EVALUATION OF SHEA BUTTER SUPPLEMENTATION IN FINISHING LAMBS' DIETS

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SUMMARY

Twelve Barki male lambs, six-month-old with an average body weight of 31.75±5.50 kg, were used in a growth trial for 63 days. Animals were randomly assigned into two similar groups to evaluate the effect of shea butter (SB) supplementation on sheep performance. Animals were fed a basal diet (control) including concentrate feed mixture (CFM) at level of 2% body weight on DM basis, and clover hay was offered ad libitum. The control ration (C) was offered to the first group without supplementation, while the other experimental group (SBR) received the control ration supplemented with 5% (w/w) crude shea butter. A digestibility trial was performed at the end of the growth experiment; finally, three lambs from each group were slaughtered in accordance with Islamic law. The obtained results showed that shea butter supplementation did not influence feed intake. Sheep on the SBR diet had numerically less average daily gain, ADG (0.196 kg vs. 0.201 kg) and more feed conversion ratio, FCR (9.14 vs. 8.54), but the differences between groups were non-significant. Supplementation of SB did not significantly affect the digestibility of dry matter (DM), organic matter (OM), crude protein (CP), nitrogen-free extract (NFE), and crude fiber (CF). Contrariwise, ether extract (EE) digestibility was significantly ($p<0.01$) higher in SBR group (82.43%) than in control ration (71.02%). The percentages of TDN and DCP were 73.32 and 11.36 vs. 74.39 and 11.35 for the control and SBR groups, respectively, with no significant differences. The reduction of nitrogen balance in the SBR group (19.79 vs. 22.06 g/day) was non-significant. Shea butter supplementation reduced all rumen parameters at two hours post-feeding. However, the reduction in pH and NH3-N was insignificant. Otherwise, rumen total volatile fatty acids, TVFA was significantly decreased (P= 0.002) at two hours post-feeding as affected by SB supplementation, being 9.96 and 8.60 for C and SBR, respectively. All blood serum metabolites were not significantly affected by SB supplementation except creatinine and triglycerides. Creatinine was significantly ($p\leq0.05$) lower (0.89 mg/dl), but triglycerides were significantly ($p\leq0.05$) higher (32.67 mg/dl) in the SBR group than the control (0.95 mg/dl and 19.33 mg/dl, respectively). All blood parameters were within the normal range according to age and sex. The hot carcass weight (HCW) and cold carcass weight (CCW) were decreased ($p\leq0.05$) in the SBR group compared to the control being 25.47 and 24.85 kg vs. 27.09 and 26.43 kg, respectively. As a dramatic result of the decrease in hot carcass weight in the SBR group, the percentage of dressing based on slaughter body weight, SBW and empty body weight, EBW for the SBR group was less than the control (52.00 and 61.22 % vs. 55.29 and 63.88 %, respectively). There were no significant differences in the rib-eye area and back fat thickness between groups.

***Keywords**: Shea butter, digestibility, rumen parameters, blood serum metabolites, and growth performance.*

INTRODUCTION

Shea tree is an African plant which is scientifically known as *Vitellaria paradoxa*. In later years, the shea tree, its products and by-products were incorporated into livestock diets. Yousuf (2003) fed shea dry leaves to goats, while Yusuf *et al.* (2010) utilized shea trees as fresh forage for growing rabbits. Yusuf *et al.* (2009) used shea butter, a fat extracted from the nut, as supplementation in the diets of sheep; in addition, Yousuf *et al.* (2014) used shea leaf extract in goats' diets. Sheanut cake, a waste product from butter extraction from shea fruits, was successfully included up to 25% of sheep diets (Obioha, 2018).

Shea butter has strong antioxidant activity due to its high levels of vitamins A and E (Saadawi *et al.*, 2020). Vitamin E, also known as tocopherol, is a fat-soluble vitamin that structurally falls into the class

of phenolic compounds. Approximately two-thirds of the vitamin E in shea butter is present as α-tocopherol, which has been shown to have the strongest antioxidant activity of all the tocopherols (Maranz and Wiesman, 2004). Supplementing cows' diets with vitamin E increases the activity of antioxidant enzymes, boosts the body's and rumen's antioxidant capacity, and lessens the inflammatory response (Moghimi-Kandelousi *et al.*, 2020). Furthermore, Wu *et al* .(2023) reported that high-dose of vitamin E supplementation to dairy cows increased the antioxidant capacity of the milk and plasma. Additionally, shea butter has comparatively high overall amounts of phytosterols, which are considered as dietary components that lower cholesterol (Krist *et al.*, 2006).

One common tactic in contemporary industrial fattening systems for ruminants is to apply a high-energy feed to enhance animal performance (Wang *et al.*, 2021). Fat supplementation is the common method for increasing the energy density of ruminant diets (Behan *et al.*, 2019). Several lipids were used in ruminant diets, such as oilseeds, vegetable oils, and calcium salts of fatty acids known as protected fat (Behan *et al.*, 2019; Eldahshan *et al.*, 2020).

