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EFFECT OF USING DIFFERENT LEVELS OF SPIRULINA ALGAE (*SPIRULINA PLATENSIS*) IN DIET ON PRODUCTIVE PERFORMANCE AND CHARACTERISTICS OF THE CARCASS OF BROILER

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Abstract

This study was conducted at the Poultry Research Station of the Agricultural Research Department, Ministry of Agriculture in Abu Gharib, for the period from 25/2/2019 to 7/4/2019 (42 days) with the aim of using several levels of *Spirulina platensis* algae (SP) in broiler diets and its effect on productive performance and some physiological characteristics and their effect on the immune response. The microbial status of the gut, the specific characteristics of broiler carcass and the oxidation state of stored meat for 60 days by measuring the oxidation indicators of the meat. In this experiment, 400 broiler chicks, one day old, of broiler chickens (Ross 308), were not unsexed, with an average starting weight of 40 g / chick. The chicks were fed on the feed of the starter 1-14 days from the age of the birds, the growth diet (Grower) 14-28 days from the age of the birds and on the final diet (Finisher) 28-42 days from the age of the birds. The chicks were randomly distributed to five treatments by four replicates per treatment (20 birds / replicates). The treatments included the following: The first treatment (T_1) is control coefficient (the main diet without additives) and the second treatment (T_2) was used in the main diet algae SP by 1% and the third treatment (T_3) was used in the diet algae SP algae at 2% and the fourth treatment (T_4) was used in the diet algae SP by 3% and the fifth treatment (T_5) was used in the diet SP algae by 4%. The results of the experiment showed a significant improvement ($P \leq 0.05$) in body weight rates for all treatments using *spirulina* algae (T_2, T_3, T_4, T_5) and the weight increase of T_2, T_3, T_4 treatments and feed consumed for T_3 and T_5 treatments as well as improved feed Conversion factor and Index Productivity and Economic index of experimental treatments (T_2, T_3, T_4, and T_5) compared to the control coefficients. The use of *spirulina* T_2, T_3, T_4 and T_5 showed significant superiority ($P \leq 0.05$) compared to the control group in the Dressing percent, relative weight of the chest segment, and there is no significance differences in the relative weight of the thigh and the drumstick for all trial treatments. The T_3 and T_4 treatments showed significant difference in the characteristic of relative liver weight and the absence of significant differences ($P \leq 0.05$) in the relative weight of the heart and abdominal fat.

Key words : Spirulina, productive performance, broilers.

Introduction

Many scientific papers proved the possibility of eating different kinds of algae for animal and human because of their good nutritional value without any side effects, like bluish green algae named Spirulina (*Spirulina platensis*) which Caught international attention because of rapid growth, ease of production and high nutritional value as a food for human. *Spirulina platensis* is atop in global markets sales now as a poultry feed (Becker, 2004 º Bhattacharjee, 2016). Spirulina algae added to poultry feed as a source of high protein (55_70%), unsaturated fatty acids, vitamins, and anti oxedents (phenols, Gama-lenolic acid, Phycocyanin, Tocopherol and â carotene), as well as contains many natural pigments (Carotene, xanthophylls, chlorophyll) which improve the color of broiler skin and egg yolk (Swiatkiewicz, *et al*., 2015). The algae contains antibacterial and antifangal materials which inhibit many microbs (Horincar, *et al.*, 2011). Dadgar *et al.*, (2011) added spirolena to broiler diets with levels 1, 5, 10 gm/kg feed improved feed conversion rate

and skin color of all treatments compare with control group. Kharde *et al.*, (2012) referred that feeding broilers with 300 and 500 mg/kg feed for six weeks resulted significant increase in body weight, gain, and decreased feed conversion rate and feed consumption values. Bellof and Alarcon (2013) mentioned the possibility of using Spirulina in broiler diet as a source of protein with the rate of 2.5% in starter diet(1-28 day), and 1.25% in finishing diet (28-56 day) which resulted improving growth and carcass weights and quality specially main cuts (breast and leg), and they noticed there was any problems in broilers health. Shanmugapriya *et al.*, (2015a) added 1% Spirulina to broiler diet caused increase in villi height and crypts depth of the intestine and therefore improved nutrients absorption, feed conversion rate and body weight. Park *et al.*, (2018) added deferent levels of Spirulina (0.0, 0.25, 0.50 and 1.0%) to broiler diet, results showed improvement in body weights and feed conversion rate and European Production Efficiency Index of the treated groups in comparison with control group.

