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Spirulina platensis Influence on the Productivity of Zaraibi Does

[1]*M.M. El-Deeb,* [2]*A.M. Abdel-Gawad,* [2]*A.L.I. Desoky,*
[3]*M.A. Aboul-Omran,* [2]*M.E. Ahmed and* [2]*M.M. Eissa*

[1]Animal Nutrition Research Department, Animal and Poultry Production Research Institute,
Agricultural Research Center, Dokki, Giza, Egypt
[2]Sheep and Goats Research Department, Animal and Poultry Production Research Institute,
Agricultural Research Center, Dokki, Giza, Egypt
[3]Buffalo Breeding Research Department, Animal and Poultry Production Research Institute,
Agricultural Research Center, Dokki, Giza, Egypt

Abstract: A number of 20 healthy Zaraibi does from the flock of El-Serw Experimental Research Station, Damietta governorate belongs to Animal Production Research Institute, Agriculture Research Center, Ministry of Agriculture, Egypt, were selected to examine the effect of adding *Spirulina platensis*(SP) in their diets on their productive performance and health. Does initial average live body weight (LBW) was 40.8±0.70 Kg and at the last third of pregnancy period. These does were divided into two equal groups (10 does each). The first group (Control) fed *ad libitum* concentrate feed mixture (CFM) plus berseem hay (BH) at the ratios of 50:50 during late pregnancy period and 49:51 during the suckling period. The second group fed daily the same ration plus SP algal extract powder at the rate of 0.5 gm/10 Kg LBW. Data statistically analyzed using a mixed model with a repeated measurements design, co-variance and one way ANOVA for different studied parameters. The obtained results clearly indicated that adding SP to the ration of dairy goats was of positive impact on their average LBW during pregnancy and suckling periods. Feeding SP improved milk yield in general by about 6.0% at the first suckling period to 8.6% after 60 days. The differences between the two experimental groups at 30 and 60 days (during suckling period) in fat, lactose, total solids and ash constituents were significant ($P<0.05$), while milk protein and solids not fat differences were not significant. Feeding SP supported kids performance (average LBW and average daily weight gain) and survival rate (13.64% *Vs.* 20.83%). The SP-treated group generally increased significant ($p<0.05$) values of the tested blood parameters than the control group. More profit is possible in the SP-treated group due to the increased average Kg weaned/doe. In conclusion, the use of SP as feed additives in rations of lactating goats had a potent to cover feeding requirements of does and their kids during both pre-kidding and suckling periods.

Key words: Spirulina · Goats · Milk · Weight · Blood

INTRODUCTION

Nowadays, with the massive increase in animal nutrition costs and the competition between producing animals' feeds and humans' food, feed additives can play a fundamental role in solving this confliction. Challenges of climate changes with its negative effect on water and animal [1] threaten sustainability of the animal production sector. In order to achieve sustainability, scientists applied micro-algae in livestock feed due to its better capability in producing the same amount of protein from lower land use than that from traditional crops (12.5 *Vs.* 1-2 tons per hectare of protein yield [2]. Moreover, micro-algae do not replace current needed crop cultivation which results from the competition on agricultural land due to its nutrient-dense properties [3]. The reduction in importing feed resources, e.g. soybean meal, also support the sustainability and help in making the feeding costs more economic and accordingly profitable. As reviewed by Spruijt *et al.* [4] micro-algae (SP) produced by about

Corresponding Author: M.M. El-Deeb, Animal Nutrition Research Department, Animal and Poultry Production Research Institute, Agricultural Research Center, Dokki, Giza, Egypt.

3000 tons/year in China, India, USA, Myanmar and Japan to use for human and animal nutrition as well as cosmetic products, e.g. powders, tablets, chips, pasta, extracts and drinks.

