J. Agric. Sci. Mansoura Univ., 30 (9): 5081 - 5092, 2005

THE NUTRITIONAL POTENTIAL OF DEHYDRATED ALGAE AND AZOLLA AS FEEDS FOR LAYING HENS

El-Mallah, G. M.; Laila D. Abd El-Samee and Sh. A. M. Ibrahim
Animal Production Dept., National Res. Centre, Dokki, Cairo, Egypt.

ABSTRACT

One hundred-sixty eight, 24-weeks old, Bovans Brown commercial egg-type laying hens were randomly and equally divided into saven groups (8 replicates per group, each of 3 birds). These groups were randomly assigned on 7 experimental diets including a typical corn-soybean control diet and diets either containing 5, 10 or 15% dried algae (*Scenedesmus acutus*); or containing 5, 10 or 15% dried *Azolla*. Each of algae and *Azolla* were used as a partial substitution for soybean meal of the control diet on an isonitrogenous basis. Hens were fed the experimental diets for 12-weeks test period.

Either dietary algae up to 10% or 5% dietary *Azolla* did not affect OM or CP digestibility, but only at the higher levels, digestibility was decreased. Non of dietary treatments affect EE, CF or NFE digestibility, excepting a decrease in EE digestibility observed with the 15 % dietary *Azolla*, and decreases in both CF and NFE digestibility with the 10 and 15% dietary *Azolla*; in addition to enhancement of NFE digestibility due to 5 and 10% dietary algae.

Egg production and egg weight were not affected by 5% algae or *Azolla* in hen diets. However, significant decreases in both parameters were observed on the higher levels. Feed intake was significantly reduced with 10 and 15% dietary *Azolla*. Up to 10% dietary algae or 5% dietary *Azolla* did not affect feed conversion, but negative effectes were observed at the higher studied levels.

Non of dietary algae or *Azolla* affect both internal and external egg quality parameters, however, significant decreases in haugh unit and albumen% were observed on the 15% *Azolla* and 5% algae levels, respectively. All levels of dietary algal meal tended to enhance yolk color, but only at the 15% level, *Azolla* significantly enhanced yolk color, compared to the control.

All the tested diets increased plasma total protein, albumin, and globulin values, except for 5% *Azolla* diet. Significant decrease was observed in total lipids on the 15% dietary *Azolla*, with significant elevations in cholesterol level occured at the 10 and 15% levels. Both algae and *Azolla* elevated plasma uric acid.

These data suggest that either dried algae or *Azolla* at 5% dietary level are useful as partial alternatives to soybean meal in laying hen diets on an isonitrogenous basis, for maintaining egg production and quality, but even this level of algae tend to enhance yolk color score.

Keywords: algae, *Azolla*, laying hens, digestibility, egg production, egg quality, blood.

INTRODUCTION

Poultry are an important constituent of agriculture and contribute large part of animal protein for human consumption. Moreover, in Egypt, many of the traditional protein sources used in laying hen diets formulation such as soybean meal are becoming extremely expensive. Therefore, the search for alternative protein sources has become urgent.

On the other hand, algae, which are chlorophyll-bearing organisms having no true roots, stems or leaf-like organs are rich in protein, and low in fiber and ash (Ali and Leeson, 1994). Algae also contain an amino acid profile similar to that of soybean meal and are a good source of fat and metabolizable energy for poultry (Ali and Leeson, 1994). The nitrogen digestibility coefficient for algae meal is 81% which is similar to most common poultry feed ingredients, and in addition, algae are also a rich source of xanthophylls, B-carotene, thiamine, riboflavin, pyridoxine, vitamin B12 and vitamin C (Ali and Leeson, 1994). Breeding Japanese quail perform satisfactorily when the diet contains up to 12% algae meal, with increasing yolk color with each level of the algae (Ross and Dominy, 1990). Blue-green algae included at 1% of the diet provide optimum yolk pigmentation in the eggs of Japanese quail when the diet is otherwise free of xanthophylls (Andreson *et al.*, 1991). In addition, consumers in Egypt prefer much color in egg yolk. Furthermore, it was reported (Lipstein and Hurwitz, 1980) that compared to other species, the capability of poultry to excrete uric acid allows for elevated dietary algal concentrations without the nucleic acids from the algal biomass endangering the birds.

Azolla is a small aquatic fern found in aquatic habitats like ponds, canals, and other wet /moist places (swamp, streams, and rice fields) in different climatic regions (Chen and Huang, 1987 and Khan, 1988). Moreover, Ali and Leeson (1994) reported that sun-dried *Azolla* is a fairly good source of crude protein and nitrogen free extract, but is high in ash. They also reported that, fresh *Azolla* can substitute for 20% of the commercial feed of chickens.

Therefore, the aim of the present investigation was to evaluate the nutritional potential of dried algae and *Azolla* to provide dietary protein for laying hens as a partial substitution for soybean meal on an isonitrogenous basis and studing their effects on egg production and quality.