The aim of this study to know the effect of using different levels of Spirulina algae in boiler diet on productive performance and some carcass characteristics at 42 days of age.

Materials and Methods

This study was conducted in poultry research station/ Ministry of Agriculture at Abo_Graib on 25th February until 7th April 2019 (42 days). 400 unsexed boiler chicks (308 Ross) one day old (40gm/chick) used in this study. Chicks were randomly located on five treatments (4 replicate/treatment), each replicate contained 20 chicks. Treatment diets contained 0, 1, 2, 3, 4 % Spirulina algae. The chicks reared on wood shaves with all environment requirements (temperature, lightening, and ventilation).

Spirulina algae (*Spirulina platensis*) was bought from Xi'an Ceres Biotech Co., Ltd. Chaina, it was bluish green powder produced on sea water. Table 1 and 2 shows its nutritional value.

Tables 3, 4 and 5 showed starter, grower and finisher diets and chemical composition which used in this study to cover birds requirements as published in Ross 308 rearing guide.

The chicks were weighed weekly also feed consumption to calculate their weight gain and feed conversion rate as mentioned by Alzubaidy (1986). There was no mortality observed among all treatments in this study. The production index and european production efficiency index were calculated according to Naji and Hanna (1999). At 42 days of age 8 birds slaughtered after fasting for ten hours to determine dressing, intestine, giblets, and carcass cuts percentage s according to Al Fayad and Naji (1989). All data were analyzed as completely Randomized Design (CRD) by using statistical program (SAS 2012) and the differences between means were tested by using Duncan Test (Duncan 1955).

Table 1: Nutritional value of Spirulina algae (*Spirulina platensis*).

The nutritional The content of 100 grams of Spirulina	
Protein	62 g
Carbohydrate	15 g
Crude fat	6 g
Fiber	2 g
Moisture content	4 g
Chlorophy II	500 mg
Carotenoid	100 mg
Phycocyanobilin	3000 mg
Calcium	600 mg
Magnesium	200 mg
Zinc	200 mg
Fe	200 mg
Vitamin B1	2 mg
Vitamin B2	3 mg
Vitamin B6	0.1 mg
Vitamin B12	0.5 mg
Vitamin E	5 mg
Vitamin PP	200 mg
Folic acid	0.05 mg
Linolenic acid	100 mg
Spirulina polysaccharide	3000 mg
Calories	1234 KJ

Table 2: Amino acids content in Spirulina algae (*Spirulina platensis*).

Amio acid	µg/gm
Aspartic acid	128.69
Serine	83.45
Glutamic acid	73.79
Proline	63.74
Glycine	92.65
Alanine	80.06
Methionine	102.47
Phenylalanine	103.85
Tyrosine	61.27
Lucien	73.49
Lysine	148.64

Results and Discussion

Results showed in table 6 no significant differences in live body weights between treatments at the four first week of age, while T_2 excel significantly ($P \leq 0.05$) at T_1

Table 3: Treatment starter diets content and chemical composition (1-14 days).

Content	Treatments				
	T_1	T_2	T_3	T_4	T_5
Yellow corn	47.5	47.5	47.5	47.5	47.5
Wheat	10	10	10	10	10
Soy bean meal(48%)	32	31	30	29	28
Protein concentrate*	5	5	5	5	5
Spirulina **	0	1	2	3	4
Fat	3	3	3	3	3
Di calcium phosphate	0.7	0.7	0.7	0.7	0.7
Salt	0.1	0.1	0.1	0.1	0.1
Lime stone	1.2	1.2	1.2	1.2	1.2
DL- Methunine	0.25	0.25	0.25	0.25	0.25
L –lysine	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Calculated chemical composition ***					
Metabolizable Energy ME(Kcal/Kg)	3059	3064	3070	3075	3080
Crude protein	22.5	22.7	22.8	23	23.1
Crude fiber	5.6	5.7	5.7	5.8	5.8
Ether extract	2.7	2.7	2.7	2.6	2.6
Lysin	1.49	1.51	1.54	1.56	1.58
Cystine +Methionine	1.12	1.14	1.15	1.17	1.19
Calcium	0.97	0.97	0.97	0.97	0.97
Available phosphorous	0.78	0.78	0.78	0.77	0.77

