

Effect of *Sargassum wightii* on Growth, Carcass and Serum Qualities of Broiler Chickens

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Research Article

Volume 3 Issue 2

Received Date: March 28, 2018

Published Date: May 08, 2018

Abstract

The basic feed supplemented with *Sargassum* powder (1%, 2%, 3% and 4%) provided more amount of essential amino acids, long chain fatty acids and minerals necessary for the growth of poultry than the basic feed. The growth promoting ability of *Sargassum* increased from 1% to 2% and then there was steady state, which is reflected in the weight gain, feed intake, feed conversion rate, carcass qualities and serum parameters of poultry. *Sargassum* powder had increased the growth to gain about 1265g more weight compared to the control and the supplementing effect was the maximum at 2% *Sargassum* powder. The feed intake per bird increased from 4647g at 1% *Sargassum* powder to 4813g at 4% *Sargassum* powder while it was 3042g in the control group. The feed conversion rate increased from 51.5 to 51.8 instead of 33.9% in the control. *Sargassum* treatment increased the liver weight from 2.26% to 2.30%, the heart weight from 0.53%-0.45%, the gizzard from 1.76% to 1.83%, the intestinal weight from 210.2 to 226.18%, the leg proportion from 3.77% to 4.57%, the breast weight from 28.26% to 30.27%, the thigh weight from 13.37% to 14.68%, the drumstick from 14.16% to 15.28% and the dressing from 70.32% to 81.12%. The maximum supplementary effect was noted at 1% and 2% of the *Sargassum* powder. Dietary treatment of broiler chicks with *Sargassum* powder significantly ($P < 0.05$) decreased plasma cholesterol and globulin while increased the total serum protein, albumin, calcium, phosphorus and triglyceride compared to control. The 1% *Sargassum* gave 1.8 fold profits while 2%, 3% and 4% *Sargassum* powder gave 1.95 fold profit compared to the control. Meat qualities of chicks fed with 1% and 2% *Sargassum* were superior to the meat of poultry fed only with the basic feed.

Keywords: *Sargassum wightii*; Macroscopic marine; Proteins; Vitamins

Introduction

In recent years poultry industry has made available some feed formulations, vitamin supplements, vaccines and drugs with which the problems of under nutrition and disease outbreaks can now be managed productively. Even though such products are relatively cheap and indispensable components for poultry production units, many growers in the rural and urban parts of India cannot grow domestic fowls profitably because of low productivity and inferior basic feeds. There has been an increasing trend towards using natural feed additives to improve the performance, increase the dietary protein, energy utilization and to maintain health of birds [1]. Perusals of available literatures make it clear that dietary supplements such as probiotics, herbal powders and algal products have been put in use in the poultry ration for enhancing the growth and reproductive attributes and innate immunity to provide adequate protection to fowls. *Sargassum wightii* is one of the dietary supplements that have increased the growth and reproductive capabilities of fowl, shrimps, ducks and mice.

The brown seaweed *S. wightii* is a macroscopic marine alga found attached to rocky bottom of shallow coastal waters of Tamilnadu and many parts of Asia, which has been used as animal feed, food ingredients, fertilizer, medicines and raw materials [2]. This marine alga is a good source of minerals, vitamins (A, B₁, B₂, C, D and E), proteins, essential amino acids, fats, fatty acids, polysaccharides, fibers and flavanoids [3,4] and its protein and lipid qualities are acceptable for humans and veterinary animals as it contains relatively high proportion of essential amino acids and unsaturated fatty acids [5]. In addition, it contains some bioactive compounds [6,7] responsible for its antiviral, anti-fungal, antioxidant, anti-inflammatory, antiallergenic, anti-thrombic, anti-carcinogenic, hepatoprotective and cytotoxic activities [8,9] due to the presence of long-chain fatty acids [10], polyphenols [11,12], saponins [13], alkaloids, sterols [13,14], flavonoids and fucoidan [15]. The unsaturated fatty acids, especially PUFAs, increase the growth and development of many fishes and animals [16-18] and at the same time decrease the levels of the expression of cytokines necessary for shifting the function of lymphocytes from the cells mediated response to antibody-mediated response. Essential amino acids present in the seaweed make it a highly valuable protein in the food [19].

