Original Article

Growth Parameters and Carcass Traits of Awassi Male Lambs Fed On Grape and Olive Pomace

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Abstract

This study evaluated the impact of grape and olive pomace dietary supplementation on the growth parameters and ultrasound carcass traits of Awassi lambs. Fifteen male Awassi lambs aged three months with an average initial body weight of 24.86 ± 0.79 kg were allocated randomly into three treatments. Lambs in the first treatment or control group (T1) were fed a base diet including 70% concentrate and 30% roughage. The second (T2) and third (T3) groups received a base diet plus 70% concentrate, 10% roughage and 20% grape or olive pomace, respectively. Their growth performance, biochemical blood parameters, and carcass traits were evaluated. Carcass traits were assessed on live animals using ultrasound equipment. Diet supplementation with grape pomace enhanced growth performance, carcass traits, and antioxidant indexes, and reduced feed costs of lambs. Meanwhile, adding olive pomace reduced feed intake, and enhanced serum antioxidant index but did not affect the carcass traits of lambs. Lambs fed grape pomace showed greater effectiveness in enhancing growth performance, which resulted in higher profitability compared to those fed olive pomace or in the control diet. Incorporating agro-industrial by-products identical to grape pomace into the diets of fattening lambs offers a beneficial strategy for improving their growth performance and carcass quality.

Keywords: Awassi lambs, carcass traits, Grape pomace, Growth performance, olive pomace

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Introduction

Sheep farming is one of the most economically important agricultural activities worldwide. Developing certified products of designated origin and ecological practices, alongside sustainable quality enhancement of sheep meat and its products, can significantly improve profitability for sheep farmers and the industry 25. Today's consumers increasingly prefer products with quality certifications and are attentive to farming methods that ensure animal welfare and protect regional breeds. Carcass quality is multifaceted, encompassing organoleptic, nutritional, and microbiological traits, all of which are influenced by genetic and environmental factors. Amongst the environmental factors, the most significant event that takes place during the fattening process is nutrition 11, a key factor in enhancing sheep's healthiness and wellbeing, eventually impacting the profitability of fattening operations 5.

To achieve excellent growth performance, sheep require a steady supply of feed with balanced nutrition. Unfortunately, intensive sheep farming in agricultural areas has been hindered by persistent shortages of high-quality fodder caused by limited land and seasonal variations which make it difficult to ensure a steady and abundant supply for livestock 19. Hence, management and feeding expenses need to be adjusted. In addition to reducing profits and increasing the value of products, innovations in animal production and carcass quality have looked for technological alternatives using surplus resources 10, given that herd nutrition expenditures make up between 50 and 70 percent of production costs. Therefore, it is vital to look for substitute foods to include in ruminant diets 17.

Natural agro-industrial by-products derived from grape and olive processing, particularly grape and olive pomace, represent sustainable alternative feed resources that can reduce animal feeding costs and improve production profitability 25, 9. Furthermore, the use of these by-products may also yield environmental advantages, as their accumulation in natural ecosystems is associated with considerable ecological hazards. The agro-industrial by-product grape pomace (GP) is valued for its substantial nutritional profile, being a rich source of phenolic compounds including epicatechin, anthocyanins, and catechins that exhibit strong antioxidant activity 2, 24, 28, 23. Moreover, the inclusion of GP to an animal's diet enhances the performance of carcass meat production 18. GP is among the most ideal options for feeding animals due to its high polyphenols. Nevertheless, excessive amounts of dietary polyphenols can be harmful to animal health 20.

Olive pomace (OP) represents a sustainable and cost-effective feed ingredient for ruminants, providing significant nutritional value while avoiding expensive and redundant extraction processes 14, 7. The solid residue that remains after extracting olive oil is known as olive pomace, olive cake, or olive husk 22, 29. However, to enhance animal health and performance, there has been growing interest in the extraction of bioactive compounds such as polyphenols, oleuropein, flavonoids, and simple phenolics from plant-based sources, including olive by-products 16. Consumers are increasingly seeking lamb meat that is of higher quality and lower fat content, and the inclusion of OP in ruminant diets may help achieve this. The high oleic acid content of olive pomace can further enhance the nutritional value of lamb for human consumption. A study by 30 showed that dietary inclusion of OP in lamb feed has been reported to influence subcutaneous fat composition, enhance the oxidative stability of meat lipids, and modulate intramuscular fatty acid composition.

In recent years, the inclusion of grape and olive pomace in animal feed has attracted significant interest owing to their potential to improve performance, carcass quality, and the shelf life of meat products. However, there is currently insufficient systematic research on the partial replacement of forage in mixed concentrate diets with grape and olive by-products to enhance growth, health, and carcass quality in fattening lambs. This study thus evaluates the effects of substituting a portion of the forage with grape or olive pomace on lamb growth performance and carcass characteristics.

