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Influence of *Spirulina platensis* Supplementation Alone or Mixed with Live Yeast on Blood Constituents and Oxidative Status of Damascus Goats and their New Born

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ABSTRACT

The goal of this study was to investigate the effect of supplementing Spirulina, either alone or in a mix with live yeast, on blood biochemical constituents and oxidative status in goats and their kids. Eighteen pregnant multiparous goats were equally distributed into three groups. The first group (control) received normal feeding without any additions. The second group (SP) received the normal diet plus 5 grams per head per day of *Spirulina platensis*, while the third group (SPSC) received the same amount of SP mixed with 3 grams per head per day of *Saccharomyces cerevisiae* for 30 days before parturition and continued for 45 days of lactation period. Results revealed that applying both additives caused (P≤0.01) decrease in serum cholesterol, urea, alanine aminotransferase, lipid peroxidase, and glutathione peroxidase. Serum insulin and triiodothyronine levels increased (P≤0.05) in goats fed diets supplemented with SP alone or mixed with SC compared to the control group. Concentrations of calcium and phosphorous were higher (P≤0.05) in both treated groups than in the control group. Birth weights for kids born from goats supplemented with SP alone or mixed with SC were higher (P≤0.05) compared to kids in the control group. Serum cholesterol concentration decreased (P≤0.05) in the SPSC kids group, while serum phosphorus level increased (P≤0.05) in SP kids group. It could be concluded that supplementation with SP alone or mixed with SC improved health and antioxidant status in both *Damascus* female goats and their newborns.

Keywords: Blood constituents, Damascus goats, live yeast, Oxidative status, *Spirulina Platensis*.

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INTRODUCTION

Goats are considered one of the most economically important animals in Egypt, where there are about 4.3 million goats (**Ashour *et al.*, 2015**). Furthermore, goats play a vital role in the economy and social life of pastoral societies in arid and semi-arid regions, as they represent the major source of meat, milk, and fibre (**Al-Sobaiy, 2010**). So, it's necessary to improve goat's productivity under limited feed resources and climate change challenges in Egypt. Numerous chemical feed additives have been used to enhance animal productivity, but they have disadvantages, including health risks for animals and consumers (**Mantovani *et al.*, 2022**). Therefore, natural feed supplements have to be searched for usage (**Matloup, 2020**).

Several studies have discussed the application of microalgae as natural feed additives for different species of animals (**Altomonte *et al.*, 2018**); **Abd El-Hamid *et al.*, 2022**. *Spirulina* is emerging as a potential candidate to fulfill these criteria. *Spirulina platensis sp.* is a filamentous, spiral-shaped cyanobacterium, formally classified as a blue-green microalgae (**Gupta *et al.*, 2008**) as it has high biological value in proteins, vitamins, minerals, vital fatty acids, and a variety of active ingredients (**El-Deeb *et al.*, 2022**). *Spirulina* supplementation improved animal health and oxidative status (**Deng and Chow, 2010**), hormonal and immunological functioning (**EL-Sabagh *et al.*, 2014**) and productivity in different animal species, including cows (**Shamsudin *et al.*, 2018**), sheep (**Abd Eldaim *et al.*, 2018**) and sows (**Lugarà *et al.*, 2022**).

In ruminants, live yeast such as (*Saccharomyces cerevisiae*) has been used to improve rumen fermentation, total VFA production, and stabilize rumen pH (**Abbas *et al.*, 2021**), reduce heat stress (**Guyot *et al.*, 2005**) and improve health status (**Desnoyers *et al.*, 2009**). Few studies focused on

whether combining the microalgae with yeast would be beneficial to ruminant performance (**Rabee *et al*., 2022**). Therefore, the objective of this study was to evaluate the effect of mixing the microalgae (*Spirulina platensis sp*.) with live yeast (*Saccharomyces cerevisiae*) during the pre- and postpartum period on blood constituents and oxidative status in *Damascus* goats and their newborns.

MATERIALS AND METHODS

Ethical approval

All experimental procedures were carried out in accordance with the guidelines established by the Desert Research Center's Animal Production Division's ethical committee and derived from the EU Directive for the protection of experimental animals (2010/63/EU).

The study location

This study was carried out at Marriott Research Station (Latitude 31° 00' N; Longitude 29° 47' E) belonging to Desert Research Center, Egypt.

Animal management

Eighteen pregnant multiparous *Damascus* female goats 3-5 years old with an average body weight of 48±0.23 kg were used in this study. The study lasted from October to December 2022. The experimental animals were housed in closed pens throughout the experimental period. According to their body weight requirements (**NRC, 1985**), a concentrate mixture was fed to all animals. Animals were given Egyptian clover hay (*Trifolium alexandrinum*) as roughage *ad libitum*. Fresh water was presented twice daily.

The Experimental design

Animals were distributed into three equal groups. The first group served as a control and received only the normal diet. The second group received the normal diet plus 5 grams per head per day of Spirulina *platensis* powder (SP). The third group received the normal diet plus 8 grams per head per day ((SPSC), a mixed diet containing 5 grams of SP with 3gram live yeast (*Saccharomyces cerevisiae*) (SC) in powder form. Administration of additives started 30 days before parturition and continued for 45 days from the lactation period. Collecting measurements was performed 15 days after the additive was supplemented in the concentrate mixture.

Blood samples

Blood samples were collected from all animals on days -15 before parturition, 0 days of parturition, 15, 30, and 45 days after parturition. Blood samples of newborns were collected biweekly for up to 45 days of parturition (early waning). Serum was then harvested after centrifugation at 5,000 g for 10 min and then stored at -20°C for further analysis.

Blood biochemistry and trace elements analyses

Serum total proteins (TP), albumin (ALB), glucose (GLU), cholesterol (CHOL), urea, alanine aminotransferase (ALT), and aspartate aminotransferase (AST) were analyzed using commercial kits (Biomed, Germany) according to **Henry, (1964); Trinder, (1969); Miyada *et al*., (1972); Tietz, (1976**); **Shephard and Mezzachi, (1983);Tietz, (1994)**, respectively. Calcium (Ca), sodium (Na), phosphorous (P), and potassium (K) were determined using colorimetric kits (Biomed, Germany), according to **Maruna, (1958**); **Erthinghasausen, (1972); Henry *et al*., (1974) and Moorehead and Briggs, (1977)**, respectively.

Biomarkers of antioxidant enzymes activities

Antioxidants enzymes activities of lipid peroxidase (LP), nitric oxide (NO) and glutathione peroxidase (GPX) were assayed calorimetrically using commercial kits (Biodiagnostic Research, Egypt) according to **Montgomery and Dymock, (1961); Paglia and Valentine, (1967**); **Satoh, (1978),** respectively.

Hormonal assay

Triiodothyronine (T_3) and insulin (INS) hormones were analyzed using ELISA kits (Cusabio, USA). The intra-and inter-assay CV's were (<15%).

Data Birth and productivity traits of new born

Data birth including type of birth and kidding rate were calculated, kids were weighed at birth and after 45 day of birth (early weaning age) using a digital balance to calculate average daily weight gain.

Statistical analysis

Data of goats including, blood biochemical concentrations, biomarkers of antioxidant enzymes activities and trace elements were analyzed throughout the periods (-15, 0, 15, 30, 45) of this study by repeated measures analysis of variance (ANOVA) to determine the fixed effects of group, day, and day by group interaction by the **SAS (2004)** procedure using the following model:

$Y_{ijk} = \mu + G_i + Day_j + G*Day_{ij} + e_{ijk}$

Y_{ijk} = observations, μ= Overall means, G_i = effect of group (i: 1-3), Day_j = effect of Days (j: 1-5), $G*Day_{ij}$ = interaction between groups and days.

e_{ijk} = Experimental error. Duncan's multiple range test used to separate means.

