NUTRITIONAL ASSESSMENT OF SPIRULINA IN GROWING BUFFALO CALVES' DIETS

A.A. Marwan[1]; Eman, I. Saddick[2], and U.A. Nayel[2]

[1]*Department of Animal Production, Faculty of Agriculture, Ain Shams University, Egypt*

[2]*Department of Animal Production, Faculty of Agriculture, Menoufia University, Egypt*

(Received 5/12/2024, accepted 16/12/2024)

SUMMARY

The current study was done to evaluate the impact of supplementing buffalo calves with *Spirulina platensis* (SP) on the nutrients digestibility, dry matter intake (DMI), average daily gain (ADG), dry matter (DM) conversion, and some biochemical blood plasma parameters. SP was cultivated, sun-dried, and ground to a fine green powder. Fifteen buffalo calves were equally divided into three groups, where three experimental diets were offered: a control diet without SP supplementation (SP0) and diet supplemented with 5 and 10 kg SP powder/ton for SP5 and SP10, respectively. Results demonstrated that, compared to the control diet, SP5 had a significant ($P \leq 0.05$) increase in organic matter (OM), ether extract (EE), and nitrogen-free extract (NFE) digestibility, whereas SP10 had a significant ($P \leq 0.05$) increase in all nutrients digestibility. Non-significant effect of supplementation on DMI was recorded. ADG was increased linearly ($P \leq 0.05$) with the level of supplementation. Both levels of supplementation significantly ($P \leq 0.05$) increased DM conversion, blood plasma total protein, albumin, and triglycerides, and conversely decreased ($P \leq 0.05$) blood plasma cholesterol. No evidence of undesirable effect on either liver or kidney function was found due to supplementation.

Keywords: *Spirulina platensis*, algae, buffalo calves, supplementation, digestibility

INTRODUCTION

In Egypt, buffaloes are the most popular animal for farmers. Egyptian buffaloes are a considerable source of high-quality meat in Egypt. Compared to beef, buffalo meat contains less fat, cholesterol, and calories, while it contains more iron content (Naveena and Kiran, 2014; Khan *et al.*, 2021). Tamburrano *et al.* (2019) recommended buffalo meat as a healthier alternative to beef meat. The economy of meat production from ruminants depends on several factors, including feeding animals until slaughtering. Dietary supplements, especially protein supplements for growing ruminants, can maximize the production rate of meat and/or improve feed efficiency (Nantongo *et al.*, 2021; Marwan *et al.*, 2024). The change in body weight gain as a response to protein supplementation quantitatively differs according to the source of supplementation (Huuskonen *et al.*, 2014). In the last decade, spirulina algae have been widely investigated for ruminant feeding (El-Sabagh *et al.*, 2014; Gaafar *et al.*, 2017; Riad *et al.*, 2019). *Spirulina platensis* is a blue-green algae, which is multicellular and known as prokaryotes (Jung *et al.*, 2019). It contains considerable amounts of high-quality crude protein (55-70% on DM), minerals, and vitamins, in addition to some essential fatty acids (Jung *et al.*, 2019; Farg *et al.*, 2021). Nasehi *et al.* (2019) found that protein in *Spirulina* algae is very high in degradability in the rumen, even more than traditional protein meals such as soybean meal. Furthermore, Spirulina sp. have properties of hepatoprotective, nephroprotective, neuroprotective, hypoglycemic, hypolipidemic, antitumor, anti-inflammatory, and immunomodulatory effects (Waheed *et al.*, 2024). Although some studies have demonstrated that supplementation with spirulina improved average daily gain and/or feed conversion for lambs (Bezerra *et al.*, 2010; El-Sabagh *et al.*, 2014; Liang *et al.*, 2020), beef calves (Glebova *et al.*, 2018; Riad *et al.*, 2019), and kids (El-Deeb *et al.*, 2022a), no research has been focused on its effect on buffalo calves. Thus, the aim of this study was to evaluate the effect of *Spirulina platensis* supplementation for growing buffalo calves on nutrients digestibility and growth performance.

MATERIALS AND METHODS

This study was carried out at the Experimental Research Station, which is property of the Faculty of Agriculture, Ain Shams University, and is located in Shalakan village, Qalubia Governorate, Egypt.

Ethical considerations:

According to the recommendations by the American Veterinary Medical Association guidelines, the Animal Care and Research Ethics of Ain Shams University, the agriculture sector committee has approved all the experimental procedures with an approval number (4-2024-13).

Cultivation of spirulina algae:

Spirulina platensis was cultured in El Nada Farm, which is located in Monsha'et El Kanater, Giza Governorate. *Spirulina platensis* was cultured in (2×1.5 m) glass water tanks containing nutrient formulation, which accelerates the growing and multiplying of algae. The pH of water was maintained to be in the range of 8:10. The water tanks were half-shaded to allow adequate sunlight exposure. After 21 days, spirulina was cultivated and rinsed well with sterile water to exclude any residual substances from the culture media. The cultivated algae were strained and spread on plastic sheets to let dry under the sunlight. After drying, the algae were ground to be in the form of fine green powder, which is the form to supplement our experimental diets.