MATERIALS AND METHODS

The present work was conducted at the poultry farm, Faculty of Agriculture Cairo University. One hundred-sixty eight, 24-weeks old, Bovans Brown commercial egg-type laying hens were randomly and equally divided into seven groups (8 replicates per group, each of 3 birds). These groups were randomly assigned on 7 experimental diets including a typical corn-soybean control diet (diet 1) and diets either containing 5, 10 or 15% dried algae (*Scenedesmus acutus*) (diets 2, 3 and 4, respectively); or containing 5, 10 or 15% dried *Azolla* (diets 5, 6 and 7, respectively). Each of algae and *Azolla* were incorporated in their respective diets to partially replace soybean meal of the control diet on an isonitrogenous basis. Therefore, in diets 2,3 and 4, algae represented substitution of 20.83, 41.67 and 62.50% of soybean meal of the control diet, respectively, while in diets 5, 6 and 7, *Azolla* represented substitution of 11.17, 22.33 and 33.50% of soybean meal of the control diet, respectively. All diets were formulated to contain calories ranged between (2715 to 2835 kcal ME/kg) and to be iso-nitrogenous (almost about 18%CP) and similar in their contents of methionine and lysine (Table 2) and met the nutritional requirements of laying hens as recommended by NRC (1994). Hens were fed the experimental diets for 12-weeks test period. Chemical analysis of the tested ingredients (dried Algae and dried *Azolla*) is found in Table 1, while feed ingredients and calculated analysis of the experimental diets are shown in Table 2. Feed and water were freely available all time. Hens were housed in wire cages (3 birds/cage) throughout the experiment. Hens were provided with 18h/d photoperiod during the experiment.

Table (1): The chemical composition of soybean meal, dried algae and *Azolla* as dry matter.

Component, %	Soybean* meal	Algae	*Azolla*
Crude protein	44.00	44.90	23.51
Ether extract	0.80	5.20	3.41
Crude fiber	5.50	12.82	12.23
Nitrogen free extract	31.88	20.43	45.13
Ash	6.82	16.65	15.72
Calcium	0.29	0.25**	1.52***
Total phosphorus	0.65	1.20 **	0.41***
Available phosphorus	0.27	1.09**	0.30***
Lysine	2.69	2.78**	0.73***
Methionine	0.62	0.93**	0.26***
Metabolizable energy (kcal/kg)	2230	3.27****	3132****

* Cited to NRC (1994).
** Cited to Becker (1978b) and Ali and Leeson (1994).
***Cited to Qota *et al.*, (2001).
**** Calculated according to Carpenter and Clegg, 1956, by applying the equation:
ME (kcal/kg) = (35.3 x CP) + (79.5 x EE) + (40.6 x NFE) + 199

Egg number and weight and also feed intake were recorded daily for each group. Egg production, egg mass and feed conversion were calculated in 4-weeks intervals from the start of the experiment at 24 weeks till 36 weeks of age. Mortality rate was also recorded.

At the end of each 4-weeks experimental period, 16 eggs from each group (2 eggs per cage) were randomly taken, weighed and cracked to determine egg quality parameters. Shape index (Carter, 1968), yolk index (Well, 1968) and Haugh unit (Stadleman, 1977) were also determined. Shell thickness in mm was measured, using micrometer, while yolk color was measured by Roche color fan.

At the end of the experiment, 28 hens (4/treatment) were randomly chosen to carry out a digestion trial to determine nutrients digestibility of each experimental diet. These birds were fed the tested diets for 5 days collection period. Chemical analyses of dried Algae, dried *Azolla*, tested diets and dried excreta were determined according to (A.O.A.C., 1990) methods.

Also, at the end of experiment, blood samples were collected, via the wing vein (3 hens from each group, chosen randomly) using EDTA as anticoagulant. Blood plasma was separated immediately by centrifugation at 3000 r. p. m. for 20 minutes and stored at -20 °C until analysis for total protein (Henry *et al.*, 1974), albumin (Doumas *et al.*, 1971), total lipids (Bligh and Dyer,1959), cholesterol (Shen *et al.*, 1982), uric acid (Caraway, 1955), ALT and AST (Reitman and Frankel, 1957), while globulin and A/G ratio were calculated.

Table (2): Composition and calculated analysis of the experimental diets.

Ingredients, %	Control	Algae			*Azolla*		
		5	10	15	5	10	15
Yellow corn	62.00	62.00	62.00	62.00	59.68	57.35	55.03
Poultry by-product meal	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Soybean meal 44%	24.00	19.00	14.00	9.00	21.32	18.64	15.96
Algae meal	-	5.00	10.00	15.00	-	-	-
Azolla meal	-	-	-	-	5.00	10.00	15.00
Limestone	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Dicalcium phosphate	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Vit.& Min. premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25
NaCl	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Dl- Methionine	0.02	0.02	0.02	0.02	0.02	0.03	0.03
Total	100	100	100	100	100	100	100
Calculated analysis							
Crude protein, %	17.93	17.98	18.02	18.07	17.65	17.36	17.25
ME kcal/kg	2715	2755	2795	2835	2717	2753	2772
Calcium, %	3.41	3.41	3.59	3.74	3.48	3.55	3.61
Total Phosphorus, %	0.67	0.70	0.73	0.75	0.67	0.66	0.66
Available phosphorus, %	0.40	0.45	0.50	0.56	0.40	0.41	41
Lysine, %	0.92	0.92	0.92	0.93	0.87	0.83	0.79
Methionine, %	0.31	0.33	0.34	0.36	0.31	0.31	0.30

*Vitamin and mineral Premix supplied the following per kilogram of diet: Vit. A 12000 IU; Vit. D_3 2000 IU; Vit. E 10 mg; Vit. K_3, 1 mg; Vit. B_1 1 mg; Vit.B_2 4 mg; Vit.B_6 1.5 mg; Pantothenic acid 10 mg; Vit. B_{12} 0.01 mg; Folic acid 1 mg; Niacin 20 mg: Biotin 0.05 mg; Choline chloride 500 mg; Zinc 45 mg; Copper 3 mg; ; Iron 30 mg; Selenium 0.1 mg; Manganese 40 mg; Iodine 3 mg and Cobalt 0.2 mg.

