1% in the feed did not display significant changes in the serum TAC.

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 improved laying performance, egg production, egg quality, hatchability and hatched chicks' number of Japanese quails. 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): Ingredients chemical composition of *Ulva Fasciata* and *Sargassum Cinereum*.

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

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

Ingredients (%)	**Layer basal diet**
Yellow corn	50.20
Soybean meal (48%)	31.42
Wheat bran	7.56
Di-calcium phosphate	1.16
Limestone	5.00
Sunflower oil	3.80
Vit. and min. mix. [1]	0.46
Salt (NaCl)	0.40
Total	100
Calculated analysis:	
Crude protein, %	20.05
ME (Kcal /kg diet)	2889
Ether extract, %	2.43
Crude fiber, %	3.00
Methionine, %	0.45
Methionine + cystine, %	0.74
Lysine, %	1.01
Calcium, %	2.63
Av. Phosphorus	0.33

[1] Each kg of vitamin and minerals mixture contained: Vit. A, 10000 I.U; vit. D3 2000 I.U;vit. E 15mg; vit. K3 1 µg; vit B1 1mg; vit. B2 5mg; vit. B12 10 µg; vit B6 1.5mg; Niacin 30mg;Pantothenic acid 10mg; folic acid 1mg; Biotin 50 mg; choline chloride 300 mg; zinc 50mg; copper4mg; iodine 0.3 mg; iron 30mg; selenium 0.1mg; manganese 60mg; cobalt 0.1mg and carrier $CaCO_3$ up to 1 kg

Table (3): Effect of dietary supplementation with green and brown seaweeds on productive performance of laying Japanese quail.

Parameters	Control	GS		BS		P-value
		1.5 %	3 %	1.5 %	3 %	
Change in body weight, g	16.85^{c} ± 4.94	28.66^{a} ± 3.64	21.07^{b} ± 2.82	22.17^{b} ± 3.47	23.75^{b} ± 3.22	0.001
Egg laying rate %	78.35^{c} ± 1.98	85.24^{ab} ± 1.29	83.95^{b} ± 1.29	87.28^{a} ± 0.20	85.38^{ab} ± 0.13	0.006
Egg number, hen/day	0.78^{c} ± 0.02	0.88^{a} ± 0.04	0.84^{b} ± 0.01	0.87^{ab} ± 0.00	0.85^{b} ± 0.00	0.026
Mean egg weight, g	13.22^{c} ± 0.07	13.74^{a} ± 0.15	13.56^{b} ± 0.08	13.74^{a} ± 0.06	13.62^{ab}±0.12	0.041
Egg mass/hen/day, g	10.35^{c} ± 0.24	12.11^{a} ± 0.15	11.39^{b} ± 0.12	11.99^{a} ± 0.06	11.18^{b} ±0.12	0.017
Feed consumed /hen /day, g	30.54 ± 0.28	31.56 ± 0.20	30.82 ± 1.03	30.13 ± 0.34	30.08 ± 0.71	0.844
Feed conversion ratio	2.97^{a} ± 0.07	2.55^{b} ± 0.13	2.68^{b} ± 0.11	2.53^{b} ± 0.03	2.58^{b} ± 0.06	0.028
Mortality rate %	8.33^{a} ± 0.11	8.33 ^{a} ± 0.09	2.78 ^{b} ± 0.05	2.78^{b} ± 0.02	8.33^{a} ± 0.08	0.035

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 quail.

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

[a-c] Means in the same row having different letters are significantly different ($P \leq 0.05$).

Table (5): Effect of dietary supplementation with green and brown seaweeds on fertility and hatchability of laying Japanese quail.

