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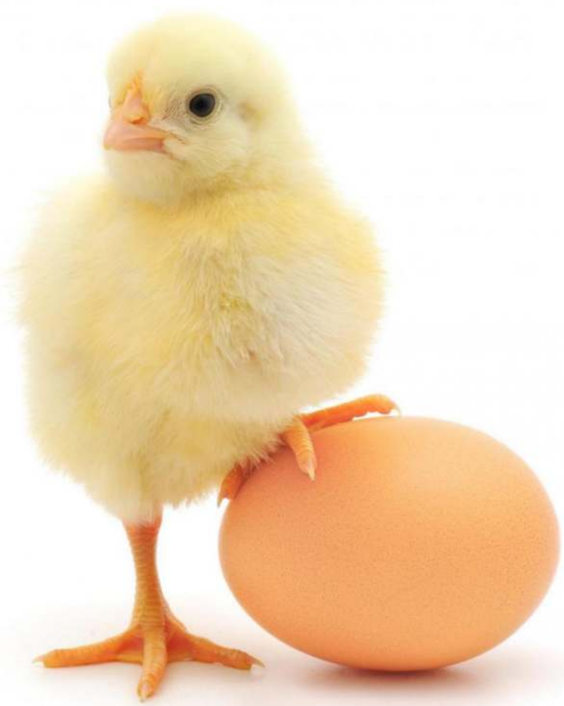

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308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

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Effect of Different Levels of Seaweed in Starter and Finisher Diets in Pellet and Mash Form on Performance and Carcass Quality of Ducks

A.A. El-Deek[1] and A. Mervat Brikaa[2]
[1]Department of Poultry Production, Faculty of Agriculture, (El-Shatby), 21545 Alexandria University, Egypt
[2]Animal Production Research Institute, Agriculture Research Center, Ministry of Agriculture, Dokki, Egypt

Abstract: Two trials were run to assess the nutritional value of seaweed as a feedstuff in starter and finisher diets for ducks. The first trial (starter period): 96, one-day old commercial ducks were weighed, wing banded and randomly distributed to battery brooders into 8 treatment groups (3 replicates x 4 ducks each). The ducks were fed the experimental diets contained 0, 4, 8 and 12% seaweed, the diets were offered *ad-libitum* in pellet and mash form from one day to 5 wks of age. The second trial (finisher period): 160 commercial ducklings (35 days of age) were weighed; leg banded and distributed to 16 treatment groups of ten ducks each. The ducks were fed the experimental diets contained 0, 5, 10 and 15% seaweed, the diets were offered *ad-libitum* in pellet and mash form from 35-63 days of age. Results of trial 1 indicate that there were no significant differences in Feed Intake (FI), Feed Conversion Ratio (FCR) due to inclusion of seaweed up to 12% in starter diet either in mash or pellet form. In general, ducks given pelleted diets utilized feed more efficiently than those given the mash one. Results of trial 2 reveal that seaweed can be included up to 15% into ducks finisher diets either in pellet or mash form without adversely affecting growth and FCR. The relative weight of dressing, liver, gizzard, thigh muscles and breast muscles were not significantly affected by including up to 15% of seaweed in finisher duck diets. Seaweed at 5 and 10% in the finisher duck diets significantly increased the relative weight of breast muscles. Seaweed up to 15% in duck diet significantly improved the texture of breast muscles and 5 and 10% seaweed improved the texture of thigh muscles. There were no significant differences in the aroma, taste, juiciness and color of meat due to seaweed up to 15% in duck diets. In conclusion, seaweed can be used in starter and finisher duck diets up to 12% and 15%, respectively, without adversely affecting growth performance and carcass quality.

Key words: Seaweed, ducks, productive performance, carcasses, meat quality

INTRODUCTION

The seaweed aquaculture production (92% of the world seaweed supply) doubled between 1996 and 2004 and is estimated at 11.3 million wet tones, with 99.7% of the biomass being cultivated in Asia. Brown seaweeds represent 63.8% of the production, while red seaweeds represent 36.0% and the green seaweeds 0.2%. The seaweed aquaculture production is valued at US$ 5.7 billion (again with 99.7% of the value being provided by Asian countries). Brown seaweeds dominate with 66.8% of the value, while red seaweeds contribute 33.0% and the green seaweeds 0.2% (FAO, 2006). Total annual value of production is estimated at almost US$ 6 billion of which food products for human consumption represent US$ 5 billion. Total annual use by the global seaweed industry is about 8 million tones of wet seaweed (FAO, 2003). Today, approximately one million tones of wet seaweed are harvested and extracted to produce about 55,000 tones of hydrocolloids, valued at almost US$ 600 million (McHugh, 2003).

Seaweed has plenty of essential nutrients, especially trace elements and several other bioactive substances. That explains why today seaweeds are considered as the food supplement for 21st century as source for proteins, lipids, polysaccharides, mineral, vitamins and enzyme (Rimber, 2007). Red and brown seaweeds are also used to produce hydrocolloids; alginate, agar and carrageenan, which are used as thickening and gelling agents.

