Journal of Desert and Environmental Agriculture, 1 (1): 35-49, 2021 JDEA
I S S N : 2 7 3 5 – 4 7 0 9

Article

Antioxidant Statues, Growth and Some Physiological Performances of the Gimmizah Male Chickens Supplemented by Dietary *Spirulina platensis* Under Chronic Heat Stress.

Abaza, I. M.[1]; A. A. Abdalla[2]; Amr M. Helal[3]and Effat.Y.Shreif[2].
1. Poultry Nutrition, Faculty of Desert and Environmental Agriculture, Matrouh University.
2. Anim. Prod. Res. Inst., Agric. Res. Center, Min. of Agric,
3. Researcher. National Institute of Oceanography and Fishers

Article info.

Received on: 16-12-2020

Accepted on: 10-1-2021

Published on: 3-2021

Open Access

Abstract

The present study was carried out to study the effect of Spirulina supplementation on the growth and some physiological performances of the Gimmizah males exposed to heat stress (HS). A total number of 150 male 4 weeks old Gimmizah were randomly allocated in five groups (3 replicates, 10 chicks each). The first (positive control, PC) was reared under 22-24OC and PH 45-55% and fed unsupplied basal diet, B). Whereas, the other groups were reused under HS (38°C±1; 55-65 % RH) for three successive days /wk from 11.00 a.m until 15.00 p.m, through the experimental period (4 to 14 wks of age) in a battery brooders. The first HS group was used as a negative control (NC) and fed B. The 3rd and 4rd groups fed B plus 250 and 150 mg Spirulina /kg diet, respectively. The 5 group was fed the B plus 75 mg VE /kg diet. The feed consumption was significantly decreased for all groups under HS compared with PC group, while FCR for the groups under HS (supplied with Spirulina or VE) were significantly improved compared with NC. The differential of leukocytic count for the NC group recorded the significant increase on Lymphocyte, Heterophil and the ratio of H/L compared with other groups. The concentration of globulin and activity of GSH-PX were significantly improved for the groups supplied with both levels of Spirolina under HS compared with the NC group. The highest Infections Bronchitis titer was recorded for the group supplied with VE and PC group. In conclusion, addition of 150 and 250 mg Spirulina platensis /kg diet improved performance, immunity and can be decreased the adverse effect of heat stress for Gimmizah mail during growing period (4-14 wks of age).

Keywords: Spirulina, Heat stress, growth and physiological performance

1. Introduction

Spirulina is a blue-green microalgae grow in fresh water, it contains substances such as phycobiliproteins (for example phycocyanin **(Eriksen, 2008),** carotenoids such as β-carotene and zeaxanthin), high iron and vitamin contents and antioxidants (**Maoka, 2011, Hemalatha et al., 2012 and Christaki *et al*., 2013).** These compounds reveal potential biological properties such as antimicrobial, antioxidant, anti-cancer immunostimulating, anti- inflammatory, colorants and hypolipidemic action **(Abu-Taweel et al., 2016; Hamed et al., 2019; Batista *et al*., 2013 ; Christaki *et al*., 2013)** and it is generally regarded as safe (GRAS) by the European Food Safety Authority (EFSA) (**Chacon-Lee et al., 2010). Anbarasan et al. (2011)** indicated that the phytochemical screening of the ethanolic extract of algae. *Spirulina platensis* shows the presence of alkaloids, flavonoids, glycosides, tannins and phenolic compounds, steroids, and saponins. The naturally essential nutrients and numerous biochemical and physiological content in *Spirulina*, make it ideal as a natural feed additive in animal and poultry nutrition (**Borowttzka, 2013). Also, Mirzaie et al. (2018)** reported that *Spirulina* supplementation in the broiler's diet decreased stress hormones concentration and serum lipid profile meanwhile increased humoral immune response and antioxidants in heat-stressed broilers.

The comfortable temperature for poultry is about 20-25 °C **(Daghir, 2008; Tumová and Gous, 2012)**, and when the ambient temperature becomes higher than 27 °C , the symptoms of heat stress (HS) begins and is readily apparent above 30 °C **(Bollengier-lee et al., 1999; Attia et al., 2006).** Since, one of the major challenges facing the poultry industry is the higher ambient temperature in the summer months that negatively affects growth performance and physiological traits **(Mashaly et al., 2004; Daghir, 2008; Yoshida et al., 2011). Enass et al., (2019)** indicated that dietary *Spirulina platensis* and organic selenium improved productive and reproductive performance, total antioxidant capacity, glutathione peroxidase, superoxide dismutase and immunoglobulins whereas decreased malondialdehyde level in blood, and can decrease the adverse effect of stress on laying hen under heat stress condition. Therefore, the present study was carried out to investigate the effect of *Spirulina platensis* levels on the growing performance, some physiological and blood biochemical constituents, antioxidant, and immune response traits of the Gimmizah male exposed to chronic heat stress.

