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Enhancing Fattening Lamb Performance with *Spirulina platensis*: Insights into Growth, Blood Metabolism and Antioxidant Status

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

This study explained Enhancing Fattening Lamb Performance with *Spirulina platensis*: Insights into Growth, Blood Metabolism, and Antioxidant Status. 20 lambs. (7-8 months old, (45.0±0.5 kg) were randomly divided into two groups, with one group receiving a commercial diet and the second group receiving the same diet but with 1g/10kg B.W/day of *Spirulina platensis* powder. The lambs were weighed at various points during the 42-day experiment and results showed that *Spirulina platensis* supplementation improved body weight gain, blood parameters (hemoglobin, white blood cells, total protein, albumin, globulin, A/G ratio, vitamin A, blood GSH, serum MDA), and reduced blood markers for liver damage (ALT, AST), glucose, cholesterol, and triglycerides. The results suggest that *Spirulina platensis* has antioxidant properties and can improve growth performance in lambs.

Keywords: Daily feed intake; daily weight gain; growth performance; fattening lambs; Spirulina platensis.

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1. INTRODUCTION

Spirulina is a blue-green microalga that is considered the oldest life form on earth. *Spirulina platensis* proved to contain a valuable protein content of 55% to 70% with plenty of essential amino acids content like Lysine, methionine, tryptophan and cysteine. Moreover, ruminants can consume *spirulina* [1]. *Spirulina platensis* is a proven source of protein and other beneficial nutritional constituents [2]. *Spirulina* can be found in salt lakes, soil, marshes, fresh water, brackish Water and seawater. It is an obligate photoautotroph, and therefore cannot grow in the dark, even when other factors are available. The optimum temperature for growth is between 35°C and 39°C [3].Sheep as a substitution for livestock requires more attention, not only for supporting the rural community's economy, but also for the benefits that would result to the farmers and the whole society as well. Sheep offer a nice eating experience due to the quality of the meat. Most farmers and breeders still use the conventional methods when it comes to feeding their sheep herds; therefore, forage is still the first choice for sheep fattening strategies. Extensive farm animal production systems may be related to a couple of stressful incidents that negatively affect immune response and the overall animal's performance. The excessive metabolic rate for the duration of in-depth feeding is accompanied by an increased manufacturing of free radicals, and any imbalance between production of these molecules and their secure disposal can culminate in oxidative stress, which can damage cells and tissues" [4,5]. "There is a continual demand for antioxidants to reduce the harmful effects of free radicals that negatively affect the immune system especially under extensive oxidative stress situations" [6]. Therefore, the substitution of synthetic for natural feeding leads to better results for animal welfare and consumer safety, due to the presence of natural antioxidant [7,8]. "Spirulina platensis is a perfectly cost-effective natural antioxidant and immune booster for humans and animals with minimal side effects."[9,10,11].

This study explained enhancing fattening lamb performance with Spirulina platensis: Insights into Growth, Blood Metabolism and Antioxidant Status.

2. MATERIALS AND METHODS

2.1 *Spirulina platensis*

Spirulina platensis powder was purchased from a local store located in California; chemical composition of *Spirulina platensis* was represented in Table 1.

Table 1. Chemical composition of *Spirulina platensis*

Item	% Content
Total Protein	68
Total Carbohydrates	30.75
Total Fat	3.3
Fiber	6.0
Moisture	4.5
Ash	9.0

2.2 Animals and Dietary Treatment

Twenty healthy California Red Sheep lambs aged between 7-8 months with a mean body weight of 45.0±0.5 kg were randomly selected from a herd of 250 lambs. The lambs were allowed to acclimate for two weeks and then divided into two equal groups; the first group (Control) received a commercial diet, while the second group (Sp) received the same commercial diet with an addition of 1 g/10 kg body weight/day of *Spirulina platensis* powder. The basal diet was formulated to meet all lambs' nutritional requirements. The lambs were fed the diet twice daily at 6:00 AM and 4:00 PM, with unrestricted access to water throughout the day. The constituents of the basal diet were presented in Table 2.