Rumen fermentation characteristics can indicate how well feed nutrients are used in the rumen. Diet impacts rumen ecology, ruminant growth performance, and product quality. Therefore, nutritional supplementation is a practical and efficient way to modify the nutritional composition of the animal's diet for better rumen ecology, growth performance, and milk or meat quality (Ding *et al.*, 2023).

Yusuf *et al.* (2009) used Shea butter as a fat supplement for fattening sheep, and they observed significant improvement in ADG, FCR and net benefit as shea butter supplementation level increased. However, the information about using shea butter in ruminant nutrition is still very few. The effects of certain fat supplementation on animal performance depend on the level of supplementation, livestock species and age of the animal (Ironkwo and Oruwari, 2004). Therefore, this study was conducted to evaluate the effect of shea butter supplementation on the performance of Barki sheep.

MATERIALS AND METHODS

This study was conducted at the Animal Research farm belonging to Department of Animal Production, Faculty of Agricultural, Menoufia University in accordance with Scientific Research Ethics and Animal Use Committee (SRE & AUC), Faculty of Agriculture, Menoufia University (Reference No. 06-SRE & AUC-MUAGR-09-2023).

Experimental animals and feeding procedure:

Twelve Barki male lambs, six-month-old with an average body weight of 31.75±5.50 kg, were assigned randomly into two similar groups (6 lambs/ group). Animals were fed, in groups, a basal diet (control) including concentrate feed mixture (CFM) at level of 2 % body weight, and clover hay was offered ad libitum. The control ration was offered to the first group without supplementation, while the other experimental group (SBR) received the control ration supplemented with 5% (w/w) crude shea butter. Shea butter was melted in the microwave, sprinkled on and mixed well with the CFM before feeding. Preparation of SBS was weekly done to avoid rancidity and oxidation processes. The amount of CFM was offered twice daily at 08:00 and 16:00 h. Free access to fresh and clean water was available to all animals. The concentrate feed mixture was formulated as follows: yellow corn 50%, soybean meal 14%, cotton seed meal 17%, wheat bran 15.5 %, limestone 1.6%, common salt 1.0%, sodium bicarbonate 0.5%, mineral 0.3%, vitamin 0.1%. Vitamin mixture provided per kg of diet: vitamin A: 200,000IU; vitamin D3: 300,000IU; vitamin E: 10,000IU; vitamin K: 2mg and Antioxidant: 1000mg/kg, Cu: 3300 mg/kg; Fe: 100mg; Zn: 16,500mg/kg; Mn: 9000mg; I: 120mg/kg; Co: 90mg/kg and Se: 90mg/kg.

Chemical composition:

The chemical composition of concentrate feed mixtures and roughage are presented in Table (1). Chemical analysis of the experimental feeds and feces was determined according to AOAC (2000).

Feed intake and growth trial:

Lambs were weighed biweekly before morning feeding. The amounts of offered feed were adjusted as the weight was changed. Records of periodic weights in addition to daily offered and rejected amounts of clover hay were kept; hence, average daily gain (ADG) and feed conversion ratio (FCR) were calculated. The growth trial lasted for 63 days. To calculate daily feed intake (FI), the amounts of feed rejected were subtracted from the amounts of feed offered. Regarding average daily gain, it was calculated as the difference between final and initial body weight divided by the period (number of days) during which

they gained weight. Finally, the feed conversion ratio was calculated by dividing the weight of FI by ADG.

Table (1): The chemical composition of the concentrate, roughage and experimental rations.

Items	Clover hay	Concentrate		Experimental rations	
		CFM[1]	SBS	C	SBR
Dry matter, DM%	89.14	90.29	90.92	89.63	89.89
On DM % basis					
Organic matter, OM	86.12	94.09	94.09	89.52	89.71
Crude protein, CP	13.58	16.04	15.98	14.63	14.62
Crude fiber, CF	29.37	7.61	8.38	20.10	20.39
Ether extract, EE	2.22	2.48	5.06	2.40	4.05
Nitrogen-free extract, NFE	40.95	67.95	64.67	52.35	50.65
Ash	13.87	5.91	5.91	10.46	10.29

[1]CFM, concentrate feed mixture in control ration; SBS, CFM supplemented with 5% (w/w) crude shea butter. C, CFM at level of 2 % body weight and clover hay. SBR, control ration supplemented with 5% (w/w) crude shea butter.

Digestibility trial:

After the end of the growth trial, the experimental animals were kept individually in 1.60 m x 0.53 m metabolic crates, which facilitated the separate collection of urine and feces according to the description of Maynard *et al.* (1979). The rations consisted of CFM, which was offered at 2% of body weight, and clover hay with 40:60% concentrate: roughage ratio. Residual feed was recorded daily. The digestibility trial lasted for 21 days, consisting of 14 days as an adaptation period and 7 consecutive days for collection.