Asar (1972) indicated that supplementation chickens basal diet with 4% seaweeds increased body weight gain. The use of 3 and 4% seaweed meal as an ingredient in broiler chickens has no adverse effect on FCR and slaughter traits except adversely affecting the flavor quality, so they recommended removing seaweed meal from the basal diet during the last stages of chicken fattening (Tomova *et al*., 1981). Maurice *et al*. (1984) concluded that sun dried *Brazilian Elodea* could be used in broiler diets at 5% without adversely affecting growth, FCR or dressing percentage. El-Ansary *et al*. (1986) observed that liver weight of chicks at 6 wks significantly decreased with increasing gradually by 2.5% the non autoclaved seaweeds level from 0-10% in basal diet, while, intestinal and caecal length were significantly increased. Liver glycogen content and pancreatic amylase activity significantly increased with feeding the seaweeds.

El-Deek *et al.* (1987) found that inclusion of seaweeds in finisher broiler diets had no significant effects on chickens growth, FI and FCR. They observed that shank pigmentation increased due to inclusion of 5 and 10% of seaweed. Gu *et al.* (1988) concluded that 2% of marine algae meal improved broiler performance and dressing percentage. Ross and Dominy (1990) found that the growth of the chickens fed diets containing up to 6.0% of *Spirulina* was not different from that of the chicks receiving the control diet (0.0%) and the birds receiving the 12% *Spirulina* diet grew significantly slower than the chicks fed the other *Spirulina* diets. Carrillo *et al.* (1990) reported insignificant difference from 1 day to 8 wks of age of broilers fed sorghum-soybean diets contain 0, 5, 10, 15% seaweed (Macrocystis *pyrifera*) in FI, but growth significantly and gradually decreased with increasing seaweed level. However, Ernest and Warren (1990) observed that performance of Hubbared male broiler chickens was not significantly affected by incorporation of blue-green algae up to 6% in the diet. Also, Venkataraman *et al.* (1994) indicated that sun dried *Spirulina platensis* alga at 14 and 17% did not affect performance of broilers and meat quality except intense color increased in meat of those fed diet containing alga. Ventura and Cast Anon (1998) reported that as dietary seaweed increased both of FI and growth rate significantly decreased and they concluded crude *U. rigida* is not a suitable ingredient for poultry diets, at least at inclusion rates of 100 g/kg or higher and seaweed did not modify TME of the rest of the diet (standard diet or glucose). Inal *et al.* (1995 a,b) found that supplemented Japanese quails diet with Maxicrop, an extract from the seaweed *Ascophyllum nodosm* at 0, 0.01, 0.1 or 1% did not affect growth, Maxicrop increased FI and decreased FCR while increased egg yolk color. Also, Maxicrop had no effect on histology of lymphoid tissue or carcass characteristics and even when fed at to 4% it caused no pathological lesion.

Studies with laying hens are encouraging for example; Strand *et al.* (1998) reported that fucoxanthin, the major carotenoid in seaweed meal, is not transferred to the yolk. However, fucoxanthin raises the metabolites of fucoxanthinol, fucoxanthinol sulphate and paracentrone, which are ascribed to enzymatic modifications occurring in the hens. The difuranoid furoxanthin encountered in the egg yolk was ascribed to violaxanthin and/or its furanoid derivatives present in the seaweed meal. Padhi *et al.* (2003) indicated that seaweeds can be included in layer diets at 7.5% without any adverse effect on FI, FCR, egg production and quality. Fredriksson *et al.* (2006) found that yolk fatty acid composition was enhanced in the phospholipids fraction (18:2n-6, 18:3n-3, 20:4n-6, 20:5n-3 and 22:6n-3) and carotenoid content of egg yolk are improved by addition of marine micro algae, *Nannochloropsis oculata* to laying hen diets.

The aim of this study was to investigate the effect of different dietary levels at 0, 4, 8 and 12% (trial 1) and at 0, 5, 10 and 15% (trial 2) in the starter and finisher diets, respectively on productive performance, carcass characteristics and meat quality of ducks.

MATERIALS AND METHODS

Preparing of dried marine seaweed: Red seaweeds *Polysiphonis SPP* were collected freshly from the coast of Mediterranean Sea of Alexandria. Seaweeds were washed using tap water several times in order to get rid of associated salts and sand. The test material was dried at 60°C for 72 h in across flow drier, then grinded and kept in bags until used in the experimental diets.

Experiment 1: This experimental was performed to assess the feeding value of seaweed as a feedstuff in starter duck diets. Ninety six one-day old commercial ducks were weighed, wing banded and randomly divided into 8 treatment groups, each consisting of 3 replicates of 4 ducks. The ducks were housed in battery brooders and fed the experimental diets containing 0, 4, 8 and 12 % seaweed. The diets were offered *ad-libitum* in pellet and mash form one day to 5 wks of age (Table 1). Data were recorded weekly for BW, FI and FCR.

Experiment 2: This experimental was designed to study the effects of feeding three levels of seaweed e.g. 5, 10 and 15% on performance and carcass traits and meat quality of ducks during the finisher period (35-63 days of age). Up to 35 days of age commercial duckling were fed on starter diet (Table 2). From 35 days of age 160 ducklings were weighed, leg banded and randomly distributed to 16 treatments groups. Each treatment consisted of 2 replicates of 5 ducks each. The ducks were fed the experimental diets containing 0, 5, 10 and 15% seaweed *ad-libitum* in pellet and mash form 35-63 days of age (Table 2). Data were recorded weekly for Body Weight (BW), FI and FCR.