2. Materials and methods

2.1. Birds used and grouping:

A total of 150 male 4 weeks old Gimmizah local strain chicks {a cross between White Plymouth Rock × Dokki-4} (Mahmoud et al., 1982) Male chicks were randomly allocated in a completely randomized design considering five treatment groups with three replicates (each contained 10 chicks). All chicks were raised in a battery brooder placed in a temperature-controlled room until 14 weeks of age. The positive control group (PC) was fed the basal diet (B, corn-soybean meal diet, Table 1) only without any supplementation and reared in the first sector under normal temperature (22-24^{O}C) and relative humidity (RH) (45-55%). Whereas, the other four treatments were kept in the last sector under chronic heat stress condition (HS) (38°C±1; 55-65 % RH) for three successive days/week from 11.00 am until 15.00 pm. The first heat stress group was fed the basal diet (B) only without any supplementation and used as a negative control (NC). Whereas, in the other three treatments, one group was fed the basal diet supplemented with 250 mg *Spirulina* /kg diet (*Spirulina* obtained from The National Institute of Oceanography and Fisheries (NIOF); Egypt.) platensis (250S), or a basal diet supplemented with 125 mg/kg diet *Spirulina* (125S), and group of 75 mg vitamin E /kg diet (75E). Feed and water were supplied *ad-libitum* along the experimental period. Vaccination and medical program were done according to common veterinarian care practice. The photoperiod was 23 hours of light per day throughout the experimental period. The feed intake (FI), body weight, and mortality were examined.

2.2. Sampling and measuring parameters:

At 14 weeks of age, five birds from each treatment were randomly selected, slaughtered. Part of the blood was collected on anticoagulants and another part without anticoagulants. Whole blood samples were used for the determination of red blood cells (RBCs), white blood cells (WBC'S) counts; hemoglobin (Hb) content and packed cell volume (PCV) according to **Wintrobe (1967).** Differential leukocytes count, blood film was prepared according to the method described by **(Lucky, 1977).** The percentage and absolute value for each type of cells were calculated according to **(Schalm, 1986).** The tubes that contain coagulated blood were kept at room temperature for an approximate half-hour to allow the clotting of blood after that the serum samples were separated by centrifugation (3000 rpm/15 min.) and stored (-20^{O}C). The analyzed parameters were total protein, albumin, Creatinine, ALT and AST by using commercial kits (from Biomerieux, Poains, France). Serum immunoglobulins (IgG, IgM, and IgA) were determined using commercial ELISA kits (Kamiya Biomedical Company, USA). Total antibody production specific for the NDV vaccine was determined in serum by means of an ELISA using commercial ELISA test kits (**Jeffery et al., 1996).** HI test was applied for the determination of an antibody response according to **King and Seal (1998).**

Liver and breast meat samples were carefully excised from the bird and immediately immersed in a saline solution (0.9% NaCl). The liver and breast meat samples (10%) were prepared in 0.01M Tris-HCl buffers (pH 7.5). The homogenate was centrifuged at 4000 r.p.m for 15 min, and the resultant supernatants were used for hepatic and meat parameters assay. Lipid peroxidation in liver and breast meat were estimated colorimetrically by measuring Malondialdehyde (MDA) by the thiobarbituric acid assay procedure using a kit purchased from Bio- Diagnostic, Egypt (CAT NO. MD 2529). Glutathione peroxidase (GPx) was determined using a kit purchased from Bio- Diagnostic, Egypt (CAT NO. GP 2524).

Statistical analysis

Data were statistically analyzed using one way ANOVA of SAS® **(SAS Institute, 2001).** Differences among treatment means were estimated by Duncan’s multiple range test **(Duncan, 1955).** The following model was used to study the effect of treatments on the parameters investigated as follows:

$$Y_{ij} = \mu + T_i + e_{ij}.$$

Where: Yij = an observation, μ = overall mean, Ti = effect of treatment (i=1,2,3,**…..5**) and eij = experimental random error.