Type of birth data was analyzed by the chi-squared test. Another General Linear Model procedure (SAS, 2004) was used for the statistical analysis of kidding rate, birth and weaning weights, average daily gain and some blood biochemical parameters of kids using the following model:

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

Y_{ij} = is the studied treat.

μ = Overall mean, T_i = Effect of treatment (i = 1-3), e_{ij} = Experimental error.

RESULTS

The levels of serum of biochemical parameters in females in the study groups

Overall means of serum total proteins (TP), albumin (ALB) and glucose (GLU) concentrations did not differ significantly among the experimental groups (Control, 5.22±0.11 g/dL, 2.65±0.11 g/dL and 62.02±2.02 mg/dL) vs. (SP, 5.05±0.12 g/dL, 2.42±0.12 g/dL and 61.57±2.21 mg/dL) or (SPSC, 5.30±0.12 g/dL, 2.67± 0.12 g/dL and 62.14± 2.21 mg/dL), respectively (Table 1). In addition, there were no interactions between days and treatments in these parameters. On the other hand, concentrations of serum albumin and glucose were affected by time (Table 1).

Providing SP and SPSC resulted in decreasing (P≤0.01) cholesterol (CHOL) in treated groups (115.06 and 119.16±2.61 mg/dL, respectively) compared with the control group (127.66±2.38 mg/dL). No interaction or days effect were found (Table 1). The overall mean of serum urea concentrations showed a similar manner of CHOL, where treated groups had lower urea values (26.42, 29.55±1.34 mg/dL, respectively) compared to the control (37.28±1.37 mg/dL). The interaction between treatment and days was non-significant, while the level of urea was affected throughout the experimental period (Table 1). Concerning the levels of liver enzymes, treatment with *S. platensis* alone or mixed with *Saccharomyces cerevisiae* led to a decrease (P≤0.05) serum alanine aminotransferase (ALT) levels (97.15, 99.73 ±1.31 IU, respectively) compared to the control group (105.28±1.14 IU/L), while serum aspartate aminotransferase (AST) activity was not affected among differing groups (Control, 15.24±1.29 IU, SP, 12.43±1.39 IU, SPSC, 11.56±1.39 IU). No interaction or time effects were detected in both liver enzymes (Table 1).

Changes in hormonal profile in female goats

Overall mean serum triiodothyronine (T_3) concentration increased (P≤0.01) in the SP group (1.22±0.05 ng/mL), followed by the SPSC group (0.94±0.05 ng/mL) compared to the control (0.64±0.05 ng/mL). No interactions between days and treatments were detected (Table 2). Concerning the serum level of insulin (INS), the obtained results demonstrated that providing SP and SPSC increased (P≤0.05) insulin (INS) concentration in treated goats (2.02, 1.85±0.21 µIU/mL, respectively) as compared to the control ones (1.24±0.20 µIU/mL). No interaction between group and time was detected (Table 2). While serum INS concentrations were affected throughout the experimental period,

Levels of some serum mineral concentrations in female goats

The overall means of serum calcium (Ca) and phosphorus (P) concentrations were higher (P≤0.05) in both treated groups SP, 6.25± 0.27 and 6.50± 0.32 (mg/dl) and SPSC, (6.06± 0.27 and 6.84 ±0.32 mg/dl), respectively than those of the control group (4.76± 0.27 and 5.70 ±0.32 mg/dL). However, serum sodium (Na) and potassium (K) levels didn't show any significant differences among the experimental groups. In addition, all of these parameters (with the exception of serum K levels) showed no interaction or days effect (Table 3).

Changes in some antioxidant activities in female goats

Serum levels lipid peroxidase (LP) decreased (P≤0.01) in SP and SPSC groups with values being 4.81 and 4.99±0.11 nM/ML, respectively, as compared to the control group (5.80±0.11 nM/mL). No interaction between days and treatments was found (Fig.1). On the other hand, the mean serum glutathione peroxidase (GPX) value decreased (P≤0.01) in the SP group (1.19±0.10 mU/mL), followed by the SPSC group (1.76±0.10 mU/mL), compared with the control group (2.66±0.10 mU/mL). The interaction between days and treatments was found. The higher (P≤0.05) values were recorded in control goats at day -15 (2.21 ± 0.22 mU/mL) and continued to reach their peak at days 0 and 15 after parturition (3.13, 3.20± 0.22 mU/mL), respectively, while the lowest values were recorded in SP and SPSC groups at day 30 (1.16, 1.74±0.22 mU/mL, respectively) and day 45 (1.24, 1.55±0.22 mU/mL) in order after parturition. Levels of serum nitric oxide (NO) did not change among different groups (SP, 20.68±1.17, SPSC, 20.76±1.17 µM/L, and control, 19.87±1.17 µM/L) (Fig.1). The interaction (group× days) or time effects were not found.

Table 1: The levels of some blood constituents in female goats fed supplementation with SP alone or mixed with SC before and after lambing.

Items	Groups	Days					±SE	Overall	SEM	*P*- value		
		-15	0	15	30	45				G	D	G×D
TP (g/dL)	Control	4.92	4.82	5.45	5.48	5.43	0.23	5.22	0.11	0.31	0.18	0.45
	SP	5.12	5.05	4.97	5.05	5.06	0.26	5.05	0.12			
	SPSC	4.80	5.35	5.41	5.77	5.16	0.26	5.30	0.12			
	Overall	4.95	5.07	5.28	5.43	5.21	0.15					
ALB (g/dL)	Control	1.83	2.41	2.91	3.20	2.90	0.25	2.65	0.11	0.29	0.01	0.41
	SP	2.03	2.48	2.09	2.81	2.70	0.27	2.42	0.12			
	SPSC	1.92	2.59	2.77	3.58	2.48	0.27	2.67	0.12			
	Overall	1.92^{Z}	2.49^{Y}	2.59^{Y}	3.20^{X}	2.69^{Y}	0.15					
GLU (mg/dL)	Control	59.52	57.74	66.07	60.71	66.07	4.52	62.02	2.02	0.98	0.05	0.53
	SP	58.57	55.00	69.28	62.85	62.14	4.95	61.57	2.21			
	SPSC	65.00	54.28	59.28	57.85	74.28	4.95	62.14	2.21			
	Overall	61.03^{XY}	55.67^{Y}	64.88^{X}	60.47^{XY}	67.49^{X}	2.78					
CHOL (mg/dL)	Control	121.59	136.55	131.8	126.79	121.53	5.34	127.66^{A}	2.38	0.01	0.29	0.17
	SP	123.92	117.39	108.1	111.21	114.63	5.85	115.05^{B}	2.61			
	SPSC	125.62	116.02	128.6	111.55	113.97	5.85	119.16^{B}	2.61			
	Overall	123.71	123.32	122.8	116.51	116.71	3.28					
Urea (mg/dL)	Control	33.83	36.85	34.48	40.95	40.30	3.06	37.28^{A}	1.37	0.01	0.05	0.48
	SP	28.66	25.86	24.13	23.06	30.38	3.06	26.42^{B}	1.37			
	SPSC	27.37	23.92	29.09	31.68	35.68	3.06	29.55^{B}	1.34			
	Overall	29.95^{Y}	28.88^{Y}	29.23^{Y}	31.89^{XY}	35.45^{X}	1.76					
AST (IU/L)	Control	14.00^{b}	27.56^{a}	7.90^{b}	16.68^{b}	10.10^{b}	2.78	15.24	1.29	0.13	0.13	0.05
	SP	15.38^{b}	16.60^{b}	7.35^{b}	13.20^{b}	9.64^{b}	3.04	12.43	1.39			
	SPSC	11.86^{b}	10.80^{b}	10.00^{b}	10.67^{b}	14.48^{b}	3.04	11.56	1.39			
	Overall	13.74	18.32	8.42	13.51	11.40	1.71					
ALT (IU/L)	Control	103.11	107.75	100.2	106.27	109.06	2.51	105.28^{A}	1.14	0.01	0.08	0.31
	SP	97.69	97.27	94.36	97.45	98.99	2.76	97.15^{B}	1.31			
	SPSC	103.73	105.59	95.94	97.60	95.80	2.76	99.73^{B}	1.31			
	Overall	101.51	103.53	96.84	100.44	101.28	1.54					