Data were statistically analyzed according to the procedures described by Steel and Torrie (1980). The significant mean differences among groups were separated using Duncan's Multiple Range Test (Duncan, 1955).

RESULTS AND DISSCUSION

The chemical composition of soybean meal, dried algae and *Azolla* is given in Table (1). The inspection of this composition indicated that dried algae (*Scenedesmus acutus*) had considerable amount of CP, being similar to that of soybean meal and almost double as much as that present in dried *Azolla*. Such high level of CP present in the dried algae permit of replacing higher portions of soybean meal CP of the control diet, as compared with the case of dried *Azolla*. On the other hand, dried *Azolla* had considerably higher NFE content compared to the dried algae. In addition, both dried algae and *Azolla* had high levels of CF and ash. Ali and Leeson, (1994) mentioned that sun-dried *Azolla* is a fairly good source of crude protein (15.4%) and nitrogen free extract (47.4%), but high in ash (20.4%) on DM basis. They also reported that Algae are rich in protein (51-63%) on a dry matter basis and low in fiber (1-6%) and ash (6-11%), while they are also a good source of fat (3-8%) and metabolizable energy for poultry. Some reports, however (Subudhi and

Singh, 1978) indicated that dried *Azolla* contains a higher level of protein (24-30% CP) and lower ash (10.5%). Furthermore, Abdella *et al.* (1998) and Namra (2000) found that dried *Azolla* contains 23.3-25.2% CP, 3-3.5% EE, 12.1-14.6% CF, 38.2-39.5% NFE and 15.6-25.3% ash, on DM basis. However, such differences in chemical composition of algae and *Azolla* may arise from many factors such as stage of growth at harvest, nutrient level of the water media where they are grown, whether or not they are washed after collection and season (Ali and Leeson, 1994). Protein level usually declines while fiber and tannins content increases with increasing age of the plant. The energy value of aquatic plants decreases sharply with age and this is associated with increasing ash level. Washing after harvesting has been shown to reduce the ash content and thus improve the concentration of organic nutrients, thereby improving their nutritional value (Ali and Leeson, 1994).

Results of nutrients digestibility of experimental diets by laying hens are shown in Table (3). Inclusion of up to 10% algae or 5% *Azolla* in hen diets did not affect OM and CP digestibility, but they were significantly decreased ($P \leq 0.05$) only at the higher levels Non of the tested diets affect EE digestibility. with exception of a decrease observed with the 15 % dietary *Azolla* ($P \leq 0.05$). Non of the tested diets affect CF digestibility, with exception of a decrease observed with the 10 and 15 % dietary *Azolla* ($P \leq 0.05$). NFE digestibility of hen diets was significantly decreased ($P \leq 0.05$) with 10 or 15% levels of *Azolla* being significantly ($P \leq 0.05$) enhanced with 5 or 10% dietary algae compared to the control. Similar results were found by Oota *et al.* (2001) who reported that nutrients digestibility by adult cocks , were not affected by dietary *Azolla* up to 8%, while 12 and 16% dietary levels impaired CP,CF and NFE digestibility. Such negative effects of the high levels of *Azolla* on nutrients digestibility may be due to its high contents of hemicellulose and lignin, which are mostly undigested by chickens (Alcantara and Querubin, 1984).

Table (3). Effect of feeding laying hens dried algae and *Azolla* at different levels on nutrients digestibility of experimental diets.

Digestibility coefficient, %	Control	Algae			*Azolla*		
		5	10	15	5	10	15
Organic matter	81.6^{bc} ±0.36	82.8^{a} ±0.07	82.3^{ab} ±0.23	81.4^{c} ±0.19	81.9^{bc} ±0.30	78.0^{d} ±0.34	75.7^{e} ±0.14
Crude protein	87.7^{a} ±0.15	87.9^{a} ±0.30	88.0^{a} ±0.21	85.5^{b} ±0.06	87.4^{a} 0.21±	81.2^{c} 0.59±	79.4^{d} 0.16±
Ether extract	62.7^{ab} ±0.54	63.3^{ab} ±2.30	62.5^{ab} ±1.58	62.5^{ab} ±1.95	64.7^{a} ±1.70	59.1^{b} ±1.49	52.4^{c} ±0.95
Crude fiber	47.7^{a} ±0.24	46.5^{a} ±1.10	43.8^{ab} ±1.93	44.7^{ab} ±1.31	43.8^{ab} ±0.66	41.2^{b} ±0.97	41.3^{b} ±2.27
Nitrogen free extract	82.9^{b} ±0.44	84.5^{a} ±0.19	84.2^{a} ±0.48	84.0^{ab} ±0.32	83.5^{ab} ±0.41	81.0^{c} ±0.36	79.2^{d} ±0.37

$^{a, b, c, d, e}$ Means in the same row with different letters are significantly different ($P \leq 0.05$).