Feces were quantitatively collected at 8:00 a.m. before feeding. A 10%-Comprised sample was removed and oven-dried at 70 ºC for 24 hours to a constant weight. Dry fecal samples were crushed to pass through a 2 mm screen and stored in plastic bags for later analysis.

The digestibility of all nutrients was calculated using the following equation:

$$\text{Nutrient digestibility, \%} = \frac{\text{Nutrient intake} - \text{Nutrient in feces}}{\text{Nutrient intake}} \times 100$$

Nitrogen balance:

To determine nitrogen balance, urine was quantitatively collected every day during the collection period at 8:00 a.m. before feeding. Urine was collected in containers containing 50 ml of 0.1N HCl to maintain pH<2.00 to avoid N loss through ammonia volatilization and to avoid bacterial growth in the urine. A quantity of 10% of the total urine from each lamb was withdrawn and kept in glass bottles in the freezer for later determination of N content. Nitrogen balance was calculated by subtracting the total nitrogen losses (urinary nitrogen, UN + fecal nitrogen, FN) from the total nitrogen intake (NI).

Rumen parameters:

Rumen fluid samples were taken individually to ascertain rumen parameters after 2 hours of feeding. A rubber stomach tube was used to withdraw rumen samples by inserting it into the rumen through the oesophagus. A digital pH meter was used to measure the rumen's pH as soon as it was collected. Three layers of cheesecloth were used to filter the rumen contents, and the fluid component was then acidified using 7.2 N H_2SO_4 at a ratio of 1 milliliter of acid to every 100 milliliters of strained ruminal fluid. Strained samples were kept frozen at -20 ºC until they were analyzed. Total volatile fatty acids in the rumen liquor (VFA) were measured according to the steam distillation procedure as described by Warner (1964). Ammonia-N (NH_3-N) concentration was determined according to Horn *et al.*(1981).

Blood serum parameters:

Blood samples were collected from each lamb before feeding via the jugular vein in non-heparinized tubes, which were then centrifuged for 15 minutes at 4000 rpm. The serum was carefully taken and stored at -20 °C until analysis. Serum samples were analyzed for concentrations of albumin, globulin, alanine transaminase (ALT), aspartate transaminase (AST), creatinine, urea-N, triglycerides, cholesterol, high-density lipoproteins (HDL), low-density lipoproteins (LDL), total antioxidant capacity (TAC),

glutathione peroxidase, alph-1-globulin, alpha-2-globulin, beta globulin, and gamma-globulin. Blood parameters were calorimetrically determined by the standard kits supplied by Spectrum, Germany. Analyses were performed at the Central Lab for Chemical Diagnosis and Blood Research of Sadat City University.

Slaughter procedure:

Finally, three lambs from each group were randomly selected and slaughtered in accordance with Islamic law. Before slaughter, lambs were fasted for 24 hours with only access to water. They were weighed just before slaughter (slaughter body weight, SBW). After slaughtering and bleeding, carcasses were skinned and decapitated. External and internal offals, except for heart, liver, spleen, kidneys, and kidney fat, were removed before recording the hot carcass weight (HCW) within one hour from slaughter. Non-carcass components, such as trachea, lungs, and testes, were immediately weighed after removal from the body. The weight of digestive contents was calculated as the difference between the weight of the full and empty digestive tract. The empty body weight (EBW) was computed as the difference between the slaughter weight and the weight of digested content. The dressing percentage based on slaughter and empty body weight was calculated as the weight of the hot carcass divided by either SBW or EBW multiplied by 100. The carcasses were chilled (at 4°C) for 24 h. After chilling, the cold carcass weight (CCW) was recorded, and then the chiller shrinkage percentage (CS %) was calculated. The carcasses were longitudinally split into two identical halves along the vertebral column. The size of the rib-eye area, as well as the thickness of the back fats, was measured by cutting the left side of the chilled carcass between the 12th and 13th ribs.

Statistical analysis:

Experimental data were subjected to One-way ANOVA using IBM SPSS Statistics for Windows, Version 22.0. (2013).

