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# Effect of SOD-Rich Melon Supplement on Performance, Serum Biochemical, Antioxidant and Meat Quality Characteristics of Tuj Lambs

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**Abstract:** The present study aimed to evaluate the effects of SOD (superoxide dismutase)-rich melon feed supplement on some performance parameters, serum biochemical and antioxidant indexes, and meat quality characteristics of weaned Tuj lambs. An independent measures design (between groups) was used to determine these effects of treatment. After one week of the adaptation period, twenty-four weaned lambs at the age of 60 ± 5.0 days with a body weight of 23.14 ± 0.5 kg were divided into two groups, i.e., the control group (CON) fed basal diet and experimental group (EXP) fed with basal diet + SOD-rich melon ($n$ = 12 per group). The results revealed a decrement in the ($p < 0.05$) feed efficiency ratio (5.88 ± 0.40 vs. 6.59 ± 0.86 kg weight gain/kg feed) and higher carcass yield (61.76 ± 0.80 vs. 60.11 ± 1.07%) in the EXP group as compared to the CON group. Additionally, the EXP group showed a significant increase ($p < 0.05$) in serum glucose and high-density lipoprotein levels, while there was a reduction in cholesterol, triglyceride, and low-density lipoprotein levels when compared to the CON group. The serum malondialdehyde was lowered (5.53 ± 0.47 vs. 5.98 ± 0.79 mmol/L) significantly ($p < 0.05$), while glutathione concentration was higher ($p < 0.05$) in the EXP group (17.82 ± 1.51 mmol/L) when compared to the CON group (16.54 ± 1.59 mmol/L). The cooking loss was also significantly ($p < 0.05$) lower in the EXP group when compared to the CON group. In conclusion, the results indicate that SOD-rich melon supplement (30 g/ton of the concentrate feed) can considerably improve carcass yield, some serum biochemical parameters, and meat quality characteristics in Tuj lambs. Thus, the supplementation of lamb diets with a SOD-rich melon additive may be used as an effective nutritional approach to improve their performance and health.

**Keywords:** SOD-rich melon feed; Tuj sheep; feed additives; antioxidants



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## 1. Introduction

It is estimated that 30% of the earth's surface is occupied by livestock systems, accounting for a global asset value of 1.4 trillion USD. The socioeconomically deprived population of the world is highly dependent upon the livestock sector for their socioeconomic uplift and survival. Livestock is the main provider of food and traction for growing crops in smallholders systems. Livestock products, at the moment, are contributing 17% to the caloric consumption and 33% to protein consumption, globally [1]. However, this contribution is changing constantly with the expansion of the world's population. As climate change continues to impact the world, it is becoming harder and harder to find enough feed resources for livestock. This is especially true in lower- and middle-income countries, where many of the feed resources are in decline. Hence, providing balanced feed to meet the nutritional needs of livestock is the biggest challenge faced by the world today. Recently, the usage of unconventional feed resources, such as vegetable and fruit wastes [2,3], shrubs and herbs [4], agro-industrial by-products [5,6], legume seeds and pods [7,8], and forages [9], has gained a strong footing and their impact on productive and reproductive traits of different animals has been evaluated. Other than a few unfavorable consequences [10], such feed resources have been found to be useful and nutritionally appropriate in meeting animals' requirements [11,12].