Results of laying hen performance are presented in Table (4). During the early period of the trial (first 4-weeks), up to 10% dietary algae and also the 5% dietary *Azolla* had no significant effect on egg production, but only the higher levels significantly ($P \leq 0.05$) reduced egg production during this early period. Moreover, all dietary treatments significantly ($P \leq 0.05$) reduced egg weight and egg mass, except for the 5% dietary algae that showed similar values to the control. Feed intake did not differ significantly among all treatments, although it tended to decrease with feeding hens diets containing either 10 - 15% algae, or 15% *Azolla*. Feed conversion (kg diet / kg egg mass) of hens fed diets containing up to 10% dietary algae or 5% dietary *Azolla* was similar to that of the control hens, but it was negatively affected with the higher levels of both.

During the 2nd 4-weeks of the trial, the same trend was continued for all the previous parameters, with significant depression in feed intake observed with the 15% level of dietary *Azolla*, compared to the control.

During the final period of the trial (3rd 4-weeks), egg production and feed intake showed similar trends as the previous 2 periods, but with more pronounced depression in feed intake recorded for the group receiving 15% dietary *Azolla* as compared to the control Non of the tested diets has significant effect on egg weight, excepting for significant decrease ($P \leq 0.05$) observed with 10 % level of dietary *Azolla* compared to the control. Up to 10% dietary algae and also the 5% dietary *Azolla* had no significant effect on egg mass, but only the higher levels significantly ($P \leq 0.05$) reduced it during this late period. Feed conversion did not differ significantly with all levels of dietary algae and also with the 5% level of dietary *Azolla*, but it was negatively affected with inclusion of 10 or 15% *Azolla* in hen diets, reflecting the effect of low feed intake during this period.

Concerning the whole experimental period, egg production and egg weight were not significantly affected on the 5% level either of dietary algae or *Azolla*, being significantly decreased with the higher studied levels of both. Egg mass was significantly reduced with feeding either the studied levels of dietary *Azolla*, or more than 5% dietary algae. Feed intake was not significantly affected due to algae inclusion in hen diets at any of the studied levels, or due to *Azolla* inclusion at 5% dietary level, but it was significantly decreased with the 10 or 15 % levels of dietary *Azolla* compared to the control. The decrease in feed intake was more pronounced with the 15 % level. Similarly, Subudhi and Singh, (1978) found that, when dried *Azolla* was given allone to white Leghorn female chickens in various proportions of a daily recommended feed intake of a commercial poultry feed as to be provided after the chickens consumed their daily stated amount of this poultry feed, they initially ate the dried *Azolla* but after a few days stopped eating. They further added that, the maturity of fresh green *Azolla* might affect the platability. Furthermore, Qota *et al.* (2001) found that using dried *Azolla* up to 8% in chicken diets did not affect feed consumption.

Up to 10% dietary algae and also the 5% dietary *Azolla* had no significant effect on feed conversion (kg diet / kg egg mass), but it was negatively affected with the higher studied levels ($P \leq 0.05$). Mortality rate was similar among all groups.

Tabel (4): Effect of feeding laying hens dried algae and *Azolla* at different levels on layers performnce.