At the end of the experimental period, 4 ducks from each treatment were randomly selected, weighed, slaughtered and then dressed to determine the carcass weight and liver, gizzard, breast muscles, thigh muscles, and abdominal fats as relative weight of live body weight (g/100 BW). Breast length and width (cm/100g BW) were also measured. Breast width was measured at the crancal top of the keel bone while, the length was measured as the keel length.

Sensory evaluation was conducted according to Tilgner's method (1957) by trained taste panel which consisted of five judges. A ten point's descriptive scale was used to score the taste, aroma, tenderness and juiciness. Higher values were more acceptable to the panelist than the lower ones.

Statistical analysis: The statistical analysis was conducted using SAS® (2001) software program. Mean differences were tested by Duncan’s New Multiple Range Test (Duncan, 1955).

Table 1: Composition of starter duck diets fed in trial 1

Ingredient	Seaweed levels (%) 0.0% (control)	4%	8%	12%
Corn, ground	66	63	61	58
Soybean meal (44%)	24	23	21	20
Concentrate*	10	10	10	10
Seaweed**	-	4	8	12
Total	100	100	100	100
Calculated analysis				
Crude protein (%)	21.5	21.64	21.43	21.58
ME (kcal/kg)	3041	3063	3098	3120
Calcium (%)	0.89	0.99	1.10	1.21
Avi. Phosphorus (%)	0.54	0.53	0.52	0.50
Lysine	1.13	1.37	1.59	1.84
Methionine	0.41	0.44	0.46	0.48
Cystein	0.38	0.37	0.35	0.34
Linolinic acid	1.35	1.29	1.24	1.18

Concentrate*: Crude protein (%) 52.00, ME (Kcal/kg) 2440, Ether Extract (%) 2.00, Crude fiber (%) 3.00, Calcium (%) 7.50, Avi. Phosphorus (%) 3.50.

Seaweed**:- Crude protein (%) 32.00, ME (Kcal/kg) 3518, Ether Extract (%) 17.0, Crude fiber (%) 14.00. According to El-Deek and Brikaa (2009)

Table 2: Composition of starter and finishing duck diets fed in trial 2

Ingredient	Starter diet (1-34 day of age)	Seaweed level in finisher diets (%) 0.0 % (control)	5.0%	10.0%	15%
Corn, ground	65	71.5	68	64.5	61
Soybean meal (44%)	25	18.5	17	15.5	14
Concentrate*	10	10.0	10	10	10
Seaweed **	-	-	5	10	15
Total	100	100	100	100	100
Calculated analysis					
Crude protein (%)	21.26	18.97	18.97	18.95	18.98
ME (kcal/kg)	2993	3070	3101	3132	3163
Calcium (%)	0.99	0.97	1.04	1.1	1.17
Avi. Phosphorus (%)	0.45	0.44	0.45	0.45	0.47
Lysine	1.15	0.98	1.28	1.58	1.88
Methionine	0.41	0.38	0.42	0.46	0.49
Cystein	0.38	0.35	0.34	0.32	0.30
Linolinic acid	1.33	1.43	1.36	1.29	1,22

Concentrate*: Crude protein (%) 52.00, ME (Kcal/kg) 2440, Ether Extract (%) 2.00, Crude fiber (%) 3.00, Calcium (%) 7.50, Avi. Phosphorus (%) 3.50.

Seaweed**:- Crude protein (%) 32.00, ME (Kcal/kg) 3518, Ether Extract (%) 17.0, Crude fiber (%) 14.00. According to El-Deek *et al.* (2009)

RESULTS AND DISCUSSION

Experiment 1: Irrespective of the diet form and the interaction between level and diet form, seaweed level (0, 4, 8 and 12%) had no significant effect on BW and BWG at 5 wks of age (Tables 3 and 4). Similar results was reported by Brune (1982) who obtained satisfactory results with growing chicks fed *Spiruline* algae meal at 5 and 10%, while the growth was depressed at level above 20%.

Regardless of seaweed level and the interaction between level and diet form, ducks received the diets in pellet form significantly increased the BW and BWG than those received the same diets in mash form. These results are in agreement with those reported by Takemasa and Hijikuro (1984), Reece *et al.* (1986) and Moran (1987). Jensen *et al.* (1962) explained the increase in growth with pelleted diet due to less energy expend in prehension of feed therefore, birds have more energy available for growth.

A significant interaction between seaweed level and the diet form showed that diets in pellet form at 0, 4 and 8% significantly increased growth compared the corresponding groups, except those fed mash diet included 12% seaweed.

There were no significant differences in FI and FCR due to inclusion seaweed at different levels in starter mash or pellet diets for duck (Table 4). In general, ducks given pelleted diets utilized feed more efficiently (6.04%) than those given the mash ones. However, inclusion of seaweed up to 12% had no effect on palatability of the diets by ducks. Similar results were reported by Wilson (1973) and El-Deek *et al.* (1987).

