Bangladesh Journal of Animal Science
Journal homepage: http://www.banglajol.info/index.php/BJAS

Effect of using *Spirulina platensis* in place of vitamin mineral premix in feed on the performance of broiler

KMS Islam*, MR Debi, R Haque and SN Moury

Department of Animal Nutrition, Bangladesh Agricultural University, Mymensingh-2202 Bangladesh

Abstract

Feed of commercial broiler fortified by the external sources of vitamin and minerals which is expensive and increase the cost of feed. Blue green algae (*Spirulinaplatensis*) would be an alternative to those synthetic micronutrients after production in laboratory scale was studied in broiler.*Spirulinaplatensis*was cultured in inorganic media contained macronutrients $NaHCO_3$, K_2HPO_4, $NaNO_3$, K_2SO_4, NaCl, $MgSO_4.7H_2O$, $CaCl_2$, and $FeSO_4.2H_2O$ and micronutrient solution containing H_3BO_4, $MnCl_2.4H_2O$, $ZnSO_4.7H_2O$, $CuSO_4.5H_2O$, MoO_3, $CoCl_2.6H_2O$. Media was autoclaved and *Spirulina*was cultured for 12 hours lighting with continuous aeration for 15 days to use in poultry feed. Day old broiler chick (180) was reared offering starter mash diet for 7 days. Birds were divided into 6 groups having 30 birds in each (10 per cage). Birds were offered 1. Control diet, 2. 75% premix+25% *Spirulina*, 3. 50% premix+50% *Spirulina*, 4. 25% premix+75% *Spirulina*, 5. 0% premix+100% *Spirulina* and 6. 0% premix+0% *Spirulina* (negative control). *Spirulina*was calculated on DM basis added minerals in the media. After 21 days (28 day old) final body weight was 1039, 1070, 1044, 1065, 1117 and 893 g/bird in group 1, 2, 3, 4, 5 and 6 where higher ($P<0.5$) weight observed in *Spirulina*group (5). Feed intake was observed more or less similar in all groups (1483±24g). Feed conversion ratio was 1.72, 1.65, 1.69, 1.62, 1.61 and 1.99 in group 1, 2, 3, 4, 5 and 6 respectively ($P<0.5$) where higher in negative control group (6) and control group (1), but was lowest in 75% *Spirulina*group (4) and highest (100%) *Spirulina* group (5). Ash% is also highest in 100% *Spirulina* group 5 (55.07) than any other group. Considering growth performance of broiler, complete replacement of vitamin-mineral premix could be possible by cultured *Spirulina*along with media in broiler diet.

Keywords: broiler, *Spirulina*, performance, diet, vitamin mineral premix

Introduction

Major constraint of poultry production in developing countries is the scarcity of quality feed. Furthermore, the competitive demand for conventional feed resources as food between poultry and man like maize, wheat, soybean, rice bran etc. Algae would be promising alternative for poultry, although it is considered as unconventional. The most commonly used alga species is Spirulina (*Spirulinaplatensis*). They are very small and microscopic and 300-500µm in length. These blue-green algae contain 50-70% protein, 10-12% carbohydrate, 6% fat, 7% minerals and a lot of vitamins (Shuvo, 2001). A considerable amount of phosphorous, magnesium zincs and pepsin found in Spirulina. It also contain 6-11% polysaccharide, the predominant are palmitic (16:0, 44.6-54.1%) gamalinolenic acid (18:3, 8.0-31.7%), linoleic (18:2, 10.8-30.7%) and oleic acids (18:1,1-15.5%). It is rich in B vitamins, minerals, trace elements, chlorophylls and enzymes (Kelly *et al*., 1995; Holman and Malau-Aduli, 2012). Spirulina capsule has improved the coalitions of in lowering blood lipid level and in decreasing white blood corpuscles after radiotherapy and chemotherapy as well as lowering immunological function (Ruan*et al.,* 1990). It has been used for last ten years as a model organism in many studies on outdoor cultivation of algal biomass as a source of proteins and chemicals (Richmond, 1987). It increases the yellowness and redness in broiler flesh when Spirulina fed with diet (Habib*et al*., 2008). Research has shown that vitamin-mineral premixes are normally not required when Spirulinahas been included in the feed (Venkataraman*et al.,* 1994). In addition, chickens receiving diets supplemented with Spirulina had better health. This may be due to an enhancement of the immune function (Belay *et al*., 1996). Recommended inclusion levels in poultry diets are 5-10% (Toyomizu*et al.,* 2001). Inclusion of Spirulina in layer diets has also been shown to reduce total cholesterol content of eggs while increasing omega-3 fatty acid levels

***Correspondingauthor**:kmsislam@bau.edu.bd

(Sujatha and Narahari, 2011). Therefore, the present work was undertaken to study the replacement of vitamin-mineral premix using Spirulina (*Spirulinaplatensis)* along with kosaric media (growth media contains Spirulina as well as residual macro and micronutrients) in broiler diet for the performance and carcass quality.