Item	Control	Algae			*Azolla*		
		5	10	15	5	10	15
Egg production, %							
First period	84.3^{a} ±0.46	84.5^{a} ±0.65	83.3^{a} ±0.48	79.4^{b} 0.93±	82.8^{a} 1.50±	77.9^{b} 1.40±	72.3^{c} 1.04±
Second period	87.5^{a} ±0.50	88.5^{a} ±1.60	85.2^{ab} ±0.97	82.7^{b} ±0.71	86.0^{ab} ±1.02	76.3^{c} ±1.44	63.6^{d} ±1.67
Third period	91 3^{a} ±1.92	91.8^{a} ±1.87	89.0^{a} ±2.28	83.1^{b} ±0.93	87.4^{ab} ±0.77	74.1^{c} ±2.02	58.4^{d} ±1.84
Overall mean	87.7^{a} ±0.76	88.3^{a} ±1.39	85.9^{a} ±1.18	81.8^{b} ±0.83	85.4^{a} ±0.98	76.1^{c} ±1.60	64.7^{d} ±1.36
Average egg weight, g							
First period	62.5^{a} ±.84	60.3^{ab} ±1.07	58.9^{bc} ±1.15	58.2^{bc} ±0.31	59.0^{bc} ±0.48	56.6^{c} ±0.71	59.3^{b} ±0.71
Second period	63.1^{a} ±0.76	61.2^{ab} ±0.97	60.4^{bc} ±0.82	60.1^{bc} ±0.41	61.0^{ab} ±0.72	58.5^{c} ±0.90	61.0^{ab} ±0.38
Third period	64.3^{a} ±0.85	62.5^{ab} ±1.09	62.7^{ab} ±0.57	62.1^{ab} ±0.46	63.2^{a} ±0.77	60.2^{b} ±1.32	61.7^{ab} ±0.60
Overall mean	63.3^{a} ±0.80	61.3^{ab} ±1.00	60.7^{bc} ±0.79	60.1^{bc} ±0.29	61.1^{ab} ±0.60	58.4^{c} ±0.97	60.7^{bc} ±0.55
Egg mass, kg/hen							
First period	1.48^{a} ±0.02	1.43^{ab} ±0.03	1.37^{bc} ±0.02	1.29^{d} ±0.01	1.37^{c} ±0.01	1.23^{e} ±0.01	1.20^{e} ±0.01
Second period	1.54^{a} ±0.02	1.52^{ab} ±0.04	1.44^{cd} ±0.02	1.39^{d} ±0.02	1.47^{bc} ±0.02	1.25^{e} ±0.02	1.09^{f} ±0.03
Third period	1.64^{a} ±0.05	1.61^{a} ±0.05	1.56^{a} ±0.03	1.44^{b} ±0.01	1.55^{a} ±0.02	1.25^{c} ±0.02	1.01^{d} ±0.02
Overall mean	1.55^{a} ±0.03	1.52^{ab} ±0.04	1.46^{b} ±0.02	1.37^{c} ±0.01	1.46^{b} ±0.01	1.24^{d} ±0.02	1.10^{e} ±0.02
Feed intake, g/hen/ day							
First period	119.1 ±1.99	119.7 ±2.24	116.4 ±3.22	116.0 ±3.42	118.9 ±3.51	119.0 ±3.67	115.7 ±1.85
Second period	125.8^{a} ±3.35	122.9^{a} ±5.48	122.3^{a} ±1.59	118.4^{a} ±2.57	123.1^{a} ±3 21	114.2^{c} ±3.94	100.5^{b} ±3.61
Third period	135.5^{a} ±4.61	127.0^{a} ±7.78	127.9^{a} ±4.88	124.6^{a} ±6.02	121.9^{a} ±5 3	119.1^{a} ±7.43	93.9^{b} ±7.84
Overall mean	126.8^{a} ±2.35	123.2^{ab} ±4.68	122.2^{ab} ±1.95	119.7^{ab} ±2.06	121.3^{ab} ±1.31	117.4^{b} ±2.36	103.4^{c} ±2.67
Feed conversion (kg diet/kg egg mass)							
First period	2 26^{c} ±0.04	2.35^{bc} ±0.02	2.37^{bc} ±0.06	2.5 ±0.07	2.44^{bc} ±0.05	2.71^{a} ±0.09	2.70^{a} ±0.04
Second period	2.28^{b} ±0.04	2.27^{b} ±0.06	2.38^{b} ±0.03	2.38^{b} ±0.05	2.35^{b} ±·.04	2.57^{a} ±0.10	2.59^{a} ±0.03
Third period	2.31^{ab} ±0.07	2.21^{b} ±0.08	2.30^{ab} ±0.11	2.42^{ab} ±0.11	2.21^{b} ±0.12	2.67^{a} ±0.13	2.60^{a} ±0.17
Overall mean	2.29^{c} ±0.03	2.28^{c} ±0.05	2.35^{bc} ±0.04	2.44^{b} ±0.03	2.33^{bc} ±0.04	2.65^{a} ±0.04	2.63^{a} ±0.05
Mortality rate, % (whole period)	4.17	-	-	-	4.17	-	-

a, b, c, d, e Means in the same row with different letters are significantly different ($P \leq 0.05$).

Similarly, Qota *et al.* (2001) found that using dried *Azolla* up to 8% in chicken diets did not affect feed conversion and mortality rate. The negative effect of the high *Azolla* levels on hen performance in the present study may be due to the pronounced low feed intake associated with low digestibility and the high contents of both fiber and ash. In this respect, Ali and Leeson (1994) reported that, aquatic weeds (including algae and *Azolla*) tend to be high in fiber and ash which limits their inclusion level in poultry diets. They further added that when fiber and ash levels of aquatic weed meal (including algae and *Azolla*) are high, inclusion is best limited to less than 5% of the diet. They also reported that, poor bird performance even at modest levels of inclusion of algae, may be due to the poor quality of some algae meal and/or the presence of residual alum following processing. Moreover, Becker (1978 a&b) found that total nucleic acids of algae (*Scenedesmus*) ranged from 4 to 6% on dry matter basis. Therefore, microalgae cannot be used exclusively or preponderantly to cover the protein requirements of birds because of their purine content. Similarly, Buckingham *et al.* (1978) reported that, the negative effect of *Azolla* at the higher levels may be due to the high content of adenine in *Azolla*, which negatively affect the efficiency of *Azolla* as feedstuff by simple-stomached animals. Ross and Dominy (1990) found no significant differences in egg production of Japanese quail due to inclusion of blue-green algae (*Spirulina platensis*) in their diets up to 12%.

Results of egg quality of hens fed the experimental diets are shown in Table (5). Inclusion of dried algae or *Azolla* at either of the studied levels in hen diets did not affect each of shape index, haugh unit, shell thickness, shell%, yolk% or albumen%, except for significant decrease in haugh unit noted for hens fed diet containing 15% *Azolla*, and significant decrease in albumen% observed in the case of birds fed the 5% algal diet. All levels of dietary algal meal tended to enhance yolk color (by 13.6 to 27.3%) compared to the control, although this enhancement was not as responsive level. On the other hand, dietary *Azolla* did not affect yolk color at the 5% level, tended to enhance yolk color (by 9.1%) at the 10% level, while it significantly enhanced yolk color (by 40.9%) at the 15% level, as compared to the control. Yolk index was significantly higher either for all algal or *Azolla* treatments versus the control. Ross and Dominy (1990) found no significant differences in egg quality of Japanese quail due to inclusion of blue-green algae (*Spirulina platensis*) in their diets up to 12%, except for yolk color, which increased with each level of algae compared to the control. In addition, Andreson *et al.* (1991) found that inclusion of blue-green algae at 1% of the diet provide optimum yolk pigmentation in the eggs of Japanese quail when the diet is otherwise free of xanthophylls. Ali and Leeson (1994) reported that, most of aquatic weeds are rich sources of xanthophylls. In this respect, Herber-McNeill and Van Elswyk (1998) found that inclusion of marine microalgal product in laying hen diets up to 4.8% significantly enhanced yolk colour in a dose response manner as early as 1 wk post feeding. They further added that, such enhancement of yolk colour reflects the deposition of the algal carotenoides and that the effects of dietary algae on egg yolk color reached a plateau after 14 d, which was sustained throughout the experiment.

