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Use of *Spirulina platensis* in place of vitamin mineral premix on the performance of broiler

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Abstract

The experiment was conducted to compare the effects of different sources of Spirulina and vitamin mineral premix as feed additive on the growth performance of broiler. Two hundred day old broiler chicks (COBB-500) were divided into five groups such as T_1-(Feed containing 0.30% Vitamin mineral premix+0.0% Spirulina), T_2-(Feed containing 0.15% Vitamin mineral premix+0.15% Spirulina from China), T_3-(Feed containing 0.0% Vitamin mineral premix+0.30% Spirulina from China), T_4-(Feed containing 0.15% Vitamin mineral premix+0.15% Spirulina from Myanmar) and T_5-(Feed containing 0.0% Vitamin mineral premix+0.30% Spirulina from Myanmar) having four replication in each group containing 10 birds/replication. The experiment was conducted for 28 days (Completely Randomized Design) with *ad libitum* feed and water. Live weight was numerically higher ($P>0.05$) in T_4 in 4^{th} weeks of age. Lower feed intake observed in T_3 and T_5 which was mainly 50% replacement of vitamin mineral premix by Spirulina. After end of the feeding trial feed conversion ratio (1.66) in control group was higher ($P<0.05$) than other groups (1.63, 1.64, 1.59 and 1.61 respectively in T_2, T_3, T_4 and T_5). Dressing percentage (63.12%), breast weight (21.22%) and thigh weight (8.54%) were higher ($P<0.05$) in T_4 than all other groups. Concentration of total cholesterol in blood plasma (64.42mg/dl) and serum albumin (1.75g/dl) was lower ($P<0.05$) in T_4. It could be concluded that Spirulina from Myanmar is better than China and 50% synthetic vitamin mineral premix could be replaced by using Spirulina from Myanmar for better growth of broiler.

Keywords: broiler performance, vitamin-mineral premix, blood profile, feed conversion ratio, spirulina

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Introduction

Poultry industry is growing very fast during last three decades and expanding rapidly than other food producing animal industries. The net trade volume of poultry products has also increased parallel to the rapid growth of global poultry meat and egg production (Windhorst, 2006). At present the ultimate aim of poultry industry is the attainment of sustainable broiler production in the shortest possible time in order to give access of people to animal protein source with minimum cost. However, the major constraints of livestock production in developing countries are the scarcity and fluctuating quantity and quality of the year-round feed supply. Providing an adequate good-quality feed to broiler to raise and maintain their productivity in proper way will be a major challenge to agricultural scientists and policy makers all over the world. For this large number of poultry production, the feed production will have to be increased. Among the feed ingredients the vitamin-mineral premix is one of the most costly items. As a less costly substitute of vitamin-mineral premix algae can be an option. Algae production could be a promising alternative as a source of feed nutrient. The most commonly used algae species is Spirulina (*Spirulina platensis*). Spirulina is multicellular, blue-green algae. They are very small and microscopic and 300 to 500µm in length. These blue-green algae contain 50-70% protein, 10-12% carbohydrate (in dry condition), 6% fat, 7% minerals and a lot of vitamins (Shuvo, 2001). It is rich in B vitamins, minerals, trace elements, chlorophylls and enzymes (Kelly *et al.,* 1995). Considerable amounts of phosphorous, magnesium zinc and pepsin found in *Spirulina platensis*. It also consist 6-11% polysaccharide; the predominant are palmitic (16:0, 44.6-54.1%) gama-linolenic acid or GLA (18:3, 8.0-31.7%), linoleic (18:2, 10.8-30.7%) and oleic acids (18:1, 1.0-15.5%). 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 (Richmond, 1987). Spirulina species not only contribute in human health but also plays considerable role as animal feed. It increases the yellowness and redness in broiler flesh when

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Spirulina fed with diet (Habib *et al.,* 2008). Feeding on Spirulina helped to improve disease resistance of some high valued fish which resulting in increase in their survival rate from 85.0%. When Spirulina was added to forage for poultry and livestock, their growth rate was improved (Toyomizu *et al.,* 2001). It is generally accepted to be a good source of protein (60-70%), essential amino acids (1.30-2.75% on DM basis), vitamins, minerals, essential fatty acids and antioxidant pigments (Holman and Malau-Aduli, 2012). Chickens receiving diets supplemented with Spirulina had better health might be due to an enhancement of the immune function (Belay *et al.,* 1996). Inclusion of Spirulina in layer diets has also been shown to reduce total cholesterol content of eggs while increasing omega-3 fatty acid levels (Sujatha and Narahari, 2011).