Materials and Methods

The experiment was conducted for a period of 28 days by using 180 DOC (Day old chick) to find out the effect of Spirulina algae as a replacement of vitamin-mineral premix on the performance of broiler

Collection and maintenance of pure stock culture of *Spirulina platensis*

Microalgae, *Spirulinaplatensis* was collected from the imported stock which was maintained at Animal Nutrition Laboratory, Department of Animal Nutrition, Bangladesh Agricultural University, Mymensingh.Pure stock culture of *Spirulinaplatensis* was maintained in the laboratory in Kosaric medium (KM) (Modified after Zarrouk's 1966). Kosaric media (KM) was prepared for culture of *S.platensis*. Different concentrations of nutrients of kosaric medium are $NaHCO_3$-9.0(g/L); K_2HPO_4-0.250(g/L); $NaNO_3$-1.250(g/L); K_2SO_4-0.50(g/L); NaCl-0.50(g/L); $MgSO_4.7H_2O$-0.10 (g/L); $CaCl_2$-0.02 (g/L); $FeSO_4.2H_2O$ -0.005(g/L); A_5 micronutrient solution-0.5(ml/L) as per (Modified after Zarrouk, 1966).

Experimental design

The experiment was conducted in a completely randomized design (CRD). One hundred and eighty chicks (DOC) were randomly divided into 6 groups having 3 replicates in each (10 birds in each replication). The 6 dietary groups are as follows:

1: Control [100% Vitamin-mineral premix (2.5g/kg) + 0% Spirulina (0g)]

2: 75% Vitamin-mineral premix (1.9g/kg) + 25% Spirulina (0.6g/kg)

3:50% Vitamin-mineral premix (1.3g/kg) + 50% Spirulina (1.2g/kg)

4: 25% Vitamin-mineral premix (0.6g/kg) + 75% Spirulina (1.9g/kg)

5: 0% Vitamin-mineral premix (0g) + 100% Spirulina (2.5g/kg)

6:0% Vitamin-mineral premix (0g) + 0% Spirulina (0g)

The ingredients which are used for ration formulation in different dietary treatments and their nutritional composition are shown in Table 1 and 2, respectively.

Table 1: Formulation of diet (kg/100kg) in different dietary groups

Groups	1	2	3	4	5	6
Wheat	55.00	55.00	55.00	55.00	55.00	55.00
Rice polish	3.70	3.70	3.70	3.70	3.70	3.70
Meat & bone meal	8.00	8.00	8.00	8.00	8.00	8.00
Soybean meal	23.00	23.00	23.00	23.00	23.00	23.00
Soybean oil	7.00	7.00	7.00	7.00	7.00	7.00
Oyster shell	1.00	1.00	1.00	1.00	1.00	1.00
Lysine	0.40	0.40	0.40	0.40	0.40	0.40
DCP	1.00	1.00	1.00	1.00	1.00	1.00
Metheonine	0.40	0.40	0.40	0.40	0.40	0.40
[a]Vit-min premix	0.25	0.19	0.13	0.06	0.00	0.00
[b]Spirulina	0.00	0.06	0.12	0.19	0.25	0.00
Salt	0.25	0.25	0.25	0.25	0.25	0.25

1-Control [100% Vitamin-mineral premix (2.5g/kg) + 0% Spirulina (0g)]; 2-75% Vitamin-mineral premix 1.9g/kg) + 25% Spirulina (0.6g/kg); 3-50% Vitamin-mineral premix (1.3g/kg) + 50% Spirulina (1.2g/kg); 4-25% Vitamin-mineral premix (0.6g/kg) + 75% Spirulina (1.9g/kg); 5-0% Vitamin-mineral premix (0g) + 100% Spirulina (2.5g/kg); 6-0% Vitamin-mineral premix (0g) + 0% Spirulina (0g). [a]Vitamin mineral premix: Vitamin A, 4,800,000 I.U/kg; Vitamin D3, 1,000,000 I.U/kg; Vitamin-E 8,000 mg/kg, Vitamin-K_3 1600 mg/kg, Vitamin-B_1 600 mg/kg, Vitamin-B_2 2000 mg/kg, Vitmin-B_3 1600 mg/kg, Vitamin-B_6 1600 mg/kg, Vitamin B_{12} 4