Farm animals, at various stages of their lifecycle, can be exposed to a variety of stresses, which may result in decreased production efficiency along with poor quality and yield of produced goods [13]. An accelerated rate of cellular damage caused by oxygen and oxygen-derived free radicals (reactive oxygen species, ROS), is a hallmark of oxidative stress. Lipids, proteins, and nucleic acids are damaged by these oxidative stressors [14]. As a result, oxidative stress may play a role in various pathological conditions in farm animals [15]. Therefore, the body has an antioxidant network, to protect itself from oxidative damage. Antioxidants can donate electrons to oxidants, which causes them to become radicals themselves. However, these radicals are far more stable and unable to cause cellular damage [16]. Superoxide dismutase (SOD) is one of the major enzymatic antioxidants, which catalytically convert $O_2^-$ to oxygen ($O_2$) and hydrogen peroxide ($H_2O_2$), thus protecting against the deleterious effects of oxidants. The SOD can be supplemented from various external sources, but its low bioavailability is the major issue that scientists are working to improve [17,18]. Another problem in supplementing the SOD in animal feed is the inactivation of the enzymes at lower pH, but its low bioavailability is the major issue that scientists are working to improve. It has been demonstrated to shield the enzyme against degradation at lower pH levels [18]. The *Cucumis melo* L. is a non-genetically modified melon variety with high levels of antioxidant enzymes, especially SOD ($2.6 \times 10^6$ IU/kg), along with glutathione peroxidase (GPx) and catalase. Supplementation of such SOD-rich sources into animal diets can help enhance the animal's endogenous antioxidant defenses [19]. The antioxidant effects of dietary supplementation of a SOD-rich melon concentrate have been shown in different animal models, including both ruminant and non-ruminant animals, i.e., hamsters [20–22], rats [19], sheep and goats [23,24], chicken [25,26], and rabbits [27]. Similar work has been reported for pigs as well [28].

Turkey harbors about 23 million heads of sheep (both fat and thin-tailed), being one of the largest sheep producers in the world. The Tuj (Tushin) breed of sheep is native to the Caucasus and they are mainly bred in the North-Eastern part of Turkey [29]. This breed is primarily used for meat, but it can also be raised for milk and wool. The animal keepers who raise this sheep breed do not use any supplements, so the animals' performance depends solely on the quality of hay and pasture they are fed on. The Tuj breed of sheep has not been studied in depth for whether or not it benefits from feed additives supplementation. In the last decade or so, a few studies have been reported, mainly focusing on different fattening systems and animal production characteristics [30–32]. However, there is a complete paucity of literature regarding the effects of feed additive supplementation in this sheep breed.

Moreover, there is almost no literature related to the usage of SOD-rich melon supplemented feed in sheep. Therefore, the present study was designed with the hypothesis that feeding Tuj lambs with a SOD-rich melon-supplemented diet may provide beneficial results in terms of various production and biochemical parameters as well as meat quality traits. The objective of the present study, specifically, was to assess the effects of SOD-rich melon feed supplement on the performance, serum biochemical and antioxidant indexes, and meat quality characteristics of Tuj lambs.

## 2. Materials and Methods

### 2.1. Study Animals and Diet

This study was conducted on weaned Tuj lambs ($n$ = 24) at the age of 60 ± 5.0 days with a body weight (BW) of 23.14 ± 0.5 kg. During the study, the lambs were housed in individual chambers with a size of 135 × 120 × 66 $cm^3$. Prior to the experiment, all animals were vaccinated (for enterotoxaemia) and treated for internal and external parasites. After a one-week adaptation period, the animals were divided into two groups, i.e., the control (CON) and the experimental (EXP) ($n$ = 12 per group). The study was conducted according to a randomized complete block design. The animals were blocked after seven days weaned, and body weights and daily body weight gains were recorded and divided into groups keeping the averages of the blocking parameters as close to each other as possible. The trial was conducted for a period of 56 days. During the study period, lambs were given a diet containing, on average, 70% concentrate and 30% forage. Thus, 700 g of concentrated feed (Table 1), 225 g of wet sugar beet pulp, and 200 g of wheat straw were fed twice a day. The average daily feed intake was adjusted, with an acceptable level of feed refusal being maintained at approximately 10% of the total daily amount supplied in order to ensure ad libitum feed intake. Water was offered ad libitum. Isocaloric (2700 kcal/kg DM) and isonitrogenic (16% DM protein) rations were prepared by calculating the daily nutrient needs of lambs for an average daily gain of 200 g/d in compliance with the recommendations of National Research Council [33]. Nutrient analysis of the concentrated feed was performed according to [34]. While no additives were added to the rations of the CON group, a new generation antioxidant additive named SOD-rich melon was added to the rations of the EXP group. The supplementation was carried out within the concentrate feed, and the dose was calculated according to the level of 30 g/ton of the concentrate in compliance with the recommendation of the manufacturer. The SOD-rich melon product was procured from a private commercial company (MeloFeed® (SOD = 2.6 × $10^6$ IU/kg), Lallemand Animal Nutrition, Lallemand Inc., Montréal, QC, Canada).