Therefore, the present work was undertaken to study the replacement of Vitamin mineral premix by Spirulina (*Spirulina platensis*) in broiler diet from different sources for the growth performance, carcass characteristics and blood profiles of broiler.

Materials and Methods

The experiment was conducted in the poultry rearing unit of Shahjalal Animal Nutrition Field Laboratory, Bangladesh Agricultural University, Mymensingh for a period of 28 days.

Chicks, ingredients and Spirulina

Day old broiler chicks (COBB-500) were purchased from CP Bangladesh Ltd. All the feed ingredients were collected from local market in Mymensingh town and Spirulina were collected from Myanmar (JUNE Pharmaceuticals Limited) and China (Jiangxi Yuchang Industry Co., Ltd). Vitamin mineral premix was collected from Renata Limited. The ingredients and nutritional composition of different dietary treatments are presented in Table 1 and 2, respectively.

Experimental design and ration formulation

Total number of 200 chicks was distributed into 5 groups having 4 replication floor cages containing 10 birds in each cage as mentioned below.

T_1- (Feed containing 0.30 % Vitamin mineral premix + 0.0% Spirulina)

T_2- (Feed containing 0.15% Vitamin mineral premix + 0.15% Spirulina from China)

T_3- (Feed containing 0.0% Vitamin mineral premix + 0.30% Spirulina from China)

T_4- (Feed containing 0.15% Vitamin mineral premix +0.15% Spirulina from Myanmar)

T_5- (Feed containing 0.0% Vitamin mineral premix +0.30% Spirulina from Myanmar)

Table 1: Formulation of diet (%) in different experimental groups

Ingredients	Treatment groups				
	T_1	**T_2**	**T_3**	**T_4**	**T_5**
Maize	53.0	53.0	53.0	53.0	53.0
Protein Concentrate	12.0	12.0	12.0	12.0	12.0
Rice polish	3.00	3.00	3.00	3.00	3.00
Soybean meal	23.0	23.0	23.0	23.0	23.0
DCP	1.50	1.50	1.50	1.50	1.50
Vitamin mineral premix	0.30	0.15	0.00	0.15	0.00
Spirulina from China	0.00	0.15	0.30	0.00	0.00
Spirulina from Myanmer	0.00	0.00	0.00	0.15	0.30
Salt	0.50	0.50	0.50	0.50	0.50
DL-Methionine	0.15	0.15	0.15	0.15	0.15
Choline Chloride	0.05	0.05	0.05	0.05	0.05
Soybean oil	2.75	2.75	2.75	2.75	2.75
Starch	3.75	3.75	3.75	3.75	3.75
Total	100	100	100	100	100

T_1-(Feed containing 0.30 % Vitamin mineral premix + 0.0% Spirulina);T_2-(Feed containing 0.15% Vitamin mineral premix + 0.15% Spirulina from China);T_3-(Feed containing 0.0% Vitamin mineral premix + 0.30% Spirulina from China);T_4-(Feed containing 0.15% Vitamin mineral premix +0.15% Spirulina from Myanmar);T_5-(Feed containing 0.0% Vitamin mineral premix +0.30% Spirulina from Myanmar).

Table 2: Nutritional composition (g/100g fresh) of different treatment groups

Parameter	T_1	T_2	T_3	T_4	T_5
Dry Matter	88.41	88.20	89.33	88.72	89.37
Crude Protein	22.84	22.79	22.20	22.66	22.60
Crude Fibre	3.65	3.41	3.59	3.73	3.29
Ether Extract	5.33	5.69	5.95	6.22	6.48
Ash	5.93	5.81	5.41	5.99	5.77

T_1-(Feed containing 0.30 % Vitamin mineral premix + 0.0%Spirulina);T_2-(Feed containing 0.15% Vitamin mineral premix + 0.15% Spirulina from China);T_3-(Feed containing 0.0% Vitamin mineral premix + 0.30% Spirulina from China);T_4-(Feed containing 0.15% Vitamin mineral premix +0.15% Spirulina from Myanmar);T_5-(Feed containing 0.0% Vitamin mineral premix +0.30% Spirulina from Myanmar).