Dietary supplementation of *S. wightii* has enhanced the weight gain of mice [15], tiger shrim [20], ducks [21], poultry [22] and pigeon [23]. In poultry, dietary

supplementation of *S. wightii* has increased the feed conversion rate and weight gain [21]. As this algal powder is rich in acceptable proteins, it has been recommended as a dietary supplement for cattle in China, Thailand, Korea, Japan, Indonesia and Philippines [24]. The present study was undertaken to analyze the suitability of the dried powder of *S. wightii* for using as a dietary supplement to White Leghorn broiler chickens under South Indian conditions.

Materials and Methods

Preparation of *Sargassum* powder

Specimens of *S. wightii* (Phaeophyceae) were collected from the coastal village Leepuram near Kanyakumari (Lat 9°11' N; Long 79° 24' E) of Tamilnadu and brought to the laboratory. They were washed repeatedly with tap water for 3 times to remove dust particles, sand and epiphytic microalgae. The whole plants were dried under shade, and then sun dried and ground into *Sargassum* powder. This powder was then stored in a refrigerator.

Chemical Analysis of *Sargassum* Powder

The protein content of *Sargassum* powder was estimated using the Biurette method described by Raymont, et al. (1964) [25]. The lipid was extracted using chloroform methanol mixture as a solvent and estimated by using the method described by Folch, et al. (1956) [26]. The method described in the AOAC (1995) [27] was followed for the quantification of minerals in *Sargassum* powder. A 0.2 g of oven dried *Sargassum* powder was taken in a dry conical flask and treated with 10 ml of diacid mixture (2:5 of Nitric acid and Perchloric acid). The content of conical flask was allowed to stand for a few hours for cold digestion. After that, the conical flask was kept on a hot plate to digest the contents under the influence of temperature. The digested content was filtered through a Whatman No.40 filter paper to get a filtrate. The filtrate was suitably diluted and fed into ICP - Perkin Elmer Mayer Optical Emission Spectrophotometer (Optima 2100 DV) as per the procedure given in the Users' Manual for analyzing the amount of Mg, Cu, Mn, Fe and Zn present in the filtrate. Na, K, I and Ca were analyzed with Flame Photometer. For the estimation of methionine, cystine and lysine contents, one gram of *Sargassum* powder was hydrolyzed with 6N hydrochloric acid in evacuated sealed tube for 24 hours at 110°C and the hydrolyzed sample was analyzed with Waters Pico-Tag HPLC Amino acid Analysis System (Column: Pico-Tag amino acid analysis column, 3.9 (150 mm); detector: Waters 2489 Dual λ absorbance detector).

Experimental Design

This experiment was conducted in the Animal House - Sivanthi Athithanar College, Pillaiyar Puram, Kanyakumari District, Tamilnadu, South India- from September 2017 to January 20018. 100 one-day unsexed broiler chicks (White Leghorns; Suguna Chickens) were purchased from a commercial hatchery and assigned at random into five experimental groups each had four replicates of five chicks; each group was kept in an open wire mesh-sided poultry house. The pens (1m²) inside the house were prepared using wire mesh partitioning. Light was provided 24 hours in a form of natural light during the day and artificial during night.

Five experimental feeds were formulated to meet the nutrient requirements of broiler chicks according to NRC, (1994) [28]. The basic feed was formulated with sorghum (65g), groundnut cake (13g), sesam cake (15g), super concentrate (5g; containing crude protein 40%, ME 2000 Kcal/kg, crude fiber 3% ; calcium 8%, lysine 12 %, Methionine 3% and available phosphorus 8%), shell powder (1g) and salt (0.15g). The basic feed was considered as control and the other four diets was formulated with the basic feed having *Sargassum* powder at the rate of 1%, 2%, 3% and 4% respectively. Feed and water were provided *ad libitum*. Chicks were vaccinated against Gumboro disease at 9 days of age and against Newcastle disease at 22 days of age. Soluble multivitamins compounds (Vimeral), and antibiotic (Colidat), were given to chicks before and after three days of the vaccination in order to guard against stress.

Laboratory Tests

Each chick was weighed weekly and feed intake was determined at the time of weighing. Mean body weight gain and feed conversion ratio (FCR) were calculated weekly. Blood samples were collected from the wing of birds before slaughter in heparinized tubes. Blood serum was separated by centrifugation at 3000 rpm for 15 min, and plasma obtained was stored at -20°C until analysis. Plasma total protein, albumin, total lipids, total cholesterol, creatine and triglycerides were determined using spectrophotometry. On the 121st day, the chicks were fasted overnight except from water. One chick from each replicate was randomly selected, individually

weighed and slaughtered then scaled in hot water, feather plucked manually then washed and drained, eviscerated and individual organs (the liver, heart, gizzard and legs) were separately weighed.