Items	Dietary treatments					P-value
	Control	GS		BS		
		1.5 %	3 %	1.5 %	3 %	
Fertility, (%)	83.60^{b} ± 0.31	85.30^{b} ± 0.72	86.91^{ab} ± 1.37	86.63^{ab} ± 0.62	88.48^{a} ± 1.11	0.031
Hatchability of total eggs (%)	51.40^{b} ± 1.40	58.23^{a} ± 3.36	59.63^{a} ± 4.35	55.08^{a} ± 2.59	59.23^{a} ± 2.34	0.005
Hatchability of fertile eggs (%)	65.77^{b} ± 0.28	65.46^{b} ± 0.34	68.18^{a} ± 0.77	69.37^{a} ± 1.66	70.70^{a} ± 0.52	0.001
Hatched chicks No.	19.00^{b} ± 0.37	20.22^{a} ± 0.56	21.67^{a} ± 1.01	20.89^{a} ± 0.43	21.44^{a} ± 0.41	0.011

$^{a-c}$ Means in the same row having different letters are significantly different ($P \leq 0.05$).

Table (6): Effect of dietary supplementation with green and brown seaweeds on carcass characteristics of laying Japanese quail.

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

$^{a-c}$ Means in the same row having different letters are significantly different ($P \leq 0.05$).

Table (7): Effect of dietary supplementation with green and brown seaweeds on blood biochemical parameters and enzymatic antioxidant activity of laying Japanese quail.

Items	Dietary treatments					P-value
	Control	GS		BS		
		1.5 %	3 %	1.5 %	3 %	
Biochemical blood parameters:						
Total lipids (mg/dl)	460.43^{a} ± 5.70	377.98^{b} ± 4.19	365.82^{b} ± 6.88	354.34^{b} ± 3.82	351.91^{b} ± 2.19	0.001
Triglycerides (mg/dl)	110.39^{a} ± 0.99	78.26^{b} ± 2.49	76.14^{b} ± 1.82	78.83^{b} ± 1.06	71.53^{b} ± 0.57	0.001
Total Cholesterol (mg/dl)	177.92^{a} ± 5.97	132.13^{b} ± 3.81	121.43^{c} ± 2.64	131.54^{b} ± 2.79	127.09^{c} ± 2.14	0.001
LDL (mg/dl)	83.59^{a} ± 1.17	46.63^{b} ± 0.47	42.39^{b} ± 1.08	42.91^{c} ± 0.94	42.78^{c} ± 1.00	0.001
HDL (mg/dl)	73.52^{a} ± 1.56	62.95^{b} ± 0.96	62.28^{b} ± 0.18	61.99^{b} ± 0.29	61.50^{b} ± 0.21	0.001
Enzymatic antioxidant activity:						
MDA (mg/dl)	37.52^{a} ± 0.46	30.56^{b} ± 0.35	27.68^{c} ± 0.67	28.28^{bc} ± 0.51	25.10^{c} ± 0.23	0.001
TAC (U/mL)	184.68^{c} ± 2.03	212.53^{b} ± 2.32	227.87^{ab} ± 7.65	227.60^{ab} ± 1.02	232.62^{a} ± 0.92	0.001
CAT (U/L)	7.70^{b} ± 0.08	9.10^{a} ± 0.23	9.52^{a} ± 0.25	9.21^{a} ± 0.07	9.75^{a} ± 0.12	0.015
GPx (U/L)	3.64^{b} ± 0.12	5.40^{a} ± 0.34	5.70^{a} ± 0.15	5.73^{a} ± 0.04	5.85^{a} ± 0.07	0.019
SOD (U/L)	9.94^{c} ± 0.26	11.92^{b} ± 0.27	13.25^{a} ± 0.36	12.23^{ab} ± 0.11	13.95^{a} ± 0.13	0.001

$^{a\text{-}d}$ Means in the same row having different letters are significantly different ($P \le 0.05$).

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 quail.

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

*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.

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Laying quail – seaweeds – performance - egg quality- antioxidant capacity

الملخص العربى

تأثير إضافه الأعشاب البحرية الخضراء والبنية على الأداء الإنتاجي، وجوده البيض، والدهون ومضادات الأكسدة في الدم في السمان الياباني البياض