$^{A-B}$ Letters between groups within the same column differ significantly.
$^{a-b}$ Letters and $^{X-Z}$ letters values within the same rows differ significantly.
Day -15: Days of late pregnancy, **Day 0:** Day of parturition
Days 15, 30 and 45: Days of early lactation period.

Table 2: The changes in Triiodothyronine (T_3) and insulin (INS) hormones in goats fed supplementation with SP alone or mixed with SC before and after lambing.

Items	Groups	Days								*P*- value		
		-15	0	15	30	45	±SE	Overall	SEM	G	D	G×D
T_3 (ng/mL)	Control	0.56	0.64	0.65	0.67	0.69	0.10	0.64^{C}	0.05	0.01	0.18	0.63
	SP	1.06	1.01	1.43	1.31	1.27	0.11	1.22^{A}	0.05			
	SPSC	0.89	0.91	0.87	0.96	1.08	0.11	0.94^{B}	0.05			
	Overall	0.84	0.86	0.98	0.98	1.02	0.64					
INS (µIU/mL)	Control	1.09	0.89	1.37	1.52	1.36	0.43	1.24^{B}	0.20	0.05	0.05	0.17
	SP	1.85	2.71	1.48	2.31	1.71	0.48	2.02^{A}	0.21			
	SPSC	1.37	3.42	0.89	1.80	1.79	0.48	1.85^{A}	0.21			
	Overall	1.43^{Y}	2.34^{X}	1.24^{Y}	1.88^{XY}	1.62^{XY}	0.26					

$^{A-C}$ Letters between groups within the same column differ significantly.
$^{X-Z}$ Letters values within the same rows differ significantly.
Day -15: Days of late pregnancy, **Day 0:** Day of parturition, **Days 15, 30 and 45:** Days of early lactation period.

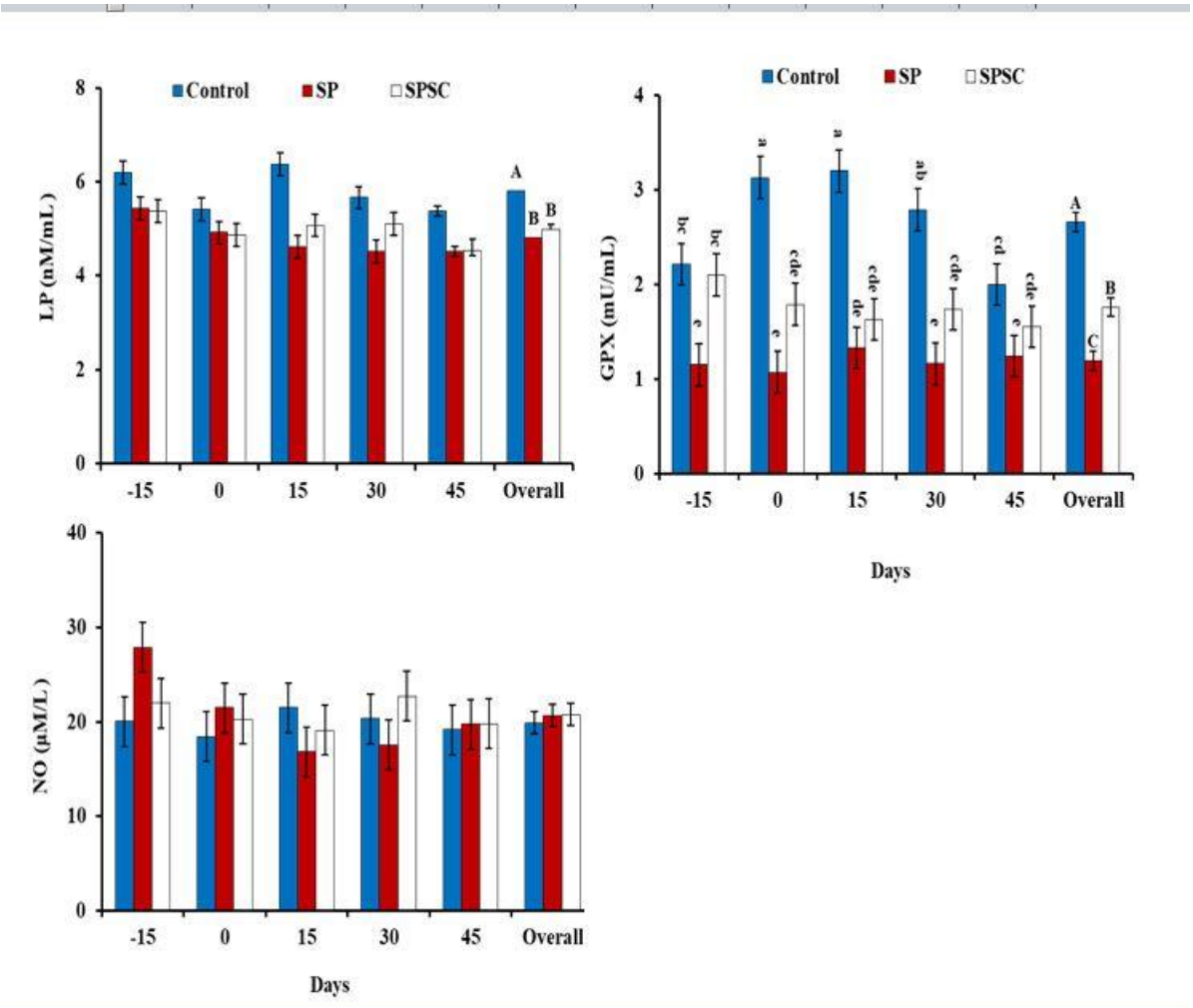

Fig. 1: The changes in some antioxidant enzymes activities in female goats fed supplementation with SP alone or mixed with SC before and after lambing.