Carcass Analysis

The carcasses were chilled at 4°C for 24 hours and cut into two halves. The left side was divided into the commercial cuts (breast, thigh and drumstick), each of which was weighed individually, deboned and the meat was frozen for panel taste. The meat was cut into small pieces, wrapped individually in aluminum foil and roasted at 190°C for 70 minutes with average internal temperature of 88°C and served warm to 10 well-trained taste panels to score color, flavor, tenderness and juiciness of meat [29].

Statistical analysis

Data obtained from this experiment was subjected to one-way ANOVA, using SPSS (1997) [30] computer software. The significant differences among the means of different dietary treatments were analyzed with the Duncan multiple range test [31].

Results

Chemical analysis according to the NRC (1994) [28] shows that a 100 gram of the basic feed contains crude proteins (16.47g), crude fats (3.61g), metabolic energy (2315.7 Kcal), calcium (1149mg), phosphorus (562mg), sodium (160 mg), copper (0.42 mg), iodine (0.1mg), zinc (2.53 mg), manganese (2.73mg), methionine (280mg), cystine (260mg), lysine (362 mg), arginine (120 mg), tryptophan (183 mg), glycine (323 mg), histidine (121 mg), leucine (340 mg), isoleucine (282mg), phenylalanine (348 mg), tyrosine (247 mg), threonine (187 mg) and valine (248mg) (Tables 1 & 2). The basic feed supplemented with *Sargassum* powder had relatively higher amount of all the above said nutrients than the basic feed used in the experiment. Further, the concentration of these nutrients increased with increase in the dosage of *Sargassum* power from 1% to 4% added to the basic feed. Vitamin concentration remains the same in all these feed formulations.

Constituents of diet*	Basal feed (Control)	Basal feed + 1% <i>S.wightii</i>	Basal feed + 2% <i>S.wightii</i>	Basal feed + 3% <i>S.wightii</i>	Basal feed + 4% <i>S.wightii</i>
Crude protein (g)	16.47	16.54	16.61	16.68	19.75
Crude fibers (g)	5.21	5.26	5.27	5.32	5.39
Fats (g)	3.61	3.62	3.63	3.64	3.65

ME (Kcal/Kg)	2315.7	2316	2316.3	2316.6	2316.8
Calcium (mg)	1149	1149.16	1149.32	1149.48	1149.62
Phosphorus (mg)	562	575	584	591	599
Sodium (mg)	160	160.69	161.36	162.07	162.76
Zinc (mg)	2.53	2.6	2.68	2.76	2.84
Manganese (mg)	2.73	2.77	2.81	2.85	2.89
Iodine (mg)	0.1	0.115	0.13	0.145	0.16
Copper (mg)	0.42	0.46	0.5	0.54	0.56
Methionine (mg)	280	317	354	391	428
Cystine (mg)	260	285	310	335	360
Lysine (mg)	362	408	454	500	546
Arginine (mg)	120	124.6	129.2	133.8	138.4
Tryptophan (mg)	183	213	243	273	303
Glycine (mg)	323	326.1	329.2	332.3	338.4
Histidine (mg)	121	125.1	129.2	133.3	137.4
Leucine (mg)	340	345.5	351	356.5	362
Isoleucine (mg)	282	286.8	291.6	296.4	301.2
Phenylalanine (mg)	348	354.1	360.2	366.3	372.4
Tyrosine (mg)	247	250.9	254.8	258.7	262.3
Threonine (mg)	187	194.3	202.8	210.7	218.6
Valine (mg)	214	219	224	229	233
Vitamins**	Constant	Constant	Constant	Constant	Constant

Table 1: Levels of different dietary components in the basal feed and *Sargassum* supplemented test feed (100g each).

* Calculated according to NRC (1994)

****Vitamins:** vit. A 2500 I.U/Kg ; D3 2500 I.U/Kg ; E 25 mg/Kg ; C 400 mg/Kg ; B2 100 mg/Kg folic acid 30 mg/Kg, choline 1000 mg/Kg.