RESULTS AND DISCUSSION

Effect of shea butter supplementation on:

Feed intake and growth performance:

It clearly appears that shea butter supplementation did not influence feed intake Table (2). The hay intake and total DM intake (DMI) were almost equal in the experimental groups (0.980 vs 0.976 and 1.67 vs 1.66 kg DM/day for the control and SBR groups, respectively). Sheep on the SBR diet had numerically less ADG (0.196 kg vs. 0.201 kg) and more FCR (9.14 vs 8.54), but the differences between groups were not significant. These results are in consonance with the report of Adeyemi *et al.* (2016), who concluded that 4% or 8% blend of canola and palm oil inclusion in goats' diets did not affect DMI, initial body weight, final body weight, weight gain, ADG and FCR. Also, Yusuf *et al.* (2009) reported that shea butter supplementation decreased forage intake, but the total DMI was not affected. Contrary to our findings, studies reported a significant reduction in DMI and growth performance due to oil supplementation (Wanapat *et al.*, 2011; Dos Santos *et al.*, 2022). Allen (2000) ascribed feed intake reduction to many reasons such, the effect of fat on ruminal fermentation, the palatability and acceptability of the diet, and the release of cholecystokinin, a gut hormone that is responsible for the satiation feeling. However, some studies revealed that fat supplementation increased ADG and FCR (Yusuf *et al.*, 2009; El-Hakeem *et al.*, 2022). Bhatt *et al.*(2011) found that coconut oil supplementation up to 50g/kg improved FCR, and it was declined when the level of supplementation was above.

Nutrients digestibility and nutritive value:

Table (3) shows nutrients digestibility in sheep as a result of shea butter supplementation. There was no significant difference ($p>0.05$) between the control and the SBR groups for the digestibility of dry matter (DM), organic matter (OM), crude protein (CP), nitrogen-free extract (NFE) and crude fiber (CF). Contrariwise, ether extract (EE) digestibility was significantly ($p<0.01$) higher in SBR group (82.43%) than in sheep fed control ration (71.02%).

Table (2): Effect of shea butter supplementation on feed intake and weight gain parameters.

Parameters	Experimental rations		SEM	*p*-value
	C	SBR		
Initial live weight (kg)	32.10	31.40	1.74	0.854
Final weight (kg)	45.20	44.20	2.36	0.847
Total weight gain (kg)	13.10	12.80	0.95	0.885
ADG (kg)	0.20	0.19	0.01	0.885
DMI (kg /day)				
Hay	0.98	0.98	0.02	0.867
CFM	0.69	0.68	0.01	0.730
Total	1.67	1.66	0.02	0.796
FCR	8.55	9.14	0.78	0.728

C, CFM at level of 2 % body weight and clover hay. SBR, control ration supplemented with 5% (w/w) crude shea butter. ADG, Average daily gain, DMI, Dry matter intake, FCR, Feed conversion rate. SEM, Standard error of mean

Table (3): Effect of shea butter supplementation on nutrient digestibility (%) and nutritive value.

Parameters	Experimental rations		SEM	*p*-value
	C	SBR		
Digestibility, %				
DM	79.49	79.22	0.85	0.880
OM	80.06	79.59	0.83	0.782
CP	77.71	77.71	0.99	0.980
EE	71.02	82.43	1.59	0.001
NFE	87.76	84.97	0.92	0.132
CF	60.69	64.95	1.32	0.108
Nutritive value %				
TDN	73.32	74.39	0.77	0.495
DCP	11.37	11.36	0.14	0.972

C, CFM at level of 2 % body weight and clover hay. SBR, control ration supplemented with 5% (w/w) crude shea butter. TDN, Total digestible nutrients, DCP, Digestible crude protein.

Similarly, supplementation of 4% or 8% oil inclusion did not affect the digestibility of DM, OM, CP and CF in supplemented goats (Adeyemi *et al.*, 2016). On the other hand, Yusuf *et al.* (2009) reported a significant increase in the digestibility of DM, OM, and CP when sheep were supplemented with 50 or 100 g/kg shea butter. Fat supplementation significantly increased the digestibility of EE (Yusuf *et al.*, 2009; Bhatt *et al.*, 2011; Adeyemi *et al.*, 2016). The improvement in EE digestibility could be attributed to enhanced emulsification and absorption of fat in the intestine, as explained by Yusuf *et al.* (2009). The most dominant fatty acids in crude shea butter are Oleic(C18:1) and Stearic(C18:0) (Abdel-Razek *et al.*, 2023). According to Porm (2020), increased Oleic acid in fat supplements resulted in increased digestibility and absorption of fatty acids, especially those containing 18 carbons. Oleic acid has amphiphilic properties, which enhance micelle formation and raise fatty acids and solubility in the micelle (Freeman, 1969). Previous studies reported reduced fiber digestibility when total fat exceeds 8-9 % in the diet (McDonald *et al.*, 2011; Benchaar *et al.*, 2012). Oil supplementation has a coating effect around feed particles and bacterial cells, making feed particles hardly accessible by bacteria and therefore reducing degradation of the feed in the rumen(Vargas *et al.*, 2020). Ibrahim *et al.* (2021) concluded that rumen fermentation could not be affected as long as the oil supplementation level is lower than 4% of dry matter. This provides a logical explanation for most nutrients, especially CF digestibility, not being affected in this study. Generally, the inconsistency of studies was suggested to be due to the type of fat supplementation, level of supplementation, roughage: concentrate ratio, animal species and age of the animal (Ironkwo and Oruwari, 2004; Adeyemi *et al.*, 2016; Candyrine *et al.*, 2019). Since ADG could be predicted by the digestibility of nutrients (Adeosun and Iyeghe-Erakpotobor, 2014), ADG in this study (table 2) is in concordance with our results of digestibility. Regarding nutritive value, there were no significant differences between the groups in TDN and DCP. The percentages of TDN and

DCP were 73.32 and 11.36 vs. 74.39 and 11.35 for the control and SBR groups, respectively. Although the digestibility of EE was higher in the SBR group, the TDN values did not differ significantly. The values of DCP were almost similar between groups. This could be a result of the similarity of CP percentages in the experimental diets and CP digestibility.