Table 2. Nutrient analysis of lamb Feed*

Item	Content
Crude Protein, min	14.0%
Crude Fat, min	5.0%
Crude Fiber, max	11.0%
Acid Fiber Detergent, max	14.0%
Calcium, min	0.9%
Calcium, max	1.4%
Phosphorus, min	o.3%
Salt, min	0.1%
Selinium**	0.2
Vitamin A***	4,250
Vitamin D***	830
Vitamin E***	50

***Includes not more than 0.85% equivalent protein from non-protein nitrogen ** Ppm *** IU/lb*

2.3 Experimental Design and Blood Collection

This experiment lasted for 42 days, and animals were weighed on days 0, 14, 28, and 42 after fasting for twelve hours after the evening meal. On day 42, blood samples were collected from the jugular vein of each lamb after fasting for 12 hours.

The collected blood samples were used for determining blood metabolites; Hemoglobin (Hb) and White blood cell counts (WBC) were analyzed according to [12]; reduced glutathione was analyzed according to [13]. Total protein (TP), Albumin, alanine amino transferase (ALT), aspartate amino transferase (AST), cholesterol (CHO), triglyceride (TG) and blood urea nitrogen (BUN) were analyzed according to [14]. Globulin was estimated by subtracting albumin value from total protein value, in the same way albumin/globulin (A/G) ratio was calculated. Malondaldehyde (MDA) concentration was done according to [15]. Vitamin A (Retinol) concentration was done as described by [16].

2.4 Statistical Analysis

Statistical analysis of the obtained data was carried out for analysis of variance according to [17]. Using SAS software version 9.4, 2020 USA. Means were compared by the L.S.D. values at 5% level.

3. RESULTS AND DISCUSSION

Spirulina platensis has proven to be an effective growth promoter and antioxidant agent for animals, due to its high concentration of beneficial organic compounds that boost immunity and enhance growth performance. In this study, *Spirulina platensis* was utilized in fattening lambs.

3.1 Growth Performance

Table 3 summarized the growth performance of lambs, *Spirulina platensis* caused highly significant increased (P<0.01) for daily weight gain (kg/day) and final weight (kg), while *Spirulina platensis* significantly increased (P<0.05) daily feed intake (Kg/day). On the other hand, feed conversion ratio highly significant decreased (P<0.01) compared to the control group. The protein content of *Spirulina platensis* used in this study is 68%, which considered the main factor enhancing the growth performance, this finding is in a full agreement with that obtained by [18,19,20], all illustrated that in order to have better growth, lambs should have a high-quality feed with a valuable rich-protein supplement. The increase in body weight and average daily weight gain could be due to the increased rumen microbial crude protein production [21,22]. *Spirulina platensis* contains valuable nutrients, like protein, vitamins, essential fatty acids, minerals, amino acid as well others, which could boost the growth rate [23]. *Spirulina* may boost and improve the growth performance by improving the development and the morphological structure of the digestive tract that lead to an increase in total tract digestibility of protein and dry matter [24]. Feed Conversion Ratio was 11.5±1.45 and 7.45±0.32 for control and *Spirulina platensis* feed group respectively, the same results was also proposed by [25].

3.2 Hematology

"The Hb concentration and WBC count of lambs fed with *Spirulina platensis* were higher than that fed with the commercial lamb diet (Table 4 and Fig. 1). The Hb concentration and WBC count were significantly higher in *Spirulina platensis* group compared to the control group. The increase in hemoglobin concentration in *spirulina platensis* supplementation compared to the control may be due to the increased iron content in *Spirulina platensis* and presence of phycocyanin. The increase in WBC count may be due to presence of phycocyanin and polysaccharides levels in *spirulina platensis"* [26]. *Spirulina platensis* supposed to boost the immunity in fish [27], and in chickens [28].

3.3 Biochemical Parameters

Table 5 and Fig. 2 showed the biochemical parameters; it is clear from the table that there was a significant increase for TP, albumin, globulin and A/G ratio. The increase in TP, albumin, globulin and subsequently A/G ratio may be due to the increased protein content in *Spirulina platensis* used in this study. The same finding was proposed by [23]. The increased plasma globulin is always indicates higher individual resistance and thought to be associated with a strong innate response [29]. Concerning ALT, AST, there was significant decrease in *Spirulina platensis* supplementation group by the end of the experiment at 42 day. *Spirulina platensis* possess a protective action against liver dysfunctions [30]. *Spirulina platensis* caused a significant decrease in glucose level of lambs by the end of the experiment. *Spirulina platensis* possess anti-diabetic properties [31].*Spirulina platensis* caused a significant decrease for both Cholesterol and triglycerides compared to the control group by the end of the experiment at 42 day. The same finding is in consistent with that proposed in rabbits by [32], in rats [33], in hamsters [34] and in human [35]. The decrease in cholesterol may be due to the increase in lipase and hepatic triglyceride lipase action [36]. [37] Proposed

another finding for the decrease of Cholesterol concentration who referred the decrease in cholesterol concentration with *Spirulina platensis* to the ileal bile acid absorption and inhibition of both jejunal CHO absorption. *Spirulina platensis* reduced triglyceride and Cholesterol [38].