*Protein concentrate contains 40%crude protein, 2107 Kcal ME, 5% Ca, 3.7% Methionine, 4.12% Methionine + Cystine, 0.42% Tryptophane, 1.70% Thyrionine, 2.50% sodium and 4.20% Chloride. ** *Spirulina platensi* contains 62% crude protein, and 1234 Kcal/Kg ME. *** Chemical analysis according to NRC 1994.

Table 4: Treatment grower diets content and chemical composition (15-28 days).

Content	Treatments				
	T_1	T_2	T_3	T_4	T_5
Yellow corn	51.75	52.75	52.75	52.75	52.75
Wheat	10	10	10	10	10
Soy bean meal (48%)	27	25	24	23	22
Protein concentrate*	5	5	5	5	5
Spirulina **	0	1	2	3	4
Fat	4.15	4.15	4.15	4.15	4.15
Di calcium phosphate	0.6	0.6	0.6	0.6	0.6
Salt	0.1	0.1	0.1	0.1	0.1
Lime stone	1.14	1.14	1.14	1.14	1.14
DL- Methionine	0.13	0.13	0.13	0.13	0.13
L –lysine	0.13	0.13	0.13	0.13	0.13
Total	100	100	100	100	100
Calculated chemical composition ***					
Metabolizable Energy ME(Kcal/Kg)	3183	3197	3203	3208	3213
Crude protein	20.5	20.3	20.4	20.5	20.7
Crude fiber	6.9	7	7	7.1	7.1
Ether extract	2.6	2.6	2.6	2.5	2.5
Lysin	1.26	1.26	1.28	1.3	1.33
Cystine +Methionine	0.94	0.95	0.97	0.99	1.01
Calcium	0.92	0.91	0.91	0.91	0.90
Available phosphorous	0.75	0.75	0.75	0.74	0.74

*Protein concentrate contains 40%crude protein, 2107 Kcal ME, 5% Ca, 3.7% Methionine, 4.12% Methionine + Cystine, 0.42% Tryptophane, 1.70% Thyrionine, 2.50% sodium and 4.20% Chloride. ** *Spirulina platensi* contains 62% crude protein, and 1234 Kcal/Kg ME. *** Chemical analysis according to NRC 1994.

(control group) in the fifth week, at the last week results showed significant increase ($P \leq 0.05$) in live body weight for all Spirulina treatments compared with control group. Table 7 showed the effect of using different levels of Spirulina algae on weight gain, results clarified no significant differences among all treatments at the first, second, third, and fifth weeks of age, but there was significant increase for T_4 in weight gain compared with T_1. At six week of age there was significant increase in weight gain for T_2, T_3, and T_4 in comparison with control group (T_1). As for total weight gain then all Spirulina treatments significantly increased compared to control group.

Table 8 showed the effect of using different levels of Spirulina algae on feed intake (gm/bird/week) of broilers. There were no significant differences between all treatments in total feed intake at throughout the experiment (42 days).

Table 9 showed the effect of using different levels of Spirulina algae on feed conversion rate. The results showed that accumulative feed conversion rate (at 42 days age) of T_5 (4% Spirulina) was significantly ($P \leq 0.05$) better than control group (T_1), and there were no significant differences between T_1 and T_2, T_3, and T_4 respectively.

Results showed in table 10 that all Spirulina treatments were significantly ($P \leq 0.05$) better than control group in production index and European Production Efficiency Index values and that agree with Mariey *et al.*, (2014) which said that Spirulina algae has economic benefit as a feed additive.

Through the results of table 11 shows a significant ($P \leq 0.05$) improvement for treatments T_2, T_3, T_4, and T_5 which contained Spirulina in dressing percent and breast cut percent in comparison with control treatment (T_1). While there was no significant differences among all treatments in thigh and drumstick cut percentages.

Through the positive and significant

Table 5: Treatment finisher diets content and chemical composition (29-42 days).