mg/kg, Vitamin-PP 12,000 mg/kg, Biotin 20 mg/kg, Iron 9600 mg/kg, Copper 2400 mg/kg, Manganese 19,200 mg/kg, Cobalt 120 mg/kg, Zinc 16,000 mg/kg, Iodine 240 mg/kg, Selenium 80 mg/kg, Antioxidant 4000 mg/kg, Lysine 1.2%, Methionin 2%. Source: NOVAVIT-L (NOVA Nutrition, Belgium). [b]*Spirulina: 0.06kg(50ml); 0.12kg(100ml); 0.19kg(150ml); 0.25kg(200ml).*

Table 2: Nutrient composition (g/100 kg) of different treatment groups

Groups	1	2	3	4	5	6
Dry matter	89.12	89.12	89.12	89.12	89.12	89.12
Crude protein	23.71	23.71	23.71	23.71	23.71	23.71
Calcium	1.05	1.05	1.05	1.05	1.05	1.05
Phosphorus	0.79	0.79	0.79	0.79	0.79	0.79
Lysine	1.53	1.53	1.53	1.53	1.53	1.53
Metheonine	0.74	0.74	0.74	0.74	0.74	0.74
Crude fibre	4.32	4.32	4.32	4.32	4.32	4.32
MetabolizableEnergy (kcal/kg)	2950	2950	2950	2950	2950	2950

1-Control [100% Vitamin-mineral premix (2.5g/kg) + 0% Spirulina (0g)]; 2-75% Vitamin-mineral premix 1.9g/kg) + 25% Spirulina (0.6g/kg); 3-50% Vitamin-mineral premix (1.3g/kg) + 50% Spirulina (1.2g/kg); 4-25% Vitamin-mineral premix (0.6g/kg) + 75% Spirulina (1.9g/kg); 5-0% Vitamin-mineral premix (0g) + 100% Spirulina (2.5g/kg); 6-0% Vitamin-mineral premix (0g) + 0% Spirulina (0g)

Management of birds

Cobb-500 commercial day old broiler chicks (180) were reared having average weight of 50.30 g/b, divided into six groups. Eighteen cages were considered for this trial each having floor space of 0.91 m^2(120cm × 76 cm). Fresh dried rice husk was spread on the floor under the cages at a depth of 4cm and maintained properly throughout the experiment. A 100 watt electric bulb for each cage was used for dual purpose (lighting and brooding). Feeds and water were supplied *ad libitum* to all broilers. Proper bio-security measures were taken during the experimental period.

The broilers were vaccinated against Newcastle Disease and Infectious Bursal Disease (Gumboro). Birds were vaccinated against Newcastle Disease (ND) and Infectious Bursal Disease (IBD) on day 7 and 14 respectively. The broilers were examined twice a day for clinical sign (slow movement, infrequent sitting, lack of appetite, significant changes of feathering, paralysis etc.) recorded as per symptoms.Broilers were weighted in a group at the beginning of the trial and then every week at the age of day 7, 14, 21 and 28. Feed offered and refusals were recorded at the end of each week. Due to the fact that there is no death of bird occur during the experiment period so there is no data was recorded for dead bird.

Determination of bone ash

Bone ash% was determined from the shank bone of the birds. At the day 28 selected birds of each replication was slaughtered and cut the shank randomly. After collection of shank bones; those were boiled for 1 hour and then skinning them, washed and dried properly; then dried in the oven at 105ºC for 24 hours. After 24 hours of drying, the oven dry weight of bones were taken; then kept the bones in the muffle furnace at 600ºC for 5 hours and then calculated the DM% and ash%.

Blood analysis

Blood from healthy chicken was collected using 10ml felcon tube directly from the heart after slaughtering at day 28 of age from randomly selected birds of each replication. To avoid blood clot, EDTA was used and tubes were put in the centrifuge machine. The collected blood was centrifuged at 1500 rpm for 20 minutes to obtain plasma and transferred into sterile 1.5ml apendrop tube. The plasma was preserved in deep freezer and the tubes were marked properly with permanent marker for easy identification during blood analysis for cholesterol and triglycerides. For quantitative determination of cholesterol in blood plasma was analyzed.

Chemical analysis

Samples feed ingredients (in duplicate) ware analyzed to determine dry matter (DM), crude protein (CP) and total ash (Ash) following the method described by AOAC (1990).

Statistical analysis

All data were analyzed by using statistical SPSS program for one way analysis of variance (ANOVA) and Duncans Multiple Range Test (Duncan, 1955) was done to know the differences among the treatment means at 5% level of significance (Steel and Torrie, 1980).