**Table 1.** Ingredients and chemical analysis of concentrate feed.

| Ingredients | % |
|---|---|
| Barley | 41.00 |
| Corn | 18.00 |
| Wheat bran | 10.20 |
| Cotton seed meal, 38% CP | 23.70 |
| Sunflower oil | 3.40 |
| Dicalcium phosphate (DCP) | 0.15 |
| Marble dust | 2.50 |
| Salt | 0.80 |
| Vit-min mix [a] | 0.25 |
| Chemical analyses | (%) |
| Dry matter | 90 |
| Metabolized Energy (kcal/kg) | 2700 |
| Crude protein | 17.00 |
| Crude fiber | 6.65 |
| Ether extract | 6.30 |
| Ash | 6.82 |
| Ca | 1.09 |
| P | 0.55 |

[a] Each 1 kg of vitamin–mineral mix contained: 12,000,000 IU vitamin A, 3,000,000 IU vitamin D3, 30,000 mg vitamin E, 40,000 mg manganese, 45,000 mg iron, 55,000 mg zinc, 9000 mg copper, 750 mg iodine, 400 mg selenium, 150 mg cobalt, 32 g calcium, 18 g phosphorus.

### 2.2. Performance Traits

For the average daily feed intake (DFI), the left-over feed was weighed the next morning, whereas the feed efficiency ratio (FER) was determined as weight gain/feed intake as prescribed earlier [35]. The method of feeding, and the timing of weighing and deducing left over were kept the same (8:00, 18:00) for the purpose of monotony in the study. The study animals were weighed on day 0 and at the end of the trial (after sacrificing) for deducting the initial and final body weights. At the termination of the experiment, all the animals were subjected to 16 h fasting, and transported to a slaughterhouse. The animals were humanely handled, properly restrained, and slaughtered by a precise incision on major vessels (carotid, jugular) behind the jaw via a sharp knife. Animals were allowed to bleed sufficiently through the carotid, jugular vessels before the skinning and evisceration. After evisceration, carcass weights were recorded, and carcass yields were calculated as prescribed [36] and given below:

$$\text{Carcass Yield (\%)} = \frac{\text{Dressed Carcass Weight}}{\text{Live Weight}} \times 100$$

### 2.3. Serum Biochemical Profile

For the purpose of serum extraction, blood collection was carried out antiseptically from the jugular vein of each animal. Blood was collected in serum-collecting vacutainers containing thixotropic gel for serum extraction (BD vacutainers®, Becton Dickinson, Franklin Lakes, NJ, USA). The collection method, timing, personnel, and restraint were standardized to minimize stress on the study animals. Samples were transported to the laboratory in ice packs for further analysis within 1 h. Blood in serum tubes was allowed to clot for 30 min before serum extraction through centrifugation (2000× *g* for 10 min). Samples were refrigerated at −20 °C until being further analyzed for serum biochemical profile.

The serum biochemical profile viz. glucose, total protein (TP), cholesterol, triglycerides (TGs), low density lipoproteins (LDL), high density lipoproteins (HDL), calcium (Ca), and phosphorus (P) were attained through commercial kits (MyBioSource, San Diego, CA, USA) as per the manufacturer's instructions using a spectrophotometer.