Experimental diets formulation:

The basal diet consisted of 60% concentrate feed mixture (CFM), 20% berseem, and 20% rice straw without supplementation (control, SP0). Spirulina algae (SPA) were included in the CFM with two levels of supplementation: 5 kg/ton (SP5) and 10 kg/ton (SP10). The chemical compositions of feedstuffs, SPA, and experimental diets are listed in table (1).

Table (1): Chemical composition of feedstuffs and experimental diets (% on DM basis)

	Ingredients			Supplement	Supplementation		
	CFM*	**Berseem**	**Rice straw**	**SPA****	**SP0**	**SP5**	**SP10**
Dry matter, DM	90.76	16.48	92.15	92.97	76.18	76.27	76.35
Organic matter, OM	92.92	88.87	82.26	89.94	90.07	90.01	90.00
Crude protein, CP	16.25	19.42	3.9	57.94	14.41	14.63	14.85
Crude fiber, CF	20.15	28.46	39.38	5.96	25.66	25.56	25.46
Ether extract, EE	3.21	3.61	1.64	4.48	2.98	2.98	2.99
Nitrogen-free extract, NFE	53.31	37.38	37.34	21.56	47.02	46.84	46.70
Ash	7.08	11.13	17.74	10.06	9.93	9.99	10.00
AIA***	5.14	4.52	13.18	0.05	6.62	6.59	6.56

SP0; SPA 0 kg/ton; SP5, SPA 5 kg/ton; SP10, SPA 10 kg/ton.
** CFM: Concentrate feed mixture, **SPA: spirulina algae, ***AIA: Acid insoluble ash*
***** The CFM composed of 38% ground maize, 15% soybean meal, 34% wheat bran, 5% rice bran, 3% molasses,1% mineral salts, 2% limestone powder,1% Sodium Bicarbonate and 1% sodium chloride.*

Chemical analysis:

According to **AOAC (2000),** samples of feedstuffs, SPA, and experimental diets were chemically analyzed**.**

Animals, management, and experimental design:

A total of fifteen buffalo calves, weighing 123.34±10.37 kg and with an average age of five months, were split into three groups at random and offered the three experimental diets: SP0, SP5, and SP10. According to the nutrient requirements of Kearl (1982), calves were fed experimental diets for 90 days preceded by an adaptation period of about 21 days. Daily diets were divided into two equal portions and offered at 8 a.m. and 4 p.m. All the animals had access to clean and fresh water. Five replicates of each treatment were used in the randomized block design experiment.

Digestibility trial:

According to Van Keulen and Young (1977), acid-insoluble ash (AIA) was used as a natural internal marker to assess the digestibility of the nutrients. The grab sample method described by Schneider and Flatt (1975) was used for fecal collection from all the animals. Fresh fecal samples were collected over a period of seven days, dried in an oven set at 65°C for 24 hours, and then combined before representative samples were taken and subjected to chemical analysis in accordance with AOAC (2000). The average daily intake was also recorded.

Feed intake and growth parameters:

For ninety days, the daily feed intake and biweekly body weights were listed to determine the dry matter intake (DMI), average daily gain (ADG), and dry matter conversion. Calves were weighed in the morning before feeding. The initial body weight was subtracted from the final body weight to get the calves' total weight gain. At biweekly intervals, ADG was computed by dividing the weight gain for a given 15-day period by 15. The total ADG was calculated by dividing the total weight gain by 90. The dry matter intake (DMI) was divided by the total gain obtained over a specific period to get the dry matter conversion (kg DM/kg gain).

Blood plasma parameters:

Finally, each calf was punctured in its jugular vein shortly prior to morning feeding, and blood samples were taken in heparinized tubes. The heparinized tubes were centrifuged (2095× g) for 15 minutes and frozen at -20 ºC for subsequent examination. The levels of albumin, alanine transaminase (ALT), aspartate transaminase (AST), creatinine, urea, triglycerides, cholesterol, and total protein were measured in plasma samples. To determine the globulin content, albumin was deducted from total protein. Analyses were performed by using commercial kits (Stanbio Laboratory, Boerne, TX, USA).

Statistical analysis:

The General Linear Model of SAS (SAS, 2002) was applied to statistically assess the experimental data in the following manner:

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

Where:

Y_{ij} = the parameters under analysis. μ = the overall mean. T_i = the treatment effect (i = 1 …and 3). e_{ij} = the random error of means. Differences among treatments were detected using Duncan (1955).