General management

Two hundred COBB-500 commercial day old broiler chicks were reared in this experiment having average weight of 45.33g/bird. 20 cages required for this trial each having floor space of $0.91m^2$ (120cm×76cm). Fresh dried saw dust was used as litter material and maintained properly throughout the experiment. Every week litter was stirred to prevent accumulation of ammonia gas and maggot formation. A 100-watt electric bulb was used for each cage to maintain proper lighting and brooding. The chicks were distributed 10 birds per cages where feeders and waterers were placed previously. Feeds were supplied as *ad libitum* basis. Proper bio-security measures were also taken during the whole experimental period.

The birds were vaccinated against Newcastle Disease (4^{th} and 20^{th} day) and Infectious Bursal Disease (11^{th} day) intraocular. 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.

Record keeping and collection of data

Broilers were weighted in a group at the beginning of the trial and then every week at the age of day 0, 7, 14, 21 and 28. Feed offered were recorded when supplied in cages and refusal at the end of each week also recorded. Feed intake, feed conversion ratio and feed conversion efficiency were calculated. Numbers of dead birds were counted during the whole experimental period.

Blood from healthy chicken was collected using 10 ml falcon tube directly from the heart after slaughtering at day 28 of age from randomly selected birds of each replication. After collection of blood samples, each tube was placed in a rack at room temperature. 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 eppendorf tube. The plasma was preserved in deep freezer and the tubes were marked properly with permanent marker for easy identification during blood analysis.

Samples of feed ingredients (in duplicate) were analyzed to determine dry matter (DM), crude protein (CP), ether extract (EE), crude fibre (CF), and total ash (Ash) following the method described by AOAC (1990).

Statistical analysis

All recorded and calculated variables were subjected to analysis of variance (ANOVA) in a Completely Randomized Design (CRD) by following a statistical package using SPSS statistical computer package program. Tukey Pairwise Comparisons was used to compare treatment means.

Results

Live weight, feed intake and feed conversion ratio

Live weight of broiler was different ($P<0.05$) in last two weeks, 3^{rd} and 4^{th} weeks of age (Table 3). In 1^{st} weeks of age, live weight was higher in $T_3$and T_4 (groups than other groups of birds. In 2^{nd} week, live weight was numerically higher inT_4 group. At 3^{rd} week, live weight was lower ($P<0.05$) in T_5 group and higher in T_4 group. Finally higher live weight ($P<0.05$) was obtained at T_4 and T_2 groups. In the present experiment replacement of 50.0% vitamin-mineral premix by adding 50.0% Spirulina of Myanmar had difference ($P<0.05$) in live weight at different weeks of age of broiler. Finally 50.0% replacement of vitamin mineral premix by Spirulina from Maynmer would be suitable for better performance($P<0.05$) shown in group T_4.Initial 2 weeks there was no difference among the groups for feed intake (Table 4). In 3^{rd} week feed intake ($P<0.05$) was higher in T_4 and T_1

groups compared to other groups but no statistical variation was observed between two groups. In the 4th weeks of age, highest feed intake ($P<0.05$) was observed in the T_4 and T_2 and T_1 groups, respectively. Feed conversion ratio at different weeks is presented in Table 5. Initially it was lower ($P<0.05$) in T_4 group. But second week it was numerically lower at T_4 and T_3 groups, respectively. But at 3rd week all the treatment groups except T_5 showed better FCR than control (T_1) ($P<0.05$). Finally T_4group showed better FCR than control ($P<0.05$).

Table 3: Live weight of birds (g) in different age supplemented with or without vitamin mineral premix or spirulina (*Spirulinaplatensis*)

Days	Treatment groups				
	T_1	T_2	T_3	T_4	T_5
Day 0	45.0±1.0	46.6±2.0	45.7±2.0	44.4±1.0	45.0±2.0
Day 7	147.01 ±20.0	158.0 ±19.1	165.0 ±18.3	179.0 ±3.1	147.0±9.5
Day 14	344.2±33.4	372.1±44.6	375.0± 56.1	372.0± 29.7	346.0±13.1
Day 21	753.0^{a}±39.1	695.0^{ab}±15.7	698.1^{a}±41.3	797.0^{a}±30.5	611.0^{c}±31.0
Day 28	1117.0^{b}±35.7	1159.0^{b}±17.2	1068.2^{bc}±20.0	1220.0^{a}±24.1	1100.2^{bc}±30.0
Day(0-28)	1072.0^{bc}±35.4	1112.3^{b}±15.1	1022.3^{c}±57.7	1175.0^{a}±40.1	1055.0^{c}±30.8