3. Results and Discussion

Spirulina is considered as a functional food due to its high protein content, high amount of vitamin and mineral content, carotene and xanthophyll phytopigments **(Farag et al., 2016; Lupatini, et al., 2017),** and it is generally regarded as safe (GRAS) by the European Food Safety Authority (EFSA) (**Chacon-Lee et al., 2010**). The results indicated that the final body weight (BW) and body weight gain (BWG) results were not significantly differed among different experimental groups at the end of experiment. Meanwhile, feed consumption (FI) is significantly decreased for the groups raised under heat stress (HS) compared with positive control group, while feed conversion ratio (FCR) was significantly improved for the groups supplied with both levels of *Spirulina* or vitamin E under HS compared with the group under HS and had no supplementation. However, the group supplemented with 125 mg*Spirulina* /kg diet recorded the significant best FCR compared with the PC, NC groups and the group supplemented with VE (Table 2). These results are compatible with the observation reported by **Kirunda et al. (2001)** that the reduction in feed intake is response to heat stress. In addition, the supplementation of basal diet with both levels of *Spirulina* or VE significantly improved the FCR for the groups reared under HS compared with the NC groups and statistically equal with the FCR for PC group. The improve on FCR in the present study is in agreement with that reported by **Kaoud (2012)** and **Kharde et al. (2012)** who found that feed conversion ratio improved by the dietary inclusion of the *Spirulina platensis* as compared to the control. **Mariey et al.(2014)** reported that supplied broiler with 0.1, 0.2 and 0.3g *Spirulina*/kg diet improved feed conversion ratio by 5, 10 and12% as compared to those fed the control diet. **Jamil et al. (2015)** noted that FCR was significantly improved among the treatment groups of broiler chicks fed with *Spirulina* diet (0, 2, 4 and 8 g *Spirulina*/kg) for 4 weeks. **Shanmugapriya et al. (2015)** found that feed conversion ratio of broiler chicks was significantly increased by the dietary inclusion of the 1% of *spirulina platinsis* as compared to the control. **Zeweil et al. (2016)** reported that dietary supplementation of *Spirulina* in chickens under heat stress conditions could decrease adverse effects of chronic heat stress on growth performance of a Gimmizah chicken. Also, **Levine et al. (2018)** demonstrated that birds receiving dried algae at 50 and 200 g/ton showed a significant improvement in broiler FCR compared to the control during HS period (days 14–20). The FCR improvement may be due to that *Spirulina* has some components which had beneficial effects improved the absorption of nutrients through the gastric tract. These findings are in harmony with those documented by **Nikodémusz et al. (2010)** who reported that broilers fed *Spirulina*-containing diets achieved superior productive performance to their control birds. Also, Gružauskas et al. (2004) reported that *Spirulina* improve absorption of minerals, protect from diarrhea and optimize nutrient digestion processes. **Enass et al. (2019)** indicated that supplementation of *Spirulina platinsis* had no adverse effect on body weight change and final body weight also, the best feed conversion had been recorded by birds fed *Spirulina platinsis* compared with control group.

Results of the blood parameters in Table (3) showed significant increase on the count of WBCs for the NC group (exposed to HS without any supplementation) compared with other groups, while the same group was significantly recorded the lowest values of RBCs and Hb compared with the other groups. However, the PCV value was statistically equal among all experimental groups. The differential of leukocytic count indicated that the NC group recorded significant increase on Lymphocyte, Heterophil and the ratio of H/L compared with other groups, while the groups supplied with *Spirulina* or vitamin E significantly improved compared with the NC group and statistically equal with the PC group. The values of Monocyte and Basophil for the NC group were significantly decreased compared with the values recorded for the

PC group, meanwhile the values for the other groups which supplied with *Spirulina* or vitamin E were significantly higher than NC group and statistically equal with the PC group. The value of Esinophil for the NC group was significantly decreased compared with the values recorded for the PC group; meanwhile the values for the other groups were flocculated. These results are an agreement with several reports **(Seyidoglu and Galip, 2014; Mariey et al., 2014; Ashgan et al., 2015). Lokapirnasari et al. (2016) and Kumari et al (2019)** noted that *Spirulina* improved the development and maturation of leukocytes, which is a pivotal part of the immune defense of broiler due to its content of phycocyanin and polysaccharides. Likewise, **Jamil et al (2015)** revealed that supplementation of Spirulina resulted in increased red blood cells count of chickens groups fed 0.1, 0.2 and 0.3 g *Spirulina*/kg diet, also increased numbers of leukocytes and that associated with improved haemoglobin. In the same line, **Zeweil et al. (2016)** demonstrated that supplementations of *Spirulina* resulted in diminishing the negative effect of heat stress on WBCs, RBCs, lymphocyte and basophile. Moreover, **Fathi et al. (2018)** noticed a decrease on heterophils to lymphocyte (H/L) ratio, which is the indicator of stress condition of broiler chickens fed dietary inclusion of *Spirulina platensis*.

