International Journal of Chemical and Biochemical Sciences
(ISSN 2226-9614)

Journal Home page: www.iscientific.org/Journal.html

Evaluation of Spirulina Algae as a growth Promoter for Friesian Heifers.2.The Effect of Feeding Spirulina Algae on Biochemical Blood Parameters and Reproductive Performance

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Abstract

The present study was carried out to evaluate Spirulina algae as a growth promoter for developing Friesian heifers. Body weight, body measurements, blood parameters, physiological parameters, reproductive performance and economic efficiency were taken as indices for the study. Fifteen Friesian heifers with initial average live body weight 215.47±9.41Kg used in study. Animals divided into three experimental groups (5 in each). 1st group (control)was fed a basal ration contained (on DM basis) 30% concentrate feed mixture (CFM), 30% fresh berseem *(Trifolium alexandrinum*; FB), 20% corn silage (CS) and 20% rice straw (RS). In 2nd group and 3rd group fed basal ration supplemented with 2gm spirulina algae /head daily and 4gm spirulina algae /head daily, respectively. The present results showed that total body weight gain was significantly (P<0.01) improved for heifers fed rations supplemented with either 2 gm or 4 gm Spirulina/head daily than those fed control ration. Body conformation measurements increased for heifers fed rations supplemented with either 2 gm or 4 gm Spirulina/head daily. Haematological parameters of blood serum were significantly (P<0.05 or P< 0.01) superior in MCH (pg), MCHC (g/dl), platelet ($\times10^3$/ml), PCT (%), MPV (fl), PDW (%), lymphocytes (%), neutrophil (%), eosinophils (%) and basophils (%) for heifers fed rations supplemented with 4 gm Spirulina/ head daily than those of heifers fed rations supplemented with 2 gm Spirulina/head daily and control group. However, insignificant differences between the Spirulina supplementation and control groups recorded in red blood cells ($\times10^6$/ml); haemoglobin (gm/dl); haematocrit (%); MCV (fl); RDW (%); leukocytes ($\times10^3$/ml) and monocytes (%). Friesian heifers fed rations supplemented with 4 gm Spirulina/head daily showed significantly (P<0.05 or P<0.01) increased total protein, urea-N, high density lipoproteins (HDL) concentrations, ferritin(mg/dl), magnesium(mg/dl), phosphorous(mg/dl), potassium(mg/dl) and calcium (mg/dl) than those of heifers fed rations supplemented with 2 gm Spirulina/head daily and control group. Aspartate aminotransferase (AST) activity was significantly (P<0.05) decreased heifers fed rations supplemented with 4 gm Spirulina/head daily than those fed rations supplemented with 2 gm Spirulina/head daily and control group. Albumin, globulin, A/G ratio, creatinine, alanine aminotransferase (ALT), cholesterol (mg/dl), triglycerides, low density lipoprotein (LDL) and sodium (mg/dl) not affected significant by supplementation of Spirulina algae to ration of Friesian heifers. Friesian heifers fed rations supplemented with 2 or 4 gm Spirulina/head daily showed significantly (P<0.5 or P<0.01) decreased rectal, white skin and black skin temperature and respiration rate than those of heifers fed basal ration. Spirulina supplementation significantly (P<0.05 or P< 0.01) improved most of postpartum reproductive parameters. Cows received 4 gm Spirulina/head daily recorded significantly (P<0.05 or P<0.01) best postpartum reproductive traits as compared with those received 2 gm Spirulina/head daily and control group. In conclusion, Spirulina is a promising natural growth stimulant to growing Friesian heifers. Adding 2 or 4 gm Spirulina/head daily to ration improved body weight and measurements, blood biochemical and haematological parameters, physiological measurements and postpartum reproductive performance of Friesian heifers.

Keywords: Friesian heifers, Spirulina, blood biochemical, physiological response, reproductive performance.