Materials and Methods

Table 1. Ingredients and composition of the experimental diet

Ingredients %	Treatments		
	T1	T2	T3
Wheat Bran	24.15	24.15	24.15
Barley	21	21	21
Corn	9.45	9.45	9.45
Soybean Meal	9.1	9.1	9.1
Wheat Flour	3.5	3.5	3.5
Greenmix Dairy 2.5%	1.12	1.12	1.12
Limestone	0.7	0.7	0.7
Salt	0.42	0.42	0.42
Soya Oil	0.35	0.35	0.35
Toxbond	0.21	0.21	0.21
Roughage (wheat straw)	30	10	10
Grape Pomace	0	20	0
Olive Pomace	0	0	20
Chemical composition of experimental feeds (% dry matter)			
Dry Matter	88.12	88	87
Metabolizable Energy Meal/Kg	1.887	2.227	2.196

Ingredients %	Treatments		
	T1	T2	T3
Crude Protein	12.22	12.84	12.4
Crude Fat	14.5	7.1	8.12
Fiber	5.22	10.2	14.68
Ash	5.61	5.54	4.74
Calcium	0.3193	0.3193	0.3193
Total Phosphorus	0.4549	0.4549	0.4549
Sodium	0.1902	0.1902	0.1902
Potassium	0.6187	0.6187	0.6187
Chloride	0.3047	0.3047	0.3047
Protein Bypass	3.3659	3.3659	3.3659
Net Energy Gain Meal/Kg	0.7251	0.7251	0.7251
ADF	19.39	16.59	19.59
NDF	36.65	32.65	32.91
Lignin	1.2894	1.2894	1.2894
TDN	48	48	48
NFE	50.6	52.3	46.86
Cost ID	376000	359000	361000

ADF: acid detergent fiber, NDF: neutral detergent fiber, TDN: total digestible nutrient, NFE: nitrogen free extract, ID: Iraqi dinar

Experimental Animals and Housing

The feeding trial was conducted at the Kosar Company local farm in Erbil city, Kurdistan Region, Iraq. The experiment, over 81 days, consisted of a 12-day acclimatization period followed by a 69-day experimental period, from January 10 to March 19, 2025. Fifteen Awassi male lambs aged three months with average initial body weight of 24.86 ± 0.79 kg/lamb were used. All lambs were maintained under identical environmental, managerial, and hygienic conditions. After weaning and completion of the 12-day acclimatization period, they were individually fed and randomly allocated to one of three treatment groups. In the first treatment (T1), the lambs were offered a basal diet containing 70% concentrate and 30% roughage, while those in the second (T2) and third (T3) treatments received diets in which 20% of the roughage was replaced with grape or olive pomace, maintaining 70% concentrate and 10% roughage. The roughage was wheat straw. For each treatment, five lambs were housed in individual pens, with each pen containing a dedicated feeder and water trough.

All lambs had access to clean water, and diets were offered daily at 4% of their body weight, divided into two feedings at 07:00 and 16:00. Drinking water was provided ad libitum throughout the experimental period. Throughout the experiment, the lambs were weighed weekly before the morning feeding, and their daily feed intake and refusals were recorded. The ingredients and chemical composition of the experimental diets are presented in **Table 1**.

Grape Pomace Preparation

The GP used in this study was obtained from wineries in Shaqlawa (Erbil, Kurdistan Region, Iraq) following juice extraction. It was air-dried, then incorporated and thoroughly mixed with the basal diet. Its chemical composition was analyzed at the Kosar feed mill factory (Kosar laboratory) according to the methods of the Association of Official Agricultural Chemists 4, revealing crude protein (7%), fat (4.63%), crude fiber (26.3%), ash (6.3%), dry matter (89.39%), and nitrogen-free extract (45.16%).

Olive Pomace Preparation

The OP used in this study was obtained from the Erbil Olive Oil Factory (Erbil, Kurdistan Region, Iraq). It was air-dried, then incorporated and thoroughly mixed with the basal diet. Its chemical composition was analyzed at the Kosar feed mill factory (Kosar laboratory) following the methods of the Association of Official Agricultural Chemists 4, revealing crude protein (4.8%), fat (10.03%), crude fiber (50.47%), ash (2.41%), dry matter (86.54%), and nitrogen-free extract (18.83%).

Growth Performance

After the acclimatization period, the lambs were weighed to determine their initial body weight, and subsequent weights were recorded at weekly intervals. Daily feed intake (DFI), total body weight (TBW), body measurements (BM), and growth period (GP) were monitored. From these data, the average daily intake (ADI), average daily gain (ADG), feed efficiency (FE; kg weight gain/kg feed intake), and feed conversion ratio (FCR; kg feed intake per kg weight gain) were calculated.

The assessment of growth performance was based on periodic measurements of body weight and the determination of average daily gain (ADG) throughout the experimental period. Initial body weight (IBW) was recorded on Day 0 using a digital livestock scale (precision ± 0.1 kg), with all lambs weighed individually. Daily feed intake was determined by recording the quantity of feed offered and refused, which was subsequently used to calculate the feed conversion ratio (FCR). All procedures adhered to the institutional guidelines for the care and welfare of experimental animals.