Results

Growth performance of birds

At the end of the trial, group 5 attained 1117g live weight, which is higher than negative control (6), and almost similar to group 2(1070g), group 4 (1065g), group 3(1044g) and group 1 (1039g) shown in table 3. In this experiment, negative control group was used for observing the effect of no vitamin-mineral premix in broiler diet. The reason of low final body weight in all the groups was feeding mash diet and no growth promoter was added.

Weekly weight gain of birds were not differed (P>0.05) among the groups where the highest weight gain was observed in group 5 during the day of 8-14 (210g) and day 22-28 (397g). In day 15-21, there were no difference (P>0.05) among dietary groups 1, 2, 3, 4 and 5; but had difference (P<0.05) with group 6 (Table 4). The highest weight gain (397g) was observed in day 22-28 in 100% *Spirulina* group. Relatively higher weight gain observed in group 5 (397g) than control (361g) and negative control (290g) during 28 days trial which were significantly different (P<0.05).

Feed intake of bird under different groups during day 8 to 14, 15 to 21 and 22 to 28 days of age differed significantly (P<0.05) from each other but feed intake of group 5 was highest at day 15-21 (Table 5). At the end of the trial, group 2 found significantly higher feed intake than other groups. Cumulative feed intake was highest in group 5 and lowest in group 4 at the day 8-28.No bird belongs to any group died during 28 days of feeding trail.

The FCR of broilers were not significant (P>0.05) at day 8-14. At day 15-21, FCR of group 1, 2, 3, 4 and 5 were not significantly different (P>0.05) among them but had significant difference (P<0.05) with group 6 (table 6). Again, there were no significant difference (P>0.05) of FCR in any group at day 22-28.At the end of trial numerically highest FCR was attained in group 6. Cumulative FCR was significantly different at day 8-21 and 8-28.

Table 3: Weight (g/bird) of birds at different age

Groups	1	2	3	4	5	6
Initial wt. (Day 7)	155±0.5	154±1.7	155±0.6	155±0.2	155±0.3	155±1.0
Day 14	344^{ab}±10	345^{ab}±11	343^{ab}±17	352^{ab}±26	365^{b}±15	328^{a}±11
Day 21	678^{b}±03	700^{b}±20	687^{b}±08	689^{b}±41	719^{b}±62	603^{a}±38
Day 28	1039^{b}±34	1070^{b}±59	1044^{b}±50	1065^{b}±36	1117^{b}±79	893^{a}±18

1-Control [100% Vitamin-mineral premix (2.5g/kg) + 0% Spirulina (0g)]; 2-75% Vitamin-mineral premix 1.9g/kg) + 25% Spirulina (0.6g/kg); 3-50% Vitamin-mineral premix (1.3g/kg) + 50% Spirulina (1.2g/kg); 4-25% Vitamin-mineral premix (0.6g/kg) + 75% Spirulina (1.9g/kg); 5-0% Vitamin-mineral premix (0g) + 100% Spirulina (2.5g/kg); 6-0% Vitamin-mineral premix (0g) + 0% Spirulina (0g). *Mean± SD; ^{abc} Means with dissimilar superscripts are significantly different (P<0.05).*

Table 4: Live weight gain of birds at different age

Groups	1	2	3	4	5	6
Day 8-14	189^{ab}± 10	190^{ab}±11	189^{ab}±16	196^{ab}±26	210^{b}±16	173^{a}±12
Day 15-21	334^{b}±14	355^{b}±27	344^{b}±11	340^{b} ±13	355^{b}±46	275^{a}±47
Day 22-28	361^{ab}±31	370^{ab}±50	373^{ab}±22	377^{ab}±26	397^{b}±54	290^{a}±42
Cumulative weight gain						
Day 8-21	523^{b}± 04	546^{b}±19	531^{b}±07	533^{b}±41	564^{b}±62	448^{a}±37
Day 8-28	884^{b}± 35	915^{b}±57	889^{b}±48	910^{b}±35	962^{b}±79	738^{a}±18

Mean± SD; ^{abc} Means with dissimilar superscripts are significantly different (P<0.05).