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1. Introduction

Heifers are consider the future stock of a dairy farm. It is important for every producer to implement best heifer management practices to bring up healthy replacement stock. Numerous chemical feed additives have been utilized to improve animal productivity, however it was had health problems to animals and human. Therefore, it was important to search about natural dietary alternative stimulant for productive and reproductive performance of animal. Spirulina algae commercially produced globally and used as a nutritional supplement for both humans and animals [1-2]. Spirulina algae has recently gained commercial importance for production of fresh supplements for animal feed and pharmaceutical products for humans, owing to its high quality nutritive value **[**3-7]. Spirulina is an important source of proteins includes all essential amino acids [8], essential fatty acids, alpha-linolenic, gamma-linolenic and linoleic [9], vitamins such as thiamine, nicotinamide, riboflavin, folic acid, pyridoxine, A, D and E [10], minerals like Ca, K, Cr, Cu, Mn, Fe, P, Mg, Na, Zn and Se [11] and is a rich source of biological colors such as carotenoids [12-14].

The Spirulina algae, have been considered as a suitable natural antioxidant [15] and immune-stimulant to humans and animals with fewer side effects [16-17]. In addition, Spirulina contains both enzymatic (superoxide dismutase, catalase and glutathione peroxidase, peroxiredoxin and ascorbate peroxidase) and non-enzymatic (carotenoids, tocopherols, ascorbic acid, glutathione and chlorophy-ll derivatives) as antioxidant defense system, which remove oxidants to protect the cells from harmful effects of stress conditions [18]. Also, Spirulina was reported to reduce the toxicity and improve digestibility and palatability [16]. Therefore, Spirulina has highly international demands and is considered as safe and healthy food and animal feed for therapeutic practices [19]. The objective of this study was to investigate effects of Spirulina algae supplementation in rations of Friesian heifers on body weight, body measurements, haamatological and biochemical blood parameters and the reproductive performance.

2. Materials and Methods

The experimental work of the present study was carried out at Sakha Animal Production Research Station, belonging to Animal Production Research Institute (APRI), Agricultural Research Center, Ministry of Agriculture and Land Reclamation, Egypt. In cooperation with Department of Animal and Poultry Production, Faculty of Technology and Development, Zagazig University, Zagazig, Egypt. The experimental work was initiated in March 2023 and terminated in August, 2023. The present experiment conducted on growing Friesian heifers (18 months of age). The laboratory work was performed at Central Lab for Soil, Foods and Feedstuffs (International accredited Laboratory, has ISO 17025, since 2012) belongs to Faculty of Technology & Development, Zagazig University, Zagazig, Egypt Fifteen Friesian heifers with average initial live body weight 215.47±9.41Kg were used in the study, Animals divided into three experimental groups (5 in each). Heifers of the *1$^{s\ t}$* group (control)were fed a basal ration contained (on DM basis) 30% concentrate feed mixture (CFM), 30% fresh berseem *(Trifolium alexandrinum*; FB), 20% corn silage (CS) and 20% rice straw (RS).

The 2nd and 3rd group were fed the control ration with 2gm and 4gm Spirulina/head daily, respectively. Chemical composition of feedstuffs and calculated composition of the basal ration are presented in Table 1. The concentrate feed mixture consisted of 32% undecorticated cotton seed cake, 24% wheat bran, 22% yellow corn, 12% rice bran, 5% linseed cake, 3% molasses, 1% limestone and 1% common salt. Heifers were housed under sheds in semi-open backyards and were fed their rations to cover their recommended requirements according to [20]**.** The concentrate feed mixture daily offered at 8 a.m. and 4 p.m. in two equal parts, fresh berseem, corn silage and rice straw offered daily at 10 a.m., 12 med day and 3 p.m., respectively. Dry Spirulina added to concentrate feed mixture at morning every day. Water was offered free to animals around day.

2.1. Temperature humidity index (THI)

Daily maximum and minimum values of ambient temperature (AT, °C) and relative humidity (RH %) during the entire length of the experimental period were recorded. Ambient air temperature was recorded using digital thermometer, while relative humidity was recorded using hair-hygrometer. Index of temperature-humidity (THI) was calculated according to equation of Livestock Poultry Heat Stress Index (1990) and modified by [21**]** as follows:

$$THI = dbT - [(0.31 - 0.31\,RH)\,(dbT - 14.4)]$$

Where: dbT =dry bulb temperature in Celsius (^{o}C) and RH = relative humidity (%).

The obtained values of THI were classified as absence of heat stress (≤ 22.2), moderate heat stress (>22.2 - ≤ 23.3), severe heat stress (>23.3 - ≤ 25.6) and very severe heat stress (> 25.6).