3.4 Antioxidant Status

Table 6 and Fig. 3 represent vitamin A, Blood GSH and Serum MDA concentrations. "It is clear from the results that there was a significant increase in Vitamin A and Blood GSH concentrations in the group fed with *Spirulina platensis* compared to the control group. On the other hand, there was a significant decrease in Serum MDA in the group fed with *Spirulina platensis* powder compared to the control group. The increase in vitamin A and blood GSH with a decrease in serum MDA are true indicators of enhanced oxidative defense of animal tissues" [39]. These results are in full agreement with that obtained by [40] who reported that "*Spirulina platensis* supplementation leads to significantly increase in superoxide dismutase activity and catalase enzyme in the erythrocytes along with a concomitant increase in reduced tripeptide glutathione content in chicken". "The antioxidative effect of *Spirulina spp.* Is referred to the presence of Phycocyanin" [41]. Moreover, [34] stated that the antioxidative effect of *Spirulina* is related to the presence of many valuable ingredients that has distinct antioxidant activities alone or in synergy such as phycocyanin, ß-carotene and polysaccharide. The antioxidant activity of phycocyanin is about 20 times more than vitamin C [42].

Table 3. Effect of *Spirulina platensis* supplementation on growth performance

Item	Treatment	
	Control	**Sp.**
Initial Weight (Kg).	45±0.5	45±0.5
Daily Weight Gain (Kg/Day).	0.135±0.02	0.245±0.016**
Daily Feed Intake (Kg/day).	1.58±0.002	1.69±0.01*
Final Weight (Kg).	51.6±0.89	54.75±2.00**
Feed Conversion Ratio	11.5±1.45	7.45±0.32**

Sp= Spirulina platensis

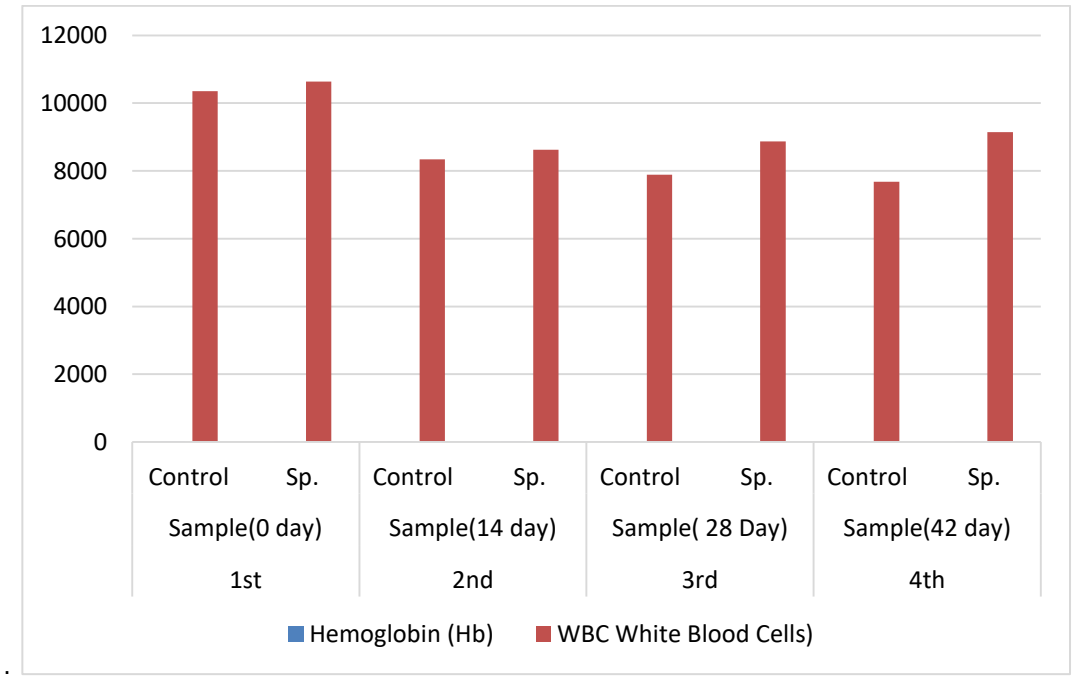

Fig. 1. Effect of *Spirulina platensis* supplementation on hemoglobin concentration and total WBC count