The results of the serum biochemistry showed that exposing to HS significantly decreased the concentration of total protein compared to the concentration of the PC group. While, the group exposing to HS (NC) significantly increased the concentration of blood albumin compared to the concentration of the PC group and statistically equal with the groups supplied with 125 mg *Spirulina*/kg diet and VE. Meanwhile, the group under HS and supplied with 250 mg *Spirulina*/kg diet recorded the significantly lowest concentration and statistically equal with PC group. The NC group recorded the lowest globulin concentration compared with the other experimental groups and the PC group showed the opposite result. However, the concentration of globulin was significantly improved for the groups supplied with both levels of *Spirolina* (205 and 125 mg/kg diet) under HS compared with the NC group (Table 4). In this connection, **Kutlu and Forbes (1993)** reported that plasma total protein may give an indication of the effect of heat stress in chicken. **Youssef *et al*. (2014)** reported that plasma protein concentration decreased significantly after acute heat stress of Golden Montazah, Fayoumi and El- Salam during starter and growing periods (1-18 wk of age). Also, **Tawfeek et al.(2014)** indicated that the heat stress (36 °C and 75% RH) significantly decreased protein, compared with the thermoneutral control group (25 C° and 67% RH) for 6 weeks of broiler chicks. **Mariey et al. (2014)** found that broiler chicks for (0 to 6wk) fed dietary *Spirulina* supplementation at levels of 0.2 and 0.3 g /kg diet significantly increased concentration of albumin and globulin in blood plasma compared with the control diet. Also, **Mariey et al. (2012)** showed that plasma total protein, albumin and globulin concentrations showed significant increase due to feeding dietary *spirulina* up to 0.2% of laying hens. **Enass et al. (2019)** recorded that *Spirulina platinsis* decreased only total protein and had insignificant effect on albumin compared with control group.

Creatinine, AST and ALT concentrations were significantly increased for the NC group compared with the other experimental groups. However, the concentrations of all of them were significantly improved due to supplementation of different levels of *spirulina* or VE and they statistically equals with PC group (Table 4). Regarding to

ALT and AST activity, these results are in agreement with **Jamil et al (2015)** who reported that ALT and AST activity significantly decreased in all the treatment groups supplemented with *Spirulina*. **Abdel-Daim et al. (2015)** who reported that 500 mg *Spirulina* /kg of male Albino Wistar rats for 5 days results in significant decreases on creatinine compared with the unsupplied group. **Selim et al. (2017)** demonstrated that there was a significant decrease in ALT and AST concentrations in laying groups fed *Spirulina platensis* algae. The observed reduction in serum ALT and AST levels of *Spirulina*-supplemented groups in the current study revealed the hepatoprotective activity of the *Spirulina platensis* as a result of its antioxidant and anti-inflammatory factors. Also, **Zeweil et al. (2019)** results indicated that different supplementations as *Spirulina* 0.5 and 1 g/kg diet) and VE (75 mg/kg diet) decreased adverse effect of heat stress on createinin, ALT and AST of Chickens.