Table 3: Body weight (g) of ducks fed different dietary levels of sea weed in pellet and mash form in trial 1 (1-35 d of age)

	Initial Body weight (g)			Body weight at 5 weeks (g)		
Level	Pellet	Mash	Mean level	Pellet	Mash	Mean level
Basel Diet	72.9±1.8	70.0±2.3	71.5±1.4	1257.3±51.5[ab]	1171.3±42.7[cd]	1214.3±33.9
4% Seaweed	67.7±2.6	72.3±2.1	70.0±1.7	1294.8±47.1[a]	1031.9±55.0[d]	1163.4±44.8
8% Seaweed	69.5±1.6	68.3±1.4	68.9±1.0	1204.3±54.9[abc]	1031.5±28.3[d]	1117.9±35.2
12% Seaweed	74.2±1.9	69.8±2.3	72.0±1.5	1100.9±44.9[cd]	1187.3±47.9[abcd]	1144.1±33.4
Overall means	71.0±1.0	70.1±1.0	70.6±0.7	1214.4±26.3	1105.5±24.1	1159.9±18.6
Significant						
Bet. Form (F)	NS			**		
Bet. Levels (L)	NS			NS		
Interaction (F x L)	NS			**		

[abcd]Means sharing the same letter in each column within row are not statistical different according to the results of Duncan's test

Table 4: Body weight gain (g), feed intake (g) and feed conversion ratio (g feed/g/gain) of ducks fed different dietary levels of sea weed in pellet and mash form in trial 1 (1-35 d of age)

	Body weight gain (g) (1-5 wks of age)		
Level	Pellet	Mash	Mean level
Basel Diet	1184.4±51.2[ab]	1101.3±1.9[cd]	1142.9±33.5
4% Seaweed	1227.2±47.7[a]	959.6±54.3[d]	1093.4±45.0
8% Seaweed	1134.8±54.8[abc]	963.2±28.5[d]	1049.0±35.1
12%Seaweed	1026.8±44.5[cd]	1117.5±46.5[abcd]	1072.1±32.9
Overall means	1143.3±26.4	1035.4±23.8	1089.3±18.5
Significant			
Bet. Form (F)	**		
Bet. Levels (L)	NS		
Interaction (F x L)	**		
	Feed Intake(g/duck)		
Level	Pellet	Mash	Mean level
Basel Diet	3231.9±78.3	3098.0±98.2	3165.1±84.9
4% Seaweed	3411.2±71.7	2966.4±98.9	3188.9±86.5
8% Seaweed	3086.1±66.7	3190.8±98.9	3138.5±79.5
12%Seaweed	3089.0±95.0	3110.4±96.7	3099.7±96.8
Overall means	3204.5±52.3	3091.4±65.6	3148.0±32.5
Significant			
Bet. Form (F)	NS		
Bet. Levels (L)	NS		
Interaction (F x L)	NS		
	Feed conversion ratio (g feed/g gain)		
Level	Pellet	Mash	Mean level
Basel Diet	2.70±0.10	2.82±0.15	2.76±0.08
4% Seaweed	2.80±0.04	3.03±0.16	2.92±0.06
8% Seaweed	2.70±0.11	3.31±0.05	3.00±0.07
12%Seaweed	3.00±0.08	2.79±0.03	2.90±0.04
Overall means	2.80±0.08	2.98±0.08	2.89±0.05
Significant			
Bet. Form (F)	NS		
Bet. Levels (L)	NS		
Interaction (F x L)	NS		

[abcd]Means sharing the same letter in each column within row are not statistical different according to the results of Duncan's test

Experiment 2: Level of seaweed and form of diet had insignificant effect on BW at 9 wks of age (Table 5). A tendency was observed towards better (3.8%) growth of ducks received diets in pelleted form compared with those received diets in mash form.

Ducks fed diets containing 5% seaweed gained significantly more weight than that of those fed diets containing 15% seaweeds (Table 6). Also, ducks fed 15% seaweeds diet had the lowest BWG compared to the other groups.

Regardless of seaweed level, diet form had no significant effect on BWG at 9 wk of age (Table 6). There was an interaction revealing that duck fed pelleted diet containing 5% seaweed had significantly heavier BWG than those given diets in either pellet or mash form at the other levels of seaweed (Table 6).

In accordance with the present results, several researchers showed that marine seaweed support the growth of chickens and Japanese quail (Asar, 1978; Tomova *et al*., 1981; Maurice *et al*., 1984; El-Deek *et al*.,1987; Gu *et al*., 1988; Ross and Dominy, 1990; Venkataraman *et al*., 1994 and Inal *et al*., 1995 a,b).

Results of FI and FCR indicated no significant effect due to incorporation of different levels of seaweed in ducks diets offered in mash or pellets form (Table 6). Ducks consumed significantly more (22.4%) feed when the diet was offered in mash form than that in pelleted form. Also, ducks fed diets in pellet form utilized feed more (22%) efficiently than those fed diets in mash form.

No significant interaction between dietary seaweed level and diet form on FI and FCR of the ducks were shown. Similarly, Maurice *et al*. (1984), El-Deek *et al*. (1987) and Carrillo *et al*. (1990) indicated that marine seaweed can be fed without adverse effect on FI and FCR for broiler chickens. Also, Coskun *et al*. (1993) and Padhi *et al*. (2003) showed similar results with laying hens and Inal *et al*. (1995 a,b) with Japanese quail.

This result reveals that seaweed could be included in the finishing diets for ducks up to 15% in pellet form without adversely affecting growth and FCR. Such practice will have a reflection on a better economic value of ducks production due to low price of seaweeds compared to other feedstuffs.