Nitrogen balance:

The results of the nitrogen balance are shown in Table (4). The nitrogen intake was significantly ($p<0.05$) lower in the SBR group than in the control. Sheep fed SBR ration secreted more nitrogen in urine and less nitrogen in the feces than the control without any significant differences. Nevertheless, the reduction of nitrogen balance in the SBR group (19.79 vs. 22.06 g/day) was not significant. The biological value of the SBR group decreased comparable to the control (70.22% vs. 75.49%). Dos Santos *et al.* (2022) used different levels of palm kernel oil (11.5, 23.0, and 34.6 g/kg DM) in bulls' diet. They noted that the amounts of N intake, excreted N either in urine or feces and retained N linearly decreased ($p<0.001$) with oil inclusion. Furthermore, replacing ground corn with buriti oil in lambs' diet linearly decreased ($p < 0.001$) N intake and N balance. It responded quadratically to fecal N ($p = 0.022$) and urinary N ($p = 0.011$) excretion (Diogénes *et al.*, 2020). Dos Santos *et al.* (2022) reported that the reduction in urinary N excretion is desirable because urine excretion includes energy expenditure because of deamination processes that occur in the liver. On the other hand, Machmüller *et al.* (2006) revealed no clear effects of different fat and oil supplements on urinary nitrogen loss.

Table (4): Nitrogen balance (g/d) as affected by shea butter supplementation.

Items (g/d)	Experimental rations		SEM	*p*-value
	C	SBR		
Nitrogen intake, NI	37.69	35.87	0.43	0.032
Fecal nitrogen, FN	8.41	8.02	0.40	0.633
Urinary nitrogen, UN	7.21	8.06	0.58	0.473
Nitrogen balance, NB	22.06	19.79	0.77	0.144
Biological value, BV	75.49	70.22	2.21	0.236

*C, CFM at level of 2 % body weight and clover hay. SBR, control ration supplemented with 5% (w/w) crude shea butter. BV= (NI-(FN+UN) / NI-FN) *100*

Rumen parameters:

Rumen parameters of lambs fed experimental diets are shown in Table (5). It is noted that shea butter supplementation reduced all rumen parameters represented as *p*H, TVFA, and NH3-N, but the differences were not significant except for TVFA. The values of *p*H and NH3-N were 6.71 and 18.34 for the control versus 6.58 and 16.66 for the SBR group, respectively. Otherwise, rumen TVFA was significantly decreased ($P= 0.002$) as affected by shea butter supplementation being 9.96 and 8.60 for C and SBR, respectively. The same findings regarding with *p*H and NH3-N were reported by many investigators (Yoshimura *et al.*, 2018; Suphrap *et al.*, 2019; Santos-Silva *et al.*, 2022) since they stated that oil supplementation, with different sources and different supplementary levels, do not affect the ammonia concentration and ruminal *p*H. Vargas *et al.* (2020) conducted an in-vitro study, and they observed a significant reduction of ammonia concentration when linseed oil was supplemented at 6% of DM. Furthermore,

Table (5): Effect of shea butter supplementation on rumen parameters

Parameters	Experimental rations		SEM	*p*-value
	C	SBR		
pH	6.71	6.58	0.05	0.271
TVFA (meq/dl)	9.96	8.60	0.59	0.002
NH3-N (mg/dl)	18.34	16.66	1.48	0.585

C, CFM at level of 2 % body weight and clover hay. SBR, control ration supplemented with 5% (w/w) crude shea butter. TVFA, total volatile fatty acids; NH3-N, ammonia nitrogen

Nur Atikah *et al.* (2018) observed that supplementation of some vegetable oils, such as palm, olive and sunflower oils, at 6% of DM in goats' diet led to significant reduction in ammonia concentration. In the current study, ruminal *p*H and NH3-N results are in ranges that could not interfere with ruminal fermentation. Mertens (1997) found that ruminal fermentation was unaffected by pH values higher than 6.2. According to Van Soest (1994), ruminal NH3-N concentrations below 13 mg/L of rumen fluid may reduce available nitrogen for rumen microorganisms, thus may impair their activity and fiber degradation.