Blood Total antioxidant capacity (TAC) and Malondialdehyde (MDA) were not significantly differed among experimental groups, while liver MDA for group exposed to HS was significantly increased compared with the other experimental groups (Table 5). Glutathione peroxidase (GSH-PX) activity in blood and meat recorded the same trend, since the activity of GSH-PX for the NC group was significantly decreased compared with the other experimental groups. However, the activity of GSH-PX was significantly improved for the supplemented group with both levels of *Spirulina platinsis* or VE and almost equal with the activity which was recorded for PC group. In this context, these results are in agreement with **Deng and Chow (2010)** who indicate that *Spirulina* had an antioxidative and an anti-inflammatory effect. **El-Damrawy (2014)** showed that Hubbard broiler chicks reared under heat stress (36 ± 1°C) and 65±5% RH for 8h (From 10 am to 6 pm) significantly decreased glutathione (GSH) activity compared to control group during 22d to 40d of age. Also, **Tawfeek et al. (2014)** demonstrated that the heat stress (36 °C and 75% RH) significantly decreased glutathione peroxidase, compared with the thermoneutral control group (25 C° and 67% RH) at 6 weeks of age in broiler chicks. It is worthnoting that, *Spirulina* contains numerous bioactive materials including phytopigments, such as phycobilins, phycocyanin, allophycocyanin and xanthophylls, which make it a potential natural dietary source of antioxidants, anti-inflammatory, immune-modulating and hepatoprotective functions **(Bermejo et al., 2008; Lokapirnasari et al., 2016; Ibrahim and Abdel-Daim, 2015; Abdel-Daim et al., 2015; Lu et al., 2006; Jamil et al., 2015 and Jeyaprakash and Chinnaswamy, 2005).** Also**, Kuhad et al. (2006)** reported that *Spirulina* is well known to have antioxidant properties, which are attributed to its content of phycocyanin, beta-carotene and tocopherol bioactive molecules. It has been found that *Spirulina* is capable of inhibiting carcinogenesis and organ-specific toxicity due to its antioxidant properties. **Zeweil et al. (2016)** demonstrated that malondialdehyde (MDA) concentration in liver was not significantly affected by *Spirulina* levels at 1 and 0.5gm/kg diet and Vit.E supplementation under normal and heat stress conditions. **Ashgan et al. (2015)** showed that mice treated with *Spirulina* (800 mg SP/kg body weight/ 0.5 ml drinking water) reduced MDA in comparison with Carbon tetrachloride (CCl_4, 1 ml/kg body weight) as a toxin group for three weeks. **Enass et al. (2019)** demonstrated that Addition of *Spirulina platinsis* significantly decreased MDA compared to control group. Moreover, *Spirulina* contains notably phycocyanin that has the ability to scavenge free radicals, including alkoxyl, hydroxyl, and peroxyl radicals and *β*-carotene that have potent antioxidant and anti-inflammatory activities. It also decreases nitrite production, suppresses inducible nitric oxide synthase (iNOS) expression, and inhibits liver microsomal lipid peroxidation **(Romay et al., 1998 & Riss et al., 2007). Zeweil et al. (2016)** indicated that supplementation of *Spirulina* (0.5 and 1 g/kg diet) and VE (75 mg/kg diet) (decreased adverse effect of heat stress on immunity of chickens.

Immunoglobulin IgA IgM and IgM for Gimmizah chicks at 14 wk of age were not significantly affected by dietary *Spirulina* levels or VE supplementation Table (6). These are in agreement with **Enass et al. (2019)** recorded that the highest significant TAC, GPx and IgG values were recorded with birds fed 0.15 g *Spirulina platinsis* /kg diet compared with control group.

Haemagglutination inhabitation test of New Castle diseases virus (HIN) on 7 and 14 days post-vaccination, Avian influenza disease titer (HI A) were not significantly changed among different experimental groups. However, haemagglutination inhabitation test of Infections Bronchitis (HI IB) titers were significantly decreased due to exposing to HC, since the lowest concentration was recorded for the NC group, while the other groups were significantly higher compared with the NC group. The highest result of HIB was recorded for the group supplied with VE and the concentration recorded for t PC group, (Table 6). In this respect, **Mirzaie et al. (2018)** reported that dietary supplementation of microalga was attributed to the higher antibody response against sheep red blood cells (SRBC) in broiler chickens. **Habibian et al. (2014)** noted that broiler chicks under HS (23.9 to 37 °C cycling) at 49 days of age fed dietary VE had a significantly reduction on antibody titers for primary and secondary antibody responses too. **Tang and Chen (2015)** found that the titers of ND antibody in HS group exposed to 40 ± 0.5°C for 2h each day, were significantly lower than those in control group of male chicks at 42 days of age. Similarly, the study by **Mirzaie et al (2018)** documented a beneficial impact of feeding *Spirulina* on the second humoral response against SRBC antigen when compared with the control. **Zeweil et al. (2016)** stated that the highest significant effect on IgG in blood and glutathione peroxidase in liver and meat and the lowest significant malondialdehyde in meat values were recorded with the chicks fed 1 g *Spirulina* / kg diet under heat stress compared with the control (NC) group.