Table 3: The levels of some trace elements Means ±SE in female goats fed diets supplemented with SP alone or mixed with SC before and after lambing

Items	Groups	Days								*P*- value		
		-15	0	15	30	45	±SE	Overall	SEM	G	D	G×D
Ca (mg/dL)	Control	5.00	4.40	4.54	5.47	4.38	0.61	4.76^{B}	0.27	0.05	0.11	0.41
	SP	6.09	6.50	6.88	6.36	5.41	0.61	6.25^{A}	0.27			
	SPSC	7.40	5.20	5.29	6.95	4.45	0.61	6.06^{A}	0.27			
	Overall	6.16	5.37	5.57	6.26	5.08	0.35					
Na (mEq/L)	Control	110.35	107.95	140.63	98.28	140.63	11.61	119.57	5.19	0.17	0.34	0.27
	SP	141.36	123.79	127.24	137.14	132.50	11.61	132.14	5.19			
	SPSC	134.91	139.03	130.38	116.73	133.14	11.61	133.14	5.19			
	Overall	128.87	123.59	132.75	117.38	135.44	6.70					
P (mg/dL)	Control	5.77	5.03	6.55	5.19	5.97	0.72	5.70^{B}	0.32	0.05	0.97	0.58
	SP	6.22	6.86	6.12	6.72	6.61	0.72	6.50^{A}	0.32			
	SPSC	7.51	7.15	5.72	7.00	6.81	0.72	6.84^{A}	0.32			
	Overall	6.50	6.35	6.13	6.30	6.46	0.42					
K (mEq/L)	Control	15.32	15.98	17.29	17.47	17.53	0.69	16.72	0.32	0.48	0.01	0.87
	SP	15.18	14.87	17.50	17.47	17.50	0.69	16.50	0.32			
	SPSC	15.68	17.17	17.38	17.50	17.47	0.69	17.04	0.32			
	Overall	15.39^{Y}	16.00^{Y}	17.39^{X}	17.48^{X}	17.50^{X}	0.39					

$^{A-B}$ Letters between groups within the same column differ significantly.
$^{X-Z}$ Letters values within the same rows differ significantly.
Day -15: Days of late pregnancy, **Day 0:** Day of parturition, **Days: 15, 30 and 45:** Days of early lactation period

Data on birth and productive traits of newly born kids

Birth weight for kids born from goats supplemented with SP was (P≤0.05) higher (2.56±0.09 Kg) flowed by the SPSC kids group (2.41±0.09 Kg) compared with the control kids group (2.13±0.09 Kg), while the kidding rate, average daily gain ADG, and weaning weight were not significantly changed. Numerical variable increases were noted in twining and triplet rates in kids' borne from treated groups compared with kids born from the control group (Table 4).

Table 4: Type of birth, kidding rate and productivity traits of kids born from goats fed supplementation with SP alone or mixed with SC before and after parturition

Items		Groups			*P*- value
		Control	SP	SPSC	
Type of Birth	Single rate (%)	62.5(5/8)	50(4/8)	37.5(3/8)	0.52
	Twins rate (%)	37.5(3/8)	37.5(3/8)	62.5(5/8)	
	Triple rate (%)	0(0/8)	12.5(1/8)	0(0/8)	
Kidding rate (%)		137.5±21.30	162.5±21.30	162.5±21.30	0.63
Birth weight (Kg)		2.13±0.09^{B}	2.56±0.09^{A}	2.41±0.09^{AB}	0.05
Average daily gain (ADG, g/d)		92.59±10.42	83.70±10.42	92.96±10.42	0.78
Weaning weight (kg)		6.30±0.54	6.33±0.54	6.60±0.54	0.91

Levels of some blood biochemical parameters in newborns

The results indicated that microalgae (*Spirulina platensis*) supplementation alone or mixed with live yeast (*Saccharomyces cerevisiae*) in doe goats had no significant effect on the serum blood of newborns, including total protein, albumin, globulin, glucose, urea, aspartate aminotransferase (AST), and alanine aminotransferase (ALT) (Table 5). However, the overall mean of serum cholesterol (CHOL) was lower (P≤0.05) in the kids SPSC group (130.83±7.58 mg/dL) and SP kids groups (138.09±8.47 mg/dL) compared with control kids groups (159.97±8.47 mg/dL). The overall mean serum phosphorus (P) concentration was (P≤0.05) higher in SP kids (4.99±0.10 mg/dL) than in the SPSC or control kids group (4.58±0.09 vs. 4.63±0.10 mg/dL), respectively. Conversely, serum calcium (Ca) concentration was not changed among differing groups of kids (control, 5.14±0.18, SP, 5.09±0.18, and SPSC, 5.20±0.18 mg/dL). Overall means of serum lipid peroxidase (LP) concentration were not affected among different groups of kids (control, 7.03±0.38 vs. SP, 5.99±0.38 and SPSC, 7.13±0.34 nM/mL). The same trend was observed in serum nitric oxide (NO) concentrations in control kids (27.57±3.25 µmol/L) compared to SP kids (35.34±3.25 µmol/L) or SPSC kids (30.54±2.91 µmol/L) (Table 5).

Table 5: Overall means of some biochemical blood parameters in new born goats fed supplementation with SP alone or mixed with SC

Items	Groups			*P*- value
	Control	SP	SPSC	
TP (g/dL)	4.87±0.21	4.87±0.21	4.81±0.19	0.97
ALB (g/dL)	3.18±0.15	3.60±0.15	3.40±0.13	0.19
GLO (g/dL)	1.70±0.27	1.27±0.27	1.40±0.24	0.53
GLU (mg/dL)	70.98±3.10	73.88±3.10	74.52±2.77	0.69
Urea (mg/dL)	35.89±1.31	38.78±1.31	36.30±1.18	0.28
CHOL (mg/dL)	159.97±8.47^{A}	138.09±8.47^{B}	130.83±7.58^{B}	0.05
AST (IU/L)	19.37±0.55	19.05±0.55	19.03±0.49	0.88
ALT (IU/L)	135.265±3.44	140.95±3.44	136.82±3.08	0.50
P (mg/dL)	4.63±0.10^{B}	4.99±0.10^{A}	4.58±0.09^{B}	0.05
Ca (mg/dL)	5.14±0.18	5.09±0.18	5.20±0.18	0.92
LP (nM/mL)	7.03±0.38	5.99±0.38	7.13±0.34	0.10
NO (µmol/L)	27.57±3.25	35.34±3.25	30.54±2.91	0.28

$^{A-B}$ Letters between groups within the same column differ significantly.

DISCUSSION

The hypocholesterolemic effect of Spirulina platensis observed in this study could be attributed to the large amount of cystine found in Spirulina content (**Bashir *et al*., 2016**). **Vedi *et al*. (2013)** reported a negative correlation between blood cholesterol levels and the amount of cystine in dietary protein. Decreasing blood cholesterol was reported in goats, sheep, and cows (**El-Sabagh *et al*., 2014; Khalifa *et al*., 2016; Atalla *et al*., 2023**). In addition, the increment in thyroid hormone (T_3) levels (Table 2) led to the oxidation of fatty acids and increased the hydroxylase levels that transform cholesterol into bile acids, reducing their serum cholesterol concentrations (**Cho and Kim, 2015**).

In the current investigation, supplementing SP, either alone or in mix with SC, reduced the serum urea concentration and ALT enzyme activity in doe goats (Table 1). In agreement with these findings, **Khalifa *et al*., (2016)** reported that urea levels decreased in lactating goats fed a diet supplemented with *S. platensis* microalga. Moreover, the urea concentrations were reduced significantly in cows fed microalgae *Arthrospira platensis* (**Lokman-Shamsudin *et al*., 2018**). In this study, the decrement in serum urea concentration was due to the ability of SP to increase branched-chain fatty acids in the rumen and increase ruminal microbial protein, which may reduce blood urea nitrogen (**Panjaitan *et al*., 2015**). Furthermore, **El-Ashry *et al*. (2001)** reported that adding live yeast to buffalo diets had a tendency to lower plasma urea levels. Generally, the blood urea levels in the present study were in the normal range for goats (**Kalio *et al*., 2014**). **El-Deeb *et al*. (2022)** reported that supplementing ewes' diets with SP algae reduced ALT enzyme activity. This decrease in our results supports the protective role of SP against

liver dysfunction (**Azab *et al.*, 2013**). As a result of *S. platensis'* containing bioactive components, including vitamins E and C, minerals, phenolics, and fatty acids, in the mass-spectrometry chemical analyses (**Garcia-Martinez *et al.*, 2007**).