RESULTS AND DISCUSSION

Nutrients digestibility:

The digestibility of nutrients by calves supplemented with spirulina is shown in table (2). The highest value of both dry matter (DM) and organic matter (OM) digestibility was observed for SP10, followed by SP5.The significant differences were documented between SP0 and SP10 and between SP5 and SP10 for DM, whereas the significant differences were noticed among all groups for OM. The DM digestibility for SP0, SP5, and SP10 was 63.70, 65.73, and 69.76%, respectively, while the values were 65.53, 70.66, and 73.33% for OM digestibility in the same respective order. The digestibility of crude protein (CP) and crude fiber (CF) had the same pattern, as they significantly increased due to spirulina supplementation at a level of 10 kg/ton, while the increase due to 5 kg/ton of supplementation was non-significant compared to the control. Values of CP digestibility were 66.84, 68.57, and 69.71%, while values of CF digestibility were 59.51, 62.10, and 64.33% for SP0, SP5, and SP10, respectively. However, the digestibility of ether extract (EE) and nitrogen-free extract (NFE) was significantly increased due to both levels of supplementation. The digestibility of EE was increased from 76.03% for SP0 to 81.09% and 83.29% for SP5 and SP10, respectively. These results are in agreement with those of Riad *et al.* (2019), who reported that supplementing Friesian calves with 1 and 2 g of *Spirulina platensis* significantly increased all nutrients digestibility compared to non-supplemented calves. Similarly, Gaafar *et al.* (2017) added spirulina and their media to the drinking water for dairy cows, and they noticed a significant increase in all nutrients digestibility due to supplementation.

Table (2): Digestion coefficient of the diets supplemented with spirulina algae.

Item (%)	Supplementation levels		
	SP0	**SP5**	**SP10**
Dry matter (DM)	63.70±0.92^{b}	65.73±1.32^{b}	69.76±0.80^{a}
Organic matter (OM)	65.53±1.19^{c}	70.66±0.63^{b}	73.33±0.72^{a}
Crude protein (CP)	66.84±0.37^{b}	68.57±1.16^{ab}	69.71±0.63^{a}
Crude fiber (CF)	59.51±0.54^{b}	62.10±0.69^{ab}	64.33±0.40^{a}
Ether extract (EE)	76.03±0.27^{b}	81.09±0.77^{a}	83.29±0.87^{a}
Nitrogen free extract (NFE)	72.03±0.94^{b}	76.97±0.25^{a}	79.16±0.28^{a}

SP0; SPA 0 kg/ton; SP5, SPA 5 kg/ton; SP10, SPA 10 kg/ton.

[a, b and c] Means of treatments within the same row with different superscript letters are significantly different ($P \leq 0.05$).

However, Heidarpour *et al.* (2011) supplemented Holstein calves with 2, 6, and 25 g of *Spirulina platensis*/day, and they noticed a reduction in the digestibility of DM, OM, CP, and neutral detergent fiber as the level of supplementation increased; nonetheless, the differences were non-significant. In the current study, the improvement in the digestion coefficients is mostly caused by the rich-nutrient chemical composition of *Spirulina platensis* and consequently more nutrition supply of supplemented rations. Furthermore, dried powder of *Spirulina platensis* contains appreciable amounts of vitamins such as vitamin C, E, B12, folic acid, and B2 (Farg *et al.*, 2021), which might have a positive effect on the viability and activity of ruminal bacteria and thus the digestibility of nutrients. Additionally, Christodoulou *et al.* (2023) pointed out that supplementing 15 g of SP/ewe/ day increased ruminal population toward cellulolytic species, which might be the reason for increased fiber digestibility in the current study.

Dry matter intake (DMI):

Table (3) represents the consumption of feed by calves expressed as DMI. The results show a slight decrease in the DMI for SP5 compared to SP0 from 0-75 days. The same trend was observed for the total average DMI regarding SP0 and SP5, being 4.62 vs. 4.53 kg/d, respectively. The group of calves that received SP10 had the highest numeric value at all the periods (0-90 days) and consequently at the total average, since it ranged from 4.17 to 5.90 with an average of 4.98 kg DM/d. However, no significant effect of both spirulina supplementation levels on DMI was noticed.

Table (3): Dry matter intake (kg/h/d) by calves supplemented with spirulina algae.

Days	Supplementation levels		
	SP0	**SP5**	**SP10**
0 – 15	3.92± 0.38	3.72± 0.54	4.17± 0.58
16 – 30	4.16± 0.43	4.00± 0.54	4.45± 0.62
31 – 45	4.45± 0.47	4.32± 0.55	5.12± 0.66
46 – 60	4.77± 0.51	4.70± 0.58	5.12± 0.68
61 – 75	5.05± 0.53	5.03± 0.60	5.47± 0.67
76 – 90	5.41± 0.57	5.41± 0.63	5.90± 0.69
Average	4.62	4.53	4.98

SP0; SPA 0 kg/ton; SP5, SPA 5 kg/ton; SP10, SPA 10 kg/ton.

Similarly, El-Deeb *et al.* (2022b) found that supplementing pregnant ewes with SP extract powder at the rate of 0.5 gm/10 kg BW had no effect on the DMI. On the other hand, El-Sabagh *et al.* (2014) observed a rise in feed intake when they supplemented fattening lambs with *Spirulina platensis* powder at a rate of 1 g/10 kg BW/day. Also, Gaafar *et al.* (2017) noticed an increase in DMI when cows supplemented with 1 ml or 2 ml of SP/kg body weight (BW). Furthermore, Christodoulou *et al.* (2023) supplemented ewes with 5, 10, and 15 g/ewe/day, and they revealed a linear increase in the DMI as supplementation level increased. From all the previous results, it is prognosed that the effect of supplementation on DMI may depend on animal species and its productive status.