Content	Treatments				
	T_1	T_2	T_3	sT_4	T_5
Yellow corn	57.84	57.84	57.84	58.34	58.34
Wheat	10	10	10	10	10
Soy bean meal (48%)	21	20	19	17.5	16.5
Protein concentrate*	5	5	5	5	5
Spirulina **	0	1	2	3	4
Fat	4.3	4.3	4.3	4.3	4.3
Di calcium phosphate	0.4	0.4	0.4	0.4	0.4
Salt	0.1	0.1	0.1	0.1	0.1
Lime stone	1.1	1.1	1.1	1.1	1.1
DL- Methionine	0.13	0.13	0.13	0.13	0.13
L –lysine	0.13	0.13	0.13	0.13	0.13
Total	100	100	100	100	100
Calculated chemical composition ***					
Metabolizable Energy ME(Kcal/Kg)	3254	3259	3265	3274	3279
Crude protein	18.1	18.3	18.4	18.4	18.5
Crude fiber	7.2	7.3	7.3	7.4	7.4
Ether extract	2.5	2.5	2.5	2.4	2.4
Lysine	1.10	1.12	1.14	1.15	1.18
Cystine +Methionine	0.88	0.90	0.92	0.93	0.95
Calcium	0.84	0.84	0.83	0.83	0.83
Available phosphorous	0.70	0.70	0.70	0.70	0.69

*Protein concentrate contains 40%crude protein, 2107 Kcal ME, 5% Ca, 3.7% Methionine, 4.12% Methionine + Cystine, 0.42% Tryptophane, 1.70% Thyrionine, 2.50% sodium and 4.20% Chloride. ** *Spirulina platensi* contains 62% crude protein, and 1234 Kcal/Kg ME. *** Chemical analysis according to NRC 1994.

results shown by the current study in body weight, weight gain and feed conversion rate when using Spirulina algae in the broiler diet. The improvement of these studied traits can be attributed to the fact that Spirulina algae contain a high percentage of amino acids, including aspartic acid and glutamic acid, which play an important role in supporting and developing the mucous membranes of the small intestine, which leads to an increase in villi height, depth of crypts, and an increase in the surface area of nutrient absorption, including improved digestibility. Absorption of the essential amino acids found in Spirulina such as lysine, methionine and cysteine are reflected in increased body weight and improved feed conversion rates, as indicated by Evans *et al.*, (2015) and Park *et al.*, (2018). While some researchers have interpreted the importance of Spirulina to the fact that the amino acid template of it can be superior to other plant feeds (such as soybean meal) and high digestibility of amino acids. (Alvarenga *et al.,* 2011). Improved growth and increased body weight may also be

Table 6: Effect of using different levels of Spirulina algae on live body weight (g) of broilers.

Week	Treatments					Significant
	T_1	T_2	T_3	T_4	T_5	
1	135.31±4.87	150.00±5.41	134.50±9.32	140.318.46±	132.00±6.79	N.S
2	413.56±12.27	415.62±6.97	405.31±7.78	414.18±2.21	407.31±22.26	N.S
3	771.43±32.46	817.43±14.23	819.50±20.42	797.62±13.40	802.16±16.59	N.S
4	1365.75±30.44	1352.18±17.12	1347.50±30.61	1323.16±36.85	1365.37±27.82	N.S
5	$2117.81±21.61^{a}$	$2006.74±24.81^{b}$	$2021.06±39.37^{ab}$	$2079.81±10.14^{ab}$	$2061.75±15.20^{ab}$	*
6	$2738.75±4.98^{b}$	$2872.27±36.86^{a}$	$2889.45±40.62^{a}$	$2861.28±25.62^{a}$	$2932.81±25.19^{a}$	*

N.S. means no significant differences between treatments. * means a significant differences between treatments ($p \leq 0.05$). T_1, T_2, T_3, T_4, and T_5 are control group (0.0%), 1%, 2%, 3%, 4% Spirulina respectively.

Table 7: Effect of using different levels of Spirulina algae on weight gain (g) of broilers.