Blood Parameters

To minimize stress, the animals were gently restrained, and blood sampling was performed in the morning at the end of the experiment to reduce diurnal variation. All equipment was sterilized, and the sampling site was disinfected prior to venipuncture. Blood samples were collected from lambs via jugular venipuncture using sterile disposable vacutainer needles and collection tubes. For hematological analysis, the blood samples were collected into tubes containing ethylenediaminetetraacetic acid (EDTA) as an anticoagulant. For biochemical analysis, blood was drawn into plain tubes without an anticoagulant, allowed to clot at room temperature, and then centrifuged at 3000 rpm for 10–15 minutes to obtain serum. The serum biochemical parameters were subsequently analyzed using a semi-automated or fully automated clinical chemistry analyzer.

The measured parameters included urea, creatinine, cholesterol, triglycerides, total protein, albumin, globulin, glutamate oxaloacetate transaminase (GOT), glutamate pyruvate transaminase (GPT), malondialdehyde (MDA), total antioxidant capacity (TAC), and glutathione peroxidase (GPx). All procedures were performed in accordance with standard veterinary protocols for blood collection and analysis in small ruminants.

Ultrasound for Evaluating Carcass Characteristics

Real-time ultrasound scanning was employed as a non-invasive technique to assess carcass traits *in vivo*. Using a portable ultrasound unit (ESAOTE Pie Medical AQUILA-410853) with a 3.5 MHz linear array transducer, images were captured at the 12th–13th rib interface to visualize the *longissimus dorsi* muscle. Prior to ultrasound scanning, wool at the measurement site was carefully clipped, and an adequate amount of acoustic coupling gel was applied to ensure proper transducer–skin contact and high-quality image acquisition.

The following parameters were measured from the ultrasound images: Subcutaneous fat thickness (FT): measured in cm over the longissimus muscle. Loin muscle thickness (LT) was measured as the vertical distance from the top of the muscle to the vertebral column, while loin area (LA) was measured in square centimeters by tracing the muscle boundary. Ultrasound yield grade (YG) was also estimated using a standard yield grade equation based on fat thickness and loin area. To ensure consistency and accuracy, all ultrasound measurements were performed by a trained and experienced specialist. At the conclusion of the experiment, ultrasound scans were conducted, and data were collected to assess carcass quality and compare the experimental groups.

Cost and Feed Efficiency

For economic evaluation, the net return was calculated as the difference between revenue from the sale of fattened lambs and the associated production costs, with the latter determined according to market prices at the time of the study. Live lambs were purchased at 8,900 ID/kg and sold at 9,000 ID/kg. Fixed labor costs were 200,000 ID per head per month, amounting to 500,000 ID for the duration of the experiment, equivalent to 33,300 ID per lamb. The concentrate diet cost 376, 359, and 361 ID/kg for T1, T2, and T3, respectively, whereas roughage (wheat straw) was priced at 133.33 ID/kg. The profitability was calculated as the difference between the selling prices of carcass and non-carcass and the total costs incurred in producing Awassi male lambs as outlined below:

Profit = Total selling price of live animal - Total costs during animal rearing in fattening periods

Statistical Analysis

The experiment followed a completely randomized design. Data obtained for all parameters were analyzed using the generalized linear model (GLM) procedure of Statistical Analysis System package (SAS) Version 9.1.3 software (SAS Institute Inc., Cary, NC, USA) 25, where the parameters fitted as dependent variables and diet as fixed effect. Duncan's multiple range test was used to separate the means of the tested parameters. The level of statistical significance was set at $P \leq 0.05$.

Results and Discussion

The findings of this study are expressed as mean ± standard error. During the experimental period, growth performance differed depending on the feeding regime and geographical location. Table 2 on the growth performance parameters of the lambs supplemented with grape (GP) and olive (OP) pomace shows that initial body weight and daily feed intake did not differ significantly among treatments. However, final body weight, total body weight gain, average daily gain, total feed intake, feed conversion ratio, and feed efficiency showed significant differences ($P \leq 0.05$). The similarity in initial body weights across all groups (24.81–24.99 kg) confirm proper animal selection and random allocation to experimental treatments.

Lambs in T2 achieved the highest final body weight (40.20 ± 2.51 kg) due to higher metabolizable energy content in GP, which was significantly greater than that of T3 (36.00 ± 1.26 kg). There is evidence showing that elevated OP levels may lower feed intake and nutritional digestibility 21. As GP is a substantial source of protein, higher dietary inclusion levels were anticipated to improve growth performance in fattening lambs. Interestingly, the treatment containing 10% GP exhibited the highest final body weight (45.28 kg) 6. Neither T2 nor T3 differed significantly from the control group (T1), which showed an intermediate final body weight (37.80 ± 1.15 kg).