In conclusion, addition of *Spirulina platensis* improved growth performance, immunity and can be decreased adverse effect stress on Gimmizah chicks during growing period under heat stress condition**.**

Table (1): Composition and calculated analysis of the basal experimental diet

Ingredients	(%)	Calculated analysis[2]	
Yellow corn	64.00	Crude protein (%)	19.11
Soybean meal (44% CP)	32.10	ME (Kcal/kg diet)	2864
Dicalcium phosphate	1.80	C/P ratio	146.2
Limestone	1.40	Crude fat (%)	2.91
DL-Methionine	0.10	Crude fiber (%)	3.82
NaCl	0.30	Calcium (%)	1.06
Vit.and mineral (premix)[1]	0.30	Phosphorus available (%)	0.47
Total	100	Methionine (%)	0.43
		Methionine + Cysteine (%)	0.75
		Lysine (%)	1.10

[1]Three kg of vitamin- mineral premix per ton of feed supplied each kg of diet with Vit. A 12000 IU; Vit. D_3 2000 IU; Vit. E. 10mg; Vit. k_3 2mg; Vit.B_1 1mg; Vit. $B_2$4mg; Vit. B_6 1.5 mg; Pantothenic acid 10mg; Vit.B_{12} 0.01mg; Folic acid 1mg; Niacin 20mg; Biotin 0.05mg; Choline chloride (50% choline) 500 mg; Zn 55mg; Fe 30mg; I 1mg; Se 0.1mg; Mn 55mg; ethoxyquin 3000 mg.

[2]**According to Feed** Composition Tables for animal and poultry feedstuffs used in Egypt (2001).

Table (2): Effect of *Spirulina platensis* supplementation and heat stress on Growth Performance of Gimmizah chicks

Groups / Parameters	T1 (B, PC)	T2 (B, NC)	T3 (B+250S)	T4 (B+125S)	T5 (B+75E)	SEM	Sig
		Under heat stress					
IBW(g)	366.6	373.6	383.9	379.6	381.1	32.22	0.2361
FBW (g)	1124.5	1049.6	1114.8	1221.4	1120.2	40.25	0.3251
BWG(g/day)	10.82	9.66	10.44	12.03	10.56	1.06	0.0852
FI(g/day)	52.19[a]	50.23[b]	46.22[b]	48.79[b]	50.29[b]	1.45	0.0034
FCR (gFI/gBWG)	4.82 [b]	5.20. [a]	4.43[bc]	4.06 [c]	4.76 [b]	0.48	0.0007

T1 (B, PC): fed Basal diet (positive control). T2 (B, NC):fed Basal diet under HS (negative control). T3 (B+250S): fed B + 250 mg Spirulina / Kg under HS. T4(B+125S): fed B + 125 mg Spirulina / Kg under HS. T5 (B+75E): fed B + 75 mg V E/ Kg under HS. IBW: Initial body weight FBW: Final body weight FI: Feed intake, FCR:Feed conversion ratio

Table (3): Effect of *Spirulina platensis* supplementation and heat stress on some blood parameters of Gimmizah chicks

Groups / Parameters	T1 (B, PC)	T2 (B, NC)	T3 (B+250S)	T4 (B+125S)	T5 (B+75E)	SEM	Sig
		Under heat stress					
WBCs	24.00 ^{b}	27.67^{a}	23.67^{b}	24.0 ^{b}	24.67 ^{b}	0.994	0.0042
RBCs /10	13.66^{a}	11.33^{b}	13.33^{a}	13.66^{a}	13.0^{a}	0.962	0.0005
PCV	33.67	32.0	33.33	33.66	33.0	1.392	0.3521
Hb	12.33 ^{b}	10.0 ^{c}	16.33^{a}	11.33 ^{b}	11.67 ^{b}	0.822	0.0045
		Differential leukocytic count					
Lymphocyte	42.33^{b}	42.24^{a}	43.49^{b}	42.40^{b}	44.33^{b}	0.736	0.0056
Monocyte	15.23^{a}	10.44^{b}	14.32^{a}	13.91^{a}	12.71 ^{ab}	0.550	0.0023
Basophil	1.65 ^{a}	0.33 ^{b}	1.71 ^{a}	1.72 ^{a}	1.47 ^{a}	0.268	0.0012
Eosinophil	16.38 ^{a}	12.10 ^{bc}	12.00 ^{bc}	14.0 ^{ab}	10.73 ^{c}	0.690	0.0003
Heterophil	24.69^{c}	33.24 ^{a}	28.0 ^{b}	27.83^{b}	29.01 ^{b}	0.556	0.0001
H/ L ratio	0.58^{c}	0.78 ^{a}	0.65 ^{b}	0.65 ^{b}	0.65 ^{b}	1.608	0.0001