Table (5): Effect of feeding laying hens dried algae and *Azolla* at different levels on egg quality characteristics during whole period.

Item	Control	Algae			Azolla		
		5	10	15	5	10	15
Average egg weight, g	60.3^{ab} ±1.89	60.3^{ab} ±1.89	64.5^{ab} ±1.19	62.0^{ab} ±1.08	65.8^{ab} ±2.25	69.3^{ab} ±4.21	58.8^{b} ±1.11
Shape index, %	75.9 ±2.75	73.9 ±1.04	76.8 ±1.04	75.4 ±1.34	76.5 2.21±	77.2 2.00±	75.7 ±0.83
Yolk index, %	34.6^{b} ±1.41	41.4^{a} ±1.34	41.9^{a} ±0.41	41.6^{a} ±0.91	43.2^{a} 1.23±	43.2^{a} 1.27±	42.8^{a} ±0.75
Haugh unit	75.3^{a} ±1.55	77.3^{a} ±0.85	75.5^{a} ±1.19	76.0^{a} ±0.41	78.3^{a} 0.63±	77.3^{a} 1.03±	73.3^{b} 1.49±
Yolk colour	5.50^{b} ±0.29	7.00^{ab} ±0.71	6.25^{ab} ±0.48	6.25^{ab} ±0.48	5.50^{b} 0.29±	6.00^{b} 0.00±	7.75^{a} 0.25±
Shell thickness, mm.	32.5 ±0.65	33.0 ±0.82	33.5 ±1.19	32.0 ±1.00	32.8 0.85±	34.8 1.89±	33.8 ±0.63
Albumin, %	62.0a ±0.14	61.3^{ab} ±0.65	62.1^{a} ±0.11	61.7^{ab} ±0.56	60.1^{b} 0.53±	61.8^{ab} 0.34±	61.9^{ab} ±0.28
Yolk, %	26.2 ±0.17	27.0 ±0.85	25.7 ±0.17	26.0 ±0.49	27.6 ±0.31	26.0 ±0.23	26.0 ±0.38
Shell, %	11.9 ±0.28	11.7 ±0.42	12.1 ±0.16	12.3 ±0.11	12 4 ±0.24	12.2 ±0.15	12.2 ±0.14

a, b Means in the same row with different letters are significantly different ($P \leq 0.05$).

Results of blood plasma constituents of experimental laying hens are given in Table (6). All the tested diets increased plasma total protein, albumin, and globulin concentrations, except for 5% *Azolla* diet that not affected plasma total protein or albumin. There were no significant effects of all dietary algae or *Azolla* on plasma A/G ratio or total lipids, with exception of significant decreases in both parameters observed with the 15% dietary *Azolla*. Also significant elevation in plasma cholesterol levels were observed only with the 10 and 15% dietary *Azolla*, but not the other tested diets. Plasma uric acid was significantly elevated due to algal or *Azolla* inclusion in hen diets excepting for the 5% level of dietary *Azolla*. Plasma activity of ALT enzyme was increased with the 10% level of dietary algae and the 10 and 15% levels of dietary *Azolla*, while activity of AST enzyme was decreased on the 10% dietary algae and 15% dietary *Azolla*. The increase in plasma uric acid concentration in diets included algae or *Azolla* may be due to high nucleic acids and purine contents of algae as reported by Becker (1978 a&b) who found that total nucleic acids of algae (*Scenedesmus*) ranged from 4 to 6 percent on dry matter basis, and due to the high content of adenine in *Azolla* as reported by (Buckingham *et al.*, 1978). Furthermore, Namra *et al.* (2003) found that inclusion of dried *Azolla* up to 10% level in broiler chickens diets had no appreciable effect on plasma total protein, albumin, triglycerides, total cholesterol, total lipids, uric acid, GOT and GPT.

Table (6). Effect of feeding laying hens dried algae and *Azolla* at different levels on blood plasma constituents