2.2. Body temperatures and respiration rate

Throughout the experimental period from March up to August, body temperatures including rectal temperature (RT) as well as skin temperatures at white (STW) and black (STB) sites recorded twice weekly at 13:00 h using the digital precision thermometer (TRD, the Ellab Cropcopen Hagen, BK8005 made in China). At same time, respiration rate (RR) measured by counting flank movements for one minute using the stop watch.

2.3. Live body weight and body measurements

Heifers were weighed at morning before feeding at 07:30 h on day 1 of the trial and finally at 24 month of age, using an electronic large animal scale. Body measurements of each experimental animal was taken monthly during the experimental period. Before measuring, t animal was allowed to stand on a horizontal concrete floor and positioned into an even stand. Body measurements were taken using steel caliper and measuring tape according to skeleton system.

2.4. Blood samples

Blood samples were taken from the jugular vein of each heifer by clean sterile needle in the heparinized clean dry plastic tube after 4 hours from the morning feeding in two parts. The 1st part was centrifuged at 4000 rpm for 15 min to separate plasma and stored at -20 ^{o}C. Total protein, albumin, globulin (total protein-albumin), aspartate aminotransferase (AST) and alanine aminotransferase

(ALT) were determined calorimetrically by spectrophotometer (Spectronic 21D, USA) using commercial kits produced by Diagnostic System Laboratories, Inc., USA. The 2nd part was used for determination hematological blood parameters. Haematological analysis was performed by MedonicVet. According to [22]. Haematology Analyzer (Medonic CA 620, Sweden) directly within 1-2 hrs after samples collection. Haematological variables measured were red blood cell count (RBC's), haemoglobin concentration (Hb), red blood cell distribution width (RDW), haematocrit (HT), main corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC). Other parameters included the platelet count (PLT), mean platelet volume (MPV), platelet distribution width (PDW) and procalcitonin (PCT). Leucocyte variables measured were white blood cell count (WBC's) and differential white cell count, lymphocytes (LY), monocytes (MO) and granulocytes (GR).

2.5. Reproductive traits

Reproductive parameters as the periods from the first estrus and first mating, days open, number of service per conception and conception rate were recorded for each cow.

2.6. Statistical analysis

Data were statistically analyzed using Least Squares Analysis of Variance according to [23] using the General Linear Model Program of [24] using the following fixed model:

$$Yij = \mu + Si + + eij$$

Where, Yij = the observed value of a given dependent variable, μ = Overall adjusted mean, Si = dry Spirulina algae effect (i = 1, 2and 3) and eij = Random error. The differences between least square means were analyzed by Duncan's New Multiple Range test [25].

3. Results and discussion

3.1. Live body weight and body weight gain

Live body weight and total body weight gain, of Friesian heifers as affected by green algae (Spirulina) are shown in Table 2. Total body weight gain were significantly improved (P<0.01) for heifers fed rations supplemented with either 2 gm or 4 gm Spirulina algae /head daily, respectively, than those fed the control ration. Friesian heifers receive 4gm Spirulina /head daily had the highest total body weight and weight gain compared to those fed the control or 2gm spirulina /head daily. These results are inagreement with those obtained by [26] for Friesian calves and [27] and [28] for growing rabbits.

Lateral body length (cm), shoulder width (cm), chest width (cm), touris width (cm), and height at shoulder were significantly improved (P<0.01) for heifers fed rations supplemented with either 2 gm or 4 gm Spirulina algae, respectively, than those of the control group. Furthermore, Hook width (cm), width at pins (cm), chest depth (cm), abdomen depth (cm), circumference of thigh (cm), circumference of chest (cm), circumference of abdomen (cm), compactemess, compression and fleshing of heifers was nearly similar for different experimental groups. Friesian heifers live weight, body conformation measurements were improved for heifers fed rations supplemented with either 2gm or 4 gm Spirulina algae/head daily, respectively.

The obtained result indication to the supplementing Spirulina algae as growth promoter to heifers, and these results are in agreement with those reported by [29-30].