### 2.4. Antioxidant Profile

The malondialdehyde (MDA) content was determined using a commercial assay kit (Sigma-Aldrich, St. Louis, MO, USA, CAT: K35000), which implies thiobarbituric acid. Reading was taken at 532 nm. Glutathione (GSH) was deduced through a commercial kit (Sigma-Aldrich, St. Louis, MO, USA, CAT: NB1214), which implies the dithio dinitrobenzoic acid method. Absorbance was read at 412 nm [25].

### 2.5. Meat Quality Characteristics

After slaughter, the *Longissimus dorsi* muscles were used for meat quality traits as prescribed earlier [37]. The samples obtained from the muscles were kept at +4 °C for 48 h, and later the cross-sectional color intensities of meat samples were determined by making four measurements (L *, a *, and b *) from each sample with a colorimeter device (Konica Minolta CR-200 Chromameter, Tokyo, Japan).

The *Longissimus dorsi* muscle samples were weighted (initial weight). They were then placed in plastic bags, and cooked at an internal temperature of 70 °C in a water bath maintained at 75 °C to calculate the cooking loss. The bags were cooled for 30 min under running tap water before being patted dry using paper towels. Samples were weighed after cooking (final weight), and cooking loss (g/kg) was determined as:

$$\text{Cooking Loss (\%)} = \frac{\text{Final Weight} - \text{Initial Weight}}{\text{Final Weight}} \times 100$$

### 2.6. Statistical Analysis

The statistical analysis was conducted using Statistical Package for Social Sciences (SPSS for Windows version 12, SPSS Inc., Chicago, IL, USA). An independent measures design (between groups) of the study was applied for ascertaining the effect of treatment as per the following equation:

$$\mu j = \mu + Tj, \tag{1}$$

For j = 1.2 (groups); if j = 0, the treatment has no significant effect. A probability level of $p < 0.05$ was considered significant. Data is presented as mean (±standard error). The difference between the two groups (control and experimental) was deduced through student *t*-test.

## 3. Results

The results of the present study regarding the performance characteristics of two study groups, i.e., control and experimental (fed with SOD-rich melon), are given in Table 2. The FER was significantly ($p < 0.05$) lower (11%), whereas the carcass yield was significantly ($p = 0.001$) higher (2.6%) in the EXP group (fed SOD-rich melon supplement in their concentrate feed) as compared to the CON group. Though the final BW increased for the experimental group (6.5%), the difference was statistically ($p > 0.05$) non-significant. No significant ($p > 0.05$) effect was noticed for average body weight gain (BWG) and DFI.

**Table 2.** Performance characteristics of control and experimental SOD-rich melon group of Tuj lambs.

| Traits | Control (*n* = 12) | Experimental (*n* = 12) | *p* * |
|---|---|---|---|
| Initial Body Weight (kg) | 24.48 ± 3.18 | 24.89 ± 2.99 | 0.767 |
| Final Body Weight (kg) | 35.71 ± 3.30 | 38.20 ± 3.15 | 0.101 |
| Average Body Weight Gain (kg/day) | 0.20 ± 0.06 | 0.24 ± 0.04 | 0.131 |
| Average Daily Feed Intake (kg/day) | 1.30 ± 0.38 | 1.40 ± 0.25 | 0.483 |
| Feed Efficiency Ratio (kg/kg) | 6.59 ± 0.86 | 5.88 ± 0.40 | 0.029 |
| Carcass Yield (%) | 60.11 ± 1.07 | 61.76 ± 0.80 | 0.001 |

* Significant at $p < 0.05$ within the rows between control and experimental group.

The serum biochemical profile of the present research work showed a significant ($p < 0.05$) increase in glucose (18.5%) and HDL (20.5%) levels of EXP group as compared to CON group. However, cholesterol, TGs, and LDL were significantly ($p$ = 0.02, 0.001, 0.001, respectively) lower in experimental groups (Table 3). The TP increased in the experimental group (10.35 ± 7.2 g/dL) as compared to the CON group (7.7 ± 1.3 g/dL); however, the results were statistically non-significant ($p > 0.05$).