T1 (B, PC): fed Basal diet (positive control). T2 (B, NC):fed Basal diet under HS (negative control). T3 (B+250S): fed B + 250 mg Spirulina / Kg under HS. T4(B+125S): fed B + 125 mg Spirulina / Kg under HS. T5 (B+75E): fed B + 75 mg V E/ Kg under HS.. H/L= Heterophil/ Lymphocyte ratio

Table (4): Effect of *Spirulina platensis* supplementation and heat stress on some serum biochemistry parameters of Gimmizah chicks

Groups / Parameters	T1 (B, PC)	T2 (B, NC)	T3 (B+250S)	T4 (B+125S)	T5 (B+75E)	SEM	Sig
		Under heat stress					
Total protein(g/dl)	7.53 ^{a}	6.20 ^{b}	6.70 ^{b}	6.75 ^{b}	6.42 ^{b}	0.407	0.0001
Albumin(g/dl)	3.23^{c}	3.74^{a}	3.16^{c}	3.66 ^{ab}	3.31^{ab}	0.092	0.0024
Globulin(g/dl)	4.29^{a}	2.46^{c}	3.54 ^{b}	3.09 ^{b}	3.12 ^{b}	0.476	0.0054
Creatinine (mg/dl)	0.57 ^{b}	0.76 ^{a}	0.58 ^{b}	0.63 $^{a\,b}$	0.57 ^{b}	0.050	0.0006
AST (U/L)	57.01 ^{b}	65.33 ^{a}	56.93 ^{b}	58.87 ^{b}	57.33 ^{b}	0.746	0.0384
ALT (U/L)	32.80 ^{b}	35.67 ^{a}	32.67 ^{b}	33.5 ^{b}	31.67 ^{b}	1.576	0.0241

T1 (B, PC): fed Basal diet (positive control). T2 (B, NC):fed Basal diet under HS (negative control). T3 (B+250S): fed B + 250 mg Spirulina / Kg under HS. T4(B+125S): fed B + 125 mg Spirulina / Kg under HS. T5 (B+75E): fed B + 75 mg V E/ Kg under HS.

Table (5): Effect of *Spirulina platensis* supplementation and heat stress on some antioxidant parameters

Parameters \ Groups	T1 (B, PC)	T2 (B, NC)	T3 (B+250S)	T4 (B+125S)	T5 (B+75E)	SEM	Sig
		Under heat stress					
Blood TAC (nmol/L)	0.33	0.33	0.37	0.36	0.34	0.016	0.2354
Blood MDA (μmol/L)	8.18	8.67	7.69	9.27	8.94	0.642	0.5641
Liver MDA (μmol/L)	8.94 [b]	10.31 [a]	8.55 [b]	8.36 [b]	8/.08 [b]	0.406	0.0008
Liver GSH-Px (mmol/ml)	213.3 [ab]	188.9 [c]	250.1 [a]	216.9 [ab]	200.1 [b]	8.722	0.0158
Meat GSH-Px (mmol/ml)	199.9 [a]	143.6 [c]	199.3 [a]	179.5 [ab]	169.4 [b]	9.788	0.0024

T1 (B, PC): fed Basal diet (positive control). T2 (B, NC):fed Basal diet under HS (negative control). T3 (B+250S): fed B + 250 mg Spirulina / Kg under HS. T4(B+125S): fed B + 125 mg Spirulina / Kg under HS. T5 (B+75E): fed B + 75 mg V E/ Kg under HS. TAC: Total antioxidant. MDA: Malondialdehyde. GSH-Px: Glutathione peroxidase

Table (6): Effect of *Spirulina platensis* supplementation and heat stress on some immune parameters

parameters \ Groups	T1 (B, PC)	T2 (B, NC)	T3 (B+250S)	T4 (B+125S)	T5 (B+75E)	SEM	Sig
		Under heat stress					
IgA	77.00	78.66	79.00	78.33	77.00	0.822	0.0725
IgM	220.33	225.33	221.67	222.00	220.33	2.058	0.0684
IgG	967.67 [b]	973.66 [ab]	977.00 [a]	970.66 [ab]	967.67 [b]	1.776	0.0002
HI IB	2.00 [a]	1.00 [c]	1.67 [b]	1.65 [b]	2.00 [a]	0.140	0.0025
HI A	1.00	1.33	0.67	1.00	1.00	0.202	0.4521
HI N7	2.33	3.33	3.00	3.33	2.33	1.026	0.2314
HI N14	3.33	4.00	3.66	4.00	3.33	0.398	0.2541