Shea butter supplementation significantly ($p \geq 0.01$) reduced The TVFA concentration from 9.96 to 8.60. This result agrees with Abubakr *et al.* (2013) and Majewska *et al.* (2017) when they supplemented feed with 5% rapeseed oil and palm oil, respectively. Matsuba *et al.* (2019) used different supplementation levels of palm oil (0, 2.5, 5, 7.5, 10 and 15%DM). They noticed that TVFA concentration decreased as the dose level increased, with a significant reduction only at 15% supplementation level. However, there are different results about the effect of fat supplementation on the TVFA concentration in rumen. For example, many investigators explained a non-significant effect (Yoshimura *et al.*, 2018; Suphrap *et al.*, 2019; Vargas *et al.*, 2020), while Mao *et al.*(2010) observed a significant increase in TVFA as a result of 3% soybean oil supplementation. The latest result may be due to a small dose of supplementation. In the current study, the slight reduction of TVFA concentration may be due to slight reduction of protozoa count in the rumen since earlier studies reported that the absence of protozoa decreased the TVFA concentration (Blanche *et al.*, 2011, Patel and Ambalam, 2018), or may be due to slightly reduced rumen fermentation which is achieved by partly coating effect of fats explained by Kongmun, *et al.* (2011).

Blood serum parameters:

The effect of shea butter supplementation on some blood metabolites is shown in Table (6). All serum metabolites were not significantly affected by supplementation except creatinine and triglycerides. Creatinine was significantly ($p \leq 0.05$) lower (0.89 mg/dl), but triglycerides were significantly ($p \leq 0.05$) higher (32.67 mg/dl) in SBR group than the control (0.95 mg/dl and 19.33 mg/dl, respectively). Generally, blood serum parameters were within the normal values according to age and sex, as recorded by Abd Hobi (2012). The results of AST, ALT, Albumin, globulin and urea-N are in accordance with Kholif *et al.* (2016), who found no effect of soybean or flaxseed oil inclusion on these parameters and creatinine. Also, Eldahshan *et al.* (2020) noted that liver function as serum AST and ALT were not altered due to soybean or flaxseed oil supplementation. Unlike our findings, fish oil supplementation significantly increased plasma protein concentrations, albumin and liver enzymes (El-Hakeem *et al.*, 2022).

Table (6): Blood parameters of sheep supplemented with Shea butter.

Parameters		**Experimental rations**		**SEM**	***p*-value**
		C	**SBR**		
Liver panel	ALT (U/l)	14.50	17.10	1.24	0.351
	AST (U/l)	126.67	138.33	7.19	0.480
	Albumin (%)	64.47	64.20	0.44	0.799
	Globulin (%)	35.53	35.80	1.05	0.674
kidney panel	Creatinine (mg/dL)	00.95	00.89	*0.01*	*0.033*
	Urea (mg/dL)	53.67	53.67	1.68	*1.000*
Complete lipid	Triglycerides (mg/dL)	19.33	32.67	*3.71*	*0.050*
profile	Cholesterol (mg/dL)	51.00	68.67	5.91	0.147
	HDL (mg/dL)	15.67	20.00	1.57	0.195
	LDL (mg/dL)	31.33	42.00	4.03	0.217
Antioxidants	TAC (mmol/ml)	00.18	00.17	0.01	0.561
	G Peroxidase (U/L)	374.93	332.53	12.84	0.094
Immunity	Alpha-1-globulin (%)	03.07	03.23	0.06	0.206
	Alpha-2-globulin (%)	09.50	09.47	0.06	0.815
	Beta globulin (%)	09.93	10.07	0.06	0.345
	Gamma globulin (%)	13.03	13.03	0.33	1.000

C, CFM at level of 2 % body weight and clover hay. SBR, control ration supplemented with 5% (w/w) crude shea butter. ALT, alanine transaminase, AST, aspartate transaminase, HDL, high-density lipoproteins, LDL, low-density lipoproteins, TAC, total antioxidant capacity, G Peroxidase, glutathione Peroxidase.

As for complete lipid profile, triglycerides were significantly ($p>0.05$) higher (32.67mg/dl) in the SBR group compared to the control (19.33 mg/dl). Cholesterol, HDL, and LDL concentrations tended to be higher in the SBR group (51.00, 15.67, and 31.33 mg/dl, respectively) than the control (68.67, 20.00, and 42.00 mg/dl, respectively) with non-significant differences. These results agree with those of Li *et al.*(2012), who found an increase ($p<0.05$) in the triglyceride concentration in the blood of goats when supplemented with 50 mg/kg DM of safflower or linseed oil without any significant differences in the concentration of cholesterol, HDL, and LDL. In opposition to that, El-Hakeem *et al.*(2022) reported no alteration in triglyceride concentrations and a significant ($p<0.05$) reduction in plasma cholesterol when goats were supplemented with fish oil at a level of 3% DM. When additional fat is administered to ruminant animals in a form that ensures the absorption of long-chain fatty acids, the animals' serum cholesterol levels rise (Nestel *et al.*, 1978). It was suggested that oil supplementation caused increased secretion of LDL into blood circulation (Kholif *et al.*, 2016; Eldahshan *et al.*, 2020).