Growth attribute	Basal feed (Control)	Basal feed + 1% <i>S.wightii</i>	Basal feed + 2% <i>S.wightii</i>	Basal feed + 3% <i>S.wightii</i>	Basal feed + 4% <i>S.wightii</i>
Initial weight (g/bird)	148 ^a	148.25 ^a	148.25 ^a	149.0 ^a	148.25 ^a
Final weight (g/bird)	1363.50 ^a	2560 ^b	2628.5 ^a	2628.50 ^a	2628.50 ^a
Weight gain (g/bird)	1215.5 ^a	2411.75 ^b	2480.25 ^a	2479.5 ^b	2480.25 ^a
Feed intake (g/bird)	3042 ^a	4647 ^b	4813 ^b	4811 ^b	4811 ^b
Feed conversion rate (%)	33.9 ^a	51.8 ^b	51.7 ^b	51.5 ^b	51.5 ^b

Table 2: Growth attributes of poultry in response to dietary supplementation of *Sargassum* powder.

Figures after ± represent standard deviation; ^a p<0.05; ^b p>0.025

Growth performance of chickens fed with *Sargassum* powder was significantly (p<0.05) higher than that in the control group (Table 2). The initial weight was 148g/chicks and the final weight increased from 2560g at

1% *Sargassum* powder to 2628g at 4% *Sargassum* powder instead of 1363g in the control. *Sargassum* powder had increased the growth to gain about 1265g more weight compared to the control and the supplementing effect was the maximum at 2% *Sargassum* powder. The feed intake per bird increased from 4647g at 1% *Sargassum* powder to 4813g at 4% *Sargassum* powder while it was 3042g in the control group. The feed intake increased from the 1% to 2% of *Sargassum* powder and then there was a

stationary phase. The statistical significance was $p < 0.05$. Diet containing 2% *Sargassum* powder showed the heaviest body weight ($p > 0.05$) compared to the tested groups, while those fed on control diet recorded significantly ($p < 0.05$) the lowest weight. The feed conversion rate increased from 51.5 to 51.8 instead of 33.9% in the control; the maximum effect was observed at 1% *Sargassum* powder. The statistical significance was ($p > 0.05$).

Carcass traits	Basal feed (Control)	Basal feed + 1% <i>S.wightii</i>	Basal feed + 2% <i>S.wightii</i>	Basal feed + 3% <i>S.wightii</i>	Basal feed + 4% <i>S.wightii</i>
Live weight (g)	1363.50 ^a	2560 ^b	2628.5 ^a	2628.50 ^a	2628.50 ^a
Liver weight (%)	2.26 ^a	2.29 ^b	2.30 ^b	2.30 ^b	2.29 ^b
Heart (%)	0.53 ^a	0.542 ^b	0.545 ^b	0.544 ^a	0.543 ^a
Gizzard (%)	1.76 ^a	1.81 ^b	1.83 ^a	1.82 ^b	1.82 ^a
Intestine (g)	210.2 ^a	222.32 ^a	226.18 ^b	226.20 ^b	226.19 ^b
Legs (g)	3.77 ^a	4.30 ^b	4.57 ^b	4.58 ^a	4.57 ^b
Breast (%)	28.26 ^a	29.31 ^b	30.27 ^a	29.26 ^b	29.26 ^b
Thigh (%)	13.37 ^a	14.58 ^a	14.67 ^b	14.68 ^b	14.66 ^b
Drumstick (%)	14.16 ^a	15.23 ^b	15.26 ^a	15.27 ^a	15.28 ^b
Wing (%)	11.24 ^a	10.72 ^a	10.64 ^b	10.62 ^b	10.61 ^b
Dressing (%)	70.32 ^a	79.21 ^b	81.12 ^b	79.32 ^b	79.33 ^b

Table 3: Variation in the carcass traits of poultry in response to dietary supplementation of *Sargassum* powder. Figures after \pm represent standard deviation; ^a $p < 0.05$; ^b $p > 0.05$

Carcass traits of chicken fed with *Sargassum* powder were significantly ($p < 0.05$) different from those of chickens fed only with the basal feed (Table 3). Live weight of a chick was 1363.50 in the control and it was in the range of 2560 -2628g in chicken fed with *Sargassum* powder, of which the maximum effect was shown at 2% of the supplement. *Sargassum* treatment increased the liver weight from 2.26% to 2.30%, the heart weight from 0.53%-0.45%, the gizzard from 1.76% to 1.83%, the intestinal weight from 210.2 to 226.18%, the leg proportion from 3.77% to 4.57%, the breast weight from 28.26% to 30.27%, the thigh weight from 13.37% to 14.68%, the drumstick from 14.16% to 15.28% and the dressing from 70.32% to 81.12%. The maximum supplementary effect was noted at 1% and 2% of the *Sargassum* powder. The statistical significance was ($P > 0.05$). Wing weight decreased significantly ($p > 0.05$) from 11.24% to 10.61%.