**Table 3.** Serum chemistry profile of control and experimental SOD-rich melon supplement group of Tuj lambs.

| Serum Profile | Control (*n* = 12) | Experimental (*n* = 12) | *p* * |
|---|---|---|---|
| Glucose (mg/dL) | 48.94 ± 5.26 | 53.97 ± 6.47 | 0.010 |
| Total proteins (g/dL) | 7.71 ± 1.35 | 10.35 ± 7.22 | 0.116 |
| Cholesterol (mg/dL) | 145.92 ± 21.55 | 132.35 ± 12.51 | 0.021 |
| Triglycerides (mg/dL) | 18.60 ± 2.05 | 16.45 ± 1.64 | 0.001 |
| High density lipoproteins (mg/dL) | 47.53 ± 15.94 | 59.79 ± 20.96 | 0.044 |
| Low density proteins (mg/dL) | 94.66 ± 22.82 | 69.26 ± 20.77 | 0.001 |
| Calcium (mg/dL) | 10.70 ± 2.97 | 11.71 ± 2.35 | 0.241 |
| Phosphorus (mg/dL) | 8.13 ± 1.58 | 8.74 ± 1.10 | 0.164 |

* Significant at $p < 0.05$ within the rows between control and experimental group.

Both the antioxidant profiles (MDA and GSH) examined in present study were significantly ($p < 0.05$) different for both studied groups. The MDA was significantly ($p < 0.05$) lower, whereas GSH was significantly ($p < 0.05$) higher for the experimentally fed group as shown in Figure 1.

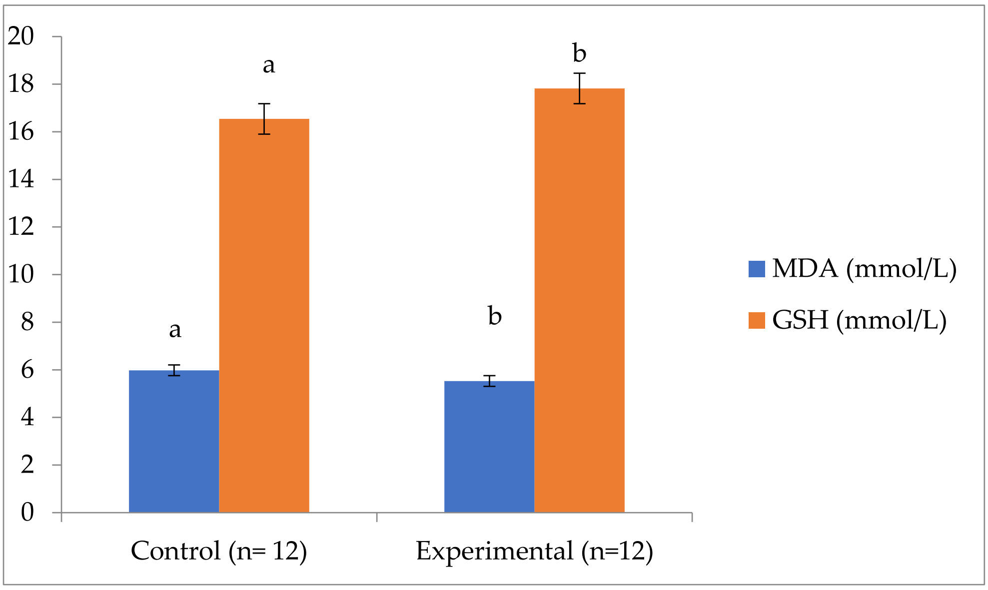


**Figure 1.** Antioxidant profile of control and experimental SOD-rich melon supplement group of Tuj lambs. MDA= malondialdehyde; GSH = glutathione; different letters (a,b) on error bars indicate significant difference at $p < 0.05$ within control and experimental group.