Blood immunity and antioxidant indexes can reflect the health status of the body (Wu *et al.*, 2023). Higher levels of immunoglobulin (gamma globulin) in the blood indicate a good animal immune status (Teama and El-Tarabany, 2016). In the current study, the supplementation of shea butter did not alter the immune status of the sheep, as the percentage of gamma-globulin was the same value (13.03%) for both groups. Nonetheless, reports of Teama and El-Tarbany(2016) revealed an improvement in immunity function of goats supplemented with capsulated Omeg-3 plus containing fish and wheat germ oils. Estimation of antioxidant capacity and activity levels in biological fluids helps to assess the presence and potential of oxidative stress, which happens when there are imbalances between oxidants and antioxidants in favor of oxidants in the body (Apak, *et al.*, 2016). Unlike our expectation based on the antioxidant function of vitamin E existing in shea butter, serum TAC and glutathione peroxidase levels were not affected ($p>0.05$) by shea butter supplementation (0.18 mmol/ml and 374.93 u/l vs. 0.17 mmol/ml and 332.53 u/l, for SBR and control, respectively). It could be attributed to the low level of shea butter supplementation.

Carcass characteristics:

The carcass characteristics of Barki lambs fed diets supplemented with Shea butter are shown in Table (7). It's clearly appearing that, although the slaughter body weight (SBW) was equal in both groups (49 kg), there was a significant decrease in the empty body weight (EBW) of SBR group (41.61 kg) than control (42.41 kg). This is because of the increased deducted contents of the digestive tract in SBR group compared to the control. Thus, the same result was achieved for the hot carcass weight (HCW) and cold carcass weight (CCW), as the HCW and CCW in the SBR group were decreased ($p\leq0.05$) compared to the control (25.47 and 24.85 kg vs 27.09 and 26.43 kg, respectively). Chiller shrinkage (CS) percentages were not significantly different between groups.

As a dramatic result of the decrease in hot carcass weight in the SBR group, the percentage of dressing based on SBW and EBW for the SBR group was less than the control (52.00 and 61.22 % vs. 55.29 and 63.88 % respectively). There were no significant differences in the rib-eye area and back fat thickness between groups. The rib-eye area of control was 8.46 versus 8.19 cm^2 of SBR, and the back fat thickness was almost equal**.** Thus, feeding diets supplemented with shea butter could reduce carcass characteristics. This may be due to increased digestive tract content as a result of supplementation.

Table (7): Carcass characteristics of Barki lambs fed diets supplemented with shea butter.

Parameters	Experimental rations		SEM	*p*-value
	C	SBR		
slaughter body weight (SBW) (kg)	49.00	49.00	0.61	0.735
Empty body weight (EBW) (kg)	42.41	41.61	0.41	*0.050*
Hot carcass weight (HCW) (kg)	27.09	25.47	0.81	0.036
Cold carcass weight (CCW) (kg)	26.43	24.85	0.75	0.047
chiller shrinkage (CS) %	2.44	2.43	0.19	0.615
Dressing % /SBW	55.29	52.00	1.22	0.029
Dressing % /EBW	63.88	61.22	1.56	0.031
Rib-eye area (cm^2)	8.46	8.19	0.35	0.206
Back fat thickness (cm)	1.95	2.00	0.11	0.345

C, CFM at level of 2 % body weight and clover hay. SBR, control ration supplemented with 5% (w/w) crude shea butter. SBW, slaughter body weight; EBW, empty body weight; HCW, hot carcass weight; CCW, cold carcass weight; CS, chiller shrinkage; DP (SBW), dressing percentage per slaughter body weight; DP (EBW), dressing percentage per empty body weight.

The plant oil supplementation resulted in a decrease in carcass yields (hot dressing percentage), rib eye area (Wanapat *et al.*, 2011), and fat thickness (Dos Santos *et al.*, 2022). On the other hand, plant oil supplementation did not affect (Ludden *et al.*, 2009; Suksombat *et al.*, 2016; Matsuba *et al.*, 2019) or can improve carcass characteristics of finishing beef due to a linear increase of dressing percentage, carcass weight, back fat thickness (Pavan *et al.*, 2007), and percentage of fat in carcass (Pavan and Duckett, 2008).

CONCLUSION

Shea butter supplementation at 5% (w/w) in the concentrate feed mixture for fattening Barki lambs led to an increase in the EE digestibility and serum triglyceride concentration. However, a reduction was noted in rumen TVFA, carcass weight, and dressing percentage. Supplementation did not affect feed intake, nutrient digestibility, growth performance, FCR and immunity status. Our results could be attributed to the low level of shea butter supplementation. There are many factors contributing to the effect of fat supplementation. Further studies should be carried out to investigate higher levels of shea butter supplementation at different ages and productive status. The fatty acid profile of meat should be taken into account.