3.2. Haematological and biochemical blood parameters

3.2.1. Haematological blood parameters

Haematological parameters of blood of Friesian heifers as affected by green algae (Spirulina) are shown in Table3. The results show that there are significant differences in some haematological parameters of blood serum of Friesian heifers, as there was a significant (P<0.05 or P < 0.01) superiority in MCH (pg), MCHC (g/dl), platelet ($\times 10^3$/ml), PCT (%), MPV (fl), PDW(%), lymphocytes (%), neutrophil (%), eosinophils (%) and basophils (%)for heifers fed rations supplemented with 4 gm Spirulina/ head daily than those of heifers fed rations supplemented with 2 gm Spirulina/head daily and the control group. However, insignificant differences were detected between the Spirulina algae supplementation and control group in red blood cells ($\times 10^6$/ml); hemoglobin (g/dl); haematocrit (%); MCV (fl); RDW (%); leukocytes ($\times 10^3$/ml) and monocytes (%). All hematological values obtained in this study on Friesian heifers are within normal physiological ranges of healthy Friesian heifers [31]. It is well known that hematological characteristics are good indicators for animal physiological status [32]. Ht, Hb and MCH are man indices for evaluating RBC_S efficiency [33].

Also, lymphocytes are considered the main type of WBCs and a good indicator for the immunity [34]. Haematological studies help in understanding the relationship between blood characteristics and adaptability of the species to environment [35]. In accordance with the present results, dietary addition of Spirulina algae enhanced haematopoiesis (Hb concentration and RBCs count) in growing pig [36], broiler chicks [37], cow [31] and weaning lambs [38].Improving most of haematological parameters after Spirulina algae supplementation to the diet of Friesian heifers might be related to strong antioxidant effect of Spirulina algae on hematopoietic cells, which appears to be particularly vulnerable in presence of unchecked accumulation of reactive oxygen species, ROS [39]. Free radicals resulting from oxidative stress by interfering with work of enzymes or acting as coenzymes and improving immune efficiency [40].Also, the benefits of Spirulina on haematological parameters may be due to the high content of folic acid and vitamin B_{12} in Spirulina algae [36]. Based on the present findings and previous results, Friesian heifers supplemented with Spirulina algae, in particular, at a level of 4 gm/ head daily had improved health status. Furthermore, it has no harmful effects on kidneies, liver or reproductive system [41].

3.2.2. Biochemical blood parameters

Blood biochemical parameters in plasma of Friesian heifers as affected by Spirulina algae are shown in Table 4. All the biochemical blood values obtained in this study for Friesian heifers are within the normal ranges of healthy Friesian heifers [26-31]. Friesian heifers fed rations supplemented with 4 gm Spirulina/head daily showed significantly (P<0.05 or P<0.01) increased total protein; urea-N, high density lipoproteins (HDL) concentrations ferritin(mg/dl), magnesium(mg/dl), phosphorous(mg/dl), potassium (mg/dl) and calcium (mg/dl) than those of heifers

fed rations supplemented with 2 gm Spirulina/head daily and the control group. However, activity was significantly (P<0.05) decreased of aspartate aminotransferase (AST) and low density lipoprotein(LDL) with heifers fed rations supplemented with 4 gm Spirulina/head daily than those fed rations supplemented with 2 gm Spirulina/head daily and the control one. However, albumin, globulin, A/G ratio, creatinine, alanine aminotransferase (ALT), cholesterol (mg/dl), triglycerides and sodium (mg/dl) were not affected significantly by supplementation of Spirulina algae to rations of Friesian heifers as compared with those the control ration. Increase the total protein of plasma may be due to the high protein content in Spirulina algae [42]. Similar results are in agreement with those obtained by [26] with Friesian calves which fed diet supplemented with 1 gm or 2 gm dry Spirulina algae/ head/ day and [43] with goats which used Spirulina algae at 0.2% of their feed intake.

Albumin concentration and ALT activity were not affected by dietary treatments. These results agree with those obtained by [44] who found that AST concentrations were the lowest with high Spirulina supplementation levels. In additions globulin, cholesterol, triglycerides, creatinine, urea-N, AST and ALT) concentrations did not significantly affected by dietary algae supplementation [26]. [27] Found that blood total protein and albumin concentrations were significantly higher with 0.2% Spirulina algae supplementation to growing lambs than those of the control group. Moreover, similar results were observed by [45]with dairy goats, in which Spirulina algae dietary at 500 mg/head/day had significantly increased total protein and glucose concentrations, significantly reduced each of cholostrol, triglycerids, AST and ALT, while did not affect the urea contents, compared with the control group. Spirulina algae supplementing to diet of Friesian heifers at the levels of 4 gm Spirulina /head daily had the better effectes on blood biochemical parameters. Moreover, many studies have concluded dietary supplementation with Spirulina algae had beneficial effects on productive and reproductive performance, good health status and more economic efficiency, fertility, and increased production in animals [28-46-47]. It has not shown any chronic or acute toxicity or even adverse effects, making it safe to use as part of human rations or as a nutritional supplement to enhance quality of ruminant rations [48].