Table 5: Feed intake of birds at different age

Groups	1	2	3	4	5	6
Day 8-14	340^{c}±00	305^{b}±05	307^{b}±06	315^{b}±26	317^{b}±01	256^{a}±14
Day 15-21	420±00	421±21	437±34	427±25	447±44	453±08
Day 22-28	754^{ab}±06	779^{b}±29	733^{ab}±18	722^{a}±09	773^{b}±44	762^{ab}±18
Cumulative feed intake						
Day 8-21	760± 00	726±16	744±32	742±37	764±43	709±13
Day 8-28	1514^{bc}±06	1505^{abc}±36	1478^{ab}±39	1464^{a}±29	1537^{c}±38	1471^{ab}±21

1-Control [100% Vitamin-mineral premix (2.5g/kg) + 0% Spirulina (0g)]; 2-75% Vitamin-mineral premix 1.9g/kg) + 25% Spirulina (0.6g/kg); 3-50% Vitamin-mineral premix (1.3g/kg) + 50% Spirulina (1.2g/kg); 4-25% Vitamin-mineral premix (0.6g/kg) + 75% Spirulina (1.9g/kg); 5-0% Vitamin-mineral premix (0g) + 100% Spirulina (2.5g/kg); 6-0% Vitamin-mineral premix (0g) + 0% Spirulina (0g). *Mean± SD; ^{abc} Means with dissimilar superscripts are significantly different (P<0.05).*

Table 6: The feed conversion ratio (FCR) of birds at different age

Groups	1	2	3	4	5	6
Day 8-14	1.32± 0.07	1.38±0.19	1.46±0.19	1.38±0.06	1.39±0.14	1.48±0.08
Day 15-21	1.50^{ab}±0.05	1.46^{ab}±0.07	1.50^{ab}±0.17	1.48^{ab}±0.27	1.53^{ab}±0.08	1.68^{b}±0.28
Day 22-28	2.10± 0.19	2.14±0.35	2.09±0.59	1.92±0.11	1.96±0.41	2.40±0.10
Cumulative FCR						
Day 8-21	1.45^{ab} ± 0.01	1.47^{ab}±0.07	1.54^{ab}±0.12	1.43^{a}±0.02	1.45^{ab}±0.05	1.59^{b}±0.12
Day 8-28	1.72^{a}± 0.07	1.65^{a}±0.14	1.69^{a}±0.28	1.61^{a}±0.03	1.62^{a}±0.41	1.99^{b}±0.07

1-Control [100% Vitamin-mineral premix (2.5g/kg) + 0% Spirulina (0g)]; 2-75% Vitamin-mineral premix 1.9g/kg) + 25% Spirulina (0.6g/kg); 3-50% Vitamin-mineral premix (1.3g/kg) + 50% Spirulina (1.2g/kg); 4-25% Vitamin-mineral premix (0.6g/kg) + 75% Spirulina (1.9g/kg); 5-0% Vitamin-mineral premix (0g) + 100% Spirulina (2.5g/kg); 6-0% Vitamin-mineral premix (0g) + 0% Spirulina (0g). *Mean± SD; ^{abc} Means with dissimilar superscripts are significantly different (P<0.05).*

Table 7: Bone ash (%) of birds of different groups

Group	1	2	3	4	5	6
Ash (g/100g)	4.00	3.63	3.67	3.73	3.80	3.13
DM (g/100g)	8.63	7.80	7.50	7.47	6.90	6.67
Ash (g/100gDM)	46.35	46.54	48.93	49.93	55.07	46.92

1-Control [100% Vitamin-mineral premix (2.5g/kg) + 0% Spirulina (0g)]; 2-75% Vitamin-mineral premix 1.9g/kg) + 25% Spirulina (0.6g/kg); 3-50% Vitamin-mineral premix (1.3g/kg) + 50% Spirulina (1.2g/kg); 4-25% Vitamin-mineral premix (0.6g/kg) + 75% Spirulina (1.9g/kg); 5-0% Vitamin-mineral premix (0g) + 100% Spirulina (2.5g/kg); 6-0% Vitamin-mineral premix (0g) + 0% Spirulina (0g). *Mean± SD; ^{abc} Means with dissimilar superscripts are significantly different (P<0.05).*

Bone Ash (%)

In this experiment, the % ash of bone is gradually increased in group 1, 2, 3, 4 and 5 (Table 7). But in group 6, there was an average percentage of ash in the bone because of deficiency of vitamin and mineral in their diet. Ash% is higher in group 5 and lower in group 1.

Blood analysis

Blood cholesterol was higher in group 5 and triglycerides level was higher in group 1 in this experiment (Table 8). Other groups of birds 2, 3, 4 were not showed any significant differences (P>0.05) among them. But group 1, 5 and 6 had significant differences among them. Cholesterol level was gradually increased from group 1to group 5 and lower in group 6.In case of triglycerides, highest level in group 1 and lowest level in group 6 (Table 9). There was no significant differences (P>0.05) between group 2 and 3. There were a great significant differences (P<0.05) among the group 1, 4, 5 and 6.