Week	Treatments					Significant
	T_1	T_2	T_3	T_4	T_5	
1	95.12±4.12	109.37±4.40	94.56±9.45	98.25±8.22	92.31±5.80	N.S
2	278.25±10.61	265.62±8.84	4.52±270.81	273.81±10.16	275.31±20.02	N.S
3	357.87±21.34	401.43±16.19	414.18±27.23	383.43±11.84	±394.8516.06	N.S
4	$594.38±5.20^{a}$	$535.12±14.17^{ab}$	^{ab} 12.67 ±528.00	$525.56±25.84^{b}$	$563.21±27.58^{ab}$	*
5	752.06±41.42	654.55±17.56	673.56±28.10	756.62±36.76	696.37±25.20	N.S
6	$620.93±24.80^{b}$	$865.52±20.75^{a}$	$868.38±65.86^{a}$	$781.46±20.46^{a}$	$871.06±59.77^{ab}$	*
1-6	$2698.56±5.69^{b}$	$2831.64±36.01^{a}$	$2849.51±40.00^{a}$	$2819.21±25.12^{a}$	$2893.12±24.47^{a}$	*

N.S. means no significant differences between treatments. * means a significant differences between treatments ($p \leq 0.05$). T_1, T_2, T_3, T_4, and T_5 are control group (0.0%), 1%, 2%, 3%, 4% Spirulina respectively.

Table 8: Effect of using different levels of Spirulina algae on feed intake(g/bird/week) of broilers.

Week	Treatments					Significant
	T_1	T_2	T_3	T_4	T_5	
1	113.44±2.88	116.12±5.49	112.06±5.40	113.68±8.61	107.31±5.71	N.S
2	326.25±3.97	337.12±3.92	327.95±11.67	335.06±2.72	310.25±16.46	N.S
3	606.18±17.96	640.43±12.14	627.43±12.14	635.06±20.89	608.25±14.06	N.S
4	925.62±18.90	929.87±7.37	941.75±20.33	932.00±16.97	919.87±21.60	N.S
5	1243.12±21.49	1173.79±35.33	1159.62±24.11	1206.96±14.03	1189.56±31.78	N.S
6	1205.25±20.29^{c}	1345.71±24.94^{b}	1356.18±35.30^{ab}	1250.81±45.28^{bc}	1374.43±44.72^{a}	*
1-6	4419.87±50.49	4543.06±66.74	4524.56±31.74	4493.58±59.62	4509.68±32.94	N.S

N.S means no significant differences between treatments. * means a significant differences between treatments ($p \leq 0.05$). T_1, T_2, T_3, T_4, and T_5 are control group(0.0%), 1%,2%,3%,4% Spirulina respectively.

Table 9: Effect of using different levels of Spirulina algae on feed conversion rate (g feed /g gain) of broilers.

Week	Treatments					Significant
	T_1	T_2	T_3	T_4	T_5	
1	1.19±0.02^{a}	1.05±0.02^{b}	1.20±0.01^{a}	1.16±0.03^{ab}	1.16±0.01^{ab}	*
2	1.17±0.03	1.27±0.03	1.21±0.05	1.22±0.05	1.13±0.06	N.S
3	1.70±0.08	1.60±0.04	1.52±0.08	1.71±0.02	1.55±0.02	N.S
4	1.55±0.04^{b}	1.74±0.06^{ab}	1.78±0.04^{a}	1.78±0.07^{a}	1.64±0.07^{a}	*
5	1.66±0.08	1.79±0.03	1.73±0.07	1.60±0.07	1.71±0.03	N.S
6	1.95±0.09^{a}	1.55±0.02^{b}	1.58±0.08^{b}	1.59±0.01^{b}	1.59±0.06^{b}	*
1-6	1.63±0.02^{a}	1.60±0.01^{ab}	1.58±0.02^{ab}	1.59±0.01^{ab}	1.55±0.04^{b}	*

N.S means no significant differences between treatments. * means a significant differences between treatments($p \leq 0.05$). T_1, T_2, T_3, T_4, and T_5 are control group (0.0%), 1%,2%,3%,4% Spirulina respectively.

Table 10: Effect of using different levels of Spirulina algae on production Index and European Production Efficiency Index values of broilers.