Data for relative weight of carcass traits are presented in (Tables 7, 8 and 9). The relative weight for dressing, liver, gizzard, thigh meat, breast length and breast wide were not significantly affected by including different levels of seaweed in finisher duck diets. However, relative weight of abdominal fat and breast muscle were significantly affected. Inclusion of seaweed at different levels significantly increased the relative weight of

Table 5: Body weight (kg) of ducks fed different dietary levels of seaweed in pellet and mash form in trial 2 (35-63 d of age)

	Initial Body weight (kg)			Body weight at 9 weeks (kg)		
Level	Pellet	Mash	Mean level	Pellet	Mash	Mean level
Basel Diet	1.4±0.02	1.4±0.02	1.4±0.01	2.7±0.04 ^{ab}	2.5±0.04 ^{c}	2.6±0.03
5% Seaweed	1.4±0.02	1.4±0.01	1.4±0.01	2.8±0.04 ^{a}	2.6±0.05 ^{bc}	2.7±0.04
10% Seaweed	1.4±0.02	1.4±0.02	1.4±0.01	2.6±0.05 ^{bc}	2.7±0.04 ^{ab}	2.7±0.05
15% Seaweed	1.4±0.02	1.4±0.02	1.4±0.01	2.5±0.03 ^{c}	2.6±0.04 ^{bc}	2.6±0.03
Overall means	1.4±0.01	1.4±0.01	1.4±0.01	2.7±0.02	2.6±0.02	2.6±0.02
Significant						
Bet. Form (F)	NS			NS		
Bet. Levels (L)	NS			NS		
Interaction (F x L)	NS			**		

^{abc}Means sharing the same letter in each column within row are not statistical different according to the results of Duncan's test

Table 6: Body weight gain (kg), feed intake (kg) and feed conversion ratio (g feed/g/gain) of ducks fed different dietary levels of seaweed in pellet and mash form in trial 2 (35-63 d of age)

	Body weight gain (kg) (6-9 wks of age)			Feed Intake(kg/duck)			Feed conversion ratio (kg feed/kg gain)		
Level	Pellet	Mash	Mean level	Pellet	Mash	Mean level	Pellet	Mash	Mean level
Basel Diet	1.30±0.04^{bc}	1.10±0.04^{d}	1.20±0.02^{ab}	4.7±0.15	5.6±0.14	5.2±0.28	3.8±0.10	5.0±0.03	4.4±0.37
5% Seaweed	1.40±0.04^{a}	1.20±0.04^{cd}	1.30±0.03^{a}	5.1±0.13	5.8±0.33	5.5±0.25	3.7±0.02	5.0±0.50	4.4±1.43
10%Seaweed	1.20±0.04^{bcd}	1.30±0.04^{bc}	1.25±0.03^{ab}	4.8±0.01	6.3±0.04	5.5±0.45	3.9±0.01	4.9±0.10	4.4±0.29
15%Seaweed	1.10±0.04^{d}	1.20±0.04^{bcd}	1.15±0.03^{b}	4.9±0.05	6.1±0.11	5.6±0.42	4.3±0.08	5.2±0.09	4.8±0.27
Overall means	1.30±0.02	1.20±0.02	1.20±0.02	4.9±0.07^{b}	6.0±0.14^{a}	5.5±0.17	3.9±0.09^{b}	5.0±0.11^{a}	4.5±0.16
Significant									
Bet. Form (F)	NS			**			**		
Bet. Levels (L)	*			NS			NS		
Interaction (F x L)	**			NS			NS		

^{abcd}Means sharing the same letter in each column within row are not statistical different according to the results

Table 7: Carcass weight (g), dressing (%) and abdominal fat (%) of 63-d old ducks fed different dietary levels of seaweed in pellet and mash form in trial 2 (35-63 d of age)

	Carcass weight (g)		
Level	Pellet	Mash	Mean level
Control (0.0%)	1758.3±43.7	1581.0±14.4	1657.0±40.20
5% seaweed	1803.3±39.7	1654.5±13.9	1728.9±34.2
10% seaweed	1728.9±34.2	1668.0±55.8	1698.5±39.1
15% seaweed	1658.8±24.0	1627.0±29.9	1642.9±18.7
Overall means	1737.3±26.4	1632.6±23.8	1683.0±18.5
Significant			
Bet. Form (F)	NS		
Bet. Levels (L)	NS		
Interaction (F x L)	NS		
	Dressing (g/100 g BW)		
Level	Pellet	Mash	Mean level
Control (0.0%)	60.2±0.25	60.8±0.60	60.5±0.39
5% seaweed	60.7±082	60.7±0.31	60.7±0.51
10% seaweed	60.6±0.41	60.3±0.39	60.4±0.27
15% seaweed	60.1±0.21	59.2±0.37	59.6±0.26
Overall means	60.4±±0.55	60.3±0.42	60.3±0.44
Significant			
Bet. Form (F)	NS		
Bet. Levels (L)	NS		
Interaction (F x L)	NS		
	Abdominal fat (g/100g BW)		
Level	Pellet	Mash	Mean level
Control (0.0%)	7.5±0.76	6.1±0.24	6.7±0.42^{b}
5% seaweed	9.1±0.41	8.0±0.43	8.5±0.34 ^{a}
10% seaweed	8.0±0.65	8.4±0.74	8.2±0.46 ^{a}
15% seaweed	8.8±0.97	7.4±0.62	8.1±0.59 ^{a}
Overall means	8.4±0.65	7.5±0.58	7.9±0.44
Significant			
Bet. Form (F)	NS		
Bet. Levels (L)	*		
Interaction (F x L)	NS		