Dietary treatment of broiler chicks with *Sargassum* powder significantly ($P < 0.05$) decreased plasma cholesterol and globulin while increased the total serum protein, albumin, calcium, phosphorus and triglyceride compared to control (Tables 3 & 4). In birds fed with *Sargassum*, serum glucose level increased from 206.2 to 208.7g/dl instead of 204.2mg/dL; total serum proteins slightly increased to 2.34 from 2.2mg/dL (control); albumin level increased from 1.7 to 1.9mg/dL instead of 1.1mg/dl in the control; triglycerides increased from 96.4mg to 113.2mg/dL instead of 80.3 in control; the serum phosphate level increased from 7.6mg to 8.6mg/dL instead of 5.5mg/dl (control); and the calcium content increased from 11.3mg to 12.2mg/dL instead of 10.4mg/dl in the control. Statistical significance in these cases was $p < 0.05$. *Sargassum* powder reduced the cholesterol level from 122.1 (control) to 96.7mg/dL and the globulin level from 1.1 mg/dl (control) to 0.41mg/dL.

Serum parameter	Basal feed (Control)	Basal feed + 1% <i>S.wightii</i>	Basal feed + 2% <i>S.wightii</i>	Basal feed + 3% <i>S.wightii</i>	Basal feed + 4% <i>S.wightii</i>
Glucose (mg/dL)	204.2 ^a	206.1 ^a	208.2 ^a	208.6 ^b	208.7 ^b
Total serum proteins (mg/dL)	2.2 ^a	2.31 ^b	2.33 ^a	2.34 ^b	2.31 ^b
Albumins (mg/dL)	1.1 ^a	1.7 ^a	1.9 ^b	1.92 ^a	1.9 ^a
Globulins (mg/dL)	1.1 ^a	0.6 ^a	0.43 ^a	0.42 ^b	0.41 ^b
Cholesterol (mg/dL)	122.1 ^a	102.2 ^b	97.6 ^a	96.7 ^b	96.7 ^a
Triglycerides (mg/dL)	80.3 ^a	96.4 ^b	112.2 ^b	113.1 ^a	113.2 ^b
Phosphate (mg/dL)	5.5 ^a	7.6 ^b	8.3 ^b	8.5 ^b	8.6 ^a
Calcium (mg/dL)	10.4 ^a	11.3 ^b	12.1 ^b	12.2 ^b	12.2 ^b

Table 4: Serum parameters of poultry in response to dietary supplementation of *Sargassum* powder. Figures after \pm represent standard deviation; ^a $p < 0.05$; ^b $p > 0.05$.

Live weight of poultry revealed that 1% *Sargassum* gave 1.8 fold profits while 2%, 3% and 4% *Sargassum* powder gave 1.95 fold profit compared to the control.

Chicks fed with 2% *Sargassum* gave the highest profit followed by those fed on diet containing 1% of this supplement (Table 5).

Meat parameter	Basal feed (Control)	Basal feed + 1% <i>S.wightii</i>	Basal feed + 2% <i>S.wightii</i>	Basal feed + 3% <i>S.wightii</i>	Basal feed + 4% <i>S.wightii</i>
Colour	Moderate	Good	Good	Good	Good
Flavour	Moderate	Good	Good	Medium	Medium
Tenderness	Moderate	Good	Good	Medium	Low
Juiciness	Moderate	Good	Good	Low	Low
Taste	Moderate	Good	Good	Low	Low

Table 5: Likely qualities of meat from the consumers.*

*Good = < 7 score; Moderate = < 5 score; Medium = < 3 score; Low => 2 score.