Table 8: Cholesterol and triglycerides in blood of birds of different groups

Groups	1	2	3	4	5	6
Cholesterol	36^{b}±03	38^{ab}±04	37^{ab}±01	39^{ab}±01	42^{a}±01	26^{c}±03
Triglycerides	128^{a}±26	104^{bc}±12	92^{bc}±10	83^{c}±09	112^{b}±12	49^{d}±09

1-Control [100% Vitamin-mineral premix (2.5g/kg) + 0% Spirulina (0g)]; 2-75% Vitamin-mineral premix 1.9g/kg) + 25% Spirulina (0.6g/kg); 3-50% Vitamin-mineral premix (1.3g/kg) + 50% Spirulina (1.2g/kg); 4-25% Vitamin-mineral premix (0.6g/kg) + 75% Spirulina (1.9g/kg); 5-0% Vitamin-mineral premix (0g) + 100% Spirulina (2.5g/kg); 6-0% Vitamin-mineral premix (0g) + 0% Spirulina (0g). *Mean± SD; ^{abc}Means with dissimilar superscripts are significantly different (P<0.05).*

Table 9: Production cost per kg live weight gain of broiler

Group	1	2	3	4	5	6
FCR(Kg feed/kgLWG)	1.79	1.65	1.69	1.61	1.62	2.06
Feed cost/kg	41.84	41.78	41.72	41.65	41.6	41.6
Production/kg	100	99.94	99.88	99.81	99.75	99.75

1-Control [100% Vitamin-mineral premix (2.5g/kg) + 0% Spirulina (0g)]; 2-75% Vitamin-mineral premix 1.9g/kg) + 25% Spirulina (0.6g/kg); 3-50% Vitamin-mineral premix (1.3g/kg) + 50% Spirulina (1.2g/kg); 4-25% Vitamin-mineral premix (0.6g/kg) + 75% Spirulina (1.9g/kg); 5-0% Vitamin-mineral premix (0g) + 100% Spirulina (2.5g/kg); 6-0% Vitamin-mineral premix (0g) + 0% Spirulina (0g). *Mean± SD; ^{abc} Means with dissimilar superscripts are significantly different (P<0.05).*

Economic analysis of using *Spirulina*

Production cost was calculated by considering cost of feed (Table 9). The cost per kilogram feed was lowest in group 5 and 6 than control. Production cost per kilogram live weight of broiler was lowest (P<0.05) in group 5 (100% *Spirulina*) followed by group 4, 3, 2 and control.

Discussion

Growth performance of birds

The result obtained in the present study revealed that, dietary Spirulina can compensate the performance of broiler by eliminating vitamin-mineral premix level in diet. The probable reason may be the Spirulina in broiler diets could improve palatability, lack of toxicity and easy digestion, antioxidant actions, hypocholesterolemic, anticancer, immunostimulant, antiviral properties which give better performance and recover the deficiency of vitamin-mineral premix (Rodriguez-Hernández *et al.,* 2001; Dernere*t al*., 2006; Colla*et al.,* 2007). Other studies that replaced groundnut cake (Saxena*et al.,* 1983) or fishmeal (Venkataraman*et al*., 1994) with Spirulina in chicken diets found no variation in growth. Research has shown that vitamin-mineral premixes are normally not required when Spirulina has been included in the feed (Venkataraman*et al*., 1994). On the other hand, the negative control group (6) had no vitamin-mineral premix or Spirulina in the diet. As a result; the dietary Spirulina group shows a higher significant difference (P<0.05) from negative control group in the live weight of broilers.

It has been shown that dietary Spirulina levels of 50-100 g/kg of feed ration will maintain typical growth rates, levels exceeding 200 g/kg will bring about declined growth rates (Toyomizu*et al*., 2001). In this experiment, replacement of vitamin-mineral premix with Spirulina has a positive effect on body weight and body weight gain of broilers. Dietary Spirulina has been associated with greater cost efficiency in chicken production. Venkataraman*et al*., 1994 found that vitamin-mineral premixes normally added to chicken feed rations can be omitted when Spirulina is included, due to its nutrient-rich composition. Saxena*et al*., 1983 found that body weights of chicks fed Spirulinalevels of 11.1 and 16.6% of diet were not different from the control group, receiving groundnut cake.

