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PRODUCTIVE PERFORMANCE AND IMMUNE RESPONSE IN GROWING JAPANESE QUAIL SUPPLEMENTED WITH SPIRULINA ALGAE EXTRACT (ARTHROSPIRA PLATENSIS) IN DRINKING WATER

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ABSTRACT: A trial was carried out to investigate the effect of drinking water supplemented with dry powder Spirulina algae extract (SP) on productive performance and immune response of growing Japanese quail. A total of 480, 1-d-old quail chicks were randomly assigned equally to 4 treatments for 5 wks. The 1st treatment served as a control, fed a basal diet and drinking water with no supplement, while, the 2nd, 3rd and 4th treatments fed the basal diet and drinking water supplemented with SP extract at a rate of 0.5, 1 and 2 g /Liter, respectively. The results indicated that there was significant improvement of SP extract supplementation on the average body weight gain, health, viability with highest decrease in chicks mortality percent of all supplemented groups. Moreover, the lowest feed consumption and feed intake beside the best significant feed conversion ratio, feed efficiency and European Production Efficiency values were observed in all treated groups. Results also revealed significant ($P \leq 0.05$) increase in the relative weights of carcass, liver, heart, lymphoid organs, sex organs, proventriculus, ventriculs, and small intestine length. Abdominal fat was significantly decreased following increasing levels of SP. Moreover, the hematological responses and serum antibody production against Newcastle virus, plasma total protein profile, total antioxidant capacity and Thyroxin (T_4) concentration were significantly ($P \leq 0.05$) increased in all treated groups. However, plasma cholesterol and total lipids had marked lower levels in all supplemented groups. Plasma ALP, ALT and AST activities are fell within the normal range among groups. Therefore, supplementing SP algae extract may possibly maximize the physiological, productive performance and immune response of growing quail chicks.

Key words:Spirulina platensis - productive performance- immune response- growing quail

INTRODUCTION

Intensive quail production systems may be associated with multiple stressful incidents like the high metabolic rate and environmental stressor as high ambient temperature, that negatively impact immune response, health and production performance of chicks(Abd El-Baky et al.,2007). Hence, under any of above mentioned stress conditions, there is an increased demand for essential nutrients and antioxidants in the chicks' diet or drinking water to reduce the deleterious effects of intensive quail production systems and reverse the impairments in health and performance of birds. The blue-green algae, Spirulina *(*Arthrospira platensis), is considered as one of the richest sources of proteins (60-70% by dry weight) and organic nutrients including a wide spectrum of vitamins, vital minerals, essential amino acids, essential fatty acids, carotene, photochemicals and profound natural antioxidant compounds as described by (Holman and Malau-Aduli, 2012: Farag et al., 2016). Moreover, other studies have demonstrated that Spirulina platensis (SP) possess some promising bioactive compounds such as antimicrobial, antiviral and anti-inflammatory (Abdel-Daim et al., 2015). These pharmaceutical and medicinal properties of SP could be attributed to some natural constituents such as phycocyanin, polysaccharides, and phenolic compounds (Chen and Wong, 2008). Because of these characteristics, SP is a promising nutritional supplement, has the ability to protect the physiological body system against oxidative damage and free radicals (Gad et al., 2011 and Banji et al., 2013), provide the body with organic essential nutrient, natural antioxidants and bioactive compounds which in all improving growth performance and immune response(Nah et al., 2012). On this aspect, many researchers studied the beneficial effects of SP as natural feed additives and reported its enhancing potential on animal productive and reproductive performance, improving general health as well as lowering the problems of different diseases like anaemia, and metabolic disorders. (Mariey et al., 2012; Nah et al., 2012;Kaoud, 2012;Holman and Malau-Aduli, 2012 ; Dalle Zotte et al., 2013; Simkus et al., 2013; Shanmugapriya and Babu, 2014; El-Sabagh et al., 2014; Evans et al., 2015; Shanmugapriya et al., 2015; Pandav and Puranik, 2015; Farag et al., 2016). To date, studies on using SP alga extraction in `growing Japanese quail chicks diets are still quite limited. Therefore, the present study was planned to determine the effect of supplemented graded levels of Spirulina (Arthrospira plantensis) alga extract in drinking water on some biological parameters.

MATERIALS AND METHODS

Birds and husbandry

Four hundred and eighty, one d-old Japanese quail chicks maintained at the Poultry experimental farm of the biological application department, Nuclear Research Center, Egypt. The chicks were randomly allocated to 4 experimental treatments for 5 wk (experimental period). Each treatment had 4 replicates of 30 chicks. Each replicate was assigned to a clean floor pen (2 x 2 m), and birds were raised on a wood shaving litter. All groups were kept at the similar conditions of controlled room temperature and under normal periods of light/dark. The first week temperature was 36 ˚C and then quails were kept at 28±2 ˚C until the end of the experiment. Relative humidity was

50±5% and photoperiod was 23 L: 1 D hours. All procedures used in this experiment were approved by the Animal Ethics Committee of National Institute of Animal Health.

Experimental treatments and bio-product supplementation

The spirulina algae (Arthrospira platensis) used in the experiment was green dry powder and purchased from "Biopellet-SOO, manufactured by Samu median Co., Ltd. (South Korea).