Treatments	Production index	European Production Efficiency Index
T_1	398.30±17.45^{b}	642.51±27.55^{b}
T_2	426.42±11.95^{a}	674.20±10.01^{a}
T_3	433.53±28.03^{a}	678.45±35.45^{a}
T_4	427.46±0.96^{a}	671.24±7.22^{a}
T_5	447.98±19.87^{a}	^{a}27.50±688.84
Significant	*	*

N.S means no significant differences between treatments. * means a significant differences between treatments($p \leq 0.05$). T_1, T_2, T_3, T_4, and T_5 are control group (0.0%), 1%, 2%, 3%, 4% Spirulina respectively.

attributed to the contribution of active compounds (carotenoid pigments, phycocyanin, unsaturated fatty acids, vitamins, micro and minerals, and many other chemical compounds) in Spirulina to increasing numbers of beneficial bacteria in the intestine (Lactobacillus), Increased villi length. Spirulina rich in polysaccharides, which acts as a vital precursor, increases the numbers of beneficial bacteria Lactobacillus (DeJesus *et al.,* 2016), and taking advantage of the products of these beneficial bacteria, such as organic acids, the most important of which are lactic acid, which is the source of energy for intestinal cells and increases their activity and divisions, thereby increasing the length of villi and increasing the surface area to absorption the digested nutrients (Gourbeyre *et al.,* 2011; Gupta *et al.,* 2017). Intensive

Table 11: Effect of using different levels of Spirulina algae on dressing percentage and carcass main cuts percentage.

Cuts	Treatments					Significant
	T_1	T_2	T_3	T_4	T_5	
Dressing percentage	72.94± 0.85^{b}	75.95± 0.50^{a}	76.10±0.60^{a}	77.62±0.39^{aa}	0.76±75.57	*
Breast %	34.03± 0.06^{b}	40.03±0.71^{a}	40.83±0.73^{a}	39.64±0.79^{a}	38.69±0.65^{a}	*
Thigh %	13.44±0.31	13.36 ±0.16	13.14± 0.26	12.85±0.47	13.23±0.25	N.S
Drum stick %	12.25 ± 0.46	11.95±0.23	12.23±0.35	11.35±0.54	12.35±0.33	N.S

N.S means no significant differences between treatments. * means a significant differences between treatments(pd" 0.05). T_1, T_2, T_3, T_4, and T_5 are control group (0.0%), 1%, 2%, 3%, 4% Spirulina respectively.

systems for broiler chickens may cause many stressful matters on the bird that negatively affect productive performance, as a high metabolic rate and intensive breeding are accompanied by an increase in the production of free radicals, and that any imbalance between the production of free radicals and safe disposal may end in oxidative stress, Which can harm body cells and tissues (Lykkesfeldt and Svendsen, 2007). So perhaps Spirulina is considered to have a higher content of phenolic compounds than other algae, especially tannic acid, as it constitutes more than 63% of phenols (Wu *et al.,* 2005) and also because it contains phycocyanin, beta-carotene and phenols (Park *et al.,* 2018) as a source of antioxidants (Asghari *et al.,* 2016), and it increases the effectiveness of antioxidant enzymes such as catalyzes (CAT), peroxidase (PX), superoxidase (SOD), and scorbit peroxidase (APX) (Bashandy *et al.,* 2016) and so this is reflected in the improvement of the bird's internal environment. Villi may improve Intestinal and epithelial cells of the intestine with the presence of antioxidants in Spirulina, which improves productive performance (Shanmugapriya *et al.,* 2015b). The significant improvement in dressing and breast percentages in the Spirulina treatments may be due to the high protein content and excellent quality of this natural product and functional food (Spirulina) in meat production and quality and improvement of the characteristics of the carcass as indicated by Peiretti and Meineri, (2011) ; Baylan *et al.,* (2012) and Farag *et al.*, (2016). Increasing the weight of the carcass a, it may also be due to an improvement in bird health and an increase in the efficiency of absorption of vital molecules in the digestive system such as amino acids, including lysine, (Zhai *et al.,* 2016). The high concentrations of glutamic acid in Spirulina added to diets improves the formation of connective tissue during the rapid growth of broilers and an increase weight gain that is reflected dressing percentage (Moran and Stilborn, 1996), and the glutamic acid has a role in preventing any occurrence defects that can adversely affect the intestinal mucosa as the absorption of digested nutrients increases (Quinteiro-Filho *et al.,* 2012).

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