Similar to final body weight, total body weight gain was significantly influenced by dietary treatment ($P \leq 0.05$). The T2 group gained the highest total body weight (15.21 ± 1.53 kg) due to higher metabolizable energy content in GP and the high total feed intake consumed, which was significantly greater than for the T3 group (11.22 ± 1.28 kg). The T1 group achieved a total body weight gain of 12.99 ± 0.66 kg, falling between the gains in T2 and T3. Lambs in the T2 group exhibited significantly higher average daily gain (ADG) at 0.22 ± 0.02 kg/day compared to the T3 group (0.162 ± 0.01 kg/day), likely due to higher feed intake in T2 and the palatability sweet taste of grape pomace. The T1 group had an ADG of 0.188 ± 0.01 kg/day, not significantly different from either T2 or T3. The T2 group consumed the highest total feed at 70.60 ± 3.83 kg, compared to 60.85 ± 3.40 kg by the T3 group, whereas in treatment, the diet containing 20% GP had the lowest DFI value of 1.04 kg 6. The T1 group consumed 65.93 ± 3.01 kg of feed while T2 showed a trend toward higher consumption.

Feed conversion ratios (FCR) were significantly influenced by dietary treatment ($P \leq 0.05$). The T2 group exhibited the most favorable FCR at 4.76 ± 0.37 kg feed/kg gain compared to T3 (5.69 ± 0.63 kg feed/kg gain) and T1 (5.13 ± 0.38 kg feed/kg gain). The observed improvements in FCR and growth performance may be associated with the dietary inclusion of GP 6. The superior FCR observed in the T2 group indicates improved productivity, as less feed was required to achieve a given body weight. Whereas 6 showed that higher levels of GP (15 and 20%) had a detrimental effect, leading to a significant decrease in DMI and ADG and a deterioration in the FCR.

The results of this study indicated that feed efficiency (FE) was also considerably impacted. It was highest in the T2 group (0.210 ± 0.01 kg gain/kg feed) compared to T3 (0.188 ± 0.02 kg gain/kg feed) and T1 (0.198 ± 0.01 kg gain/kg feed). The improved FCR in lambs receiving grape pomace supplementation may be due to its abundant polyphenols, which are known to alleviate stress and promote overall health, as reported by 8. It has been stated that incorporating GP into the diet of fattening small ruminants, including lambs, enhances performance parameters, including feed efficiency, owing to its rich polyphenolic content.

Table 2. The impact of grape and olive pomace diet supplementation on the growth performance of Awassi lambs

Traits	Treatment[1]			P value[4]
	T1	T2	T3	
Initial body weight (kg)	24.81 ± 1.19	24.99 ± 1.65	24.78 ± 1.57	0.9942
Final body weight (kg)	37.80 ± 1.15^{b}	40.20 ± 2.51^{a}	36.00 ± 1.26^{b}	0.0276
Total body weight (kg)	12.99 ± 0.66^{ab}	15.21 ± 1.53^{a}	11.22 ± 1.28^{b}	0.0408
Average daily gain (kg)	0.190 ± 0.01^{ab}	0.22 ± 0.02^{a}	0.162 ± 0.01^{b}	0.0501
Total feed intake (kg)	65.93 ± 3.01^{ab}	70.60 ± 3.83^{a}	60.85 ± 3.40^{b}	0.0160
Daily feed intake (kg)	0.96 ± 0.04	1.02 ± 0.05	0.88 ± 0.04	0.0597
FCR (kg feed/kg gain)[2]	5.13 ± 0.38^{ab}	4.76 ± 0.37^{a}	5.69 ± 0.63^{b}	0.0412
FE (kg gain/feed kg)[3]	0.20 ± 0.01^{b}	0.21 ± 0.01^{a}	0.19 ± 0.02^{b}	0.0538

[1]T1 = 70% concentrate + 30% hay, T2 = 70% concentrate + 10% hay + 20% GP, T3 = 70% concentrate +10% hay + 20% OP.
[2]FCR = feed convention ratio, [3]FE = feed efficiency.
[4]Means with different letters within rows differ significantly at P ≤ 0.05 according to Duncan's test.

Blood and biochemical parameters, which are essential for evaluating animal activity, health status, immune function, and productive traits, are influenced by factors such as breed, age, sex, season, physiological state, and nutrition 1. The blood metabolite profiles of the Awassi lambs fed diets supplemented with GP or OP are presented in Table 3. The inclusion of GP and OP in the diet significantly influenced ($P \leq 0.05$) the serum concentrations of urea, creatinine, cholesterol, triglycerides, total protein, albumin, globulin, GOT, and GPT.

The T3 group lambs were associated with higher levels of urea (44.6mg/dl), creatinine (0.845 mg/dl), triglyceride (21.8 mg/dl), total protein (4.055 g/dl), albumin (3.16 g/dl), GOT (180 IU/L), and globulin (0.895 g/dl), while cholesterol (55.45 mg/dl) and GPT (16.9 IU/L) were low compared to the T1 and T2 groups. These results are consistent with 3, who demonstrated that the including OP in lamb diets increased blood biochemical parameters, suggesting greater metabolic activity and improved liver function. In comparison with the T1 group, the T2 group demonstrated elevated concentrations of urea (46.7 mg/dl), triglyceride (21.25 mg/dl), total protein (3.97 g/dl), albumin (3.155 g/dl) and globulin (0.815 g/dl).