The results for meat quality characteristics of the present study are presented in Table 4. Cooking loss decreased significantly ($p = 0.016$) for the EXP group. However, L *, a *, and b * values for meat color index and pH were non-significantly ($p > 0.05$) different within both study groups.

**Table 4.** Meat quality characteristics of control and SOD-rich melon supplement group of Tuj lambs.

| Traits | Control ($n$ = 12) | Experimental ($n$ = 12) | $p$ * |
|---|---|---|---|
| Cooking Loss (%) | 28.6 ± 1.3 | 26.9 ± 1.5 | 0.016 |
| Lightness (L *) | 41.5 ± 2.3 | 43.6 ± 2.2 | 0.059 |
| Redness (a *) | 14.6 ± 0.7 | 15.2 ± 0.5 | 0.086 |
| Yellowness (b *) | 7.2 ± 1.1 | 7.6 ± 1.8 | 0.532 |
| pH | 5.9 ± 0.4 | 5.9 ± 0.6 | 0.911 |

* Significant at $p < 0.05$ within the rows between control and experimental group.

## 4. Discussion

This is the first such study that reports the effect of supplementation (SOD-rich melon supplement) on various physiological characteristics of Tuj lambs. As limited work has been reported for SOD-rich melon supplementation in sheep, the logical discussion and comparisons have been made with other species.

Regarding the performance characteristics attained in the present study for the EXP and CON groups, the carcass yield was improved in the EXP group fed SOD-rich melon supplement. However, our study found no significant effect of the SOD supplementation on body BW, BWG, and DFI. A prior study conducted on West African Dwarf (WAD) goats ($n$ = 80) to ascertain the growth, nutritional intake, and digestibility of melon husk and palm oil slurry (POS) as a substitute to maize offal at 30% in concentrate diets [23] has revealed better results for DFI, feed conversion ratio (FCR), daily average weight gain, protein intake, and dry matter digestibility of the animals given melon husk than those fed diets containing 30% POS. It became clear from this study that goats could consume melon husk at the optimal inclusion levels of 30%, at which performance characteristics are improved. Our results are also in line with those reported in another study conducted on WAD goats fed with *Moringa oleifera* as a supplement [38]. Similarly, Raza [39], while working on broiler growth performance parameters, has reported that live weight, average body weight gain, DFI and FCR did not change between treatment groups fed SOD-melon supplements and control group. Melon supplementation has also been given to other species in other research works, such as on rabbits and hamsters, and it has been reported that almost all performance characteristics tend to increase for melon husk-fed rabbits and hamsters [20,27]. Bezerra et al. [40] found that a high-concentration feed including various antioxidants (castor and cashew nut shell oils, selenium and vitamin E) did not affect the lambs' performance characteristics. The difference in results of various performance traits recorded globally for different antioxidants could be attributed to variation in species, breed, type and concentration of antioxidants fed as a supplement, or management practices. In addition, by adding SOD, the animal's body is better prepared to defend itself against the damaging effects of oxidative stress, which enhances the efficiency of nutrient utilization, muscle growth, and carcass yield.

In the present study, FER was decreased by SOD-rich melon supplementation in Tuj lambs compared to the CON group. This is in concordance with prior studies on lambs, which have demonstrated that supplementation may reduce FER in sheep and goats owing to ruminal acidosis [23,31]. Furthermore, higher carcass yield, as noticed in our study, can be resulted with lower FER in sheep and goats.