Item, %	Control	Algae			*Azolla*		
		5	10	15	5	10	15
Total protein, g/dl	3.53^{c} ±0.11	4.15^{ab} ±0.06	4.22^{a} ±0.18	3.96^{ab} ±0.16	3.80^{bc} ±0.08	4.12^{ab} ±0.09	4.14^{ab} ±0.10
Albumin, g/dl	1.61^{b} ±0.03	1.90^{a} ±0.03	1.94^{a} ±0.05	1.78^{ac} ±0.09	1.80^{ab} ±0.04	1.85^{a} ±0.09	1.79^{ab} 0.07±
Globulin, g/dl	1.92^{c} ±0 08	2.25^{a} ±0.05	2.27^{a} ±0.13	1.18^{ab} ±0.07	1.99^{bc} ±0.07	2.27^{a} ±0.02	2.35^{a} ±0.08
A/G ratio	0.84^{ab} ±0.02	0.85^{ab} ±0.02	0.86^{ab} ±0.03	0.82^{ab} ±0.02	0.91^{a} ±0.04	0.82^{ab} ±0.04	0.77^{b} ±0.04
Total lipids, mg/dl	373.7^{a} ±4.10	631.0^{ab} ±6.51	352.0^{ab} ±9.17	355.0^{ab} ±7.51	354.3^{ab} ±7.51	353.0^{ab} ±11.59	340.7^{b} ±4.10
Cholesterol, mg/dl	120.0^{b} ±4.36	129.7^{ab} ±4.18	117.3^{b} ±4.33	114.7^{b} ±5.49	127.0^{ab} ±5.20	136.3^{a} ±4.91	136.3^{a} ±3.84
Uric acid, mg/dl	3.44^{c} ±0.07	3.76^{ab} ±0.05	3.76^{ab} ±0.07	3.82^{ab} ±0.08	3.57^{bc} ±0.06	3.92^{a} ±0.17	3.99^{a} ±0.08
ALT, unit/l	71.0^{b} ±2.08	77.3^{ab} ±4.98	86.7^{a} ±4.98	81.0^{ab} ±2.52	69.0^{b} ±0.58	86.0^{a} ±5 88	85.7^{a} ±5.21
AST, unit/l	24.3^{a} ±1.45	19.7^{ab} ±3.28	16.3^{b} ±1.76	19.7^{ab} ±0.88	21.7^{ab} ±1.45	19.7^{ab} ±4.26	15.3^{b} ±0.88

[a, b, c] **Means in the same row with different letters are significantly different ($P \le 0.05$).**

It is concluded that both dried algae (*Scenedesmus ar rus*) and *Azolla* have a nutritional potential to be utilized at 5% dietary levels as a source of dietary CP as to provide efficient partial alternatives to soybean meal in laying hen diets on an isonitrogenous basis without any adverse effects on egg production performance or egg quality, but even this level of algae tend to enhance yolk color score.

REFERENCES

Abdella, M. M.; G.A.E. El-Sayaad; F.M. Ghazal and T. A. El-Baz (1998). Sun dried azolla as new feedstuff in growing rabbits. Egypt. J. Rabbit Sci., 8:81-93

Alcantara, P. E. and L. J. Querubin, (1984). Feeding value of *Azolla* meal to poultry and swine. PSAS Annualk Convention. 22-33

Ali, M. A. and S. Leeson (1994). Nutritional value and utilization of aquatic weeds in the diet of poultry.World ́s Poult. Sci. j., 50:237-251.

Andreson, D. W. ; C. Tang and E. Ross (1991).The xanthophylls of Spirulina and their effect on egg yolk pigmentation. Poult. Sci., 70: 115-119.

A.O.A.C.(1990). Association of Official Analytical Chemistry. Official Methods of Analysis. 15th Ed. Published by the A.O.A.C., Washington, D. C., U.S.A.

Becker, E. W. (1978a). Major results of the Indo-German algae project. Arch. Hydrobiol. Beih. Ergebn. Limnol. 11: 23-40.

Becker, E. W. (1978b). The legislative background for utilization of microalgae and other types of single cell protein. Arch. Hydrobiol. Beih. Ergehn. Limnol. 56-64.

Bligh, E. G. and Dyer, W J. (1959) A rapid method of total lipid extraction and purification. Canad.J. Biochem. Physiol. 37: 911-913.

Buckingham, K. W.; S. W. Ela ; J. G. Morris and C. R. Goldman (1978). Nutritive value of the nitrogen-fixing aquatic fern *Azolla fihculaides*. J. Agric. Food Chem. 26: 1230-1234.

Caraway, W. (1955). American Journal Clinical and Pathology, 25,840.

Carpenter, K. J. and K. M. Clegg (1956). The metabolizable energy of poultry feedstuffs in relation to their chemical composition. J. Sci. Food Agric., 7: 45-51.

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

Chen, D. L. and C. Y. Huang (1987). Study on *Azolla* as a fresh fodder. Workshop on *Azolla* use. Fuzhous, Fujian April. 1985 270.

Doumas, B. T.; W. Watson and H. G. Biggs (1971). A method for determination of plasma albumin. Clin. Chim. Acta, 31 : 87.

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

Henry. R. J.; C. D. Cannon and J. W. Winkelman (1974). A method for determination of plasma total protein. Clin. Chem., Principles and Technics, Harper and Row, Publ., p.415.

Herber-McNeill S. M. and M. E. Van Elswyk (1998).Dietary marine Algae maintains egg consumer acceptability while enhancing yolk color. Poult. Sci., 77: 493-496.

Khan, M. M. (1988). Azolla agronomy " Utilization of *Azolla*" Chapter XI:121-134 Published by Asian Development Bank, Los Banos, Philippines.

Lipstein. B. and S.Hurwitz (1980). The nutritional value of algae fo poultry. Dried *Chlorella* in broiler diets. British poult. Sci., 21:9-21.

Namra, M. M. M (2000). Fresh and dried *Azolla* as feedstuff for broilers and layers. Ph. D. Thesis, Fac., of Agric., Cairo Univ.

Namra, M. M. M.; A. A. Darwish; N. A. Hataba; H. M. Abdel Wahed and E. M. Omar (2003). Air dried *Azolla* as a feedstuff for broilers. Egypt. Poult. Sci., 23: 71-89.