^{abc} Means sharing the same letter in each column within row are not statistical different according to the results of Duncan's test

Table 8: Liver (%), gizzard (%) and breast meat (%) of 63-d old ducks fed different dietary levels of seaweed in pellet and mash form in trial 2 (35-63 d of age)

	Liver (g/100g BW)		
Level	Pellet	Mash	Mean level
Control (0.0%)	8.0±0.25	8.4±0.32	8.2±0.21
5% seaweed	7.9±0.13	7.8±0.05	7.8±0.07
10% seaweed	7.5±0.19	8.1±0.37	7.8±0.22
15% seaweed	7.9±0.44	8.0±0.21	8.0±0.23
Overall means	7.8±0.35	8.1±0.28	7.9±0.21
Significant			
Bet. Form (F)	NS		
Bet. Levels (L)	NS		
Interaction (F x L)	NS		
	Gizzard (g/100g BW)		
Level	Pellet	Mash	Mean level
Control (0.0%)	9.6±0.51	9.9±0.44	9.8±0.31
5% seaweed	9.1±0.21	9.6±0.31	9.4±0.20
10% seaweed	8.9±0.30	9.9±0.31	9.4±0.30
15% seaweed	8.4±0.26	10.3±0.55	9.4±0.45
Overall means	9.0±±0.42	9.9±0.54	9.5±0.24
Significant			
Bet. Form (F)		NS	
Bet. Levels (L)		NS	
Interaction (F x L)		NS	
	Breast meat (g/100g BW)		
Level	Pellet	Mash	Mean level
Control (0.0%)	26.3±0.51^{a}	25.7±0.44^{a}	25.9±0.33^{b}
5% seaweed	26.9±0.61^{a}	25.5±0.41^{a}	26.2±0.43^{a}
10% seaweed	25.8±0.69^{a}	26.4±0.48^{a}	26.1±0.40^{a}
15% seaweed	21.9±0.19^{b}	26.1±0.63^{a}	24.0±0.59^{b}
Overall means	25.2±0.45	25.9±0.58	25.6±0.44
Significant			
Bet. Form (F)	NS		
Bet. Levels (L)	**		
Interaction (F x L)	**		

^{abc}Means sharing the same letter in each column within row are not statistical different according to the results of Duncan's test

Table 9: Thigh meat (%), breast width (%) and breast length (%) of 63-d old ducks fed different dietary levels of seaweed in pellet and mash form in trial 2 (35-63 d of age)

	Thigh meat (g/100g BW)			Breast width (cm)			Breast length (cm)		
Level	Pellet	Mash	Mean level	Pellet	Mash	Mean level	Pellet	Mash	Mean level
Control (0.0%)	21.4±0.40	22.8±0.27	22.2±0.35	17.0±0.55	16.5±0.52	16.7±0.36	14.7±0.88	15.3±0.25	15.0±0.38
5% seaweed	21.8±0.15	22.5±0.33	22.1±0.22	16.0±0.41	16.0±0.41	16.0±0.27	15.3±0.48	15.0±0.41	15.1±0.30
10% seaweed	22.5±0.46	22.5±0.33	22.5±0.46	16.3±0.25	16.0±0.00	16.1±0.13	15.3±0.25	15.3±0.25	15.3±0.16
15% seaweed	21.9±0.19	21.7±0.36	21.8±0.20	16.8±0.25	16.3±0.25	16.5±0.19	15.8±0.25	15.3±0.25	15.5±0.19
Overall means	21.9±0.25^{b}	22.4±0.29^{a}	21.1±0.39	16.5±0.35	16.2±0.25	16.4±0.24	15.3±0.48	15.2±0.25	15.3±0.34
Significant									
Bet. Form (F)	**			NS			NS		
Bet. Levels (L)	NS			NS			NS		
Interaction (F x L)	**			NS			NS		

^{abc} Means sharing the same letter in each column within row are not statistical different according to the results of Duncan's test

Table 10: Sensory evaluation of breast and thigh muscles of 63-d old ducks fed different dietary levels of seaweed in pellet and mash form in trial 2 (35-63 d of age)

		Texture		Aroma		Taste	
Level		Breast	Thigh	Breast	Thigh	Breast	Thigh
0.0% (Contrl)	P	8.18±0.18	8.18±0.26	8.09±0.16	8.18±0.12^{a}	8.54±0.21	8.45±0.25
	M	7.64±0.31	7.54±0.25	8.36±0.20	8.00±0.23^{a}	8.54±0.21	8.27±0.24
Mean level		7.91±0.18^{B}	7.86±0.19^{B}	8.23±0.13	8.09±0.13	8.54±0.14	8.36±0.17
5% seaweed	P	8.64±0.15	9.00±0.27	8.09±0.16	7.91±0.21^{a}	8.54±0.21	8.45±0.16
	M	8.54±0.15	8.45±0.25	8.27±0.19	8.18±0.18^{a}	8.45±0.16	8.45±0.21
Mean level		8.59±0.10^{A}	8.73±0.19^{A}	8.18±0.13	8.04±0.14	8.50±0.13	8.45±0.13
10% seaweed	P	8.74±0.03	8.73±0.27	8.09±0.16	7.91±0.16^{a}	8.45±0.28	8.27±0.19
	M	8.91±0.32	9.00±0.23	8.00±0.23	8.45±0.21^{a}	8.54±0.21	8.09±0.28
Mean level		8.82±0.22^{A}	8.86±0.18^{A}	8.05±0.14	8.18±0.14	8.50±0.17	8.18±0.17
15% Seaweed	P	8.45±0.25	8.09±0.28	7.91±0.34	7.18±0.33^{b}	8.45±0.25	8.18±0.18
	M	8.64±0.34	8.27±0.33	8.09±0.32	8.36±0.24^{a}	7.82±0.23	8.27±0.30
Mean level		8.54±0.21^{A}	8.18±0.21^{B}	8.00±0.23	7.77±0.24	8.14±0.18	8.23±0.17
Significant							
Bet. Form (F)		NS	NS	NS	**	NS	NS
Bet. Levels (L)		**	**	NS	NS	NS	NS
Interaction (F x L)		NS	NS	NS	*	NS	NS