This study was based on 4 treatments, the 1st group was fed a basal diet and served as a control, while, the 2nd, 3rd and 4th groups were experimental groups fed the basal diet and SP was supplemented to drinking water at a rate of 0.5, 1 and 2 g per liter, respectively. The treated drinking water given to the groups after 24 hour passes. The diet was formulated to meet the nutrient requirements of Japanese quail chicks (NRC, 1994). The ingredients' composition and calculated chemical analysis of the basal diet are given in Table 1. Mash feed and water were available *ad libitum* throughout the experimental period.

Growth Performance Traits

Clinical signs and mortality were monitored daily during the whole experimental period. Body weight gain and feed consumption were recorded weekly during the experiment period, feed intake, daily weight gain, feed efficiency and feed conversion ratio (FCR) was calculated as the ratio between feed intake and body weight gain at the end of each week. Feed conversion ratio was determined for the overall experimental period (for 5 wk), and European Production Efficiency Index (EPEI) were calculated guide (1999).

EPEI = BW (kg) x LA x 100/PP x FCR.

Where:

BW: Body weight (kg).

LA: Livability (100% mortality).

PP: Production period (days), FCR : Feed conversion ratio (kg feed / kg gain).

All measurements were performed on the pen basis using a high precision electronic scale.

Carcass traits and blood analysis

At the end of experimental period (5 weeks), 24quail birds (6 birds/pen) from each group (chosen on the basis of pen average final weight. Carcass, liver, heart, proventriculus, ventriculs spleen, thymus bursa of Fabricius, sex organs (tests and ovary), abdominal fat, small intestine (g) and small intestine length (cm) for each slaughter bird were calculated as a relative percentage of live body weight. Blood samples were collected from slaughtered birds and placed in two tubes, one with lithium heparin to determine hematological parameters and the other without anticoagulant and left to clot then centrifuged at (4000 rpm) for 10 minutes, and the resulting serum was kept at -20ºC for hormonal and chemical analyses.

Serum total proteins, albumin, alkaline phosphates (ALP), alanine aminotransferase (ALT), aspartate aminotransferase (AST), total antioxidant, triglyceride, total lipids and cholesterol were determined colorimetrically using commercial kits produced by Stanbio Company, USA by computerized spectrophotometer model Milton Roy 1201. Serum Globulin values were calculated by subtracting albumin values from their corresponding total proteins values of the same sample. Albumin: Globulin ratio was calculated by divided albumin values to Globulin values. Concerning, blood hematological parameters, red blood cell (RBCs) and white blood cell (WBCs) counts were determined using a hemocytometer according to Natt and Herrick, (1952). Hemoglobin concentration (Hb) and packed cell volume (PCV %) were determined according to Dacie and Lewis, (1991). Thyroxin (T4) hormone was determined using radioimmunoassay (RIA) Commercial Kit produced by IZOTOP Company (INSTITUTE OF ISOTOPES Ltd.) Hungarian Company (http://www.izotop.hu), and samples were counted on Packard Gamma Counter.

Immunological test

At the end of the experiment, six birds from each group were chosen at random and housed in multidisc batteries. Each bird was vaccinated against Newcastle disease with NDV clone 30 (Nobilis ND Clone 30; Intervet) by eye-drop. Blood samples were collected from wing vein using an insulin syringe at three times 3, 7 and 9 days of post-vaccination. Blood was allowed to clot then centrifuged immediately to separate serum to determine immune response (antibody titer) of the chickens derived from vaccination against Newcastle disease virus by performed Hemagglutination inhibition (HI) test on serum samples according to the method of (King and Seal, 1998).

Statistical analysis

Obtained data were statistically analyzed using linear models procedure using SAS (2008) software version 9.2. Differences among means were tested using Duncan's (1955) multiple range tests. One way analysis model was applied for experiment:

$Y_{ij} = \mu + T_i + E_{ij}$

Where: Y_{ij} =Observations

μ =The overall mean

T_i =Effect of i^{th} treatments

E_{ij} =Experimental error

RESULTS AND DISCUSSION

Effects of S. platensis on productive performance of Japanese quail

Growth performance

The Spirulina algae extract was tested in terms of live body weight and body weight gain as shown in Table2. The results indicated that live body weight starting from 3rd week towards the end of experiment at 5th week of age was significantly ($P \leq 0.05$) higher in chicks given drinking water supplemented with 0.5, 1 or 2 g /L SP, respectively, as compared to the control group. As a result, the average body weight gain of supplemented groups with SP was significantly ($P \leq 0.05$) higher compared to the control. The best effect was found for the dose of 2 g L^{-1} of SP. The improved body weight gain of treated groups with 0.5, 1 or 2 g /L SP, respectively, compared to control group could be attributed to the nutritive value of this bio-product which, enriched drinking water of treated groups with natural source of many compounds, e.g., 60-70% protein, minerals, fatty acids (e.g., ã-linolenic acid), polysaccharides, pigments (chlorophyll, carotenoids, phycobilins) and nearly all essential vitamins. Beside, the biologically active substances content of SP can stimulate body metabolism and improve digestion and the absorption of nutrients. Many studies conducted by Jamil et al., (2015) reported that the nutritional value of SP as it is one of the richest sources of proteins (60-70% by dry weight), containing a wide spectrum of organic nutrients that include all essential amino acids, essential fatty acids and poly unsaturated fatty acids . It also has phycocyanin and other photochemicals (Chamorro et al., 2002 and Farag et al., 2016). It contains vitamins B1 (thiamine), B2 (riboflavin), B3(nicotinamide), B6 (pyridoxine), B9 (folic acid), C (ascorbic acid; AA) as well as D, A and E vitamins and it is also a source of calcium, potassium, chromium, copper, manganese, iron, phosphorus, magnesium, sodium, zinc and selenium (Pandav and Puranik, 2015). Additionally, this algae implies the presence of more than one group of growth-promoting substances Michalak et al.,, (2016) as, (auxins, cytokinins and gibberellins) which may be influenced the body growth. Several reports showed the beneficial effect of these microalgae on the growth performance such as, Shanmugapriya and Babu, (2014) who showed significant improvement in the body weights and feed conversion ratio of broiler chicks fed diet included 1% of SP. On the same context, Pandav and Puranik, (2015) recorded an increase in body weight and a decrease in feed consumption of broilers fed diet supplemented with SP. Evans et al., (2015) fed broiler chicks diet supplemented with different levels of SP (6, 11, 16 and 21%) resulted in significant increase in performance. Similarly, Shanmugapriya et al., (2015) showed significant increase in feed conversion ratio and villi length, villi height, body weight gain of broiler chicks fed diet included on 1% SP.

Viability and mortality rate

Table 2 showed also the effect of treated quail chicks with SP extract on the viability and mortality rate. The results indicated that, SP supplementation in drinking water significantly ($P \leq 0.05$) reduced mortality rate compared to control and did not cause any adverse effects during the whole experimental study on chicks health. Generally, the observed viability of all birds during the experimental period was improved by SP supplementation. Based on the results, the significant improvement of SP extract on health and chicks mortality may be due to the multiple health benefits of SP including antimicrobial, antioxidant properties, immuno-stimulating , anti-inflammatory effects Abdel-Daim et al., (2015) , that have hepatoprotective effects and other bioactive components that have various therapeutic properties which used in the treatment of many diseases e.g., anemia, helping birds to enhance their immune system and resist against inappropriate or stressful environmental condition and producing healthy chicks Peiretti and Meineri, (2008) showed significant improvement in the survival with no mortalities and growth rates in growing rabbit fed for 24 days diet included SP up to 15%. Also, Pankaj, (2015) showed significant improvement of the litter survival of mice after treated with SP. According to our findings, SP supplementation had no adverse effect on production as no health problems or high mortality were observed in the experiment.

Feed consumption

The effect of supplementing graded levels of SP in drinking water on feed consumption was presented in Table 2. The average total feed consumption per bird during the whole experimental period was significantly lower in supplemented groups than control one, the lowest feed consumption at the overall period obtained by using 2g/ L SP. Moreover, feed intake starting from 3rd week towards the end of experiment at 5th week of age was significantly ($P \leq 0.05$) lower in treated groups than the control group. The best significant feed conversion ratio and feed efficiency was obtained by supplementing graded levels of SP in drinking water compared to control. This improvement in feed consumption as mentioned above may be attributed to rich content of Bio organic nutrients in SP (Farag et al., 2016). In addition, birds supplemented with SP may adequately utilized and the consumed nutrients absorbed easily and faster. These results agreed with those obtained by Gerencséret al.,(2012) who reported no adverse effect on body weight, feed consumption, morbidity and mortality rate of growing rabbits fed diet supplemented with Spirulina. Investigation by (Nah et al., 2012; Dalle Zotte et al., 2013; Simkus et al., 2013; Shanmugapriya et al.,2015; Pandav and Puranik, 2015 and Evans et al.,2015) showed that SP improved the growth, productive performance of poultry through improving feed intake, feed conversion, nutrient absorption and utilization. Also, El-Sabagh et al., (2014) and Shanmugapriya et al., (2015) reported that SP supplementation have multiple beneficial effects in improving productive and reproductive performance of animal and poultry.

European Production Efficiency Index

The technical evaluation expressed as European Production Efficiency Index (EPEI) in the present study Table 2, cleared that feeding Japanese quail chicks on diets supplemented with SP up to 1g/L in drinking water recorded the highest significant EPEI value (18.7) among treatments. This result may be due to the increase in body weight gain and the best feed conversion ratio.

Carcass characteristics

Statistical analyses of carcass characteristics in different groups were illustrated in Table 3. All levels of SP algae supplementation significantly affect the relative weights of carcass, liver, heart, lymphoid organs, sex organs, proventriculus, ventriculs, small intestine and small intestine length (cm). On the other hand, abdominal fat was significantly decreased by increasing levels of SP. These results indicate an improvement in chicks growth performance and feed utilization when consumed SP enriched drinking water up to 2g / L. Otherwise, SP contains several nutrients, especially vitamins and minerals, that may aid growth promotion. These results agree with those found by Simkus et al., (2013) who reported that carcass yield percentage was significantly higher in pigs fed Spirulina biomass than control. Baylan et al., (2012) reported significant improves in carcass traits and muscles of broiler fed dietary SP up to 40 g kg diet .On the other hand, Peiretti and Meineri, (2008) reported no changes in the carcass yield or the proportions of the different carcass parts and organs of growing rabbits fed high dietary inclusions of SP up to 150 g / kg diet.