Mean± SD; ^{abc} Means with dissimilar superscripts are significantly different ($P<0.05$); T_1-(Feed containing 0.30 % Vitamin mineral premix + 0.0%Spirulina);T_2-(Feed containing 0.15% Vitamin mineral premix + 0.15% Spirulina from China);T_3-(Feed containing 0.0% Vitamin mineral premix + 0.30% Spirulina from China);T_4-(Feed containing 0.15% Vitamin mineral premix +0.15% Spirulina from Myanmar);T_5-(Feed containing 0.0% Vitamin mineral premix +0.30% Spirulina from Myanmar).

Table 4: Cumulative feed intake (g) in different age of birds supplemented with or without vitamin mineral premix or spirulina (*Spirulina platensis*)

Days	Treatment groups				
	T_1	T_2	T_3	T_4	T_5
Day (0-7)	151.0±3.1	164.1±13.0	155.3±5.3	164.2±6.1	148.3± 4.6
Day (0-14)	452.0±31.0	486.0±30.0	460.0±10.4	472.1±36.1	464.0± 15.7
Day(0-21)	1109.1^{a}±35.0	1012.0^{b}±46.7	982.2^{b}±58.3	1108.9^{a}±66.8	897.0^{c}±47.0
Day(0-28)	1787.3^{a}±67.8	1806.5^{a}±74.2	1676.7^{b}±50.9	1869.2^{a}±70.0	1698.7^{b}±94.4

Mean± SD; ^{abc} Means with dissimilar superscripts are significantly different ($P<0.05$); T_1-(Feed containing 0.30 % Vitamin mineral premix + 0.0% Spirulina);T_2-(Feed containing 0.15% Vitamin mineral premix + 0.15% Spirulina from China);T_3-(Feed containing 0.0% Vitamin mineral premix + 0.30% Spirulina from China);T_4-(Feed containing 0.15% Vitamin mineral premix +0.15% Spirulina from Myanmar);T_5-(Feed containing 0.0% Vitamin mineral premix +0.30% Spirulina from Myanmar).

Table 5: Cumulative FCR (Kg FI/Kg LWG) in different age of birds supplemented with or without vitamin mineral premix or spirulina (*Spirulina platensis*)

Days	Treatment groups				
	T_1	T_2	T_3	T_4	T_5
Day (0-7)	1.48^{a}±0.13	1.47^{a}±0.11	1.30^{ab}±0.14	1.22^{b}±0.03	1.45^{a}±0.15
Day (0-14)	1.52±0.17	1.49±0.19	1.40±0.09	1.39±0.03	1.54±0.13
Day (0-21)	1.57^{a}±0.05	1.56^{a}±0.04	1.51^{ab}±0.04	1.47^{b}±0.01	1.57^{a}±0.05
Day (0-28)	1.66^{a}±0.02	1.63^{a}±0.06	1.64^{ab}±0.16	1.59^{b}±0.03	1.61^{a}±0.14

Mean± SD; ^{abc} Means with dissimilar superscripts are significantly different ($P<0.05$); T_1-(Feed containing 0.30 % Vitamin mineral premix + 0.0% Spirulina);T_2-(Feed containing 0.15% Vitamin mineral premix + 0.15% Spirulina from China);T_3-(Feed containing 0.0% Vitamin mineral premix + 0.30% Spirulina from China);T_4-(Feed containing 0.15% Vitamin mineral premix +0.15% Spirulina from Myanmar);T_5-(Feed containing 0.0% Vitamin mineral premix +0.30% Spirulina from Myanmar).

Table 6: Carcass characteristics (%) in different age of birds supplemented with or without vitamin mineral premix or spirulina (*Spirulina platensis*)

Days	Treatments				
	T_1	T_2	T_3	T_4	T_5
Breast	21.66^a	20.49^b	19.63^c	21.22^a	19.38^c
Thigh	7.99^c	7.57^c	7.77^b	8.54^a	7.82^b
Drumstick	3.98^d	4.62^a	4.25^c	4.26^b	4.42^b
Shank	3.51	4.48	4.53	4.17	5.01
Liver	2.82^c	3.45^a	3.01^b	2.55^d	3.35^a
Gizzard	3.28^c	3.72^a	3.55^b	3.02^d	3.71^a
Skin	6.41	6.37	6.06	6.27	6.82
Dressing percentage	62.05^a	61.08^b	60.27^b	63.12^a	57.42^c