The significant modulation of key blood metabolites by both pomaces reflects their unique nutritional composition and bioactivity. The observed effects may be mediated by their abundant phenolic compounds, which exert potent antioxidant properties that reduce oxidative stress.

Table 3. The impact of grape and olive pomace diet supplementation on blood metabolites parameters in Awassi lambs

Traits	Treatment[1]			P value[3]
	T1	T2	T3	
Urea (mg/dl)	36.5 ± 0.28[c]	46.7 ± 0.17[a]	44.6 ± 0.23[b]	<0.0001
Creatinine (mg/dl)	0.69 ± 0.01 [b]	0.68 ± 0.01 [b]	0.845 ± 0.01 [a]	<0.0001
Cholesterol (mg/dl)	61.77 ± 0.13[a]	57.5 ± 0.29[b]	55.45 ± 0.32[c]	<0.0001
Triglyceride (mg/dl)	16.04 ± 0.02[c]	21.25 ± 0.14[b]	21.8 ± 0.12[a]	<0.0001
Total protein (g/dl)	3.77 ± 0.01[c]	3.97 ± 0.02[b]	4.055 ± 0.03[a]	0.0003
Albumine (g/dl)	3.05 ± 0.02[b]	3.16 ± 0.01[a]	3.16 ± 0.03[a]	0.0203
GOT (IU/L)[2]	121.00 ± 0.57[b]	119.00 ± 0.57[c]	180.00 ± 0.58[a]	<0.0001
GPT (IU/L)[3]	19.50 ± 0.28[a]	15.90 ± 0.06[c]	16.9 ± 0.06[b]	<0.0001
Globulin (g/dl)	0.73 ± 0.01[c]	0.82 ± 0.01[b]	0.895 ± 0.01[a]	<0.0001

[1]T1 = 70% concentrate + 30% hay, T2 = 70% concentrate + 10% hay + 20% GP, T3 = 70% concentrate +10% hay + 20% OP.
[2]GOT = glutamate oxaloacetate transaminase, [3]GPT = glutamate pyruvate transaminase.
[3]Means with different letters within rows differ significantly at P ≤ 0.05 according to Duncan's test.

Feeding both GP and OP dietary supplements significantly influenced ($P \leq 0.05$) malondialdehyde (MDA), total antioxidant capacity (TAC), and glutathione peroxidase (GSH-Px), as seen in **Table 4**. MDA concentrations were lower ($P<0.05$) in both the T3 and T2 groups than T1 at 1.87 ± 0.04, 1.93 ± 0.02, and 3.73 ± 0.02, respectively. The T3 group demonstrated the most pronounced reduction, achieving the lowest MDA level. TAC values were significantly elevated in T2 (789.36 ± 5.05) and T3 (716.15 ± 1.99) compared to the T1 group (412.65 ± 12.55), with T2 having the highest antioxidant capacity among treatments.

These results contrast with those reported by **20**, who found that TAC was significantly higher in lambs fed 10% compared to 20% GP ($P \leq 0.05$). GSH-Px activity was significantly elevated in the T3 and T2 groups (70.83 ± 0.08 and 61.83 ± 0.23, respectively) compared to the T1 group at 24.75 ± 0.58), with T3 group showing the highest activity. This suggests that the high polyphenol content in these supplements, particularly in OP, is a major contributor to mitigating oxidative stress **13**.

Table 4. The impact of grape and olive pomace diet supplementation on the serum oxidative stress index of Awassi lambs

Traits	Treatment[1]			P value[5]
	T1	T2	T3	
MDA (n.mol/ml)[2]	3.73 ± 0.02[a]	1.93 ± 0.02[b]	1.87 ± 0.04[b]	<0.0001
TAC (n.mol/ml)[3]	412.65 ± 12.55[c]	789.35 ± 5.05[a]	716.15 ± 1.99[b]	<0.0001
GSH-Px (n.mol/ml)[4]	24.75 ± 0.58[c]	61.83 ± 0.23[b]	70.83 ± 0.08[a]	<0.0001

[1]T1 = 70% concentrate + 30% hay, T2 = 70% concentrate + 10% hay + 20% GP, T3 = 70% concentrate +10% hay + 20% OP.
[2]MDA = malondialdehyde, [3]TAC = total antioxidant capacity, [4]GSH-Px = glutathione.
[5]Means with different letters within rows differ significantly at P ≤ 0.05 according to Duncan's test.