The significant increase in the relative weight of sex organs (testes and ovary), heart and liver Table3 following SP supplementation up to 2g/ L drinking water of quail chicks could be attributed to the high nutritive value of SP as previously mentioned above and its particular composition of essential amino acids, essential fatty acids(e.g., ã-linolenic acid) and polysaccharides, which influenced the accumulation of fatty acid in sex organs of treated groups, beside the antioxidant and anti-proliferative properties of selenium enriched SP (Chen and Wong, 2008). As a result, enhanced the relative weight of sex organs, heart and liver. The current findings are consistent with the results of

Nah et al., (2012) who showed the highest weight of testis, seminal vesicles and Leydig cell number in male rats, treated with Spirulina maxima extracts. In another study conducted by Mariey et al., (2012), they showed significant increase in egg production and fertility of Gimmizah hens fed diets supplemented with SP up to 0.2 % which may indicate the significant increase in the relative weight of ovary. Similarly, Pankaj, (2015) showed significant improve the reproductive performance of mice after treated with SP.

The significant ($P \leq 0.05$) increase in the relative weights of small intestine and length (cm) Table3 revealed the certain influence of SP on gastrointestinal tract weight and length and might be due to improving the cell energy metabolism as a result of improved the utilization of nutrients for muscle accretion and growth. In this sense, Shanmugapriya et al., (2015) showed significant increase in villi length and villi height of small intestine of broiler chicks fed diet included on 1% SP.

The effect of SP on the relative weight of abdominal fat was also investigated in this study as shown in Table 3. The significant decrease in the relative weight of abdominal fat in all treated groups as compared to the control group were in harmony with the results of previous studies such as Simkus et al., (2013) who reported significant decrease in intramuscular fat in pigs fed Spirulina biomass than control. The significant decrease in the relative weight of abdominal fat in all treated groups may be due to the hypoglycemic and hypolipidimic effects of SP which decreased the total lipid and cholesterol (Pankaj and Varma, 2013).

The relative weights of lymphoid organs as (spleen, thymus and bursa of Fabricius) were increased by the SP supplemented in drinking water. The significant increase in relative weight of bursa of Fabricius may be attributed to increase the number of immune cells possibly due to the effect of SP on the functional activities of the immune system responses which led to increase in the number of lymphocytes in the primary lymphoid organs. Measurement of immune organ weight is a common method for evaluation of immune status in chickens (Heckert et al., 2002). Such related organs include thymus, bursa of Fabricius, liver and spleen. Good development of these organs is crucial for optimal immunoglobulin synthesis. In the same context, Nazmi, et al., (2006) reported that lymphoid organ weights are easily measured and reflect body's ability to provide lymphoid cells during an immune response. They also documented that primary and secondary lymphoid organs weight provides the site for maturation lymphocytes and for the interaction between lymphocytes and antigens in broiler chicks. The spleen and bursa are the important lymphoid organs involved in the development and differentiation of T or B lymphocytes. Therefore, beneficial effects of SP supplementation resulted in an improvement of overall quail chicks health, performance and immune response. The significant effect of SP supplementation on above mentioned parameters confirmed the immune modulation effects of some Bio organic nutrients of SP, as previously mentioned above and reported by Farag et al.,(2016),where SP increased the production of antibodies, regulating of immunoglobulin, improved the macrophage functions and enhanced the activities of lysozyme (Ragap et al., 2012; Soltani et al., 2012; Chu et al., 2013; Krishnaveni et al.,2013; Jamil et al.,2015 and Sahan et al.,2015).

Hematological responses

The results of the hematological responses Table 4 showed significant improvement (P≤0.05) among the treated groups with SP algae extract compared to control in red and white blood cell counts, hemoglobin level and hematocrit values. The results of hematological traits represent strong indicators of assessing clinical and nutritional health status of the treated chicks with SP. Hence, these observations showed no physiological stressful condition was introduced in quails through given SP in drinking water. Therefore, the positive effects on hematological profile in quail chicks supplemented with SP, seems to associate with decreased risk of developing stress conditions and consequently, confirmed the highest health of treated groups during the whole experimental period due to the high chemical composition of SP with several biologically-active compounds , antioxidant, antifungal, and antibacterial properties. The values obtained were in consonance with the findings of Krishnaveni et al., (2013) who showed significant improvement in fish fed diet supplemented with SP in terms of hematological parameters beside parameters immunological performance including lymphocyte, lysosome activity, monocytes, IgM, phagocytic Index and Phagocytic Activity. In a similar study by Sahan et al., (2015) addition of SP to fish diets up to 10.0 g kg diet for 75 days resulted in a highly significant increase in the hematological and immune system. El-Sabagh et al., 2014) stated the significant improvement in blood traits of fattening lambs fed diet supplemented with SP (1 g/10 kg body weight/day) for 35 days.

Effect of S. platensis supplementation on immune response

There is increasing interest in evaluating non-medicinal alternatives for antimicrobials and antiviruses in terms of their ability to improve disease resistance enhance overall health and production of birds. Therefore, in the present study, attempts were made to evaluate SP supplementation on immune response.