Several feeding trials for SP have been conducted on chickens, pigs, rabbits and ruminants [5]. *Spirulina sp.* is a potential candidate characterized by exceptional nutritional profile [6]. This distinguished structure give it the ability to bypass rumen degradation causing increased digestion and absorption of protein and nutrients within the abomasum [7] which produce 77.6% digestibility coefficient [8]. Quigley and Poppi [9] and Zhang *et al.* [10] stated that SP showed to express its effect through increasing microbial crude protein synthesis and reducing its retention time in the rumen. Becker [11] found that, nutritionally, the quality of algae protein either comparable or better than that of conventional plants. Moreover, micro-algae protein contains low amounts of lysine, cysteine and tryptophan, comparable or higher amount of methionine, threonine and isoleucine than that of soybean. This is of importance when micro-algae use as the main source of protein rich nutrient, which diminish the importance of carbohydrate content.

Moreover, SP supplementation found to have positive effect on milk production and composition [11-13]. Kulpys *et al.* [14] reported that feeding cattle on SP at the rate of 200 g/day was economically effective in increasing animal body weight and daily milk production. Heidarpour *et al.* [15] recorded no significant (P>0.05) effect for SP treatment on Holstein calves final weight, daily gain as well as feed intake, efficiency and its digestibility coefficient. Biochemical blood parameters were also found to be affected with adding SP to poultry and Holstein's calves diets [11 & 15 respectively].

Therefore, the present work implemented to examine the effect of adding *Spirulina platensis* to Zaraibi goat rations on their productive performance and health indicators.

MATERIALS AND METHODS

The Experimental Animals and Their Management: A number of 20 healthy Zaraibi does were selected from the flock of El-Serw Experimental Research Station located in the Northeast part of Nile Delta at Damietta governorate, which belongs to Animal Production Research Institute, Agriculture Research Center, Ministry of Agriculture, Egypt. The selected Zaraibi does (according to previous season data of parity and milk production) were, at the last third of pregnancy period, with initial average live body weight (LBW) of 40.8±0.70 Kg. These does were divided into two equal groups (10 does each). The first group represented the control which fed *ad libitum* concentrate feed mixture (CFM) plus berseem hay (BH) at the ratios of 50:50 during late pregnancy period and 49:51 during the suckling period. The second group fed daily the same ration at the ratio of 50:50 plus SP algal extract powder at the rate of 0.5 g/10 Kg LBW using rice paper sacks during the whole experimental period.

Each group was housed in a semi-roofed yard (4x3x5 meters) and animals were weighed twice monthly during the experimental period. This period started about 30 days before kidding and lasted for 90 days post-kidding (weaning time of kids).

The nutrients requirement was calculated according to NRC [16]. Animals were fed the above mentioned ingredients (CFM; 25% un-decorticated cotton seed meal, 43% yellow corn, 25% wheat bran, 3.5% molasses, 2.0% limestone, 1.0% common salt and 0.5% vitamin and minerals mixture). The vitamin and minerals mixture (per 3 kg) consist of vits. A, D_3, E, B_1, B_2, B_6, B_{12}, Biotin, Colin chloride, Pentothenic, Niacin, Folic acid at the rate of 1000000 IU; 200000 IU; 10000 mg; 1000 mg; 5000 mg; 1500 mg; 10 mg; 50 mg; 250000 mg; 10000 mg; 30000 mg; 1000 mg, respectively. Minerals included of Manganese, Zink, Iron, Copper, Iodine, Selenium and Cobalt at the rates of 60000; 50000; 3000; 4000; 300; 100 and 100 mg, respectively). Drinking water was available all over the times and diets were offered twice at 8.00 am and 3.00 pm daily.

Chemical Analysis of the Experimental Feed Ingredients: Proximate chemical analysis of the experimental ingredients was carried out according to A.O.A.C. [17] and presented in Table (1). Total digestible nutrients (TDN), digestible energy (DE) and metabolizable energy (ME) were calculated according to NRC [18].