The results showed that serum T_3 and INS levels increased in treated goats (Table 2). Few studies investigated the effect of SP alone or mixed with live yeast SC on (T_3) and (INS) hormonal profiles. **Abd El-Hamid *et al*., (2022)** reported that serum T_3 levels increased as a result of *Nannochloropsis oculata* microalga supplementation in rabbits; the same result was found with SP in broilers (**Omar *et al*., 2022**), and in rats (**Bashandy *et al*., 2016**). On the other hand, dietary yeast supplementation had no effect on (T_3) concentration in goats throughout the transition period (**Abbas *et al*., 2021**). In this study, the improvement in thyroid hormone levels may be due to the higher contents of antioxidants, specifically -carotene, active biliprotein, and phycocyanin in SP (**Lissi *et al*., 2000; Ibrahim and Abdel-Daim, 2015**), which play an essential role in reducing oxidative stress by inhibiting lipid peroxidation (**Turrens, 2003**), leading to increased secretion of thyroid hormones by increasing the incorporation of iodine into the thyroglobulin (**Abd El-Hamid *et al*., 2022**).

Furthermore, the observed elevation in INS levels might be due to the ability of SP to stimulate insulin release via pathways such as adenylate cyclase/cAMP or the phosphatidylinositol pathway (**Hannan *et al.*, 2006**), or through direct effects on β-cell stimulation via Ca^{2+} ion channel closure to induce insulinotropic action (**Wang *et al.*, 2015**). Additionally, the active components of SP, such as ascorbic acid, carotenoids, and fatty acids, inhibit the production of lipid peroxides that disrupt the hormone insulin and the oxidation of the insulin hormone by free radicals (**Kata, *et al.*, 2018**). In agreement with our findings, **Sucu *et al.* (2017)** reported that serum insulin levels increased in lambs fed *Schizochytrium limacinum* microalga. Also**, Hannan *et al.* (2020)** reported that INS secretion increased in lab animals treated with non-toxic doses of SP. Moreover, **Du *et al.* (2022)** reported that the addition of live yeast (*Saccharomyces cerevisiae*) to cows' diets exposed to heat stress promotes INS production in the body and reduces heat stress-induced damage.

Our findings demonstrated that serum Ca and P concentrations increased with supplementing *Spirulina platensis*, either alone or in combination with live yeast (Table 3). Increment of Ca and P levels among treatment groups might be due to the fact that SP is rich in phosphorous and calcium (**Leema *et al.*, 2010**). In addition, live yeast improved mineral solubility by promoting the colonization of bacteria that produce short-chain fatty acids and decreasing intestine pH (**Scholz-Ahrens *et al*., 2007**). This reflects the good transfer of trace elements to blood (**Huert *et al*., 2002**). These results are in agreement with those of **Rojita *et al*. (2019)** who reported that supplementation with brown algae improved serum concentrations of calcium and phosphorus in goats. In sheep, **Aly and Omar (2003)** found that serum calcium and phosphorus levels were increased with the addition of *S. platensis*. Rabbits supplemented by *Nannochloropsis oculata*, had higher serum K and P concentrations **(Abd El-Hamid *et al*., 2022)**. Similar to these findings, **Bagnicka *et al*., (2014)** reported that live yeast improved the serum calcium concentration of goats.

In the current study, supplementing SP, either alone or in mix with SC, reduced the serum LP and GPX concentrations in doe goats (Figure 1). These results are in agreement with previous reports stating that treatment with SP reduced LP and GPX levels in lambs (**EL-Sabagh *et al*., 2014**). Protective effects of SP supplementation against oxidative damage have also been reported in broiler chickens by (**Mirzaie *et al*., (2018**) and laboratory animals (**Gargouri *et al*., 2018**). Furthermore, **Du *et al*., (2022)** reported that serum LP was reduced in lactating cows treated with *Saccharomyces cerevisiae*. Glutathione peroxidase is a major enzyme in the antioxidant defence system of microorganisms (**Alla *et al*., 2007**). Lipid peroxidase is an indicator of the amount of lipid oxidative damage in cell membranes (**Pirincciogl*u et al*., 2010**). In this study, the improvement in antioxidant status might be due to the active components present in Spirulina biomass, such as total phycocyanin, triterpenoids, α-tocopherol, ascorbic acid and β-carotene (**Estrada *et al*., 2001; Riss *et al*., 2007**).

The results showed that the birth weight of borned kids from goats supplemented with Spirulina platensis was significantly higher compared with other groups (Table 4). This finding is supported by (**Khalifa *et al*., 2016 and El-Deeb *et al*., 2022**), who reported that the average birth weight of borned kids from goats fed Spirulina platensis during the third trimester of pregnancy was higher than that of borned kids from control goats. In late-pregnant ewes, supplementation with SP increased newly born lambs' birth weights (**Abd Eldaim *et al*., 2018**). This increase in birth weight was related to feeding pregnant dams with S. platensis, which provided adequate energy, essential amino acids, minerals, and vitamins to maintain the metabolic processes and support the growth of the foetus (**Parimi *et al*., 2015**).

In this study, the average daily gain and weaning weight of borned kids of treated groups were

not changed compared with kids born of control goats. These results are confirmed by **Meale *et al*., (2014)** in lambs (**El-Deeb *et al*., 2022**) in does' kids during 45 days of suckling period. These results can be explained by the litter size and kidding rate of goats (Table 4), which are the most important factors that have a significant effect on both average daily gain and weaning weight for goat kids during the suckling period (**El-Raghi and Hashem 2022**). In addition, the type of birth is inversely proportional to ADG and weaning weight; single-born kids had a higher average ADG than multiple or triplet-born kids during all phases of suckling (**Belay *et al*., 2014**), this may be attributed to the competition of multiple or triplet-born kids for milk (**Oramari *et al*., 2011**).

Our results showed that serum CHOL concentration was lower in the kids born from goats supplemented with SP, either alone or in a mix with SC (Table 5). More studies have confirmed our findings that SP reduces cholesterol levels in lambs (**Liang *et al*., 2020**) and in mice treated with phycocyanin isolated from SP (**Ou *et al*., 2013**). This could be explained by the fact that SP has few calories but is rich in nutrients such as protein, beta-carotene, gamma-linolenic acid, and other micronutrients that can regulate fat metabolism. Moreover, the improvement in lipid and hormonal metabolism and the oxidative status of goats during late pregnancy and early lactation (Table 2) is reflected in the improvement in the CHOL level in kids born to treated goat doe groups.

In this investigation, serum P concentration was higher in the SP kids group (Table 5). The increase in serum P concentration may be attributable to the increase it's in treated dames (Table 3) and the efficient transfer of trace elements to the blood offspring (**Abd El-Hamid *et al*., 2019**).

CONCLUSION

In conclusion, supplementing SP microalga alone or in mix with live yeast in goats' diets improved their antioxidant status by decreasing LP and GPX activity, in addition to improving blood constituents by decreasing cholesterol, urea, and alanine aminotransferases and increasing calcium and phosphorus levels. Triiodothyronine and insulin levels were improved. Also, the birth weight of newly born kids and their health status improved; this will pay off well for the livestock, economy, and profitability, especially in arid and semi-arid regions.