Carcass composition parameters, assessed via ultrasound following the palpation-guided placement of the transducer between the 12th and 13th ribs, were influenced by the GP and OP dietary supplementation. The carcass evaluation via ultrasound showed that fat thickness (cm), loin thickness (cm), loin area (cm^2), and yield grade were significantly affected ($P \leq 0.05$) by dietary supplementation (**Table 5**). The T2 group had the highest fat thickness (0.45 ± 0.01 cm), significantly exceeding that for the T1 (0.35 ± 0.01 cm) and T3 (0.34 ± 0.02 cm) groups. This finding aligns with the better growth performance (i.e., higher final body weight and total gain) observed in the T2 group. The T2 group exhibited the greatest loin thickness (1.94 ± 0.01 cm) compared with T1 (1.84 ± 0.03 cm) and T3 (1.77 ± 0.01 cm). Similarly, the largest loin area was observed in T2

(7.70 ± 0.06 cm²), exceeding T3 (6.91 ± 0.05 cm²) and T1 (7.16 ± 0.05 cm²). Yield grade, a key indicator of fattening program success, was highest in the T2 group (2.49 ± 0.05), significantly above the T1 (2.33 ± 0.02) and T3 (2.29 ± 0.01) groups.

Ultrasound technology provides accurate and objective information on body and carcass composition of live animals, which can be crucial for improving productivity and decision-making in the sheep industry 12, 27. In this study, the observed yield grades fell within the ideal 2–3 range, indicating that the animals had heavier carcasses, a higher proportion of lean tissue, and desirable fat content. Yield grade is particularly advantageous for meat producers, as producing lean tissue is more cost-efficient than fat.

Table 5. The impact of grape and olive pomace diet supplementation on carcass traits in Awassi lambs

Traits	Treatment[1]			P value[2]
	T1	T2	T3	
Fat thickness (cm)	0.35 ± 0.01[b]	0.45 ± 0.01[a]	0.34 ± 0.02 [b]	0.0020
Loin thickness (cm)	1.84 ± 0.03[b]	1.94 ± 0.01[a]	1.77 ± 0.01[b]	0.0048
Loin area (cm)^2	7.16 ± 0.05[b]	7.70 ± 0.06[a]	6.91 ± 0.05[c]	0.0002
Yield grade	2.33 ± 0.02[b]	2.49 ± 0.05[a]	2.29 ± 0.01[b]	0.0203

[1]T1 = 70% concentrate + 30% hay, T2 = 70% concentrate + 10% hay + 20% GP, T3 = 70% concentrate +10% hay + 20% OP.
[2]Means with different letters within rows differ significantly at P ≤ 0.05 according to Duncan's test.

The financial performance of the lambs across the three experimental groups is presented in Table 6, which also details the main cost components and final profitability expressed in Iraqi Dinars (IQD). Profitability was highest in the T2 group (IQD 80744), driven by the maximum selling price (IQD 361800) which offset its highest total cost. In contrast, the T3 group, despite having the lowest costs, generated the smallest profit (IQD 47391) due to its substantially lower selling price (IQD 324000). Profitability was a universal outcome across all treatments.

Table 6. The impact of grape and olive pomace diet supplementation on cost and profitability of the Awassi lambs

Price and Cost per head (IQD)	T1	T2	T3
Purchasing price	220809	222411	221343
Cost of labor and housing	33.300	33.300	33.300
Cost of feed	24789	25345	21966
Total cost	278898	281056	276609
Selling price	340200	361800	324000
Profit (Income)	61302	80744	47391

IQD = Iraqi dinar

Conclusion

The findings of this study revealed that feeding grape pomace to Awaasi lambs improved growth performance (live body weight and feed conversion ratio) and carcass characteristics (subcutaneous fat thickness and loin muscle area) compared to lambs fed the olive pomace or control diets. In addition, the dietary inclusion of both grape and olive pomace effectively mitigated oxidative stress in the lambs as evidenced by alterations in MDA, TAC, and GSH-Px levels. The feed cost of lamb-fattening in this study ranked as follows: grape pomace < control < olive pomace. These results indicate that agro-industrial byproducts, particularly grape pomace, show significant potential as cost-effective feed supplements to enhance lamb production efficiency and health.