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أجريت هذه التجربة لتقييم تأثير إضافه الأعشاب البحرية الخضراء (*Ulva Fasciata*) والبنية (*Sargassum Cinereum*) المجففه إلي علائق السمان الياباني البياض على الأداء الإنتاجي وتقديرالوزن النسبي لبعض الأعضاء وإختبار جودة البيض وتقدير محتوي الصفار من الدهون والكوليسترول الكلي ومكونات سيرم الدم من الدهون ومضادات الأكسدة. تم توزيع عدد 180 طائر من السمان الياباني البياض عمر 10 أسابيع توزيعا عشوائيا إلى خمس مجاميع متساوية فى كل مجموعة ثلاث مكررات متساوية، بكل مجموعه (120 سمان بياض وعدد 60 ذكر). وتم إختيار الطيور علي أساس الوصول الي مرحله إنتاج بيض أكثر من 70 ٪. تم تغذية هذه المجاميع كالأتي: المجموعه الأولى وهي الكنترول تم تغذيتها على العليقة الأساسية بدون أي إضافات، بينما تم تغذيه المجموعات الثانية والثالثة والرابعه والخامسه على العليقة الأساسية مضاف اليها أعشاب بحرية خضراء (GS) وبنية (BS) بمعدل 1.5 ٪ و 3 ٪ على التوالي لمدة 14 أسبوعًا. وكانت أهم النتائج المتحصل عليها كلأتي:

أوضحت النتائج أن مكملات العلف من الأعشاب البحرية الخضراء والبنية بمعدل 1.5 ٪ و 3 ٪ أدي إلي تحسن ملحوظ في معدلات وضع البيض وزيادة عدد و وزن وكتلة البيض مقارنةً بمجموعه الكنترول. لم يتأثر إستهلاك العلف بشكل معنوى من المعاملات المختلفة بينما لوحظ تحسن معنوى فى معدل التحول الغذائى أثناء فترة التجربة الكلية مقارنة بالمجموعة الكنترول. أدى تغذية السمان البياض على علائق مضاف إليها 1.5 ٪ و 3 ٪ من الأعشاب البحرية الخضراء (GS) والبنية (BS) الى زيادة معنوية فى سمك قشر البيض كما ساعد في تحسين كلا من وزن صفار البيض، مؤشرالصفار ولون الصفار مقارنة بالمجموعة الكنترول. أدى إضافه الأعشاب البحرية الخضراء والبنية المجففة بمعدل ٪ 1.5 و 3 ٪ إلى إنخفاض في قيمة وحدة Haugh، وإنخفاض في محتوى صفار البيض من الدهون الكليه والكوليسترول الكلي، بينما أدت هذه الإضافات إلي زياده نسبة الخصوبة ونسبة الفقس مقارنةً بمجموعة الكنترول. سجلت مجموعات السمان التي تغذت علي معاملات مضاف إليها الأعشاب البحرية الخضراء والبنية المجففة بمعدل ٪ 1.5 و 3 ٪ نسبة تصافي أعلى من الكنترول، بينما سجلت نسبة أقل من دهون منطقة البطن مقارنةً بمجموعة الكنترول. كما إنخفض إلى حد كبير كل من تركيزات الدهون الكليه في الدم، والدهون الثلاثية، والكولسترول الكلي، والدهون مرتفعه الكثافه (HDL)، والدهون منخفضه الكثافه (LDL) بالمقارنة مع مجموعة الكنترول. كان هناك تأثير إيجابي على الأنشطة المضادة للأكسدة حيث إرتفعت تركيزات الانزيمات المضادة للأكسدة في الدم نتيجه إضافه الأعشاب البحرية الخضراء والبنية المجففة بمعدل ٪ 1.5 و 3 ٪.

أوضحت الدراسة أن إضافة الأعشاب البحرية الخضراء والبنية المجففه في أعلاف السمان البياض أدي إلي تحسن في معدلات وضع البيض كما أن لها تأثير إيجابي على جوده البيض وخفض محتوي صفار البيض من الدهون الكليه وزياده نسب كل من الخصوبة والفقس، وكذلك خفض كل من الدهون الكليه والكوليسترول الكلي في الدم و صفار البيض، وزياده القدرة المضادة للأكسدة، وكذلك تؤثر إيجابيا على الكفاءه الإقتصادية. وبالتالي فإن هذه النتائج تشير إلى أن مسحوق الأعشاب البحرية الخضراء والبنية يمكن إستخدامها كإضافات آمنة في أعلاف السمان الياباني البياض.