		Juiciness		Color	
Level		Breast	Thigh	Breast	Thigh
0.0% (Contrl)	P	8.54±0.21	8.18±0.26^{ab}	8.91±0.09	8.82±0.12
	M	8.00±0.38	8.82±0.12^{a}	8.82±0.23	8.82±0.12
Mean level		8.27±0.22	8.50±0.16	8.86±0.12	8.82±0.08
5% seaweed	P	8.82±0.18	8.27±0.27^{ab}	9.00±0.00	8.91±0.10
	M	8.64±0.20	7.82±0.30^{b}	8.82±0.23	8.86±0.07
Mean level		8.73±0.13	8.04±0.20	8.91±0.11	8.91±0.07
10% seaweed	P	8.45±0.25	8.45±0.21^{ab}	8.82±0.12	8.91±0.10
	M	8.27±0.41	8.18±0.26^{ab}	8.73±0.30	8.64±0.20
Mean level		8.36±0.23	8.32±0.17	8.77±0.09	8.77±0.11
15%Seaweed	P	8.27±0.24	8.36±0.15^{ab}	8.73±0.19	8.73±0.19
	M	8.18±0.30	7.73±0.23^{b}	8.82±0.12	8.82±0.18
Mean level		8.23±0.18	8.04±0.17	8.77±0.11	8.77±0.13
Significant					
Bet. Form (F)		NS	NS	NS	NS
Bet. Levels (L)		NS	NS	NS	NS
Interaction (F x L)		NS	*	NS	NS

^{ab}or^{AB}Means sharing the same letter in each column under similar treatment are not statistical different according to the results of Duncan's test

P = pellet diet M = mash diet

abdominal fat, may be to increasing in energy availability. Seaweed at 5 and 10% in the finisher diets significantly increase the relative weight of breast meat compared to the other levels, regardless of diets form or the interaction (Table 8).

All carcass traits except for relative thigh meat were not significantly affected by diet form. Ducks fed mash diet containing 15% seaweed significantly increased relative weight of breast muscle. Similarly, El-Deek *et al*. (1987) and Maurice *et al*. (1984) reported no adverse effect on ducks and broiler carcass quality due to different dietary seaweed levels. However, Wilson (1973) and Choi *et al*. (1986) indicated that duckling and chickens fed diets in mash form significantly increased gizzard than those fed pellets diet. This result in contrary to the present result that mash and pellet forms did not affect gizzard percentage significantly.

A significant improvement in the texture of breast muscle of ducks was detected due to inclusion seaweed up to 15% compared to those fed control diet (Table 10). However, the inclusion of 5 and 10% seaweed improved the thigh texture of ducks compared to those fed either the diets with zero (control diet) or 15% seaweed. There were no significant differences in the aroma, taste, juiciness and color due to feeding various levels of seaweed.

The form of seaweed diet had no significant effect on all sensory treats except the thigh aroma which significantly increased by feeding the diets in mash form than those fed diets in pellet form.

There was a significant interaction indicating that only the aroma and juiciness of thigh muscle was affected. Inclusion of 15% seaweed in the diets offered in pellet form decreased aroma in ducks thigh meat when compared with the other groups. Juiciness of thigh meat showed no meaningful trend. Tomova *et al.* (1981) found that using 4% seaweed in broiler finishing diet adversely affected flavor quality.

The results of this research indicated that seaweed can be included in starter and finisher duck diets up to 12% and 15%, respectively, without adversely affecting growth performance and carcass quality.

REFERENCES

Asar, M., 1972. The use of some weeds in poultry nutrition. M.Sc. Thesis. Alexandria University.

Asar, M., 1978. The use of new sources of protein in poultry nutrition. Ph.D Thesis. Alexandria University.

Brune, H., 1982. Zur vertraglickeit der Einzelleralgen Spirulina maxima und Scenedesmus acutus als alleininge Eiwei Bquelle fur Broiler, Z. Tierphysiol Tierernaehr. Futtermittelked, 48: 143-154.

Carrillo, D.S., V.M.M. Casas, G.M.I. Castro, G.I. Perez and V.R. Garcia, 1990. The use of Macrocystis pyrifera seaweed in broiler diets. Investigation Agraria Production Sanidad Animals, 5: 137142.

Choi, J., B. So, K. Ryu and S. Kang, 1986. Effects of pelleted or crumbed diets on the performance and the development of the digestive organs of broilers. Poult. Sci., 65: 594-597.