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Conflict of Interest

The author has no conflict of interest.

REFERENCES

ABBAS, T.M., ORMA, A., MOHAMED, T.I., and ABD EL-WAHAB, A., 2021. Effects of dietary probiotic supplementation on growth, rumen development and selected blood metabolites of growing calves. Mansoura Veterinary Medical Journal. 22 (4): 166-171. https://doi.org/ 10.21608/MVMJ.2021.47831.1012

ABD ELDAIM, M., RAMADAN, S., and ELSABAGH, M., MAHBOUB, H., 2018. Impact of *spirulina platensis* algae and vitamin a supplementation to late pregnant ewes on their lamb's survivability and performance. Assiut Veterinary Medicine Journal. 64 (159): 144-153.

ABD EL-HAMID, I.S., FOUDA, W.A., SHEDEED, H.A., MOUSTAFA, S.A., ELBAZ, A.M., BAKR, S.A., MOSA, B.H., MORSY, A.S., HASAN, A.M., and EMAM, K.R., 2022. Influence of microalgae *Nannochloropsis oculata* on Blood constituents, reproductive performance and productivity in *Hi-Plus* doe rabbits under North Sinai conditions in Egypt. Journal of Animal Health and Production. 10 (2): 135-145. http://dx.doi.org/10.17582/journal.jahp/2022/10.2.135.145

ABD EL-HAMID, I.S., YOUNIS, F.E., FARRAG, B., EL-RAYES, M. A-H., and SHEDEED, H.A., 2019. Influence of organic or inorganic forms of salts rich in phosphorus, copper and zinc on reproduction, productivity and blood constituents in sheep. Australian Journal of Basic and Applied Sciences. 13(6): 14-22. https://doi.org/10.22587/ajbas.2019.13.6.2

ALLA, M., BADAWI, A., HASSAN, N.M., EL-BASTAWISY, Z.M., and BADRAN, E.G., 2007. Induction of Glutathione and glutathione-associated enzymes in butachlor-tolerant plant species. American Journal of Plant Physiology. (2): 183–91. https://doi.org/10.3923/ajpp.2007.195.205

AL-SOBAIYL, K.A. 2010. Effect of breeding season and pregnancy status on serum progesterone, sodium, potassium, copper and iron of estrous synchronized Aradi goat does. Saudi Journal of Biological Sciences. (17): 259-263. https://doi.org/10.1016/j.sjbs.2010.04.012

ALTOMONTE, I., SALARI, F., LICITRA, R., and MARTINI, M., 2018. Use of microalgae in ruminant nutrition and implications on milk quality-

A review. Livestock Science. (214): 25-35. https://doi.org/10.1016/j.livsci.2018.05.006

ALY, M.S., and OMAR, M.A., 2003. *Spirulina Platensis* as nutritional promoter for sexual puberty in Rahmany sheep. Journal of Agricultural Chemistry and Biotechnology. 28 (5): 4001-4012. https://doi.org/10.21608/jacb.2003.244630

ASHOUR, G. A., NEAMA, ASHMAWY. M., DESSOUK, S.H., and SHIHAB, O.H., 2015. Blood hematology, metabolites and hormones in newborn sheep and goat from birth to weaning. International Journal of Advanced Research. 3 (7): 1377-1386. (ISSN 2320-5407). www.journalijar.com

ATALLA, S., YOUSSEF, M.A., EBRAHEEM, E.M., EL-DIASTY, M., and RIZK, M.A., 2023. Effect of prebiotic and *Spirulina* on blood gas parameters and acute phase proteins in dairy cattle with sub-acute ruminal acidosis. International Journal of Veterinary Science. 12(1): 24-30. https://doi.org/10.47278/journal.ijvs/2022.149

AZAB, S., ABDEL-DAIM, M., and ELDAHSHAN O., 2013. Phytochemical, cytotoxic, hepatoprotective and antioxidant properties of Delonix regia leaves extract. Medicinal Chemistry Research. (22): 4269-4277. https://doi.org/10.1007/s00044-012-0420-4

BAGNICKA, E., JARCZAK, J., KOSCIUCZUK, E., KABA, J., JÓZWIK, A., CZOPOWICZ, M., STRZALKOWSKA, N., and KRZYZEWSKI, J., 2014. Active dry yeast culture supplementation effect on the blood biochemical indicators of dairy goats. Advances in dairy Research. 2 (2): 2-7. http://doi.org/10.4172/2329-888X.1000123

BASHANDY, S.A.E., SALLY, A., EL AWDAN, EBAID. H., and ALHAZZA, I.M., 2016. Antioxidant Potential of Spirulina platensis mitigates oxidative Stress and reprotoxicity induced by sodium arsenite in male rats. Oxidative Medicine and Cellular Longevity. (16): pp. 8. http://dx.doi.org/10.1155/2016/7174351

BASHIR, S., SHARIF, M.K., BUTT, M.S., and SHAHID, M., 2016. Functional Properties and Amino Acid Profile of Spirulina Platensis Protein Isolates. Pakistan Journal of Scientific and Industrial Research Series. 59 (1): 12-19.

BELAY, S., GEBRU, G., GODIFEY, G., BRHANE, M., ZENEBE, M., HAGOS, H., and TEAME, T., 2014. Reproductive performance of *Abergelle* goats and growth rate of their crosses with *Boer* goats. Livestock Research for Rural Development. 26(5).

CHO, Y.A., and KIM, J., 2015. Effect of probiotics on blood lipid concentrations: A Meta-Analysis of Randomized Controlled Trials. Medicine (Baltimore). 94(43): e1714. https://doi.org/10.1097/MD.0000000000001714

DENG, R., and CHOW, T.J., 2010. Hypolipidemic, antioxidant, and antiinflammatory activities of microalgae *Spirulina*. Cardiovascular Therapeutics. (28): e33–e45

DESNOYERS, M., GIGER-REVERDIN, S., BERTIN, G., DUVAUX-PONTER, C., and SAUVANT, D., 2009. Meta-analysis of the influence of *Saccharomyces cerevisiae* supplementation on ruminal parameters and milk production of ruminants. Journal of Dairy Science. 92 (4): 1620-1632. https://doi.org/10.3168/jds.2008-1414

DU, D., FENG, L., CHEN, P., JIANG, W., ZHANG, Y., LIU, W., ZHAI, R., and HU, Z., 2022. Effects of *Saccharomyces Cerevisiae* cultures on performance and immune performance of dairy cows during heat stress. Frontiers in Veterinary Science. (9):851184. https://doi.org/ 10.3389/fvets.2022.851184

EL-ASHRY, M.A., KHOLIF, A.M., EL-ALAMY, H.A., EL-SAYED, H.M and EL-HAMAMSY, T.A., 2001. Effect of different yeast cultures supplementation to diet on the productive performance of lactation buffaloes. Egyptian Journal of Nutrition and Feeds. (4): 21-33.

EL-DEEB, M.M., ABDEL-GAWAD, M., ABDEL-HAFEZ, M.A.M., SABA, FATMA, E., and IBRAHIM, E.M., 2022. Effect of adding Spirulina platensis algae to small ruminant rations on productive, reproductive traits and some blood components. Acta Scientiarum Animal Sciences. (45): e57546. https://doi.org/10.4025/actascianimsci.v44i1.57546

EL-RAGHI, A. A., and HASHEM, N. M., 2022. Maternal, postnatal, and management-related factors involved in daily weight gain and survivability of suckling *Zaraibi* goat kids in Egypt. Animals. 12(20): 2785. https://doi.org/10.3390/ani12202785.