Immunological changes of growing Japanese quail represented by heamagglutination inhibition test (HI) against Newcastle disease virus are presented in Table 5. Results showed the significant increase in serum antibody titers production against Newcastle disease virus was observed in treated groups on days 3, 7 and 9 post vaccinations compared with untreated group, where supplementation 2g/L SP in drinking water was superior among treatments. The significant increase in antibody titer production against Newcastle disease virus after vaccination in treated group with graded levels of SP confirmed the role of SP as an immunity promoter agent, beside SP has some unique bioactive compounds that have various medicinal properties against inflammation through enhancing the primary immune functions of chicks, increasing the antibody production against Newcastle disease virus, stimulating the phagocytic activity of macrophages and enhancing the production of interleukins. Hence, it may be used in the treatment of many diseases. These findings were confirmed by Chu et al., (2013) who showed significant enhance in the primary immune response in terms of antibody production after vaccination in mice fed diet supplemented with SP (50 and 150 mg/ kg body weight) they indicating the results to immune modulatory and protective activities of SP. Similarly, Ragap et al.,(2012) and Jamil et al., (2015) reported that SP can act as a good growth and immune modulatory agent for broiler chicks. Soltani et al., (2012) showed immune modulatory and protective effects against candidiasis infection in mice treated with SP extract.

Blood constituents responses

The results of the estimated blood plasma parameters as affected by SP supplementation are presented in Table 6. Plasma total protein, albumin and globulin were significantly increased in all treated groups with SP compared to control. The significant observed increase in plasma protein profile in birds treated with SP up to 2g/L drinking water as compared to control confirm the nutritional adequacy and composition of SP as it is one of the richest sources of proteins (60-70% by dry weight) and containing a wide spectrum of organic essential amino acids. Since plasma protein profile is generally influenced by total protein intake. As a result, the greater total plasma protein content of quail chicks which received SP in drinking water might be an indication of the good protein content and/or quality of the SP algae extract (Alikwe et al.,2010). Also, abnormal serum albumin usually indicates an alteration of normal systemic protein utilization. In addition, a low albumin: globulin ratio in all treated groups indicated better disease resistance and immune response of birds, this means that immunity of treated birds was improved compared to the control group. These results were similar to those observed by El-Sabagh et al., (2014)who showed significant increase in serum total protein and globulin of fattening lambs fed diet supplemented with SP(1 g/10 kg body weight/day) for 35 days.

Plasma cholesterol and total lipids had lower levels in all supplemented groups than control as shown in Table 6. These results could be evidence of the hypolipidemic effect of SP on plasma cholesterol reduction. Deng and Chow, (2010) and Pankaj and Varma, (2013) reported the useful effects of using SP as a dietary supplementation in preventing or regulating hyperglycerolemia, hypercholesterolemia, hyperlipidemia activities through lowering the level of blood total lipid and triglyceride.

Concerning, the significant increase ($P \leq 0.05$) in plasma total antioxidant capacity in supplemented groups compared to control group Table 6 indicated that SP have strong antioxidant properties could reduce the lipid peroxidation as well as has powerful scavenging activity of free radical. This result may explain the positive effect of SP on nutrient metabolism of treated groups. This result is supported by the works of Abd El-Baky et al., (2007); Chen and Wong (2008) and Gadet al., (2011), as they reported that SP had a beneficial effect on antioxidant functions due to its high contents of natural carotenoids, tocopherols, ascorbic acid and glutathione.

Regarding to liver function, our results revealed that there were a slight significant decrease in plasma alkaline phosphatase (ALP), Alanine amino transferase (ALT) and Aspartate amino transferase (AST) activities among supplemented groups compared to control one. Although, there was a slight decrease in plasma ALP and liver enzymes activities the obtained values are fell within the normal range among groups in the present study and may reflect normal liver function. The decrease in ALP, ALT and AST activities among supplemented groups indicated that SP has hepato-protective effect that can normalize the elevation of liver enzymes activities led to enhancing the liver health (Abdel-Daim et al., 2015).Since, the increasing serum ALP, ALT and AST activities have all been associated with physiological stressful condition.

Finally, this study showed a marked increase in plasma Thyroxin (T_4) level in the treated groups with SP compared to control one. The observed positive effect of SP supplementation in drinking water on treated chicks appeared the role of SP as growth and immunity promoter agent as described by Jamil et al., (2015) who reported that SP can act as a good growth and immune modulatory agent for broiler chicks. Furthermore, the higher nutritive value of SP, as it rich in protein content and essential amino acids as previously reported was associated with higher circulating plasma thyroid hormones levels (Rahimi and Hassanzadeh,2007**)**. Thus, The observed significant increase ($P \leq 0.05$) in the T_4 in the treated groups as compared with control group in this study is logic since T_4 secretion is necessary for most body physiological functions and metabolic processes.

The present study may be reports for the first time that, the influence of SP supplementation on the level of thyroid hormone in the blood serum of growing Japanese quail chicks and provides new interesting data about a possible causal relationship between the growth promoting effect of SP and thyroid hormone.