Mean; ^{abc}Means with dissimilar superscripts are significantly different ($P<0.05$); T_1-(Feed containing 0.30 % Vitamin mineral premix + 0.0% Spirulina);T_2-(Feed containing 0.15% Vitamin mineral premix + 0.15% Spirulina from China);T_3-(Feed containing 0.0% Vitamin mineral premix + 0.30% Spirulina from China);T_4-(Feed containing 0.15% Vitamin mineral premix +0.15% Spirulina from Myanmar);T_5-(Feed containing 0.0% Vitamin mineral premix +0.30% Spirulina from Myanmar).

Table 7: Blood parameters in different age of birds supplemented with or without vitamin mineral premix or spirulina (*Spirulina platensis*)

Days	Treatments				
	T_1	T_2	T_3	T_4	T_5
Glucose (mmol/L)	4.99 ± 0.23^b	6.10 ± 0.38^b	12.51 ± 0.269^a	5.76 ± 0.29^b	11.52 ± 0.25^a
Creatinine (mg/dL)	0.056 ± 0.008^c	0.64 ± 0.056^a	0.163 ± 0.004^{bc}	0.114 ± 0.003^{bc}	0.24 ± 0.056^b
Urea (mg/dL)	16.65±0.28	16.53±0.032	16.19±0.084	16.65±0.21	16.14±0.35
Albumin (g/dL)	2.43 ± 0.09^{ab}	2.07 ± 0.11^{bc}	2.28 ± 0.14^b	1.75 ± 0.07^c	2.87 ± 0.14^a
Cholesterol (mg/dL)	111.13 ± 8.03^a	84.14 ± 5.75^{bc}	86.25 ± 6.63^{bc}	64.42 ± 4.32^c	96.47 ± 3.95^{ab}

Mean± SD; ^{abc}Means with dissimilar superscripts are significantly different ($P<0.05$); T_1-(Feed containing 0.30 % Vitamin mineral premix + 0.0% Spirulina);T_2-(Feed containing 0.15% Vitamin mineral premix + 0.15% Spirulina from China);T_3-(Feed containing 0.0% Vitamin mineral premix + 0.30% Spirulina from China);T_4-(Feed containing 0.15% Vitamin mineral premix +0.15% Spirulina from Myanmar);T_5-(Feed containing 0.0% Vitamin mineral premix +0.30% Spirulina from Myanmar).

Carcass characteristics

Dressing percentage was higher ($P<0.05$) in T_4 where 50% synthetic vitamin mineral premix were replaced by 50% Spirulina from Myanmar than other groups of birds (Table 6). Breast weight was higher ($P<0.05$) in T_4 and T_1. Drumstick was highest in T_2 and weight of thigh was also higher in T_4.

Blood profile

Concentration of albumin (1.75) and cholesterol (64.42) in blood plasma were lower ($P<0.05$) in T_4 and higher ($P<0.05$) in T_5 and T_1 (Table 7). Glucose concentration was higher ($P<0.05$) in T_3. Creatinine concentration (0.056) was lower ($P<0.05$) in T_1 groups.

Discussion

Live weight, feed intake and feed conversion ratio

Copper present in Spirulina helps in growth, improving feed efficiency and egg production (Pesti and Bakalli, 1998) and Spirulina rich in copper and phosphorus which helps in growth efficiency and protein synthesis in the body which supports the results of our experiment because the best live weight was found when 50%Spirulina was used in feed as a replacement of 50% synthetic vitamin-mineral premix. This is because all the minerals that are present in synthetic vitamin-mineral premix are not fully available in utilizable form for birds but phosphorus availability from Spirulinais 41.0% (Yoshida and Hoshii, 1980; Blum *et al.,* 1976). Kharde *et al.* (2012) also agrees with the result of the present experiment as he gets the best growth rate when Spirulina were used at a rate of 0.30% with feed.Inclusion level of Spirulina affect the weight gain of broiler and in the present experiment live weight gain was highest in the control group where full synthetic vitamin-mineral premix is used and the closest result was found when 50% synthetic vitamin-mineral premix are replaced by Spirulina from Myanmar. Shanmugapriya *et al.* (2015) reported that dietary inclusion of 1.0% of Spirulina as compared to the control feed, body weight gain was significantly increased in broilers.