For water soluble vitamins determination, ten grams of SP powder were homogenized with methanol for extraction, while acetone-chloroform (30:70 v/v) was used for extraction of fat soluble vitamins. The mixtures after shaken on a vortex mixer for 5 min was centrifuged at 4000 rpm for 5 min and filtered. The filtrates were evaporated under nitrogen and the residues were re-dissolved in 1 ml water for water soluble vitamins and in 1 ml butanol for fat soluble vitamins tell quantified by HPLC [19]. The β-carotene level was determined by spectrophotometric method according to A.O.A.C. [20]

Table 1: Chemical composition of the ingredients and calculated feeding values

Ingredients	Chemical composition (on DM basis, %) DM	OM	CP	EE	CF	NFE	Ash	TDN (%)	DE (Mcal/Kg DM)	ME (Mcal/Kg DM)
CFM	91.29	91.41	14.47	3.29	14.41	58.70	8.52	60.52	2.67	2.25
BH	89.13	86.71	12.19	1.74	35.51	38.69	14.81	59.50	2.62	2.20
**Spirulina* OM constituents	—	—	65.00	18.00	5.00	9.00	7.50	—	—	3.15

DM= Dry matter; OM= Organic matter; CP= Crude protein; EE= Ether extract; NFE= Nitrogen free extract;

TDN= Total digestible nutrients; DE= Digestible energy; CFM= Concentrate feed mixture and BH= Berseem hay (Egyptian clover hay).

Total Digestible Nutrients (TDN, %) = 129.39- 0.9419 (CF+NFE).

Digestible Energy (DE, Mcal/Kg DM) = % TDN x 0.04409.

Metabolizable Energy (ME, Mcal/Kg DM) = - 0.45 + 1.01 DE.

* Vitamins, minerals and pigments in each 10 gm of Spirulina: 32000 IU β-carotene, 0.31 mg Vit. B_1, 0.35 mg Vit. B_2, 1.46 mg Vit. B_3 10 µg Vit. B_5 80 µg Vit. B_6, 1 µg Vit. B_9, 32 µg Vit. B_{12} 29 µg Vit. A, 66 mg Choline, 10.1 mg Vit. C, 5 mg Vit. E, 25.5 µg Vit. K, 100 mg Calcium, 90 mg Phosphorus, 120 mg Potassium, 15 mg Iorn, 0.16 mg Manganese, 0.3 mg Zinc, 0.003 mg Selenium, 120.0 mg, Cupper, 60 mg Sodium, 1500 mg Phycothianine and 115 mg Chlorophyll

method number 2005.07. Mineral content of SP was determined according to A.O.A.C. [20] at 550-600°C for ashing process and prepared samples was diluted with 1:1 (10% HCL: Water) for measuring in Atomic Absorption Spectroscopy Shimadzu Model (AA-6650).

Does Performance: Live weight of the experimental does was recorded at the beginning of the experimental period and at the end of pregnancy (150 days) and after kidding as well as their weight at weaning of their kids. Post-kidding, LBW of does was recorded every 15 days tell 90 days post-kidding (weaning of kids) to follow the impact of SP addition on does' LBW. After kids weaning, does were hand milked twice daily and total milk production were recorded for 60 days.

Milk Production of Does: During suckling period, milk yield for individual ewes was recorded twice daily at 7 am and 5 pm using the technique of weigh-suckle-weigh (WSW) according to Ünal *et al.* [21]. From birth day, kids were all time with their dams and fed on dam's milk up till weaning (90 days). Kids were separated from their dams at 5 pm for the whole evening till the following day morning at 7 am. They were weighed and allowed to suckle their dams for 15 minutes period and reweighed and body weights were then recorded. After finished suckling, does were hand milked to remove any residual milk and the amount of daily milk yield of the doe was calculated from the difference in kids' weight before and after suckling plus the amount of milk milked by hand. Individual milk samples (100 ml) were hand milked of both sides of the udder from each doe in both experimental groups weekly through lactation period and pooled into one sample per doe for later analysis of fat, protein, lactose and total solids concentrations using a milk Oscan device (Mark®, 133B, N. FOSS, Electric, Denmark).

Kids Growing Performance: A number of 46 kids (From does in the two experimental groups) with an average LBW of 2.13±0.05 were weighed at birth and every 15 days (15, 30, 45, 60, 75 and 90 days) to study their growth performance.