T1 (B, PC): fed Basal diet (positive control). T2 (B, NC):fed Basal diet under HS (negative control). T3 (B+250S): fed B + 250 mg Spirulina / Kg under HS. T4(B+125S): fed B + 125 mg Spirulina / Kg under HS. T5 (B+75E): fed B + 75 mg V E/ Kg under HS. HI N= Haemagglutination inhabitation test of New Castle diseases virus (NDV). HI IB = Haemagglutination inhabitation test of Infections Bronchitis (IB).HI A= Haemagglutination inhabitation test of Avian influenza disease (H5N1). HI N7 = Haemagglutination inhabitation test of (NDV) on 7 day. HI N14 = Haemagglutination inhabitation test of (NDV) on 14 day.

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الملخص العربى

الحالة المناعية وصفات النمو والأداء الفسيولوجي لذكور دجاج الجميزة المعرضة للإجهاد الحرارى والمغذاة على طحلب الأسبيرولينا

الملخص العربى

أجريت هذه التجربة لدراسة تأثير طحلب الأسبيرولينا على صفات النمو و كذلك الأداء الفسيولوجي لذكور دجاج الجميزة تحت ظرف الإجهاد الحرارى. تم توزيع عدد 150 ديك عمر 4 أسابع عشوائيا فى بطاريات الى خمسة معاملات(3 مكررات بكل مكررة 10 ذكور). استخدمت المجموعة الأولى كمجموعة مقارنة ايجابية وغذيت على عليقة اساسية بدون أضافات وربيت تحت الظروف الطبيعية (درجة الحرارة 22-24 مئوية ورطوبة نسبية 45-55%). تم تربية المجموعات التجريبية الأربعة الأخرى فى غرفة تحت التحكم فى ظرف بيئية مختلفة حيث تم رفع درجة الحرارة بها الى درجة 38±1 درجة مئوية و رطوبة نسبية 55-65%.و ذلك من الساعة 11 صباحا الى الثالثة بعد الظهيرة خلال فترة الدراسة(4-16 اسبوع من العمر.

تم استخدام المجموعة التجريبية الثانية تحت ظرف الإجهاد الحرارى كمجموعة مقارنة سلبية وغذيت كذلك على العليق الأساسية بدون اى أضافة. غذيت المجموعتين الثالثة والرابعة تحت الإجهاد الحرارى على 250 و 150 مجم من الأسبيرولينا على التوالى إضافة الى العليقة الأساسية ، كما غذيت المجموعة الخامسة تحت ظروف الإجهاد الحرارى على العليقة الأساسية مضافا اليها 75 مجم من فيتامين هـ.

أوضحت الدراسة وجود انخفاض معنوى فى معدل استهلاك العلف لجميع المعملات تحت الأجهاد الحرارى مقارنة بمجموعة المقارنة الإيجابية بينما المجموعات التى غذيت على العليقة الأساسية مضافا اليها الأسبيرولينا او الفيتامين تحسنا معنويا فى الكفاءة التحويلية للعلف مقارنة بمجموعة المقارنة السلبية. أظهر العد لمكونات كرات الدم البيضاء لمجموعة المقارنة السلبية زيادة معنوية فى عدد الخلايا الليمفاوية والهيتيرو والنسبة بينهما مقارنة بالمجموعات الأخرى. إرتفع تركيز الجلوبيولين بالدم و نشاط انزيم الجلوتاثيون بيروكسيديز معنويا معنوية للمجموعات المرباة تحت ظروف الأجهاد الحرارى و المغذاة على العليقة الأساسية مضافا اليها كلا من الأسبيرولينا او الفيتامين مقارنة بمجموعة المقارنة السلبية. سجلت أعلى قيمة للأجسام المناعية المضادة لفيروس الإلتهاب التنفسى للمجموعة التى غذيت على العليقة الأساسية مضافا اليها فيتامين هـ. خلصت الدراسة الى أن إضافة 250 و 150 مجم من طحلب الأسبيرولينا لعلف ذكور الجميزة النامية (4- 14 أسبوع) المعرضة للأجهاد الحرارى حسنت من الأدء خلال فترة النمو والكفاءة التحويلية للعلف و بعض المعاييرالفسيولوجية بالدم فضلا عن مضادات الأكسدة والإستجابة المناعية كما خفضت من الاثر السلبى للاجهاد الحرارى على الكتاكيت .