Blood plasma parameters:

The effect of spirulina supplementation on some blood plasma biochemicals is illustrated in Table (4). All the blood plasma biochemical parameters were within the normal reference range reported by Abd Ellah *et al.* (2013). The concentration of total protein in the blood plasma of calves was significantly ($p \leq 0.05$) increased as more spirulina was incorporated in their diets, being 5.62, 6.32, and 6.80 g/dl for SP0, SP5, and SP10, respectively. The highest ($p \leq 0.05$) concentration of albumin was found in SP5 (2.45 g/dl), while the highest ($p \leq 0.05$) globulin concentration was found in SP10 (4.85 g/dl). The AST and ALT were significantly reduced due to 10 kg/ton of spirulina supplementation. The spirulina supplementation did not have significant effects on either plasma urea or creatinine. Supplementation increased ($p \leq 0.05$) the triglyceride concentration and conversely decreased ($p \leq 0.05$) cholesterol concentration in blood plasma. The concentration of triglycerides was 69.88, 73.44, and 72.74 mg/dl for SP0, SP5, and SP10, respectively, while the concentration of cholesterol was 87.56, 83.77, and 81.25 for the same respective order.

Table (4): Effect of spirulina supplementation on some blood plasma constituents of calves.

Item	**Supplementation levels**		
	SP0	**SP5**	**SP10**
Total protein (g/dl)	5.62^{c}	6.32^{b}	6.80^{a}
Albumin (g /dl)	1.71^{c}	2.45^{a}	1.95^{b}
Globulin (g /dl)	3.91^{b}	3.87^{b}	4.85^{a}
AST (unit /L)	42.64^{a}	41.47^{b}	39.66^{b}
ALT (unit /L)	38.88^{a}	39.06^{a}	26.51^{b}
Urea (mg /dl)	32.74	30.65	31.50
Creatinine (g /dl)	1.65	1.60	1.55
Triglyceride (mg/dl)	69.88^{b}	73.44^{a}	72.74^{a}
Cholesterol (mg/dl)	87.56^{a}	83.77^{b}	81.25^{b}

SP0; SPA 0 kg/ton; SP5, SPA 5 kg/ton; SP10, SPA 10 kg/ton.

[a, b and c] Means of treatments within the same row with different superscript letters are significantly different ($P \leq 0.05$).

Increased plasma total protein, albumin, and globulin in supplemented calves are logically obtained results due to increased protein in their diets. Consistent with our results, supplementation with SP caused a significant increase in total protein (Gaafar *et al.*, 2017; Ghattas *et al.*, 2019; Riad *et al.*, 2019; Liang *et al.*, 2020), albumin (Liang *et al.*, 2020), and globulin (El-Sabagh *et al.*, 2014; Gaafar *et al.*, 2017; Ghattas *et al.*, 2019). However, a non-significant effect of supplementation on blood albumin was reported (Gaafar *et al.*, 2017; Riad *et al.*, 2019). Chorfi *et al.* (2004) revealed that serum total globulin is positively correlated with both serum gamma globulin and IgG concentration; therefore, increased plasma globulin in calves on SP10, in the current study, might indicate better immune status. Similarly to our results, both blood plasma AST and ALT (El-Sabagh *et al.*, 2014) or only blood plasma AST (Gaafar *et al.*, 2017) significantly declined in animals that received SP. Nevertheless, Riad *et al.* (2019) found that SP did not significantly affect both blood AST and ALT. Zaitsev *et al.* (2020) indicated that a pronounced elevation in the AST and ALT is evidence of liver disorder. In our study, despite the AST and ALT reduction, values remain within normal range.

Although our values of plasma urea and creatinine declined linearly with supplementation, nonetheless, the non-significant effect of supplementation indicates that spirulina supplementation did not adversely affect kidney function. The same non-significant effect of SP on blood urea and creatinine was reported by Riad *et al.* (2019). Contrarywise, El-Sabagh *et al.* (2014) pointed out an increase in blood urea nitrogen due to SP supplementation.

Regarding blood plasma triglycerides, it was supposed that relatively spirulina content of EE (table 1), in addition to increased EE digestibility (table 2), are responsible for increased plasma triglycerides in our supplemented calves compared to non-supplemented. This result is supported by El-Sabagh *et al.* (2014), who found that supplementation led to an increase in blood triglycerides. On the other hand, Liang *et al.* (2020) reported a reduction in blood serum triglycerides of sheep supplemented with SP. Our result of plasma cholesterol supports results of many investigations that are in agreement (Colla *et al.*, 2008; El-Sabagh *et al.*, 2014; Liang *et al.*, 2020). The hypocholesterolemic effect of spirulina was suggested to be due to its high content of gamma-linolenic acid (Samuels *et al.*, 2002), high content of cystine (Nagaoka *et al.*, 2005), increased lipid metabolism towards the high-density lipoprotein at the expense of low-density lipoprotein (Torres-Duran *et al.*, 2007), or due to increased activity of lipoprotein enzyme (Karkos *et al.*, 2011). Additionally, Li *et al.* (2024) demonstrated that some peptides can lower blood cholesterol.