Does' Blood Profile Measurements: For health-status purpose follow up of the experimental animals, some biochemical parameters in the serum were studied. Blood samples were collected three times, two weeks before parturition, one week post-parturition and the third one at weaning before feeding, from the jugular vein of 3 does in each group. The collected blood samples were centrifuged at 4000 round per minute for 20 minutes and separated serum stored frozen at -20°C till the biochemical analysis. Serum samples were analyzed for the determination of glucose (mg/dl), total protein (g/dl), albumin (g/dl), globulin (g/dl), urea nitrogen (Urea-N, mg/dl), aspartate aminotransferase (AST, u/L), alanine aminotransferase (ALT, u/L), cholesterol (mg/dl) and total lipids (mg/dl). Appropriate local commercial kits (Diamond Diagnostics, Egypt) were used for colorimetric biochemical determinations according to the procedure outlined by the manufacturer.

Statistical Analysis: A mixed model with a repeated measurements design was used to analyze does and kids weighing data of the whole experimental period. The model considered the variation between animals in litter size and gender. Litter size values used as a co-variance in the mixed model used for milk production data analysis. All computations implemented using software computer package [22]. Duncan multiple range test used to determine the significance of the results were considered at $P<0.05$ [23].

RESULTS AND DISCUSSION

Live Body Weight of Does: Following the recorded data of LBW every two weeks showed that their averages in Table (2) were without significant differences between the two experimental groups. But, its average in general significantly (P<0.05) increased with pregnancy advancement with high values for SP group. In the meantime, after kidding, SP-treated group weight loss was less than the control without significant differences. While, during the whole experimental period it was significantly (P<0.05) differed (Figure 1). These results clearly indicated that adding SP to the ration of dairy goats was of positive impact on their average LBW during pregnancy, suckling and weaning periods. This effect led to maintained LBW of does from loss during kidding time or even the whole experimental period.

Table 2: Live body weight of Zaraibi does and its changes

Group	Initial weight	Weight during pregnancy Before kidding	After kidding	Weight during suckling at 15 days	at 30 days	at 45 days	at 60 days	at 75 days	Weight at weaning (90 days)	Weight change at kidding	Total weight change
Control	40.8	46.2	37.6	36.6	35.8	34.9	34.0	33.6	33.2	-4.4	-7.6
SP	40.8	46.4	38.5	37.6	36.7	36.4	35.9	35.6	35.1	-3.4	-5.7
LSD (0.05)	NS	2.09				1.99				NS	1.66

LSD= Least significant difference at P<0.05. NS= Not significant

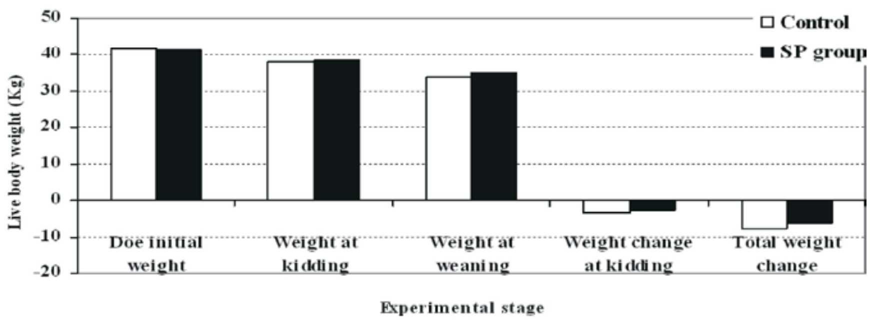

Fig. 1: Does' average live body weight and its changes during the experimental period stages

It is evident from the literature that food passage rate and protein absorption increases in the rumen at late pregnancy period by about 15%. So that, it is of importance to fed animals in the last third of pregnancy period with high energy content diets to improve feed efficiency via ME which recommended to be at least 12 MJ/kg DM. This can be achieved either by using good quality ingredients without dependence on low energy by-products [24]. The high values of SP content from both CP and ME (Table 1) may be reflected on the nutritional value of the diets, which in turn improved LBW of does and reduced weight loss at kidding and weaning of kids. In this concern, El-Deeb *et al.* [25] recorded that Rahmani ewes in the SP-treated group were superior in LBW post-lambing compared to the control. They added that adding SP to the diets of Rahmani ewes kept their weight loss less than that of the control ones.