Coskun, B., F. Inal, E. Seker, N. Gulsen and H.D. Arik, 1993. The effect of seaweed soluble powder Maxicrop on performance in hens. Veteriner Fakultesi Dergisi Selcuk Universitesi., 9: 83-86.

Duncan, D.B., 1955. Multiple range and Multiple Test. Biometrics, 11: 1-42.

El-Ansary, E., A.A. El-Deek, M.A. Asar and M.A. Kosba, 1986. Response of blood glucose level, liver glycogen content and panceatic amylase activity of broiler chick fed non and autouclaved seaweed. Egyptian Poult. Sci. J., 6: 1986.

El-Deek, A.A., M.A. Asar, M.A. Safaa Hamdy, M.A. Kosba and M. Osman, 1987. Nutritional value of marine seaweed in broiler diets. J. Agric. Sci. Mansoura Univ., 12: 707-717.

El-Deek, A.A. and Mervat A. Brikaa, 2009. Nutritional and biological evaluation of marine seaweed as a feedstuff and as a pellet binder in poultry diet. Int. J. Poult. Sci., 8: (In press).

Ernest, R. and D. Warren, 1990. The nutritional value of dehydrated, Blue-Green algae *Spirulina Plantensis* for poultry. Poult. Sci., 69: 794-800.

FAO, 2003. A guide to the Seaweed industry. Food and Agriculture Organization of the United Nations, Rome. www.fao.org/DOCREP/006/Y4765E/y4765e00.htm.

FAO, 2006. The state of world aquaculture 2006. Food and Agriculture Organization of the United Nations, FAO Fisheries Technical Paper 500, Rome. www.fao.org/docrep/009/a0874e/a0874e00.htm.

Fredriksson, S., K. Elwinger and J. Pickova, 2006. Fatty acid and carotenoid composition of egg yolk as an effect of microalgae addition to feed formula for laying hens. Food Chem., 99: 530-537.

Gu, H.Y., Y.G. Liu and Z.Z. Shu, 1988. Nutrient composition of marine algae and their feeding on broilers. Chinese J. Anim. Sci., 3: 12-14.

Inal, F., B. Coskun, I. Celik, S. Inal, Gulsenn and Z. Yener, 1995a. Use of seaweed extract in diets for Japanese quails, 2.The effects of seaweed extract on growth performance. Vet. Bilimleri Dergisi, 11: 99-104.

Inal, F., Coskunb, Ciftcimk and Gulsenn 1995b. Use of seaweed extract in diets for Japanese quails, 2. The effects of seaweed extract on egg yield. Vet. Bilimleri Dergisi, 11: 73-76.

Jensen, L., H. Louis, C. Reddy and J. McGinnis, 1962. Observation on eating patterns and rate of food passage of birds fed pelleted and unpelleted diets. Poult. Sci., 41: 1414-1419.

Maurice, D.V., J.E. Jones, C.R. Dillon and J.M. Weber, 1984. Chemical composition and nutritional value of *Brazilian elodea* Egeria densa for the chick. Poult. Sci., 63: 317-323.

McHugh, D.J., 2003. A guide to the seaweed industry. FAO Fisheries Technical Paper. No. 441.

Moran, E.T., Jr. 1987. Effect of pellet quality on the performance of meat birds. London, UK. Butterworth, pp: 87-108.

Padhi, M.K., R.B. Raim, P. Chandra, S. Senani, S.K. Saha and S.P.S. Ahlawat, 2003. Effect of feeding sea weeds on performance of Nicobari layer. Anim. Sci., 73: 948-949.

Reece, F.N., B.D. Lott and J.W. Deaton, 1986. Effect of environment temperature and corn particle size on response of broilers to pelleted feed. Poult. Sci., 65: 636-641.

Rimber Ir. Indy, 2007. Why seawees. M.Sc Faculty of Fisheries and Marine Sciences, Sam Ratulangi University, Jln. Kampus Bahu, Manado 95115, Indonesia.

Ross, E. and W. Dominy, 1990. The nutritional value of dehydrated, blue-green algae (Spirulina platensis) for poultry. Poult. Sci., 69: 794-800.

SAS, 2001. SAS user's guide, Statistics, Version 10th Edn. SAS institute Inc., Cary NC.

Strand, A., O. Herstad and S. Liaaen Jensen, 1998. Fucoxanthin metabolites in egg yolks of laying hens. Comp Biochem Physiol A Mol Integr Physiol. Apr., 1194, 96374.

Takemasa, M. and S. Hijikuro, 1984. Possibility of seaweed as a pellet binder. J. Poult. Sci., 21: 231-234.

Tilgner, D.J., 1957. Analiza organoleptyczna, Poland.

Tomova, D., I. Mandev, D. Chotinski, I. Tsvtanova and E. Duneva, 1981. Testing poultry mixed feeds containing seaweeds, influence on broiler performance indicators. Cited in Nutr. Abst. and Rev., 1982 (52).

Venkataraman, L.V., T. Somasekaran and E.W. Becker, 1994. Replacement value of blue-green alga *Spirulina platensis* for fishmeal and a vitamin mineral premix for broiler chicks. Br. Poult Sci., 35: 373-381.

Ventura, M.R. and J.I.R. Cast Anon, 1998. The nutritive value of seaweed *Ulva lactuca* for goats. Small Rumin. Res., 29: 325-327.

Wilson, B.J., 1973. Effects of diets form on the performance of table duckling. Br. Poult. Sci., 14: 589-593.