Growth parameters:

The ADG by calves supplemented with spirulina is illustrated in Table (5). From Table (5), calves on SP0 and SP5 had the same final weight, being 180.33 kg, whereas the calves on SP10 had final weight of 196.66 kg. The total weight gain was increased linearly as the supplementation level increased; the lowest value was accounted for SP0 (56.66 kg), while the highest value was accounted for SP10 (67.00 kg). No significant differences were detected regarding final weight, total weight gain, and periodic (15-day interval periods) ADG. However, both supplementation levels had a significant ($p \leq 0.05$) effect on total ADG; the total ADG was 0.629 kg/d for calves on SP0, and it was improved to 0.707 and 0.744 kg/d for SP5 and SP10, respectively.

Table (5): Effect of spirulina supplementation on the changes of body weights and daily gain (kg/h/d).

Item	Supplementation levels		
	SP0	**SP5**	**SP10**
Animal weight			
Initial weight	123.66± 12.44	116.66± 17.53	129.66± 18.67
Final weight	180.33± 19.05	180.33± 21.05	196.66± 23.21
Total gain	56.66± 6.69	63.66± 3.52	67.00± 4.58
Days	**Average daily gain (kg/h/day)**		
0 – 15	0.466±0.03	0.488±0.04	0.622±0.05
16 - 30	0.533±0.11	0.622±0.02	0.622±0.09
31 – 45	0.644±0.08	0.711±0.02	0.755±0.09
46 – 60	0.711±0.08	0.844±0.05	0.733±0.03
61 – 75	0.622±0.05	0.733±0.03	0.777±0.02
76 – 90	0.800±0.07	0.844±0.08	0.955±0.05
Average	0.629^{c}	0.707^{b}	0.744^{a}

SP0; SPA 0 kg/ton; SP5, SPA 5 kg/ton; SP10, SPA 10 kg/ton.

$^{a,\ b\ and\ c}$ Means of treatments within the same row with different superscript letters are significantly different ($P \leq 0.05$).

Formerly, Shimkiene *et al.* (2010) found that supplementing pregnant ewes with SP delivered heavier lambs with greater daily gain compared to lambs from non-supplemented ewes. Bezerra *et al.* (2010) supplemented lambs with cow milk enriched with SP, and they observed higher body weight and ADG of supplemented lambs than non-supplemented. El-Sabagh *et al.* (2014) demonstrated that SP supplementation led to higher final BW and ADG for supplemented lambs compared to non-supplemented lambs. Recently, studies revealed the same trend of increased ADG due to supplementation (Liang *et al.*, 2020; El-Deeb *et al.*, 2022a; El-Deeb *et al.*, 2022b). These results are consistent with our results, which mainly could be attributed to higher nutrient digestibility by calves on SP-supplemented diets (table 2) and higher plasma total protein (table 4). On the other hand, Ghattas *et al.* (2019) reported a non-significant increase in the body weight of calves supplemented with SP.

DM conversion:

As shown in Table (6), the best conversion of DM was achieved by calves on SP5 from 16-90 days, followed by SP10 compared to SP0. The same trend was noticed for the total average of DM conversion, since it significantly improved from 7.07 kg/kg gain for SP0 to 6.00 and 6.28 kg/kg gain for SP5 and SP10, respectively. No significant difference between SP5 and SP10 was detected. Our results are in accordance with several studies that indicated an improvement in feed conversion due to SP supplementation (El-Sabagh *et al.*, 2014; Gaafar *et al.*, 2017; Riad *et al.*, 2019). In the current study, the improvement in the ADG (table 5) even with the close values of DMI among groups (table 3) is a clear indication of improvement in DM conversion due to supplementation. Christodoulou *et al.* (2023)

demonstrated that supplementation with SP reduced the population of amylolytic bacteria in the rumen; thus, a part of starch can bypass the rumen and be digested in the small intestine, leading to more net energy and so more feed conversion efficiency (Brake and Swanson, 2018). Another acceptable reason for improved efficiency is the higher digestibility of supplemented diets.

Table (6): Dry matter conversion (kg DM/ kg gain) by calves supplemented with spirulina in their diets.

Days	Supplementation levels		
	SP0	SP5	SP10
0 – 15	7.93±0.25	7.08±0.50	6.20±0.35
16 – 30	7.82±1.18	5.97±0.88	6.77±0.44
31 – 45	6.48±0.11	5.58±0.61	5.89±0.28
46 – 60	6.26±0.03	5.07±0.32	6.49±0.63
61 – 75	7.64±0.10	6.36±0.50	6.64±1.09
76 – 90	6.30±0.17	5.94±0.40	5.69±0.38
Average	7.07^{a}	6.00^{b}	6.28^{b}

SP0; SPA 0 kg/ton; SP5, SPA 5 kg/ton; SP10, SPA 10 kg/ton.
$^{a,\ b\ and\ c}$ Means of treatments within the same row with different superscript letters are significantly different (P ≤ 0.05).