These results are supported by Jameson [24] suggested a preserve effect for such supplying sources (minerals and vitamins via adding SP to ewe's diets) ensuring the maintenance of body functions with limited available body reserves during late pregnancy. Holman *et al.* [26] also reported an increase in the weight of sheep with dietary SP with increased body condition and other body conformity traits. The rich structure of SP from CP can explain the increase in LBW of SP-treated group upon the opinion of Panjaitan *et al.* [27] who stated that SP intake with 5.7 g in cattle provided greater increases in microbial crude protein (MCP) production and could also be fed safely at higher levels of nitrogen (N) intake, leading to increase their rumen degradable protein (RDP) and growth rate.

Milk Yield of Does: According to the milk yield figures recorded in Table (3) and Figure (2) the obtained results showed that there were no significant differences between the two experimental groups in total milk yield of does during suckling period. Meanwhile, with time order advancement of suckling period such differences in milk production were significant (P<0.05). It is of interest to note that feeding SP improved milk yield in general by about 6.0 at the first suckling period to 8.6% after 60 days (being, 2.13 Vs. 2.01 and 1.90 Vs. 1.75, respectively).

These results are in harmony with Yaakob *et al.* [28] and Khalifa *et al.* [29] who reported, in general, that SP induced valuable effect in increasing milk production. Enriching diets with sufficient energy considered one of the coverage factors to have good milk production after lambs born [24]. Khalifa *et al.* [29] used SP with goats and found positive correlation coefficients between its feeding and does body weight, suckling milk flow and energy of suckling milk.

Table 3: Average daily milk yield of Zaraibi does fed SP during suckling period

	Experimental groups			
Lactation days	Control	SP	Effect of time of lactation	Improvement % in milk yield
15	2.01±0.09	2.13±0.15	2.07±0.04	5.97
30	1.93±0.09	2.08±0.15	2.01±0.05	7.77
45	1.84±0.09	1.99±0.16	1.92±0.05	8.15
60	1.75±0.08	1.90±0.15	1.83±0.05	8.57
75	1.66±0.08	1.79±0.16	1.73±0.06	7.83
90	1.57±0.09	1.70±0.15	1.64±0.06	8.28
LSD (0.05)	NS			0.26

LSD= Least significant difference at P<0.05. NS= Not significant

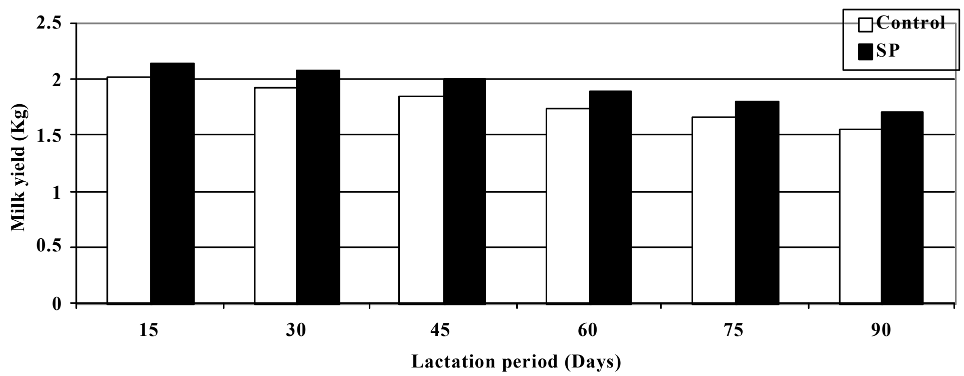

Fig. 2: Daily milk yield of does fed SP in their diets during the suckling period

Milk Composition Characteristics: Milk composition traits (Table 4) showed significant (P<0.05) differences between the two experimental groups at 30 and 60 days during suckling period in fat, lactose, total solids and ash constituents. These differences were not significant in both experimental groups in terms of protein and solids not fat contents.