EL-SABAGH, M.R., ELDAIM, M.A.A., MAHBOUB, D.H and ABDEL-DAIM, M., 2014. Effects of *Spirulina Platensis* algae on growth performance, antioxidative status and blood metabolites in fattening Lambs. Journal of Agricultural Science. 6 (3): 92-98. https://doi.org/10.5539/jas.v6n3p92

ERTHINGHASAUSEN, G. 1972. Clinical Chemistry. (18): 263.

ESTRADA, J.P., BESCOS, P.B., and DEL FRESNO, A.V., 2001. Antioxidant activity of different fractions of Spirulina platensis protean extract. Il Farmaco. 56(5-7):497-500.
https://doi: 10.1016/s0014-827x(01)01084-9

GARCIA-MARTINEZ, D., RUPEREZ, F.J., UGARTE, P., and BARBAS, C., 2007. Tocopherol fate in plasma and liver of streptozotocin-treated rats that orally received antioxidants and *Spirulina* extracts. International Journal for Vitamin and Nutrition Research. 77(4):263-71. https://doi:10.1024/0300-9831.77.4.263

GARGOURI, M., SOUSSI, A., AKROUTI, A., CHRISTIAN, MAGNÉ and EL FEKI, A., 2018. Ameliorative effects of *Spirulina platensis* against lead-induced nephrotoxicity in newborn rats: modulation of oxidative stress and histopathological changes. EXCLI Journal. 2 (17): 215-232. https://doi: 10.17179/excli2017-1016.

GUPTA, R., BHADAURIYA, P., CHAUHAN, V.S., and BISEN, P.S., 2008. Impact of UV-B radiation on thylakoid membrane and fatty acid profile of *Spirulina platensis*. Current Microbiology. 56(2):156-61. https://doi: 10.1007/s00284-007-9049-9

GUYOT, S., FERRET, E., and GERVAIS, P., 2005. Responses of *Saccharomyces cerevisiae* to thermal

stress. Biotechnol Bioeng 4, 403-409. https://doi:10.1002/bit.20600

HANNAN, J.M., MARENAH, L., and ALI, L., 2006. Ocimum sanctum leaf extracts stimulate insulin secretion from perfused pancreas, isolated islets and clonal pancreatic beta-cells. Journal of Endocrinology. 189(1):127-36. https://doi: 10.1677/joe.1.06615.

HANNAN, J.M.A., ANSARI, P., AZAM, S., FLATT, P.R., and ABDEL WAHAB, Y.H.A., 2020. Effects of *Spirulina platensis* on insulin secretion, dipeptidyl peptidase IV activity and both carbohydrate digestion and absorption indicate potential as an adjunctive therapy for diabetes. British Journal of Nutrition. 124(10):1021-1034. https://doi.org/10.1017/S0007114520002111

HENRY, R.F ., 1974. Clinical Chemistry Principles and Technics. 2nd Ed, Harper and Row, Harper and 3-Row, Hargersein, M.D. https://www.amazon.com/Clinical-chemistry-principles-technics-Richard/dp/0061411817

HENRY, R.J., 1964. Clinical Chemistry, Principles and Technics. Harper and Row Publishers, New York, USA.

HUERT, M., KINCAID, R.L., CRONRATH, J.D., BUSBOOM, J., JOHNSON, A.B., and SWENSON, C.K., 2002. Interaction of dietary zinc and growth implants on weight gain, carcass traits and zinc in tissues of growing beef steers and heifers. Animal Feed Science and Technology. 2(14): 15–32. https://doi.org/10.1016/S0377-8401(01)00334-0

IBRAHIM, A., and ABDEL-DAIM, M., 2015. Modulating effects of Spirulina platensis against tilmicosin-induced cardiotoxicity in mice. Cell Journal (Yakhteh). 17(1): 137–144. https://doi: 10.22074/cellj.2015.520

KALIO, G.A., OKAFOR, B.B., and INGWEYE, J.N., 2014. Haematology and biochemistry of West African Dwarf (WAD) bucks fed crop by-products in Humid Tropical Nigeria. The Experiment. 18(2):1227-1234.

KATA, F.S., ATHBI, A.M., MANWAR, E.Q., AL-ASHOOR, A., ABDEL-DAIM, M.M., and ALEYA, L., 2018. The rapeutic effect of the alkaloid extract of the cyanobacterium *Spirulina platensis* on the lipid profile of hypercholesterolemic male rabbits. Environmental Science and Pollution Research. 25 (20): 19635-19642. . https://doi:10.1007/s11356-018-2170-4

KHALIFA, E.L., HASSANIEN, H.A.M., MOHAMED, A.H., HUSSEIN, A.M., and AZZA, A.M., 2016. Influence of addition *Spirulina Platensis* algae powder on reproductive and productive performance of dairy *Zaraibi* goats. Egyptian Journal of Nutrition and Feeds. (19): 211–225. https://doi:10.21608/ejnf.2016.74901

LEEMA, J.M., KIRUBAGARAN, R., VINITHKUMAR, N., DHEENAN, P., and KARTHIKAYULU, S., 2010. High value pigment production from Arthrospira (Spirulina) platensis cultured in seawater. Bioresour Technology. 101 (13):9221. https://doi.org/10.1016/j.biortech.2010.06.120

LISSI, E.A., PIZARRO, M., ASPEE, A., and ROMAY C., 2000. Kinetics of phycocyanine bilin groups destruction by peroxyl radicals. Free Radical Biology and Medicine. 28 (7): 1051–1055. https://doi.org/10.1016/S0891-5849(00)00193-3

LIANG, Y., BAO, Y., GAO, X., DENG, K., AN, S., WANG, Z., HUANG, X., LIU, D., LIU, Z., WANG, F and FAN Y., 2020. Effects of *Spirulina* supplementation on lipid metabolism disorder, oxidative stress caused by high-energy dietary in Hu sheep. Meat Science. (164): 108094. https://doi 10.1016/j.meatsci.2020.108094

LOKMAN-SHAMSUDIN, SYARIFAH. A.R., AZMAN, N.A., WAN, ZAHARI. M., and HAFIS, H.L., 2018. The milk index, blood chemistry status and growth performance of local Malaysian cow (Bos Sundoicus) fed Arthrospira platensis supplement. Malaysian Applied Biology. 47(4): 35-43.

LUGARÀ, R, GRZE´SKOWIAK, Ł., ZENTEK, J., MEESE, S., KREUZER, M., GILLER, K.A., 2022. High-energy diet and *Spirulina* supplementation during pre-gestation, gestation, and lactation do not affect the reproductive and lactational performance of primiparous sows. Animals. (12): 1171. https:// doi.org/10.3390/ani12091171

MANTOVANI, A., AQUILINA, G., CUBADDA, F., MARCON, F., 2022. Risk-Benefit assessment of feed additives in the one health perspective. Frontiers in Nutrition. 10 (9): 843124. https://doi.org/10.3389/fnut.2022.843124

MARUNA, R.F.L., 1958. Clinica Chimica Acta 2, pp 581.

MATLOUP, O.H., 2020. Feed additives and lactating animals: research and applications Egyptian Journal of Animal Production. (57): 93-98.