CONCLUSION

Supplementation Spirulina algae extract up to 2g/L in the drinking water of growing quail chicks resulted in better effects on growth, feed performance parameters, carcass characteristics, immune organs , immune response and blood constituents than control group. The best results occurred by Supplementation 2g/L Spirulina in drinking water of growing quail. Thus, the bio-efficiency of Spirulina algae suggesting that this bio-product could be considered a promising new bio-feed additive for poultry.

Table (1): The composition and calculated analysis of diet.

INGREDIENTS	%
Ground yellow corn 8.5%	53.81
Soybean meal 44%	34.15
Corn gluten meal 60%	9
Dicalcium phosphate	0.85
Limestone	1.35
Sodium chloride (NaCl)	0.30
Vitamins and minerals premix[1]	0.30
DL-Methionine	0.09
L-Lysine-Hcl	0.15
Total %	100
Calculated values[2]	
CP%	24.01
Metabolizable energy (.KCal/Kg feed)	2906
Ca %	0.81
Avail. Ph.%	0.31
Meth. %	0.50
Lysine%	1.3

[1]Vitamin and mineral (contained per Kgm):- vit A, 1200 IU; vit D 1100 IU; vit E, 12mg; vitB12, 0.02mg; vit B1, 1mg; choline chloride, 0.16 mg; copper, 3mg; iron, 30 mg; manganese, 40mg; zinc, 45 mg; and selenium, 3mg.

[2] Accoeding to NRC, 1994.

Table (2): Productive performance (Means ±SE) of growing quails supplemented with Spirulina Platensis extract in drinking water

Traits	Treatments			
	[1]T1	[2]T2	[3]T3	[4]T4
Initial live body weight (g/bird)	12.1	12	11.9	12.1
live body weight (g)				
1^{st} week	39.0±0.3	38.2±0.1	38.2±0.2	38.1±0.2
2^{nd} week	76.6±3.0	77.6±0.9	78.8±0.5	78.8±0.5
3^{rd} week	110.3^{b}±4.6	116.3^{a}±1.0	121.3^{a}±1.2	121.3^{a}±1.2
4^{th} week	146.7^{b}±3.4	155.4^{a}±3.4	161.8^{a}±1.0	161.8^{a}±1.1
Final live body weight (g/bird) at 5^{th} week	196.5^{c}±2.1	206^{b}±3.1	210.3^{a}±2.8	211.4^{a}±2.9
live body weight gain (g/bird)	184.4	194	198.1	199.5
Total feed consumption(g)/bird/35d	632.1^{a}±21.2	631.4^{a}±25.3	614.6^{b}±22.1	592.2^{c}±26.3
Feed conversion (g feed:g gain)	3.5^{a}±0.2	3.31^{b}±0.2	3.15^{b}±0.1	3.03^{c}±0.1
Feed efficiency (gain:feed)	0.28^{b}±0.1	0.3^{a}±0.1	0.32^{a}±0.09	0.33^{a}±0.09
Feed intake (g)/bird/day				
1^{st} week	12.9±0.0	13.3±0.0	13.5±0.0	13.2±0.0
2^{nd} week	14.9^{b}±0.7	15.1^{b}±0.5	16.2^{a}±0.6	16^{a}±0.6
3^{rd} week	17.3±0.6	17.8±2.9	17.7±1.2	17±1.2
4^{th} week	22.1^{a}±1.6	20.5^{ab}±2.6	19.7^{b}±1.7	18.7^{c}±1.5
5^{th} week	23.1^{a}±1.6	21.5^{ab}±2.6	20.7^{b}±1.7	19.7^{c}±1.4
[5]EPEI	18.1^{c}±0.5	18.7^{a}±0.5	18.4^{b}±0.5	17.9^{c}±0.4
Chicks mortality rate %	8^{a}±0.33	4^{b}±0.33	3^{c}±0.33	2^{d}±0.33

a, b, c, means with different superscripts within the same row are statistically different at (P≤0.05).

[1]T1: control, fed a basal diet; [2]T2: fed a basal diet supplemented with 0.5g/L SP in the drinking water. [3]T3: fed a basal diet supplemented with 1g/L SP in the drinking water [4]T4: fed a basal diet supplemented with 2g/L SP in the drinking water

[5]EPEI= European Production Efficiency Index.

Table (3): Carcass and some organs (Means ±SE) of growing Japanese quail supplemented with Spirulina Platensis extract in drinking water