CONCLUSION

Supplementation of *Spirulina platensis* for growing buffalo calves enhanced all nutrients digestibility, blood plasma total protein, albumin, and globulin, which all contributed to an improvement in ADG and DM conversion. Calves received SP have higher triglycerides and lower cholesterol in their blood plasma. Supplementation did not have any undesirable effect on either liver or kidney functions.

REFERENCES

Abd Ellah, M. R., I. Hamed, D. R. Ibrahim and H. Z. Rateb. (2013), 'Reference Values for Hematological and Serum Biochemical Constituents in Late Pregnant Buffaloes', *Assiut Veterinary Medical Journal* Vol. 59, No. 136, pp. 35-46. DOI: 10.21608/avmj.2013.192537

AOAC (2000) Official Methods of Analysis. 17th Edition, The Association of Official Analytical Chemists, Gaithersburg, MD, USA. Methods 925.10, 65.17, 974.24, 992.16.

Bezerra, L. R., A. M. A .Silva, S. A. Azevedo, R. S. Mendes, J. M. Mangueira and A. K. A. Gomes. (2010), 'Performance of Santa Inês Lambs Submitted to the Use of Artificial Milk Enriched with *Spirulina platensis*.' DOI: 10.5216/cab.v11i2.1198.

Brake, D. W. and K. C. Swanson. (2018), 'Ruminant Nutrition Symposium: Effects of Postruminal Flows of Protein and Amino Acids on Small Intestinal Starch Digestion in Beef Cattle', *Journal of animal science* Vol. 96, No. 2, pp. 739-750. DOI: 10.1093/jas/skx058

Chorfi, Y., A. Lanevschi-Pietersma, V. Girard and A. Tremblay. (2004), 'Evaluation of Variation in Serum Globulin Concentrations in Dairy Cattle', *Veterinary Clinical Pathology* Vol. 33, No. 3, pp. 122-127. DOI: 10.1111/j.1939-165x.2004.tb00360.x

Christodoulou, C., A. Mavrommatis, D. Loukovitis, G. Symeon, V. Dotas, B. Kotsampasi and E. Tsiplakou. (2023), 'Effect of Spirulina Dietary Supplementation in Modifying the Rumen Microbiota of Ewes', *Animals* Vol. 13, No. 4, pp. 740. https://doi.org/10.3390/ani13040740

Colla, L. M., A. L. Muccillo-Baisch and J. A. V. Costa. (2008), '*Spirulina platensis* Effects on the Levels of Total Cholesterol, Hdl and Triacylglycerols in Rabbits Fed with a Hypercholesterolemic Diet', *Brazilian Archives of Biology and Technology* Vol. 51, pp. 405-411. https://doi.org/10.1590/S1516-89132008000200022

Duncan, D. B. (1955). Multiple ranges and multiple F-test. Biometrics, 11: 1- 42.

El-Deeb, M. M., A. M. Abdel-Gawad, A. L. I. Desoky, M. A. Aboul-Omran, M. E. Ahmed and M. M. Eissa. (2022a), '*Spirulina platensis* Influence on the Productivity of Zaraibi Does', *Europ. J. Biol. Sci* Vol. 14, pp. 49-57. DOI: 10.5829/idosi.ejbs.2022.49.57

El-Deeb, M. M., M. Abdel-Gawad, M. A. M. Abdel-Hafez, F. E. Saba and E. M. M. Ibrahim. (2022b), 'Effect of Adding *Spirulina platensis* Algae to Small Ruminant Rations on Productive, Reproductive Traits and Some Blood Components', *Acta Scientiarum. Animal Sciences* Vol. 45, pp. e57546. Doi: 10.4025/actascianimsci.v45i1.57546

El-Sabagh, M. R., M. A. Abd Eldaim, D. H. Mahboub and M. Abdel-Daim. (2014), 'Effects of *Spirulina platensis* Algae on Growth Performance, Antioxidative Status and Blood Metabolites in Fattening Lambs', *Journal of Agricultural Science* Vol. 6, No. 3, pp. 92. doi:10.5539/jas.v6n3p92

Farg, H., A. El-Makhzangy and A.-G. El-Shawaf. (2021), 'Chemical and Technological Studies on Micro Algae Extracts and Its Utilization in Some Food Products. 1-Chemical, Biochemical Characteristics and Nutritional Value of Spirulina Algae', *Journal of productivity and development* Vol. 26, No. 1, pp. 107-117. DOI: 10.21608/jpd.2021.147019

Gaafar, H. M., W. A. Riad, A. E. G. Y. Elsadany, K. F. El-Reidy and M. A. Abu El-Hamd. (2017), 'Effect of Spirulina (Arthrospira Platensis) on Productive and Reproductive Performance of Friesian Cows', *Egyptian Journal of Agricultural Research* Vol. 95, No. 2, pp. 893-911. DOI: 10.21608/ejar.2017.148904

Ghattas, T. A., E. N. Dawoud, A. F. Mahrous and E. A. Elgabry. (2019)'Effect of *Spirulina platensis* Supplementation on Growth, Some Biochemical and Immunological Parameters in Suckling Calves', *J. Egypt. Vet. Med. Assoc* Vol. 79, pp. 443-460.