MEALE, S.J., CHAVES, A.V., HE, M.L., and MCALLISTER, T.A., 2014. Dose-response of supplementing marine algae (Schizochytrium spp.) on production performance, fatty acid profiles, and wool parameters of growing lambs. Journal of Animal Science . 92 (5): 2202-13. https://doi.10.2527/jas.2013-7024

MIRZAIE, S., ZIRAK-KHATTAB, F., HOSSEINI, S.A., and DONYAEI-DARIAN, H., 2018. Effects of dietary *Spirulina* on antioxidant status, lipid profile, immune response and performance characteristics of broiler chickens reared under high ambient temperature. Asian-Australasian J. of Anim. Sci. 31(4): 556-563. https://doi.10.5713/ajas.17.0483

MIYADA, D.S et al., 1972. Clinical Chemistry 18, pp:52

MONTGOMERY, H.A.C., and DYMOCK, J.F., 1961. The determination of nitrite in water. Analyst. (86): 414-416.

MOOREHEAD, W.R and BRIGGS A.R., 1977. Clinical Chemistry. (20): pp 1458.

NRC., 1985. Nutrition Requirements of Sheep, 6th rev. ed. National Academy Press, Washington, D.C., USA.

OMAR, A.E., AL-KHALAIFAH, H.S., OSMAN, A., GOUDA, A., SHALABY, S.I., ROUSHDY, E.M., ABDO, S.A., ALI, S.A., HASSAN, A.M and AMER, S.A., 2022. Modulating the growth, antioxidant activity, and immunoexpression of

proinflammatory cytokines and apoptotic proteins in broiler chickens by adding dietary *Spirulina platensis* Phycocyanin. Antioxidants (Basel). 5 (11): 991. https://doi.org/10.3390/antiox11050991

OU, Y., LIN, L., YANG, X., PAN, Q., and CHENG, X., 2013. Antidiabetic potential of phycocyanin: effects on KKAy mice. Pharmaceutical Biology. 51 (5): 539-544. https://doi.org/10.3109/13880209.2012.747545

ORAMARI, R., ALKASS, J., HERMIZ, H., HUSSEIN, Y., 2011. Some placental factors and their relevance to variation in birth weight of *Karadi* lambs. Research Opinions in Animal and Veterinary Sciences. (1): 165–168.

PAGLIA, D.E and VALENTINE, W.N., 1967. Journal of Laboratory and Clinical Medicine. (70): 158-169.

PARIMI, N.S., SINGH, M., KASTNER, J. R., DAS, K. C., FORSBERG, L.S., and AZADI, P., 2015. Optimization of protein extraction from Spirulina platensis to generate a potential Co-Product and a biofuel Feedstock with reduced nitrogen content. Frontiers in Energy Research. 3 (30): https://doi.org/10.3389/fenrg.2015.00030

PANJAITAN, T., QUIGLEY, S.P., MCLENNAN, S.R., SWAIN, A.J., POPPI, D.P., 2015. Spirulina (*Spirulina platensis*) algae supplementation increases microbial protein production and feed intake and decreases retention time of digesta in the rumen of cattle. Animal Production Science. (55): 535–543. https://doi: 10.1071/AN13146

PIRINCCIOGLU, A.G., GÖKALP, D., PIRINCCIOGLU, M., KIZIL, G., and KIZIL, M., 2010. Malondialdehyde (MDA) and protein carbonyl (PCO) levels as biomarkers of oxidative stress in subjects with familial hypercholesterolemia. Clinical Biochemistry. (43): 1220. https://doi.org/10.1016/j.clinbiochem.2010.07.022

RABEE, A.E., YOUNAN, B.R., and KEWAN, K.Z., 2022. Modulation of rumen bacterial community and feed utilization in camel and sheep using combined supplementation of live yeast and microalgae. Scientific reports. (12): 12990. https://doi.org/10.1038/s41598-022-16988-5

RISS, J., DÉCORDÉ, K., SUTRA, T., DELAGE, M., BACCOU, J.C., JOUY, N., BRUNE, J.P., ORÉAL, H., CRISTOL, J.P and ROUANET, J.M., 2007. Phycobiliprotein C-phycocyanin from *Spirulina platensis* is powerfully responsible for reducing oxidative stress and NAD PHoxidase expression induced by an atherogenic diet in hamsters. Journal of Agricultural and Food Chemistry. 55 (19): 7962–7967. https://doi.10.1021/jf070529g

ROJITA, Y., PUTAN, S., NIRMALA, M., KANTI, R., BORNALEE, H., and VENKATESWARAN, K., 2019. Supplementation of brown Seaweed (*Turbinaria conoids*) powder and its effect on blood metabolites and mineral profile in adult goats. Indian Journal of Animal Nutrition. (1): 103-106. http://doi.org/10.5958/2231-6744.2019.00019.7

SATOH, K.., 1978. Serum lipid peroxide in cerebrovascular disorders determined by a new colorimetric method. Clinica Chimica Acta. (90): 37-43. http://doi.org/10.1016/0009-8981 (78) 90081-5

SAS, Institute. 2004. SAS User's Guide: Statistics. Release 9.1. SAS Institute Incorporated, Cary, North Carolina.

SCHOLZ-AHRENS, K.E., SCHOLZ-AHRENS, P., ADE, B., MARTEN, P., WEBER, W., TIMM, Y., ASIL, C.C., and GLUER, J.S., 2007. Prebiotics, probiotics, and synbiotics affect mineral absorption, bone mineral content, and bone structure. The Journal of Nutrition. (137): 838-846. http://10.1093/jn/137.3.838S

SHAMSUDIN, L., RASHID, S.A.B., ABDULLAH, A.N., MOHAMED, W.Z., and LOKMAN, H.H., 2018. The Milk index, blood biochemistry status and growth performance of local *Malaysian* cow (*Bos sundoicus*) fed *Arthrospira platensis supplement*. Malaysian Applied biology Journal. 47 (4): 35-43.

SHEPHARD, M.D., MEZZACHI, R.D., 1983. The Clinical Biochemist Reviews. (4): 61-67.

SUCU, E., UDUM, D., GÜNEŞ, N., CANBOLAT, Ö., and FILYA, I., 2017. Influence of supplementing diet with microalgae (*Schizochytrium limacinum*) on growth and metabolism in lambs during the summer. Turkish Journal of Veterinary & Animal Sciences. 41(2): 4. https://doi.org/10.3906/vet-1606-65.

TIETZ, N.W. 1976. Fundamentals of Clinical Chemistry. W.B. Saunders Co., Philadelphia. https://doi.org/10.1093/clinchem/32.4.717.

TIETZ, N.W., 1994. Fundamentals of Clinical Chemistry:2 nd ed.NW Tietz, editor, pp 692.

TRINDER, P., 1969. Determination of glucose in blood using glucose oxidase with an alternative oxygen acceptor. Annals of Clinical Biochemistry. (6): 24-27. https://doi.org/10.1177/000456326900600108.

TURRENS, J.F., 2003. Mitochondrial formation of reactive oxygen species. The Journal of Physiology. 15 (552): 335-344. http://dx.doi.org/10.1113/jphysiol.2003.049478

VEDI, M., KALAISELVAN, S., RASOOL, M and PRINCE SABINA, E., 2013. Protective effects of blue green algae spirulina fusiformis against galactosamine-induced hepatotoxicity in mice. Asian Journal Pharmceutical Clinical Research. 6 (3): 150 - 154. ISSN: 2455-3891

WANG, Y., WANG, S., and HARVAT, T., 2015. Diazoxide, a K (ATP) channel opener, prevents ischemia-reperfusion injury in rodent pancreatic islets. Cell Transplant. 24 (1): 25–36. http:// dx.doi.org/10.3727/096368913X673441

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