Chickens receiving dietary Spirulina have been found to be of better health than their un-supplemented counterparts (Venkataraman*et al*., 1994). At the inclusion rate of 12%, broilers showed slower growth in comparison with those fed 0, 1.5, 3.0, or 6.0% algae. Toyomizu*et al. (*2001) fed broilers with up to 8% *Spirulina* sp. and reported no differences in their body weight, liver weight, abdominal fat, or kidney weight at 16 d of age. This is due to increased functionality of macrophage and overall mononuclear phagocyte system indicative of enhanced disease resistance with increased dietary Spirulina levels in chickens (Qureshi *et al*., 1996; Al-Batshan*et al.,* 2001).

In the present study, feed intake of broilers in different groups was significantly increased. This is might be due to incase of low energy, because feed intake was more to recover the energy requirements. Ross and Dominy (1990) supplemented diets for broiler chickens with up to 20% blue-green algae, and found the 3 week-old broilers experienced depressed growth when algae inclusion levels were higher than 10%.

As mentioned above, the feed conversion ratio is related with feed intake and live weight gain in all groups of birds. In group 1, 2, 3, 4 and 5, birds received the proper nutrients available in their diet. So, the feed intake of these groups are good and the FCR were not significantly different (P>0.05). But in group 6, birds were deficient in their needed vitamins and minerals, so their feed intake was more to recover the nutrient requirements. So, their FCR was higher than other group though there were no significant difference among them (P>0.05). Khardee*t al.,* 2012 and Shanmugapriya*et al.*, 2015 reported that feed conversion ratio improved by the dietary inclusion of the Spirulina as compared to the control. Baojiang (1994) reported that Spirulina is good for the beneficial intestinal flora which also helps in the effective utilization of feed and easy conversion of feed to animal protein by the broiler. But when 100% Spirulina was added with feed for the replacement of total synthetic vitamin-mineral premix and that was also supported by the result of the experiment conducted by Toyomizu*et al.* (2001) that increase the addition Spirulina in feed will depress the production and feed conversion ratio.

With increasing the level of Spirulina in broiler diet, ash% was increased and the best result was obtained when supply the 100% Spirulina.

Blood profile

In the present study, both the level of cholesterol and triglycerides of blood were lower in group 6.

So, it could be assumed that Spirulina can provide adequate amount of cholesterol and triglycerides in blood of the birds in the Spirulina treated groups. On the other hand, Torres *et al.* (1998) and Fong*et al.* (2000) reported that a significant reduction of triglycerides and cholesterol concentrations for rats or mice fed Spirulina diets. Tsuchihashi*et al.* (1987) and Mariey*et al.* (2012) also reported that the significant reduction in plasma cholesterol of broiler chickens fed dietary spirulina could be attributed to reducing the absorption and/or synthesis of cholesterol in the gastro-intestinal tract by Spirulina supplementation that increase Lactobacillus population. Further research is needed for the confirmation about the feasibility of Spirulina to recommend in diets of different poultry species.

Economic analysis of using Spirulina

Production cost per kilogram live weight of broiler was lowest (P<0.05) in group 5 (100% *Spirulina*) compared to other groups 4, 3, 2 and control. Qureshi *et al. (*1996) found improved chicken health with low dietary Spirulina levels of 10 g/kg in the ration, indicating greater production cost efficiency.

Conclusion

From the above discussion, it is clear that the diet which contains no vitamin-mineral premix might be compensated by the addition of 100% Spirulina as an efficient alternative organic source of vitamin-mineral for the supplementation in broiler diet to produce natural organic products. Moreover, Spirulina enhances to increase feed intake without toxicity. Further research is needed for the confirmation about of economic and feasibility to recommend in diets of different poultry species.

Acknowledgements

Authors deeply acknowledge the Bangladesh Agricultural Research Council, Dhaka, Bangladesh for financial support to conduct the research.

Conflict of interest

The authors would like to declare that there is no conflict of interest.

References

Al-Batshan HA, SI AL-Mufarrej, AA Al-Homaidan and MAQureshi (2001). Enhancement of chicken macrophage phagocytic function and nitrite produvtion by dietary *Spirulina Platensis*. *Immunopharmocology and Immunotoxicology* 23:281-289.

AOAC (1990). Official Method of Analysis (15th Edt). *Association of Official Analytical Chemists*. Washington D. C., U.S.A.

Baojiang G (1994). Study on effect and mechanism of polysaccharides on *Spirulina platensis* on body immune functions improvement. *Second Asia- Pacific Conference on Algal Biotechnology* 24: 25-27.Prebiotic competence of *spirulina* on the production performance of broiler chickens.

Belay A, T Kato and Y Ota (1996). Spirulina (*Arthrospira*): Potential application as an animal feed supplement*. Journal of Applied Phycology* 8: 303–311.