3.3. Physiological measurements

The Physiological measurements as rectal, white skin and black skin temperature and respiration rate of Friesian heifers fed ration supplemented with Spirulina algae are shown in Table5. All the physiological measurements values obtained in this study of Friesian heifers are within the normal ranges [31, 26]. Friesian heifers fed rations supplemented with 2 or 4 gm Spirulina/head daily showed significante (or P<0.01) decrease of rectal, white skin and black skin temperature and respiration rate than those of heifers fed control ration.

3.4. Reproductive performance

Postpartum reproductive parameters of Friesian cows as affected by Spirulina algae additive are shown in Table 6. Dietary Spirulina algae supplementation improved significantly (P<0.05 or P< 0.01) most of the postpartum reproductive parameters i.e. age at conceive service (month), service period (days), number of service per conception and age at parturition (month**)**. However, the age at first service (month) was not affected significantly by Spirulina supplementation. Cows received 4 gm Spirulina/head daily recorded significantly (P<0.05 or P<0.01) the best postpartum reproductive traits as compared with those received 2 gm Spirulina/head daily and the control group. The obtained results agree with those reported by [49] who found that Spirulina improved significantly (P<0.05) all the postpartum reproductive parameters of Friesian cows. Moreover, [45] indicated that with dairy goats Spirulina algae dietary at 500 mg/head/day had significantly improved total number of kidding, triple rate, quaternary rate and litter size compared to the control groups. Beneficial effects of additive *Spirulina platensis* powder related to highest protein [28], vitamin as β-carotene [50], minerals mixture [51] and energy [52] that played a major protective role in reproductive performance, increased fertility function, and played a significant role in ovary cell signaling and immune responses.

Table 1. Chemical composition of feedstuffs used in the experimental rations (as DM basis).

Item	DM%	**Composition of DM %**					
		OM	**CP**	**CF**	**EE**	**NFE**	**Ash**
CFM	90.20	88.22	16.76	9.19	3.76	58.51	11.78
FB	19.61	87.10	18.21	23.50	2.25	43.14	12.90
CS	25.64	91.11	9.72	24.60	2.19	54.60	8.89
RS	91.12	82.21	3.40	31.43	0.86	46.52	17.79
DS	91.54	87.12	62.93	5.29	4.82	14.08	12.88

CFM = Concentrate feed mixture, FB= Fresh berseem, CS =Corn silage, RS= Rice straw and DS= Dry *Spirulina* algae

Table 2. Live body weight (kg), weight gain (kg) and body measurements (cm) of Friesian heifers fed ration supplemented with Spirulina algae.

Items	1st group (Control)	2nd group (2 gm *Spirulina*/head daily)	3rd group (4 gm *Spirulina*/head daily)	Sig.
Initial body weight (kg)	218.00±23.14	210.00 ±15.55	218.00 ±11.90	N.S
Final body weight (kg)	320.00±24.08	328.00 ± 13.38	346.00 ±14.27	N.S
Total weight gain (kg)	102.00^{b} ±2.87	118.00 ^{a} ± 2.98	128.00 ^{a} ± 4.06	**
Lateral body length(cm)	118.20^{b}± 1.85	128.00^{a} ±4.32	133.40^{a}± 1.72	*
Shoulder width(cm)	25.00^{b}± 0.55	29.40^{ab} 2.42	32.40^{a}± 0.24	*
Chest width(cm)	28.80^{b}± 0.73	36.00^{a}±2.92	35.20^{a}± 0.66	*
Touris width(cm)	27.80^{b}± 2.18	32.80^{a} ± 0.66	29.60^{ab}± 0.40	*
Hook width(cm)	39.80±1.77	40.60± 0.75	42.60 ± 2.20	NS
Width at pins(cm)	23.80± 1.24	24.60± 0.93	25.60± 0.40	NS
Chest depth(cm)	46.80 ± 0.97	48.60 ± 3.23	46.40 ± 1.33	N.S
Abdomen depth(cm)	52.20± 0.73	52.80± 3.09	54.60± 1.21	NS
Circumference of thigh(cm)	68.20 ± 1.20	70.00± 2.86	70.20± 0.92	NS
Circumference of chest(cm)	158.80 ±6.46	166.40 ± 1.89	163.80 ±1.02	NS
Circumference of abdomen(cm)	183.00 ± 5.15	190.40 ± 3.08	194.60 ± 2.40	NS
Height at shoulder(cm)	120.86^{b}± 1.23	129.18 ^{a} ± 2.67	134.80^{a}± 1.62	*
Compactemess	0.28± 0.02	0.24± 0.003	0.26± 0.003	NS
Compression	0.37± 0.02	0.38± 0.006	0.34±0.01	NS
Fleshing	2.47± 0.15	2.72± 0.10	2.56±0.09	NS