Glebova, I., N. Besedin, O. Gryaznova, A. Glinushkin, V. Cheiko, A. Kislov and V. Kosolapov. (2018), 'The Use of *Spirulina platensis* in Cattle Feeding', *Entomology and Applied Science Letters* Vol. 5, No. 2-2018, pp. 78-85. ISSN No: 2349-2864

Heidarpour, A., A.D. Fourouzandeh-Shahraki, and S. Eghbalsaied.(2011). Effects of *Spirulina platensis* on performance, digestibility and serum biochemical parameters of Holstein calves. *African Journal of Agricultural Research*, *6*(22), pp.5061-5065. https://doi.org/10.5897/AJAR11.1076

Huuskonen, A., P. Huhtanen and E. Joki-Tokola. (2014), 'Evaluation of Protein Supplementation for Growing Cattle Fed Grass Silage-Based Diets: A Meta-Analysis', *Animal* Vol. 8, No. 10, pp. 1653-1662. https://doi.org/10.1017/S1751731114001517

Jung, F., A. Krüger-Genge, P. Waldeck and J. H. Küpper. (2019), '*Spirulina platensis*, a Super Food?', *Journal of Cellular Biotechnology* Vol. 5, No. 1, pp. 43-54. DOI: 10.3233/JCB-189012

Karkos, P. D., S. C. Leong, C. D. Karkos, N. Sivaji and D. A. Assimakopoulos. (2011), 'Spirulina in Clinical Practice: Evidence-Based Human Applications', *Evidence-Based Complementary and Alternative Medicine* Vol. 2011, No. 1, pp. 531053. DOI: 10.1093/ecam/nen058

Kearl, L. C. (1982). Nutrient Requirements of Ruminants in Developing countries. International Feedstuff Institute, Utah Agricultural Experiment Station, Utah State University, Logan, Utah, USA.

Khan, S., S .M. B. Rahman, B. K. Roy, N. Huda, M. A. Habib and M. Sarkar. (2021), 'Meat Quality Assessment of Local Cattle and Buffalo through Nutritive and Physiochemical Evaluation of Blood and Meat', *Buffalo Bulletin* Vol. 40, No. 3, pp. 431-441.

Li, J., C. Bollati ,L. d'Adduzio, M. Fanzaga, I. Cruz-Chamorro, A. Arnoldi, C. R. Sirtori and C. Lammi. (2024), 'Food-Derived Peptides with Hypocholesterolemic Activity: Production, Transepithelial Transport and Cellular Mechanisms', *Trends in Food Science & Technology* Vol ,143 .pp. 104279. https://doi.org/10.1016/j.tifs.2023.104279

Liang, Y., Y. Bao, X. Gao, K. Deng, S. An, Z. Wang, X. Huang, D. Liu, Z. Liu and F. Wang. (2020), 'Effects of Spirulina Supplementation on Lipid Metabolism Disorder, Oxidative Stress Caused by High-Energy Dietary in Hu Sheep', *Meat science* Vol. 164, pp. 108094. https://doi.org/10.1016/j.meatsci.2020.108094

Marwan, A., E. Saddick, and U. Nayel.(2024), ' Evaluation of Defatted Black Soldier Fly Larvae Supplementation in Growing BUFFALO Calves' diets', *Egyptian J. Nutrition and Feeds* Vol. 27, No. 3, pp. 291-301. DOI: 10.21608/ejnf.2024.394135

Nagaoka, S., K. Shimizu, H. Kaneko, F. Shibayama, K. Morikawa, Y. Kanamaru, A. Otsuka, T. Hirahashi and T. Kato. (2005), 'A Novel Protein C-Phycocyanin Plays a Crucial Role in the Hypocholesterolemic Action of *Spirulina platensis* Concentrate in Rats', *The Journal of nutrition* Vol. 135, No. 10, pp. 2425-2430. DOI: 10.1093/jn/135.10.2425

Nantongo, Z., M. Kiggundu, J. Moorby, A. Kigozi, H. K. Walusimbi and S. Mugerwa. (2021), 'The Influence of Supplemental Feed Protein Concentration on Growth and Carcass Characteristics of Short Horn Zebu Bulls Grazing Natural Pastures', *Scientific African* Vol. 13, pp. e00856. https://doi.org/10.1016/j.sciaf.2021.e00856

Nasehi, M., M. Entesarian and R. Pourjamshidian. (2019), 'Comparison Nutritive Value of *Spirulina platensis* Algae with Some Protein Meals Used in Ruminant Nutrition', *Research On Animal Production* Vol. 10, No. 24, pp. 27-36. doi:10.29252/rap.10.24.27

Naveena, B. M. and M. Kiran. (2014), 'Buffalo Meat Quality, Composition, and Processing Characteristics: Contribution to the Global Economy and Nutritional Security', *Animal frontiers* Vol. 4, No. 4, pp. 18-24. https://doi.org/10.2527/af.2014-0029

Riad, W. A., A .Y. Elsadany and Y. M. El-Diahy. (2019), 'Effect of *Spirulina platensis* Microalga Additive on Performance of Growing Friesian Calves', *Journal of Animal and Poultry Production* Vol. 10, No. 2, pp. 35-40. DOI: 10.21608/jappmu.2019.40308

Samuels, R., U. V. Mani, U. M. Iyer and U. S. Nayak. (2002), 'Hypocholesterolemic Effect of Spirulina in Patients with Hyperlipidemic Nephrotic Syndrome', *Journal of medicinal food* Vol. 5, No. 2, pp. 91-96. DOI: 10.1089/109662002760178177

SAS (2002). Statistical Analysis Systems Institute Inc., Release 8.1, Cary, NC., USA.