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References

1. Abdel-Lattif, F.H., & Al-Muhja, R.K. (2021, April). Some blood and biochemical parameters and body dimensions in Awassi sheep. In IOP Conference Series: Earth and Environmental Science (Vol. 735, No. 1, p. 012010). IOP Publishing. https://doi.org/10.1088/1755-1315/735/1/012010.
2. Aachary, A. A., & Prapulla, S. G. (2011). Xylooligosaccharides (XOS) as an emerging prebiotic: Microbial synthesis, utilization, structural characterization, bioactive properties, and applications. Comprehensive Reviews in Food Science and Food Safety, 10(1), 2–16. https://doi.org/10.1111/j.1541-4337.2010.00135.x
3. Ali, M. R. K., & Al Sile, S. A. M. (2025). Effect of olive cake on growth performance, carcass and hematological parameters of local Barbary lambs. *Libyan Journal of Medical and Applied Sciences*, *3*(2), 99–109. https://doi.org/10.64943/ljmas.v3i2.69
4. Horwitz, W. (Ed.). (2000). Official methods of analysis of AOAC International (17th ed.). Gaithersburg, MD: AOAC International.
5. Bodas, R., Prieto, N., García-González, R., Andrés, S., Giráldez, F. J., & López, S. (2012). Manipulation of rumen fermentation and methane production with plant secondary metabolites. Animal Feed Science and Technology, 176(1–4), 78–93. https://doi.org/10.1016/j.anifeedsci.2012.07.010
6. Bampidis, V. A., & Robinson, P. H. (2006). Citrus by-products as ruminant feeds: A review. Animal Feed Science and Technology, 128(3–4), 175–217. https://doi.org/10.1016/j.anifeedsci.2005.12.002
7. Balli, D., Cecchi, L., Innocenti, M., Bellumori, M., & Mulinacci, N. (2021). Food by-products valorisation: Grape pomace and olive pomace (pâté) as sources of phenolic compounds and fiber for enrichment of tagliatelle pasta. Food Chemistry, 355,129642. https://doi.org/10.1016/j.foodchem.2021.129642
8. Bashtani, M., Baghsiyah, M.B., Farhangfar, S.H., & Ghavipanje, N. (2025). Dietary application of grape (Vitis Vinifera L.) pomace for fattening lambs: implications on growth performance, rumen fermentation, and meat fatty acid composition. Veterinary Medicine and Science,11(5), e70495. https://doi.org/10.1002/vms3.70495
9. Blasi, F., Trovarelli, V., Mangiapelo, L., Ianni, F., & Cossignani, L. (2024). Grape pomace for feed enrichment to improve the quality of animal-based foods. Foods,13(22), 3541. https://doi.org/10.3390/foods13223541
10. Boudalia, S., Smeti, S., Dawit, M., Senbeta, E.K., Gueroui, Y., Dotas, V., Bousbia, A., & Symeon, G.K. (2024). Alternative approaches to feeding small ruminants and their potential benefits. Animals,14(6), 904. https://doi.org/10.3390/ani14060904
11. Cadavez, V. A., Popova, T., Bermúdez, R., Osoro, K., Purriños, L., Bodas, R., Lorenzo, J. M., & González-Barron, U. (2020). Compositional attributes and fatty acid profile of lamb meat from Iberian local breeds. Small Ruminant Research, 193, 106244. https://doi.org/10.1016/j.smallrumres.2020.106244
12. de Vargas Junior, F.M., Fernandes, T., de Matos, A.T., Fernandes, A.R.M., Alves, L.G.C., Rossatti, J.A., Britez, G.D.V., & Zagonel, N.G.T. (2021). Evaluator effect on the ultrasound measurement of subcutaneous fat deposition and loin eye area from weaning to slaughter lambs. Veterinary World, 14(1), 259. https://doi.org/10.14202/vetworld.2021.259-264
13. Eder, K., Ringseis, R., & Gessner, D.K. (2025). Effects of grape by-products on oxidative stress and inflammation in farm animals: an overview of studies performed in pigs, chickens, and cattle. Animals, 15(11), 1536. https://doi.org/10.3390/ani15111536
14. Guerra-Rivas, C., Vieira, C., Rubio, B., Martinez, B. and Gallardo, B. (2016) 'Effects of grape pomace in growing lamb diets compared with vitamin E and grape seed extract on meat shelf life', *Meat Science*, 116, pp. 221–229. https://doi.org/10.1016/j.meatsci.2016.02.022
15. Habeeb, A.A.M., Gad, A.E., El-Tarabany, A.A., Mustafa, M.M. and Atta, M.A.A. (2017) 'Using of olive oil by-products in farm animals feeding', *International Journal of Scientific Research in Science and Technology*, 3(6), pp. 57–68.
16. Herrero-Encinas, J., Blanch, M., Pastor, J.J., Mereu, A., Ipharraguerre, I.R., & Menoyo, D. (2020). Effects of a bioactive olive pomace extract from Olea europaea on growth performance, gut function, and intestinal microbiota in broiler chickens. Poultry Science,99(1), 2-10. https://doi.org/10.3382/ps/pez467
17. Jalal, H., Giammarco, M., Lanzoni, L., Akram, M.Z., Mammi, L.M., Vignola, G., Chincarini, M., Formigoni, A., & Fusaro, I. (2023). Potential of fruits and vegetable by-products as an alternative feed source for sustainable ruminant nutrition and production: a review. Agriculture, 13(2), 286. https://doi.org/10.3390/agriculture13020286
18. Kafantaris, I., Stagos, D., Kotsampasi, B., Hatzis, A., Kypriotakis, A., Gerasopoulos, K., Makri, S., Goutzourelas, N., Mitsagga, C., Giavasis, I., & Petrotos, K. (2018). Grape pomace improves performance, antioxidant status, fecal microbiota and meat quality of piglets. Animal,12(2), 246-255. https://doi.org/10.1017/S1751731117001604
19. Li, S., Du, M., Zhang, C., Wang, Y., Lee, Y., & Zhang, G. (2022). Diet type impacts production performance of fattening lambs by manipulating the ruminal microbiota and metabolome. Frontiers in Microbiology, 13, 824001. https://doi.org/10.3389/fmicb.2022.824001
20. Li, Y., Shi, C., Deng, J., Qiu, X., Zhang, S., Wang, H., Qin, X., He, Y., Cao, B., & Su, H. (2024). Effects of grape pomace on growth performance, nitrogen metabolism, antioxidants, and microbial diversity in Angus bulls. Antioxidants,13(4), 412. https://doi.org/10.3390/antiox13040412
21. Mioč, B., Pavić, V., Vnučec, I., Prpić, Z., Kostelić, A., & Sušić, V. (2007). Effect of olive cake on daily gain, carcass characteristics and chemical composition of lamb meat. Czech Journal of Animal Science, 52(2), 31–36. https://doi.org/10.17221/2261-CJAS
22. Neifar, M., Jaouani, A., Ayari, A., Abid, O., Salem, H.B., Boudabous, A., Najar, T., & Ghorbel, R.E. (2013). Improving the nutritive value of olive cake by solid state cultivation of the medicinal mushroom Fomes fomentarius. Chemosphere,91(1), 110-114. https://doi.org/10.1016/j.chemosphere.2012.12.015
23. Ouyang, H. (2026). Effects of agro-industrial by-products on health and growth performance of livestock: Studies on white grape marc extract in broilers and three different fibrous by-products in weaned piglets (Doctoral dissertation, Freie Universität Berlin). Refubium. https://refubium.fu-berlin.de/handle/fub188/51692
24. Parry, JW., Li H., Liu JR., Zhou K., Zhang L., & Ren, S. (2011). Antioxidant activity, antiproliferation of colon cancer cells, and chemical composition of grape pomace. Food and Nutrition Sciences 2, 530–540. https://doi.org/10.4236/fns.2011.26076
25. Salih, S. and Mahmood, A. (2023) 'Effect of olive pomace as supplement on growth, carcass and meat characteristics of Karadi lambs', *The Indian Journal of Animal Sciences*, 93(10), pp. 1004–1009. https://doi.org/10.56093/ijans.v93i10.133555
26. SAS Institute Inc. (2004). SAS version 9.1.3 [software]. Cary, NC: SAS Institute Inc.
27. Silva, S.R. (2017). Use of ultrasonographic examination for *in vivo* evaluation of body composition and for prediction of carcass quality of sheep. Small Ruminant Research, 152,144-157. https://doi.org/10.1016/j.smallrumres.2016.12.020
28. Sordillo, L.M. (2016) 'Nutritional strategies to optimize dairy cattle immunity', *Journal of Dairy Science*, 99, pp. 4967–4982. https://doi.org/10.3168/jds.2015-10354
29. Spizzirri, U. G., Esposito, L., Restuccia, D., Crupi, P., Fosco, D., Desideri, G., Vescovo, D., Clodoveo, M. L., Martuscelli, M., & Aiello, F. (2026). Valorization of olive milling by-products: Development and application of an antioxidant-enriched leavening powder for bakery products. Foods, 15(9), 1488. https://doi.org/10.3390/foods15091488
30. Sucu, E., Akbay, K.C., Şengül, Ö.M.E.R., Yavuz, M.T., & AK, İ. (2018). Effects of stoned olive pomace on carcass characteristics and meat quality of lambs. Turkish Journal of Veterinary & Animal Sciences, 42(6), 533-542. https://doi.org/10.3906/vet-1702-52