NS= Not significant and * = P< 0.05, and** =P < 0.01.
a, b and c means in the same raw with different superscript, differ significantly(P < 0.05).

Table 3. Blood Haematological parameters of Friesian heifers fed ration supplemented with *Spirulina* algae.

Items	1st group (Control)	2nd group (2 gm Spirul*ina*/head daily)	3rd group (4 gm Spirulina/head daily)	Sig.
Red blood cells(×10^{6}/ml)	6.21±0.23	6.80±0.29	6.93± 0.20	N.S
Haemoglobin (gm/dl)	9.59±0.32	10.39±0 .46	10.65± 0.37	N.S
Haematocrit (%)	33.80±0.28	35.14± 0.77	35.85± 0.52	N.S
MCV (fl)	55.90 ± 0.60	56.67 ± 0.52	57.57 ± 0.55	N.S
MCH (pg)	15.25^{b}± 0.17	16.29^{ab}±0.28	17.61 ^{a} ± 0.68	*
MCHC (gm/dl)	27.45^{c}± 0.26	33.50^{b}± 0.40	35.65^{a}± 0.45	**
RDW (%)	18.51 ± 1.31	19.38 ± 0.23	19.75 ± 0.41	N.S
Platelet (×10^{3}/ml)	264.50^{c}±16.2	356.50^{b}±5.54	464.20^{a}± 13.60	**
PCT (%)	0.24 ^{c} ± 0.01	0.44 ^{b} ± 0.01	0.63 ^{a} ± 0.014	**
MPV (fl)	7.78 ^{b} ± 0.40	8.37 ^{b} ± 0.25	9.44 ^{a} ± 0.11	*
PDW(%)	8.87 ^{b} ± 0.31	9.50 ^{b} ± 0.08	10.81 ^{a} ± 0.20	**
Leukocytes(×10^{3}/ml)	9.87 ±0 .47	11.90 ±0 .83	12.60 ± 1.19	N.S
Lymphocytes (%)	71.4^{a}±0.71	63.72 ^{b}±2.26	65.75 ^{b} ±0 .44	*
Neutrophil (%)	14.12^{b}±0.96	17.85^{a}±0.38	18.26 ^{a} ± 0.63	*
Monocytes (%)	9.42±0.38	10.00 ± 0.17	10.00 ± 0.30	N.S
Eosinophils (%)	4.42^{b}± 0.43	7.65 ^{a} ± 0.41	5.16 ^{b} ± 0.19	**
Basophils (%)	0.57^{a} ±0 .02	0.41 ^{b} ±0 .03	0.63 ^{a} ± 0.018	**

NS= Not significant, * = P< 0.05 and **= P< 0.01.
a,b and c means in the same raw with different superscript, differ significantly(P < 0.05).

Table 4. Biochemical blood of Friesian heifers fed ration supplemented with *Spirulina* algae