Schneider, B. H. and P. W. Flatt (1975). The evaluation of Feeds through Digestibility Experiments the Univ. of Georgia Press Athens 30602.

Shimkiene, A., Z. Bartkevichiute, J. Chernauskiene, A. Shimkus, A. Chernauskas, A. Ostapchuk and M. Nevitov. (2010), 'The Influence of *Spirulina platensis* and Concentrates on Lambs' Growth.' 47(1):9-14.

Tamburrano, A., B. Tavazzi, C. A. M. Callà, A. M. Amorini, G. Lazzarino, S. Vincenti, T. Zottola, M. C. Campagna, U. Moscato and P. Laurenti. (2019), 'Biochemical and Nutritional Characteristics of Buffalo Meat and Potential Implications on Human Health for a Personalized Nutrition', *Italian journal of food safety* Vol. 8, No. 3. https://doi.org/10.4081/ijfs.2019.8317

Torres-Duran, P. V., A. Ferreira-Hermosillo and M. A. Juarez-Oropeza. (2007), 'Antihyperlipemic and Antihypertensive Effects of Spirulina Maxima in an Open Sample of Mexican Population: A Preliminary Report', *Lipids in Health and Disease* Vol. 6, pp. 1-8. https://doi.org/10.1186/1476-511X-6-33

Van Keulen, J. and B. A. Young. (1977), 'Evaluation of Acid-Insoluble Ash as a Natural Marker in Ruminant Digestibility Studies', *Journal of animal science* Vol. 44, No. 2, pp. 282-287.

Waheed, D. M., M. El-Diasty and E. M. Gabr. (2024), 'Spirulina as an Animal Feed and Its Effect on Animal Health and Productivity', *Journal of Advanced Veterinary Research* Vol. 14, No. 2, pp. 342-344. ISSN: 2090-6277/2090-6269

Zaitsev, S. Y., N. V. Bogolyubova, X. Zhang and B. Brenig. (2020), 'Biochemical Parameters, Dynamic Tensiometry and Circulating Nucleic Acids for Cattle Blood Analysis: A Review', *PeerJ* Vol. 8, pp. e8997. DOI: 10.7717/peerj.8997

التقييم الغذائى للسبيرولينا فى علائق عجول الجاموس النامية

أحمد عبدالله مروان[1] و إيمان إبراهيم صديق[2] و أسامة أبوالعز نايل[2]

[1]قسم الإنتاج الحيواني، كلية الزراعة، جامعة عين شمس، مصر

[2]قسم الإنتاج الحيواني، كلية الزراعة، جامعة المنوفية، شبين الكوم، مصر

تم إجراء الدراسة الحالية لتقييم تأثيرإضافة طحلب الاسبيرولينا (سبيرولينا بلاتنسيس) لعجول الجاموس على هضم العناصر الغذائية، وتناول المادة الجافة، ومتوسط النمواليومي، وتحويل المادة الجافة (DM)، وبعض قياسات بلازما الدم. تم زراعة الاسبيرولينا، وتجفيفها في الشمس، ثم طحنها إلى مسحوق أخضر ناعم. تم تقسيم خمسة عشر عجلًا من الجاموس بالتساوي إلى ثلاث مجموعات، حيث تم تقديم ثلاث وجبات تجريبية: عليقة مقارنة بدون مكملات (SP0)، وعلائق مضاف اليها 5 و10 كجم من مسحوق الاسبيرولينا/ طن (SP5) و(SP10)) على التوالي. أظهرت النتائج أنه مقارنة بالعليقة المقارنة، أظهرت SP5 زيادة معنوية ($P \leq 0.05$) في هضم المادة العضوية، ومستخلص الأثير، والمستخلص الخالى من النيتروجين، بينما أظهرت SP10 زيادة معنوية ($P \leq 0.05$) في هضم جميع العناصر الغذائية. كان تأثير الإضافة غير معنويا على كمية المادة الجافة المأكولة. زاد معدل النمو اليومى خطيًا ($P \leq 0.05$) مع مستوى الإضافة. قام كل من مستويي الإضافة بزيادة معنوية ($P \leq 0.05$) فى تحويل DM، والبروتين الكلى في بلازما الدم، والألبيومين، والدهون الثلاثية، وعلى العكس من ذلك انخفض ($P \leq 0.05$) الكوليسترول في بلازما الدم. لا يوجد أى دليل على اى تأثيرات غير مرغوب فيها على وظائف الكبد أو الكلى بسبب الإضافة.