N.R.C (1994). National Research Council. Nutrient requirements of poultry 9^{th} Rev. Ed. National Academy Press, Washington, DC., USA.

Qota E. M. A.; B. M. F. Khashab and Hala, S. M. Arief (2001) Evaluation of Azolla as a feedstuff for poultry diet. Egypt. Poult. Sci., 21: 795-810.

Reitman, S. and S. Frankel (1957). Method for determination of enzymatic activities. Amer. J. Clin. Path. 28:56.

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

Shen, Ch. S. J.; Chen, I. S. and Sheppard, A. J. (1982) enzymatic determination of Cholesterol in egg yolk. J. Assoc. Off. Anal. Chem. 65:1222-1224.

Stadleman, W. J. (1977). Quality identification of shell egg in : Egg Science and Technology. 2^{nd} Ed by W. j. Stadleman and O. J. Cotterill Pub by AVI publishing company. Inc. Connecticut. P.36.

Steel R. G. D. and J. H Torrie (1980). Principles and procedures of statistics. Mc Graw-Hill Book Co. Inc. Connecticut.

Subudhi, B. P. R. and P.K. Singh (1978). Nutritive value of the water fern *Azolla pinnata* for chicks. Poult. Sci., 57: 378-380

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

القيمة الغذائية للطحالب والأزولا المجففة كغذاء للدجاج البياض

جمال منصور الملاح، ليلى دسوقى عبد السميع، شوقى أحمد محمد ابراهيم
قسم الإنتاج الحيوانى، المركز القومى للبحوث، الدقى، القاهرة، مصر

استخدم فى هذه الدراسة عدد ١٦٨ دجاجة من النوع بوفانز براون البياض عمر ٢٤ أسبوع، حيث قسمت عشوائيا وبالتساوى إلى ٧ مجاميع(بكل مجموعة ٨ مكررات فى كل منها ٣ دجاجات). تم توزيع هذه المجاميع عشوائيا على ٧ علائق تجريبية منها عليقة المقارنة ، وثلاث علائق تحتوى على٥، ١٠ أو ١٥% من الطحالب المجففة، وثلاث علائق أخرى تحتوى على ٥، ١٠ أو ١٥% من الأزولا المجففة. تم إحلال كل من مسحوق الطحالب والأزولا المجففة جزئيا محل كسب فول الصويا الموجود بعليقة المقارنة، وذلك على أساس أزوتى وقد استمرت التجربة لمدة ١٢ أسبوع.

أشارت النتائج إلى أن استخدام مسحوق الطحالب المجففة حتى مستوى ١٠% أو الازولا المجففة حتى مستوى ٥% لم يؤثر على معاملات هضم المادة العضوية أو البروتين الخام بالعليقة. كما لم تؤثر ايا من المعاملات المختلفة على معاملات هضم مستخلص الإثير أو الألياف الخام أوالمستخلص الخالى من الأزوت باستثناء حدوث انخفاض فى معامل هضم مستخلص الإثير عند استخدام ١٥% من مسحوق الأزولا المجففة وانخفاض في معامل هضم الالياف الخام والمستخلص الخالى من الأزوت عند استخدام ١٠ أو ١٥% من مسحوق الأزولا المجففة بالإضافة لحدوث تحسن في هضم المستخلص الخالى من الأزوت عند استخدام ٥ أو ١٠% من مسحوق الطحالب المجففة.

لم يتأثر انتاج البيض أو وزن البيضة باستخدام ٥% من مسحوق الطحالب أو الأزولا المجففة بالعليقة. بينما انخفضت هذه القياسات مع المستويات الأعلى. وقد انخفض معدل استهلاك الغذاء عند استخدام ١٠ أو ١٥% من مسحوق الأزولا المجففة بينما لم يؤثرمسحوق الطحالب حتى مستوى ١٠% أو الأزولا عند مستوى ٥% على كفاءة تحويل الغذاء ولكن حدث تأثر سلبى مع استخدام المستويات الأعلى.

لم تتأثر قياسات جودة البيض باحتواء العلائق علىمسحوق الطحالب أو الأزولا باستثناء حدوث انخفاض في قيمة haugh unit ونسبة الألبيومين مع مستوى ١٥% أزولا أو ٥% طحالب. كما لوحظ زيادة لون الصفار مع جميع مستويات الطحالب وكذلك مع استخدام ١٥% من مسحوق الأزولا المجففة .

رفعت المستويات المستخدمة من مسحوق الطحالب أو الأزولا كل من البروتين الكلى ، الألبيومين، الجلوبيولين ببلازما الدم باستثناء مستوى ٥% أزولا. كذلك خفض مستوى ١٥% أزولا من مستوى الليبيدات الكلية بالبلازما بينما ارتفع مستوى الكوليستيرول بالبلازما مع استخدام ١٠ أو ١٥% أزولا كما أدى استخدام الطحالب أو الأزولا إلى رفع تركيز حمض اليوريك بالبلازما.

من هذه الدراسة يمكن استخلاص أنه يمكن استخدام الطحالب أو الأزولا المجففة في علائق الدجاج البياض بمستوى ٥% كبديل جزئى لكسب فول الصويا على أساس نيتروجينى دون حدوث تأثير ضار على انتاج البيض أو جودته، مع تحسن في لون الصفار عند استخدام الطحالب.