Items	1st group (Control)	2nd group (2gm *Spirulina*/head daily)	3rd group (4 gm *Spirulina*/head daily)	Sig.
Total protein(gm/dl)	7.3^{b}±0.21	7.92 ^{ab}± 0.13	8.44 ^{a} ± 0.40	*
Albumin (gm/dl)	3.49±0.78	3.79± 0.21	3.96± 0.19	N.S
Globulin (gm/dl)	3.82±0.19	4.13± 0.13	4.48± 0.21	N.S
A/G ratio	92.11±4.29	92.67 ± 7.93	88.46 ± 1.59	N.S
Urea (mg/dl)	35.15^{b}±0.26	36.10^{ab} 0.34	36.64^{a} ± 0.39	*
Creatinine(mg/dl)	0.65±0.03	0.69 ± 0.01	0.68 ± 0.17	N.S
AST (u/l)	49.10^{a}±2.85	46.98^{a} ±0.15	40.38^{b} ± 0.46	*
ALT (u/l)	46.00±1.63	45.00± 0.20	43.27± 0.49	N.S
Cholesterol (mg/dl)	170.04±8.61	165.20±0.18	160.50 ±0.39	N.S
Triglycerides (mg/dl)	30.35±1.07	31.56± 0.34	32.20±0 .37	N.S
HDL (mg/dl)	67.19^{c}±0.85	77.82^{b}± 0.35	80.91^{a} ± 0.46	**
LDL (mg/dl)	97.18^{a}±0.78	67.50^{b} ±0.18	60.21^{c} ± 0.80	**
Ferritin (mg/dl)	6.33^{c}± .16	7.48^{b} ± 0.27	8.91^{a}± 0.25	**
Magnesium(mg/dl)	1.74^{c}±0.01	2.07^{b}±0 .11	2.54 ^{a} ± 0 .06	**
Phosphorous(mg/dl)	6.02^{b}±0.06	6.62^{ab}± 0.40	6.95 ^{a} ± 0.08	*
Potassium (mg/dl)	4.57^{b}±0.09	4.74^{b} ±0.25	5.26 ^{a} ± 0 .09	*
Sodium (mg/dl)	136.04±1.94	143.83±2.95	145.83±4.12	NS
Calcium (mg/dl)	9.08^{b}±0 .30	10.34^{a}±0.09	10.41^{a}±0 .15	*

NS= Not significant, * = P< 0.05 and **= P< 0.01.

a, b and c means in the same raw with different superscript , differ significantly P<0.05).

Table 5. Rectal, white skin and black skin temperature and respiration rate of Friesian heifers fed ration supplemented Spirulina algae.

Items	1st group (Control)	2nd group (2 gm Spirulina/head daily	3rd group (4 gm Spirulina/head daily)	Sig.
Rectal temperature (^{o}c)	39.24^{a} ±0.18	38.35^{b}±0.15	38.21^{b} ± 14	**
White skintemperature(^{o}c)	37.05^{a} ±0.16	36.47^{b}±0.14	36.28^{b}± 0.11	**
Black skin temperature(^{o}c)	37.82^{a}±0.16	37.40^{b}±0.13	37.12^{b}±0.12	**
Respiration rate (r.p.m)	31.38^{a}±0.73	28.83^{b}±0.45	28.31^{b}±0.45	**

**= P< 0.01.

a, b and c means in the same raw with different superscript, differ significantly (P <0.05).

Table 6. Reproductive performance Friesian heifers fed ration supplemented with Spirulina algae

Item	Experimental treatments			Sig.
	1st group (Control)	2nd group (2 gm Spirulina/head daily	3rd group (4 gm Spirulina/head daily)	
	Mean $\bar{X}$	Mean $\bar{X}$	Mean $\bar{X}$	
Age at first service (month)	19.1+0.61	18.6+0.60	17.6+0.74	NS
Age at conceive service (month)	21.9 ^{a} +0.51	20.6^{b}+0.61	19.64^{c}+0.77	*
Service period (days)	49.6^{a}+0.68	36.8^{b}+1.24	31.8 ^{c}+0.73	**
No of service per conception	2.2^{a} +0.20	1.6^{b} +0.25	1.4^{c} +0.24	*
Age at parturition (month)	31.30+0.41^{a}	29.6+0.57^{ab}	29.6+070^{b}	**

NS= not significant, *=P<0.05; and ** = P<0.01.

a, b, c: Values in the same row with different superscripts differ significantly (P<0.05).

4. Conclusions

In conclusion, Spirulina algae is a promising natural growth promoters and improvements of productive and reproductive performance of Friesian heifers. Adding 2 or 4 gm Spirulina/head daily of growing Friesian heifers increased body weight and improved body measurements, biochemical and haematological blood parameters, physiological measurements and postpartum reproductive performance. Further studies should be carried out using a larger number of animals and higher doses of Spirulina algae to ensure the effectiveness of its use as a growth promoter and optimize of nutritional utilization for developing Friesian heifers.

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