Items	Treatments			
	[1]T1	[2]T2	[3]T3	[4]T4
Carcass %	70.7 ^{c}±0.3	72.85 ^{b}±0.15	74.7 ^{a}±0.13	75.2 ^{a}±0.22
Liver %	1.95 ^{c}±0.22	2.2 ^{b}±0.22	2.35 ^{a}±0.17	2.48 ^{a}±0.2
Heart %	0.74 ^{c}±0.013	0.8 ^{bc}±0.015	0.84 ^{b}±0.02	0.93 ^{a}±0.02
lymphoid organs %				
Bursa %	0.05 ^{c}±0.004	0.07 ^{b}±0.004	0.09 ^{ab}±0.002	0.1 ^{a}±0.002
Spleen%	0.045 ^{c}±0.002	0.067 ^{b}±0.004	0.078 ^{a}±0.003	0.088 ^{a}±0.003
Thymus %	0.3 ^{b}±0.03	0.35 ^{b}±0.03	0.4 ^{a}±0.03	0.45 ^{a}±0.03
Proventriculus%	1.62 ^{c}±0.028	1.93 ^{b}±0.03	2.12 ^{ab}±0.09	2.21 ^{a}±0.09
ventriculs %	0.32 ^{b}±0.013	0.37 ^{a}±0.02	0.37 ^{a}±0.01	0.38 ^{a}±0.02
Small intestine %	4.64 ^{b}±0.03	5.5 ^{a}±0.04	5.7 ^{a}±0.08	5.9 ^{a}±0.04
Small intestine length (cm)	63 ^{b}±2	64 ^{b}±2	64.5 ^{b}±1.7	69 ^{a}±2
Abdominal fat%	2.4 ^{a}±0.47	1.45 ^{b}±0.28	0.5 ^{c}±0.27	0.4 ^{c}±0.32
Ovary %	0.36 ^{d}±0.04	0.44 ^{c}±0.04	0.53 ^{b}±0.04	0.64 ^{a}±0.05
Tests%	2.6 ^{c}±0.12	2.72 ^{c}±0.06	3.1 ^{b}±0.18	3.51 ^{a}±0.04

a, b, c, means with different superscripts within the same row are statistically different at (P≤0.05).

[1]T1: control, fed a basal diet; [2]T2: fed a basal diet supplemented with 0.5g/L SP in the drinking water. [3]T3: fed a basal diet supplemented with 1g/L SP in the drinking water [4]T4: fed a basal diet supplemented with 2g/L SP in the drinking water

Table (4): Blood hematology (Means ±SE) of growing Japanese quail supplemented with Spirulina Platensis extract in drinking water

Traits	Treatments			
	[1]T1	[2]T2	[3]T3	[4]T4
R.B.Cs Count×10^6	4.11 ^{c}±1.33	4.85 ^{b}±1.4	5.01 ^{b}±2.5	5.39 ^{a}±2.38
Hb (g/dl)	10.33 ^{b}±0.17	11.36 ^{b}±0.27	13.23 ^{a}±0.53	13.6 ^{a}±0.38
P.C.V %	40.3 ^{c}±1.46	53.3±0.33 ^{b}	55.7 ^{ab}±0.33	57.7 ^{a}±1.46
W.B.Cs Count×1000	14.3 ^{d}±0.33	17.3±0.33 ^{c}	19.3 ^{b}±0.33	20.7 ^{a}±0.33

a, b, c, means with different superscripts within the same row are statistically different at(P≤0.05).

[1]T1: control, fed a basal diet; [2]T2: fed a basal diet supplemented with 0.5g/L SP in the drinking water. [3]T3: fed a basal diet supplemented with 1g/L SP in the drinking water [4]T4: fed a basal diet supplemented with 2g/L SP in the drinking water

[4]RBCs: red blood cell [5]Hb: Hemoglobin concentration [6]PCV:packed cell volume [7]WBCs:white blood cell

Table (5): Antibody titres against Newcastle disease virus(Means ±SE) of growing Japanese quail supplemented with Spirulina platensis extract in drinking water

Days of treatment	Treatments			
	[1]T1	**[2]T2**	**[3]T3**	**[4]T4**
3rd day	3.75 ^{b} ± 0.25	4.5 ^{ab} ± 0.2	5.25 ^{a} ± 0.2	5.25 ^{a} ± 0.1
7th day	5.25^{c} ± 0. 1	7 ^{b}± 0.15	8 ^{a} ± 0.15	10 ^{a} ± 0.1
9th day	4.25 ^{b} ± 0.2	5.75 ^{a} ± 0.25	6.75 ^{a} ± 0.3	8.25 ^{a} ± 0.25

a, b, c, means with different superscripts within the same row are statistically different at (P≤0.05).

[1]T1: control, fed a basal diet; [2]T2: fed a basal diet supplemented with 0.5g/L SP in the drinking water. [3]T3: fed a basal diet supplemented with 1g/L SP in the drinking water [4]T4: fed a basal diet supplemented with 2g/L SP in the drinking water

Table (6): Some blood constituents (Means ±SE) of growing Japanese quail supplemented with Spirulina Platensis extract in drinking water

Parameters	Treatments			
	[1]T1	**[2]T2**	**[3]T3**	**[4]T4**
Total protein(g/dl)	4.5 ^{c}±0.07	4.9 ^{b}±0.07	5.4 ^{a}±0.05	5.5 ^{a}±0.09
Albumin (g/dl)	2.45 ^{b}±0.09	2.5 ^{b}±0.1	2.7 ^{a}±0.05	2.8 ^{a}±0.1
Globulin (g/dl)	2.05 ^{c}±0.18	2.4 ^{b}±0.32	2.7 ^{a}±0.1	2.7 ^{ab}±0.3
Albumin: Globulin ratio	1.19 ^{b}±0.1	1.04 ^{a}±0.06	1.0 ^{a}±0.09	1.03 ^{a}±0.07
Total Lipids(mg/dl)	505 ^{a}±49.9	465.7 ^{b}±27.4	391.4 ^{c}±16.5	365.5 ^{d}±10.7
Cholesterol (mg/dl)	261 ^{a}±7.2	204 ^{b}±5.7	176 ^{c}±6.6	170 ^{d}±5.7
[5]AST (U/L)	45.3 $^{\mathbf{a}}$±1	44.6 $^{\mathbf{a}}$±1.1	40.3 $^{\mathbf{b}}$±1	40.3 $^{\mathbf{b}}$±1.13
[6]ALT (U/L)	12.00 ±1.09	11.83 ±1.09	11.97 ±1.09	11.67±1.09
Alkaline Phosphatase (IU/L)	320 ^{a}±4.5	314.7 ^{b}±2.66	300 ^{c} ±3.7	292.7 ^{c}±1.33
Total antioxidant capacity(mmol/L)	0.53 ^{c}±0.01	0.55^{c} ±0.01	0.60 ^{b}±0.01	0.71 ^{a}±0.01
[7]T_4 (nmol/L)	60 ^{d} ±0.75	62 ^{c} ± 1.56	64.15 ^{b} ±1	66.15 ^{a} ± 1