Regarding the serum biochemical profile results of this study, a significant increase was noticed in glucose and HDL levels in the EXP group as compared to the CON group. However, cholesterol, TGs, and LDL were significantly lower in the experimental group. The TP increased in the experimental group as compared to the CON group; however, it was statistically non-significant. In general, variable results have been reported for serum chemistry profiles globally for lambs supplemented with SOD-rich melon and other antioxidants. A study conducted earlier on WAD goats fed with three different diets (control, locust bean pulp, and melon husk) has shown that the glucose level tends to increase in goats fed with 20% melon husk (64.8 mg/dL) as compared to those fed with 10% melon husk (55.2 mg/dL) and the control group (47.2 mg/dL) [41]. It was put forth that supplementations such as melon husk tend to increase the energy level of the animals, resulting in an elevated glucose level, as noticed in the results of glucose levels in the present study. It has been elucidated that energy production, expenditure, and its metabolism are a mainstay in regulating the glucose levels of an animal [42,43]. The observed shift in serum glucose levels following SOD-melon supplementation could be due to changes in metabolic hormones that regulate energy and nutritional demands in response to oxidative stress conditions. Previous studies have also shown that such physiological responses involve the modulation of metabolic pathways via the action of glucocorticoids and insulin and result in increased blood glucose levels [44,45]. Specifically, during stress conditions, serum levels of glucocorticoids increase, which in turn decreases the responsiveness to insulin [46]. This rise in glucocorticoids promotes glycogenolysis and gluconeogenesis in the liver [47] and facilitates the conversion of alpha-ketoacid to glucose [48]. These metabolic changes ultimately result in higher glucose levels in the bloodstream, which serve to modulate oxidative stress.

The increase in the TP level for the EXP group in our study is in corroboration with earlier studies, which have given a plausible justification of the feed type and protein content of the feed as primary factors in controlling TP levels in the body [49]. Furthermore, the levels of circulating Ca and P did not alter between the SOD-melon fed group and the CON groups of the present study. Similar results have been reported for blood Ca and P levels in the lambs fed selenium [50] and male buffalo calves fed selenium and copper [51]. Owing to the paucity of literature on the effects of SOD-rich supplements/other antioxidants on circulating Ca and P in the serum of sheep, a comparison is difficult. A higher population size combined with different dosages of SOD-rich melon feed may reveal these phenomena.

The biological benefits of SOD-melon are believed to be primarily due to its antioxidant qualities, which may be crucial in the prevention of diseases associated with oxidative stress.

The preventive impact of antioxidants on a healthy lipid profile has been shown by many studies [20,21]. Compared to the CON group, the SOD-melon-supplemented group in the current research had lower plasma levels of cholesterol, TG, and LDL. Our findings are consistent with those of Jiang et al. [52], who discovered that supplementing the diet with an antioxidant (lycopene, which is mainly contained in tomatoes and tomato byproducts) reduced blood cholesterol, TGs, and LDL. Decreased cholesterol in the EXP group of the present study (132.3 ± 12.5 mg/dL) as compared to the control group (145.9 ± 21.5 mg/dL) is in line with most of the research conducted on various feed supplements to goats and sheep [41,53]. Free radicals are thought to be responsible for the development of degenerative illnesses such as atherosclerosis, which has a positive correlation with serum LDL and an inverse correlation with HDL, according to Amarenco et al. [54]. Free radicals are produced excessively in all living things as a consequence of enhanced metabolic activity brought on by stress. Cholesterol and TG levels are likewise raised by stress, and supplementing with antioxidants lowers these elevated levels [55]. Cholesterol also tends to decrease in summer as compared to winter in all ruminants, being a temperature-related adaptation [56]. Furthermore, total body water and acetate concentration also are the main factors that control circulating cholesterol levels in goats and sheep [56].