Table 4: Average milk component (%) Zaraibi does fed SP during suckling period

	At 30 days			At 60 days		
Item	Control	SP	LSD (0.05)	Control	SP	LSD (0.05)
Fat	3.56±0.14	4.90±0.31	0.76	3.67±0.14	5.78±0.25	0.63
Protein	2.49±0.07	2.49±0.07	NS	2.53±0.07	2.64±0.07	NS
Lactose	3.91±0.17	3.63±0.18	NS	3.93±0.21	3.40±0.09	0.51
Total soluble solids	10.67±0.17	11.76±0.32	0.81	10.86±0.26	12.58±0.32	0.91
Solids not fat	7.11±0.14	6.86±0.14	NS	7.18±0.17	6.79±0.10	NS
Ash	0.72±0.004	0.75±0.007	0.02	0.72±0.003	0.76±0.008	0.02

LSD= Least significant difference at P<0.05. NS= Not significant

Within this frame milk composition may be affected with total volatile fatty acids (VFA) produced in the rumen as well as digestion coefficients, since the reduction in VFA and nutrients availability in the small intestine considered responsible for decreasing milk composition. Spirulina found to decrease protein degradability in the rumen and caused changes in rumen bacteria diversity with increased microbial crude protein synthesis efficiency in steers' rumen [7]. Spirulina not only increased microbial crude protein synthesis, but also decreased its retention time in the rumen [9]. Moreover, about 20% of the dietary SP is bypass rumen degradation and turned available for direct absorption in the abomasum [7, 9, 10].

The beneficial effects of adding SP may be due to its high protein, β-carotene vitamin, minerals mixture and energy [30-33] which provide pregnant does with sufficient nutrients to support maintenance of metabolic processes, mammary gland, colostrum and milk yield and composition.

Growth Performance of Kids: Data in Table (5) kids borne from does fed SP indicated that the significant ($P<0.05$) effect of started to be noticed after 60 days of suckling. Spirulina group gained more significant ($P<0.05$) weight than the control group. Although, SP group recorded higher ($P<0.05$) average kilogram kids born / doe than the control group, both groups were not significantly differed in average kilogram weaned / doe. Meanwhile, SP-treated group gave 22 live kids from which 19 kids lasted till weaning, while the control group produced 24 kids from which 19 kids lasted till weaning. This indicated that mortality ratio in the control group estimated by 20.83% *Vs.* 13.64% in the SP-treated group. This positive result may be attributed to the amount and composition of the produced milk in the SP-treated group which related to the type of birth (1, 2, 3 or 4). These results generally suggest that feeding SP supported the productive performance of the experimental does in terms of average LBW of their kids, average daily weight gain, average kilogram kids born / doe and high survival rate. This can be attributed to the rich composition of SP from metabolizable energy as well as various vitamins, minerals and pigments which interfere with different metabolic cycles that led to increasing milk production quantity and quality. The increased average Kg weaned / doe increase the opportunity of doe profitability.

Table 5: Growth performance of Zaraibi does' kids during the suckling period

Item	Experimental groups ------------------------- Control	SP	LSD (0.05)
No. of does	10	10	-
No. of stillbirth kids	0	0	-
No. of alive kids at 0 day	24	22	-
No. of alive kids at 90 days (at weaning)	19	19	-
Average birth weight, Kg	2.09±0.06	2.16±0.08	NS
Average LW at 15 days of age, Kg	4.01±0.19	4.04±0.14	NS
Average LW at 30 days of age, Kg	4.81±0.31	5.52±0.27	NS
Average LW at 45 days of age, Kg	6.30±0.48	7.14±0.46	NS
Average LW at 60 days of age, Kg	7.64±0.57	8.91±0.77	0.24
Average LW at 75 days of age, Kg	9.05±0.68	10.51±0.90	0.39
Average LW at 90 days of age, Kg (Weaning)	10.87±0.81	12.25±1.05	0.84
Average daily body gain, gm	41.82±2.53	78.17±6.63	14.12
Average Kilogram kids born / doe	2.75±0.21	3.30±0.38	0.85
Average Kilogram weaned / doe	27.47±1.09	28.82±2.29	NS
Mortality, %	20.83±0.08	13.64±0.07	0.20