Colla LM, EB Furlong and JAV Costa (2007). Antioxidant properties of Spirulina (*Arthrospira platensis*) cultivated under different temperatures and nitrogen regimes. *Brazilian Archives of Biology and Technology* 50: 161-167.

Derner RB, S Ohse and M Villela (2006).Microalgas, produtos e aplicações.*Ciência Rural* 36:1959-1967.

Fong B, M Cheung and M Lee (2000). Effect of dietary *Spirulina* on plasma cholesterol and triglyceride levels in mice. In: Abstracts. *4th Asia-Pacific Conference on Algal Biotechnology*.pp.150.

Habib MB, A Parvin, Mashuda, C Huntington, T Hasan and R Mohammad (2008). a review on culture, production and use of spirulina as food for humans and feeds for domestic animals and fish. *Food and Agriculture Organization of The United Nations*. Italy.

Holman BWB and AEO Malau-Aduli (2012). *Spirulina* as a livestock supplement and animal feed. *Journal of Animal Physiology and Animal Nutrition* 97: 615–623.

Kelly J, Moorhead and CM Helen (1995).*Spirulina,* Nature's superfood, Illustrated by Sunny pau ole, *Published by Nutrex*,Inc 2nd Printing USA.

Kharde SD, RN Shirbhate, KB Bahiram and SF Nipane (2012). Effect of *Spirulina* supplementation on growth performance of broilers. *Indian Journal of Veterinary Research* 21: 66-69.

Mariey YAHR, MA Samak and Ibrahem (2012). Effect of using spirulina platensis algae as a feed additive for poultry diets: 1- productive and reproductive performances of local laying hens. *Egyptian Poultry Science* 32 (I): 201-215.

Qureshi MA (1996). *Spirulina platensis* exposures enhances macrophage phagocytic function in cats. *Immunopharmacology and Immunotoxicology* 18: 457-463.

Richmond A (1987). Handbook of microalgal culture. *Beckwell,* Oxford.

Rodriguez-Hernandez A, JLBlé-Castillo and MA Juárez-Oropeza (2001).*Spirulina maxima* prevents fatty liver formation in CD-1 male and

female mice with experimental diabetes. *Life Sciences* 69: 1029-1037.

Ross E and W Dominy (1990). The nutritional value of dehydrated, blue-green algae (*Spirulinaplatensis*) for poultry. *Poultry Science* 69: 794-800.

Ruan JS, Guo and LH Shu (1990). Effect of *Spirulina* polysaccharides on changes in white blood corpuscles induces by radiation in mice. *Journal of Radiation Research Technology* 8: 210-213.

Saxena PN, MR Ahmed, R Shyam and DV Amla (1983). Cultivation of *Spirulina*in sewage for poultry feed. *Experientia* 39: 1077.

Shanmugapriya BS, SaravanaBabu, T Hariharan, S Sivaneswaran and MB Anusha (2015). Dietery administration of *Spirulina*platensis as probiotics on growth performance and pathology in broiler chicks. *International Journal of Recent Scientific Research* 6: 2650-2653.

Shuvo AK (2001). Spirulina is future food. Professors.*Current Affairs* pp. 78.

Steel GD and HJ Torrie (1980). Principles and procedure of statistics. *McGrow Hill Book Company Inc.* New York.

Sujatha T and D Narahari (2011). Effect of designer diets on egg yolk composition of 'White Leghorn' hens. *Journal of Food Science and Technology* 48: 494–497.

Torres-Duran PV, R Miranda-Zamora, MC Paredes-Carbajal, D Mascher, JC Diaz-Zagoya and M Juarez-Oropeza (1998). *Spirulina* maxima prevents induction of fatty liver by carbon tetrachloride in the rat. *Biochemistry* and *molecular biology international* 44: 787- 793.

Toyomizu MK, H Sato,T Taroda, Kato and Y Akiba (2001). Effects of dietary *Spirulina* on meat colour in muscle of broiler chickens. *British Poultry Science* 42: 197–202.

Tsuchihashi N, T Watanabe and Y Takai (1987). Effect of Spirulinaplatensis on caecum content in rats. *Bull Chiba Hygiene College* 5:27-30.

Venkataraman LV, T Somasekaran and EW Becker (1994). Replacement value of blue-green alga (*Spirulinaplatensis*) for fishmeal and a vitamin-mineral premix for broiler chicks. *British Poultry Science* 35: 373–381.

Zarrouk C (1966). Contribution à l'étuded'unecyanophycéeinfluencée de divers facteurs physiques etchimiquessur la croissanceet la photosynthés de Spirulina maxima (Setch. et Gardner) Geitler. *University of Paris*, Paris, France.