a, b, c, means with different superscripts within the same row are statistically different at (P≤0.05).

[1]T1: control, fed a basal diet; [2]T2: fed a basal diet supplemented with 0.5g/L SP in the drinking water. [3]T3: fed a basal diet supplemented with 1g/L SP in the drinking water [4]T4: fed a basal diet supplemented with 2g/L SP in the drinking water

[5]ALT: alanine aminotransferase [6]AST: aspartate aminotransferase [7]T_4 :Thyroxin

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الملخص العربي

الأداء الإنتاجى والاستجابة المناعية فى السمان اليابانى النامى باستخدام مستخلص طحالب الاسبيرولينا فى ماء الشرب

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أجريت هذه التجربة لدراسة تأثير ماء الشرب المضاف إليه مستخلص مسحوق طحالب الاسبيرولينا على الأداء الإنتاجى والاستجابة المناعية فى السمان اليابانى النامى. حيث تم استخدام عدد 480 كتكوت سمان عمر يوم قسمت عشوائيا بالتساوي إلى 4 معاملات تجريبية لمدة 5 أسابيع . المجموعة الأولى (الكنترول) تم تغذيتها على عليقة وماء الشرب بدون إضافات بينما باقى المجموعات الثانية والثالثة والرابعة تم تغذيتها على عليقة وماء الشرب مضاف إليه مستخلص مسحوق طحالب الاسبيرولينا بمستويات 0.5 ، 1 ، 2 جم لكل لتر ماء شرب على الترتيب.

وكانت النتائج المتحصل عليها كالآتي:

أظهرت النتائج تحسن معنوي في وزن الجسم المكتسب والصحة والحيوية ومصاحب ذلك بأقل نسبة نفوق للكتاكيت في جميع المجموعات المضاف إليها مستخلص مسحوق طحالب الاسبيرولينا مقارنة بالمجموعة الكنترول خلال فترة التجربة. بالإضافة إلى ذلك سجلت الطيور المعاملة ب 2 جم / لتر ماء شرب بمستخلص مسحوق طحالب الاسبيرولينا أقل نسبة علف مأكول وقد سجلت جميع المعاملات أفضل معامل تحويل غذائي وكفاءة غذائية مقارنة بالمجموعة الكنترول.لوحظ أيضًا أن المجموعة المعاملة ب 1 جم / لتر ماء الشرب بمستخلص مسحوق طحالب الاسبيرولينا أعلى قيمه لمعامل كفاءة الإنتاج الأوربي مقارنة بالمجاميع الأخرى.

وأشارت النتائج أيضا إلى وجود زيادة معنوية فى جميع المعاملات في الوزن النسبي للذبيحة و جميع أعضاء الجسم من القلب والكبد والأعضاء الليمفاوية (الطحال- البرسا- الثيموس) والأعضاء الجنسية (المبيض والخصيتين) والمعدتين ووزن وطول الأمعاء بينما كان هناك انخفاض معنوى فى الوزن النسبى لدهن البطن المرتبط بزيادة مستوى مستخلص مسحوق طحالب الاسبيرولينا فى ماء الشرب.

أظهرت النتائج أيضا وجود استجابات معنوية لجميع المعاملات فى مقاييس الدم الهيماتولوجى وإنتاج الآجسام المضادة لفيروس النيوكاسل ومستوى البلازما من البروتينات الكليه والآلبيومين والجلوبيولين ومضادات الآكسدة الكليه وهرمون الثيروكسين مقارنة بالكنترول بينما كان هناك انخفاض معنوى ملحوظ فى مستوى البلازما من الكولسترول والليبيدات الكليه بين جميع المعاملات مقارنة بالكنترول وكان مستوى أنشطة إنزيمات الكبد والفوسفاتيز القاعدى فى الحدود الطبيعيه بين جميع المجموعات والكنترول.

وتوصى الدراسة بأمكانية تعظيم الأداء الإنتاجى والفسيولوجى والمناعى بكفاءة عاليه وانعكاس ذلك على زيادة المقاومة للأمراض والإنتاج بشكل عام وذلك بإضافة مستخلص مسحوق طحالب الاسبيرولينا بمستوى 2 جم/ لتر فى ماء الشرب للسمان النامى وذلك لإمداد طحلب الاسبيرولينا الجسم بمنشطات نمو وبدائل دوائية طبيعيه.