Table 4. Effect of *Spirulina platensis* supplementation on hemoglobin concentration and total WBC count

Item	1st Sample (0 day)		2nd Sample (14 day)		3rd Sample (28 Day)		4th Sample (42 day)	
	Control	Sp.	Control	Sp.	Control	Sp.	Control	Sp.
Hemoglobin (Hb)	11.12 e	11.23 d	11.24 d	11.54 c	11.43 c	11.69 b	11.51 c	11.85 a
White blood cells	10356 b	10638 a	8340 f	8623 e	7890 g	8865 d	7675 h	9140 c

Sp= Spirulina platensis; Hb= Hemoglobin; WBC= White blood cells
Different superscripts on the same row show significant difference (P<0.05)

Table 5. Effect of *Spirulina platensis* supplementation on biochemical parameters

Item	1st Sample (0 day)		2nd Sample (14 day)		3rd Sample (28 day)		4th Sample (42 day)	
	Control	S.p.	Control	S.p.	Control	S.p.	Control	S.p.
TP (g/dl)	4.44 f	4.56 e	4.67 d	4.86 c	4.78 c	4.98 b	4.93 b	5.45 a
Albumin (g/dl)	2.10 e	2.19 d	2.18 d	2.37 c	2.33 c	2.56 b	2.46 b	2.74 a
Globulin (g/dl)	2.24 f	2.43 d	2.36 e	2.49 d	2.42 d	2.68 b	2.58 c	2.76 a
A/G ratio	0.90 c	0.92 c	0.88 d	0.95 c	0.95 c	1.06 a	1.00 b	1.01 b
ALT(U/ml)	20.90 c	20.44 e	21.31 b	20.74 d	21.54 a	20.46 e	21.34 b	19.39 a
AST(U/ml)	51.10 a	50.00 e	50.89 b	50.73 c	50.65 c	50.49 d	50.54 d	49.15 a
Glucose (mg/dl)	40.40 c	39.60 e	42.3 b	40.23 c	42.66 b	40.00 d	43.3 a	37.77 a
Cholesterol (mg/dl)	46.45 c	45.8 d	47.32 b	46.23 e	47.98 b	45.90 d	48.44 a	45.55 e
Triglycerides (mg/dl)	40.40 c	39.76 d	40.78 c	40.10 cd	41.56 b	39.78 d	42.30 a	37.90 e

S.p= Spirulina platensis TP= Total Protein; A/G ratio= Albumin/Globulin ratio; ALT= Alanine amino transferase; AST = Aspartate amino transferase, Different superscripts on the same row show significant difference (P<0.05)

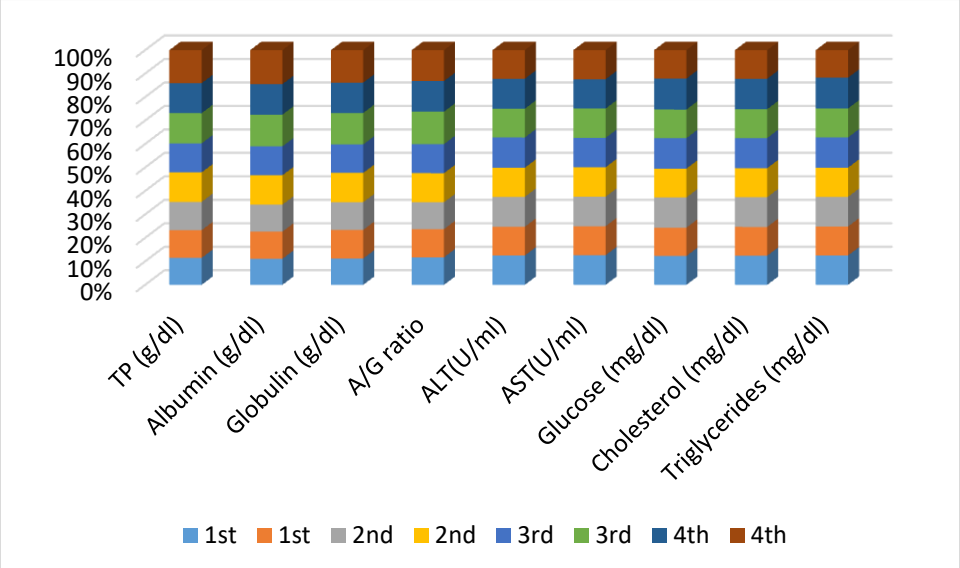

Fig. 2. Effect of *Spirulina platensis* supplementation on biochemical parameters