Unsaturated fatty acids, in particular, are readily oxidized and may start chain reactions that lead to more oxidative damage. Lipids are significant components of the lipid bilayer that makes up the cellular membrane. Polyunsaturated lipids are more vulnerable to oxidation. Therefore, several diseases have been linked to lipid peroxides and their byproducts, which may harm membrane-bound enzymes and other macromolecules such as DNA (deoxyribonucleic acid) [55]. Malondialdehyde can be used to measure lipid oxidation. Malondialdehyde is a lipid breakdown product that may be measured as a lipid hydro-peroxide [57]. Regarding the antioxidant profile of the present study (GSH and MDA), the EXP group had higher GSH and decreased levels of MDA. This is in line with a work conducted on broilers fed SOD-rich melon in which MDA level decreased in the SOD-fed group [39]. However, higher levels of both GSH and MDA in growing rabbits fed with SOD-rich diet have been conversely reported [27]. The capacity of SOD-melon to alter the antioxidant defense system could be a cause of the reduction in the plasma MDA level.

Numerous studies have connected diet to changes in meat quality parameters [6,58–60]. The present study showed that compared to the CON group, the EXP group fed with SOD-rich melon had considerably decreased cooking loss and higher meat color index values. Similar results have been reported for Boer goats fed with *Andrographis paniculata,* which showed an improved ratio of the carcass to fat, lean to the bone, lean to fat, and meat composition resulting in lower cooking losses [61]. Similar results have also been reported for lambs fed grass and concentrate [62,63]. However, in a study conducted on broilers, the quality of breast meat remained unaffected by a SOD-rich diet [39]. The consumer perception of meat color, which is still of utmost importance, is affected by a variety of factors [64]. The link between myoglobin levels and lightness is not statistically significant; however, there was a strong correlation between myoglobin concentration and redness [65]. Our results show a higher meat L * value; nevertheless, the a * value remained unaffected among the studied groups. According to Khliji et al. [66], customers generally find the color of fresh meat satisfactory when the a * and L * values are equal to or higher than 9.5 and 34, respectively. Our meat color parameters are in the customers' 95% confidence acceptance range, as described earlier [66].

Similarly, the pH level is the most significant meat quality indicator of meat. Following the rigor mortis period, fresh meat's pH level significantly impacts several meat quality traits, such as water-holding capacity and texture. Therefore, determining the pH value is crucial in determining the quality of the meat and the preferences of the customer. It is well-recognized that the nutritional and homeostatic condition of myofibers before slaughter, which is relevant during rigor mortis, affects the quality of breast meat [67,68]. As a result of the anaerobic glycolytic pathway's production of lactic acid, which turns the muscle into meat after slaughter, the pH of the muscle decreases [69]. The pH of meat affects the characteristics of meat quality by establishing an equilibrium between oppositely charged groups of muscle proteins that bind water, reducing the solubility of proteins, increasing the shrinking of proteins owing to charge attraction, and reducing protein solubility. The electrostatic repulsion between protein chains is resolved, and further shrinking occurs when the attraction between the opposing charges on the nearby proteins occurs [70,71]. This makes the flesh more exudative, soft, and pale. The meat pH in the present study was unaffected by the treatments since the pH of the meat was comparable among the groups. The cooking loss percentage of the present study was in the range of different native sheep breeds in Turkey, which have cooking loss values between 25.57 to 34.78% [72–74].

In conclusion, the results of the study indicate that the Tuj lambs fed with SOD-rich melon (supplemented at the rate of 30 g/ton of the concentrate) considerably enhance the carcass yield, some serum biochemical parameters, and meat quality characteristics of Tuj lambs. Specifically, the supplemented group had greater carcass yield; higher serum glucose levels, high density lipoproteins; and reduced serum cholesterol, low-density lipoproteins, and triglycerides. SOD supplementation also enhanced antioxidant status (as evidenced by higher levels of GSH and lower levels of MDA). Furthermore, the meat from the supplemented group displayed a lower cooking loss while all the other studied meat quality traits remained unaffected. Our results imply that SOD-rich melon supplementation can be an effective nutritional approach for enhancing the production, health status, and meat quality of lambs. It is recommended that variable doses of melon feed be tested under different raising conditions, and certain other characteristics such as hematochemical profile, nutrient digestibility, fatty acid profile in the blood, and fatty acid composition of meat be added in future studies, as they are the limitations of the present study.

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