In the consumer point of view, colour is good in all the *Sargassum* treatments but flavor was medium at 3 and 4% of *Sargassum* powder. Tenderness was good at 1% and 2% of this supplement. Juiciness and taste were good at 1% and 2% of the dietary supplement but low at higher dosages (3% and 4%). The average meat quality scores were above moderate level at the 1% and 2% *Sargassum* powders.

Discussion

Nutritional components in the feed and supplements are the determinants of the growth, maturation and reproduction of birds [32]. Banergee has stated that the daily diet of a broiler chick should contain crude protein (16g), crude fiber (7.0g), crude fat (3.5g), methionine (450mg), cystine (200 mg), lysine (600 mg), arginine (500

mg), tryptophan (130 mg), glycine (600 mg), histidine (200mg), leucine (750 mg), isoleucine (400mg), phenylalanine (640 mg), tyrosine (400 mg), threonine (400 mg) and valine (450 mg), phosphorus (600mg), calcium (1.0 g), Zinc (25mg), iodine (0.35mg), sodium (0.15mg), copper (0.2 mg), manganese (5.0mg), iron (trace amount), vitamin A (2000 IU), Vitamin D₃ (200 IU), Vitamin B₁ (0.30 mg), Vitamin B₂ (0.30 mg), Vitamin B₆ (0.30 mg), Vitamin B₁₂ (1.0 mg), biotin (6 μ g), choline (70 mg), folic acid (0.10 mg), niacin (3.0mg) and panthothenic acid (10 mg). The basic feed used in our experiment could provide adequate amount of crude proteins, crude fiber, crude fat, metabolic energy, phosphorus, calcium, iodine, sodium, copper, vitamin A, vitamin D₃, Vitamin B₁, Vitamin B₂, Vitamin B₆, Vitamin B₁₂, biotin, choline, folic acid, niacin and panthothenic acid to pigeons, but it had inadequate amount of zinc, manganese, methionine,

cystine and lysine, which have to be supplied in yet other form for effective growth of pigeons. Since *Sargassum* powder had Na (690 µg/g), K (182µg/g), P (45mg/g), Ca (80µg/ g), Mg (5892µg/ g), Mn (21.3µg/ g), Zn (73.4 µg/ g), Cu (39.5 µg/ g), Fe (256µg/ g), Al (182µg/ g), Co (1.2 µg/ g), methionine (280mg/g), cystine (260mg/g) and lysine (367 mg/g), it could also enrich the diet with all these minerals and enabled the diet to have adequate quantity of manganese and zinc.

Essential amino acids present in the seaweed make it a highly valuable protein in the food of animals and man [19,33-36]. *Sargassum* powder contains aspartic acid (1.80%), glutamic acid (1.15%), serine (0.54%), glycine (0.45%), histidine (0.45%), arginine (0.60%), threonine (0.71%), alanine (0.44%), proline (0.38%), tyrosine (0.49%), valine (0.50%), methionine (0.37%), cystine (0.25%), isoleucine (0.55%), leucine (0.55%), phenylealanine (0.63%), tryptophan (0.21%) and lysine (0.50 [36], of which methionine, cystine and lysine are the essential amino acids for poultry [37]. Powder of *S.wightii* contains fatty acids like caproic acid, caprylic acid, capric acid, lauric acid, tridecylic acid, myristic acid, pentadecylic acid, palmitoleic acid, margaric acid, stearic acid, oleic acid, linoleic acid, γ-linolenic acid, α- linolenic acid, arachidic acid, dihomo-γ-linolenic acid, arachidonic acid, heneicosylic acid, eicosapentaenoic acid, behenic acid, docosahexaenoic acid and lignoceric acid [38,10], of which unsaturated fatty acids (UFAs) like myristic acid, palmitoleic acid, oleic acid, γ-linoleic acid, α-linolenic acid, arachidonic acid and eicosapentaenoic acid are found in larger proportions. Since these UFAs are essential fatty acids for animals, they increase the growth and development of many fishes and animals [16-18] and at the same time decrease the levels of the expression of cytokines necessary for shifting the function of lymphocytes from the cells mediated response to antibody-mediated response. It is therefore concluded that *Sargassum* powder could improve the dietary values of the basic diet and its effect was increasing with increase in the dosage from 1% to 4% added to the basic diet.