LSD= Least significant difference at P<0.05. NS= Not significant

Several authors [34-36] observed that the resulted improvement in milk yield of does fed SP-ration was associated with increasing growth rate of does and their kids. Abd Eldaim *et al.* [33] concluded that high level of vitamin A in SP supplementation for pregnant ewes improved their lambs' survivability and performance. Jameson [24] stated that meeting the rapid increase in energy and protein requirements of ewes during the last eight weeks of pregnancy via good nutritional management, assure that mortality is increased in lambs with a low weight at birth and/or those born to poor body condition's ewe. Moreover, El-Deeb *et al.* [25] reported that ewes fed SP in their diets reared their lambs and gave them more weight during the suckling period with significant ($P<0.01$) higher weights than those in the control group.

Blood Parameters Indicators: The tested blood parameters of does (Table 6) showed that SP group generally has higher significant ($P<0.05$) values of the tested blood parameters than the control group. The increased values of glucose, total protein, globulin and albumin (Immunity indicators) and urea-N reflect the improvement in health status and accordingly productivity of does fed SP. The increased levels of total proteins (TP), albumin (AL) and globulin (GL) in the SP-treated group might be owing to high N-concentration. Similar trend was recorded in the concentration of blood urea-N. Moreover, there were no significant changes in liver enzymes (AST & ALT) with tendency to a slight reduction in SP group than the control ones.

Table 6: Blood parameters of Zaraibi does fed SP in their rations

Item	Experimental groups ----------------------------------- Control	SP	LSD (0.05)
Glucose (mg/dl)	65.77±1.81	72.37±0.43	6.32
Total protein (gm/dl)	6.89±0.19	7.83±0.07	0.67
Albumin (gm/dl)	3.00±0.02	3.19±0.05	0.17
Globulin (g/dl)	3.89±0.16	4.64±0.02	0.56
Urea-N (mg/dl)	15.96±0.24	17.49±0.24	1.14
Cholesterol (mg/dl)	103.8±0.29	106.2±0.29	1.38
Total lipids (mg/dl)	308.87±0.67	313.30±0.33	2.54
AST (u/l)	47.33±0.27	47.26±0.27	NS
ALT(u/l)	16.81±0.19	16.53±0.17	NS

LSD= Least significant difference at P<0.05. NS= Not significant

The obtained findings in the present experiment were in the normal range and followed similar trend to those obtained by El-Deeb *et al.* [25] on Rahmani ewes. The increase in TP, AL, GL and urea-N levels in blood of SP-treated group can be attributed to the high protein content in Spirulina, which is efficiently utilized by rumen microflora [38]. *Spirulina platensis* found to have a hepato-protective effect in rats throughout normalizing the increase in AST and ALT [39].

Garcia-Martinez *et al.* [40] explained that such hepato-protective potential of SP induced by the natural antioxidant components (vitamins E & C, minerals, phenolic compounds and some fatty acids) which may act individually or together. Hassanien *et al.* [41] found that SP in ration of Damascus lactating goats tended to higher non-significantly serum total protein, albumin, urea-N, AST, cholesterol and triglycerides.

CONCLUSION

Upon the aforementioned findings, it can be concluded that SP as feed additives in rations of lactating goats is of respect potential to cover feeding requirements of does and their kids during both pre-kidding and suckling periods. The study encourages the use of similar rich condensed nutrient resource during last third of pregnancy period to improve meet nutrient requirements and feed utilization.

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