Devi *et al.* (1981) noted that Spirulina is approximately 65.0to 71.0 percent protein, depending on growing conditions and these proteins are biologically complete, which means they provide all eight essential amino acids in the proper ratios. Spirulina provides all the required amino acids in a form that is easier to digest than meat or soy protein (Devi *et al.,* 1981). Amino acid in proper ratio are essential in different digestive enzyme synthesis, which enhance feed utilization and rate of passage through the digestive tract and for these reasons maximum feed intake was observed in those treatment where Spirulina were used as replacement of synthetic vitamin-mineral premix. Shanmugapriya *et al.* (2015) reported that dietary inclusion of 1.0% of Spirulina in broilers increased Villi length that indicates better feed utilization and feed intake. From morphological point of view, longer villi increased surface area that allowed greater absorption of available nutrients and enhance feed intake especially in the distal intestinal segment (Caspary, 1992). It was found that body weight, average daily weight gain, carcass yield percentage and feed conversion ratio improved by the dietary inclusion of the Spirulina as compared to the control (Khardeet *al.,* 2012; Shanmugapriyaet *al.*, 2015). Under oxidative stress conditions, there is an increased demand for antioxidants to reduce the deleterious effects of free radicals on the immune system (Carroll and Forsberg, 2007). Spirulinaplatensis, have been considered as a suitable natural antioxidant and immune-stimulant to humans and animals with fewer side effects and more cost effectiveness than synthetic products (Belay, 2008; Khan *et al.*, 2005; Lykkesfeldt and Svendsen, 2007). 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 increases the addition Spirulina in feed will depress the production and feed conversion ratio.

Carcass characteristics

Raach-Moujahed *et al.* (2011) stated that Spirulina improved the carcass yield of Arbor Acres broiler. A similar result was observed by Razafindrajaona *et al.* (2008) who found that Spirulina incorporated according to 100 mg/kg body weight, improve the carcass yield. According to Razafindrajaona *et al.* (2008), the improvement of the carcass yield indicates a better development of the thighs and the breast which also support the result of the present experiment, when 50% synthetic vitamin-mineral premix were replaced by Spirulina from Myanmar as maximum thigh and breast weight was found in this group of broiler. Jansons and Jemeljanovs (2010) established that the applied phytogenic supplements improve the quality of the final product as the slaughter weight increases with 4.4% and the content of muscular tissue in the carcass increases with 2.7%.

Blood profile

Torres-Duran *et al.* (1998) and Fong*et al.* (2000) reported a significant reduction of triglycerides and cholesterol concentrations for rats or mice fed Spirulina diets which supports the result of the present experiment. Cholesterol concentration was lower in T4 where 50% vitamin-mineral premix is replaced by 50% Spirulina from Myanmer. The most widely published metabolic effect of Spirulina is the anticholesterolaemic effect, which have supported our results because cholesterol concentration was lower in Spirulina treated group.

Tsuchihashi *et al.* (1987) and Marieyet *al.* (2012) reported that the significant reduction in plasma cholesterol of broiler chickens fed dietary Spirulina could be attributed to reduce the absorption and/or synthesis of cholesterol in the gastro-intestinal tract by Spirulina supplementation that increase Lactobacillus population. Lactobacillus has found to have a high bile salt hydrolytic activity and to reduce the cholesterol in the blood by de-conjugating bile salts in the intestine (Surono, 2003), thereby preventing them from acting as precursors in cholesterol synthesis (Abdulrahim*et al.*, 1996). Concentration of plasma total protein, albumin and globulin may be related to the high level and good quality of protein contents in Spirulina (55-65%) which was also in the agreement with result of the present experiment because albumin concentration in blood plasma was maximum in T5. These results are in line with the findings of Tewe (1985) and Eggum (1989), who stated that total serum protein, globulin and albumin were directly responsive to protein quantity and quality.

Conclusion

From the present result, it may conclude that, replacement of synthetic vitamin mineral premix by Spirulina could increase production performance of broiler as well as it could reduce the cholesterol concentration and increase protein synthesis as Spirulina is a good source of protein having amino acid in well proportion that we found by analysing the concentration of albumin in blood plasma. But source and inclusion level of Spirulina have also impact on broiler production that was observed in the present study. Spirulina from Myanmar is better than China and 50 % synthetic vitamin mineral premix could be replaced by using 50% Spirulina which would be helpful for safe broiler production.

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Conflict of interest

There is no conflict of interest among the authors.

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