Growth of chicken has been reflected in the live weight of body weight and carcass qualities. As has been reported by Mariey, et al. (2013) [39], who had demonstrated that yeast supplementation has increased the body weight of pigeons, *Sargassum* powder had increased the body weight of broiler chickens due to its dietary supplementing property that is associated with rich minerals, and vitamins [6, 7], long-chain fatty acids [10], essential amino acids [11-13] sterols [14] and fucoidan. The rate of increase in the body weight of fowls

and veterinary animals is determined by feed intake and subsequent conversion of the feed into various metabolites and body tissues [40-44]. The feed intake of birds generally varies greatly depending on the genetic race of bird, age group and the type of feed provided to them [45,46]. However, it is further altered by nutritional supplements added to the feed [47]. Dietary supplementation of *Sargassum* extract had enhanced the feed intake and body weight gain in poultry, ducks [21], pigeon [23] and aquaculture fishes and shrimps [20]. In this line of investigation, these results agree with the findings of El-Sayed (1982) [48], El-Deek, et al., (1987) [22], Gu, et al., (1998) [49], Wong and Cheung (2001) [50], Sim, et al., (2004) [51], EL-Deek, et al., (2011), Breikaa (1993) [21], Felix, et al. (2004) [20] and Athis Kumar (2017) [23]. 2% *Sargassum* powder is enough in the daily diet to produce the maximum weight gain in poultry since it can promote the maximum food conversion rate. As natural feed additives, *Sargassum* improved the diet palatability to intake more food compared to the control and enhanced its digestion followed by intestinal absorption as noted by Michael and Kumawat, (2003) and Alloui, et al., (2012) .

The high level of feed conversion is reflected in the meat qualities and carcass traits of poultry [51]. As a consequence, live weight, liver weight, heart (%), Gizzard (%), Intestine weight, legs (%), breast (%), thigh (%), drumstick (%) and dressing (%) are increased and the wing (%) is slightly decreased while feeding the chickens with *Sargassum* powder. In this context, the present study coincides with the findings of Guo, et al., (2004) [49], Alloui, et al., (2012), Mukhtar, et al., (2013) [51,52], Amal, et al., (2013) [53] and Tariq Mamoun, et al. (2014) [54] who reported improvement carcass qualities of broiler feed with lemon grass oil, Halfa bar essential oil and fenugreek powder respectively.

Since *Sargassum* is a good source of minerals, vitamins, proteins, essential amino acids [5], it might have improved the protein synthetic machinery to produce more amounts of proteins in poultry as reported El-Sayed (1982) [48], Gu, et al. (1998) [49], Sim, et al. (2004) [51], and Breikaa (1993) [21]. Therefore, total serum protein and albumins are produced in large proportions. *Sargassum* powder reduces cholesterol synthesis and as a consequence triglycerides are increased in the blood of poultry due to the presence of certain chemical constituents that promote faster metabolism of triglycerides [14,11,13,10,23]. The hypocholesterolemic effect of *Sargassum* powder may also be due to its active ingredients such as saponins, hemicelluloses, mucilage, tannin and pectin, which help lower blood LDL-

cholesterol levels by inhibiting bile salts [51,52,54]. Phosphate and calcium enriched by *Sargassum* might have increased their concentration in the serum as confirmed by reports of Mukhtar, et al., (2013)[51,52].

The meat quality score is always superior to the meat produced from the control group but taste is slightly changed at 3% and 4% of *Sargassum* powder because of over accumulation of minerals that are not assimilated for the growth of chicken. However, all these qualities of meat obtained from poultry fed with *Sargassum* are above the acceptable level. These results coincide with the findings of Mukhtar, et al., (2013) [51,52].

Conclusion

The present investigation confirms that *Sargassum* powder has increased the weight gain of poultry partly due to its minerals, essential amino acids and long chain fatty acids necessary for growth and partly due to enhancement of food-intake and food conversion rate of chicks. 2% of *Sargassum* powder added to the diet has the maximum growth promoting activity as well as body weight gain of fowls. Live weight of poultry is reflected in the ratio of carcasses and meat quality, which are the deciding factor for the profits to the growers. The growers can get 1.9 folds more income while chickens are fed with 2% *Sargassum* powder along with the basic diet. Since *Sargassum* has reduced the globulin content and cholesterol in the serum, it is presumed that cholesterol content of meat is also reduced simultaneously. As low cholesterol level is likely to avoid heat problems, and as the meat score is good for human consumption, this is superior to meat of poultry maintained only with the basal feed.

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