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تقييم إضافة زبدة الشيا في علائق الحملان الناهية

إيمان ابراهيم صديق و اسامة أبوالعز نايل و السيد الدهشان
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فى هذه الدراسة تم استخدام 12 حمل ذكر برقى، عمر ستة أشهر ومتوسط وزنها 31.75 ± 5.50 كجم، في تجربة للنمو استمرت لمدة 63 يومًا. تم تقسيم الحيوانات بشكل عشوائي إلى مجموعتين متشابهتين لتقييم تأثير إضافة زبدة الشيا على أداء الأغنام. تم تغذية الحيوانات جماعيا على عليقة أساسية تشمل خليط العلف المركز بمستوى 2% من وزن الجسم على أساس الماده الجافه، وتم تقديم دريس البرسيم بصورة مفتوحة. تم تقديم العلائق للمجموعة الأولى (المقارنة) بدون أى إضافات، بينما تلقت المجموعة التجريبية الأخرى (SBR) نفس العليقة مضاف اليها 5٪ (وزن / وزن) من زبدة الشيا الخام. تم إجراء تجربة الهضم بعد نهاية تجربة النمو؛ وأخيراً تم ذبح ثلاث حملان من كل مجموعة وفقاً للشريعة الإسلامية. أظهرت النتائج التي تم الحصول عليها أن مكملات زبدة الشيا لم تؤثر على كمية الغذاء المأكول. كان معدل النمو اليومى للحملان المغذاة على (SBR) اقل (0.196 كجم مقابل 0.201 كجم) وكانت كفاءة التحويل الغذائى أكثر (9.14 مقابل 8.54)، لكن الاختلافات بين المجموعتين كانت غير معنوية. لم تؤثر إضافة زبدة الشيا بشكل كبير على معاملات هضم كل من المادة الجافة (DM)، والمادة العضوية (OM)، والبروتين الخام (CP)، والمستخلص الخالي من النيتروجين (NFE)، والألياف الخام (CF). على العكس من ذلك، كان معامل الهضم للمستخلص الأثيرى (EE) أعلى بشكل ملحوظ ($P < 0.01$) في مجموعة SBR (82.43٪) عنها في مجموعة المقارنة (71.02٪). وكانت النسب المئوية للمركبات الغذائية المهضومة وكذلك البروتين المهضوم73.32 و11.36 مقابل 74.39 و11.35 لمجموعتي المقارنة وSBR، على التوالي، مع عدم وجود فروق ذات دلالة إحصائية. كان انخفاض ميزان النيتروجين في مجموعة SBR (19.79 مقابل 22.06 جم / يوم) غير معنوى. أدت إضافة زبدة الشيا إلى خفض جميع معايير الكرش بعد ساعتين من التغذية ومع ذلك، فإن الانخفاض في الرقم الهيدروجيني وكذلك نيتروجين الأمونيا بالكرشNH3-N كان غير معنوى. بخلاف ذلك، انخفضت الأحماض الدهنية الطيارة TVFA بالكرش بشكل ملحوظ ($P = 0.002$) بعد ساعتين من التغذية نتيجة إضافة زبدة الشيا، حيث بلغ 9.96 و8.60 للمجموعة المقارنة وSBR، على التوالي. لم تتأثر جميع قياسات مصل الدم بشكل كبير نتيجة إضافة زبدة الشيا باستثناء الكرياتينين والدهون الثلاثية. كان الكرياتينين أقل بشكل ملحوظ ($p \geq 0.05$) (0.89 مجم / ديسيلتر)، لكن الدهون الثلاثية كانت أعلى بشكل ملحوظ ($p \geq 0.05$) (32.67 مجم / ديسيلتر) في مجموعة SBR مقارنة بالمجموعة المقارنة (0.95 مجم / ديسيلتر و 19.33 مجم / ديسيلتر على التوالى). وكانت جميع مؤشرات الدم ضمن المعدل الطبيعي حسب العمر والجنس. انخفض وزن الذبيحة الساخنة (HCW) ووزن الذبيحة الباردة ($p<0.05$) (CCW) في مجموعة SBR مقارنة بالمجموعة المقارنة حيث كانت 25.47 و24.85 مقابل 27.09 و26.43 كجم على التوالي. نتيجة للانخفاض في وزن الذبيحة الساخنة في مجموعة SBR، كانت نسبة التصافى على أساس SBW وEBW لمجموعة SBR أقل من المجموعة المقارنة(52.00 و61.22% مقابل 55.29 و63.88%، على التوالي). لم تكن هناك فروق ذات دلالة إحصائية في حجم العضلة العينية وسمك دهن الظهر بين المجموعات.