Table 6. Effect of *Spirulina platensis* supplementation on vitamin A, GSH and MDA concentrations

Item	1st Sample (0 day)		2nd Sample (14 day)		3rd Sample (28 Day)		4th Sample (42 day)	
	Control	S.P	Control	S.P	Control	S.P	Control	S.P
Vitamin A (⌠g/dL)	61.20 f	61.65 f	63.6 e	66.5 d	67.9 d	72.8 b	68.3 c	86.3 a
Blood GSH (⌠M/L)	2.6 e	3.3 d	2.8 e	4.3 c	3.6 d	6.1 b	4.2 c	9.4 a
Serum MDA (nM/ml)	7.3 f	7.45 f	8.3 d	7.8 e	11.9 b	9.9 c	13.6 a	12.4 b

S.p= Spirulina platensis. Different superscripts on the same row show significant difference (P<0.05)

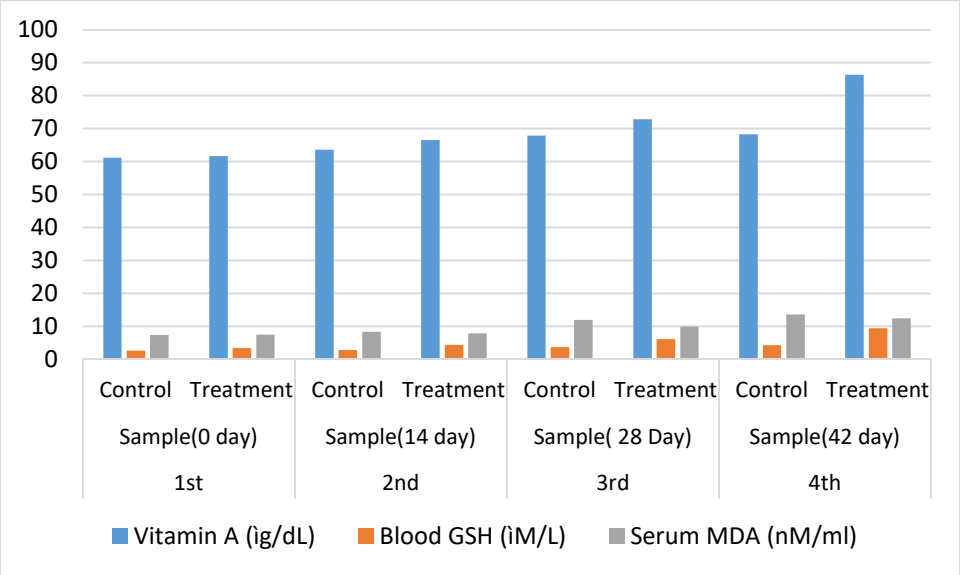

Fig. 3. Effect of *Spirulina platensis* supplementation on vitamin A, GSH and MDA concentrations

The whole results of the present study indicate that *Spirulina platensis* supplementation had a positive impact on the growth performance, blood metabolites, and antioxidant properties of fattening lambs. The increase in body weight gain and blood parameters such as hemoglobin, WBC count, total protein, albumin, globulin, A/G ratio, and vitamin A could be attributed to the high protein content and essential amino acids present in *Spirulina platensis*. The decrease in ALT, AST, glucose, cholesterol, and triglycerides levels could be due to the antioxidant properties of *Spirulina platensis*, which led to the reduction of oxidative stress and improved liver function. The increase in blood GSH and decrease in serum MDA levels indicate that *Spirulina platensis* supplementation had a positive impact on the antioxidant status of lambs.

4. CONCLUSSION

In conclusion, the results of this study suggest that *Spirulina platensis* supplementation had a positive impact on the growth performance, blood metabolites, and antioxidant status of fattening lambs. Therefore, it can be considered as a natural and cost-effective alternative to improve the health and welfare of lambs.

ETHICAL APPROVAL

This study was undertaken at a private lamb herd, California, USA, and the use of animals and procedures adopted in this study were in accordance with the Animal Welfare Act of Practice for the Care and Use of Animals for Scientific Purposes.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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