مقالة أصيلة

معايير النمو وصفات الذبيحة للحملان العواسية الذكور المغذاة على تفل العنب والزيتون

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الخلاصة

أجريت هذه الدراسة لتقييم تأثير استخدام مكملات تفل العنب والزيتون على معايير النمو وتقييم الذبيحة بالموجات فوق الصوتية للحملان العواسي. تم توزيع خمسة عشر حملاً من سلالة العواسي بعمر ثلاث اشهر وبمتوسط وزن جسم ابتدائي قدره 24.86 ± 0.79 كغم عشوائياً على ثلاث مجموعات معاملات. غذيت الحملان في المعاملة الأولى (T1)نظامًا غذائيًا أساسي يتضمن 70% علف مركز و30% علف خشن (معاملة السيطرة)، بينما غذيت الحملان في المعاملة الثانية (T2) والثالثة (T3) نظامًا غذائيًا أساسيًا يتضمن 70% علف مركز، 10% علف خشن و 20% تفل العنب (المعاملة الثانية)، او تفل الزيتون (المعاملة الثالثة). لتقييم تأثيرات تفل العنب والزيتون، تم قياس أداء النمو، المؤشرات الدموية الكيميائية، وصفات الذبيحة. وتم تقييم خصائص الذبيحة في الحيوانات الحية باستخدام تقنية الموجات فوق الصوتية .أظهرت النتائج أن العلف الذي يحتوي على تفل العنب حسن من أداء النمو وخصائص الذبيحة ومؤشرات مضادات الأكسدة، كما ساهم في تقليل تكاليف العلف. بينما ادت العليقة التي تحتوي على تفل الزيتون على تقليل من العلف المتناول وزيادة مؤشرات مضادات الأكسدة دون تاثيرها على صفات الذبيحة للحملان. وبناءً على نتائج الدراسة الحالية، تبين أن استخدام المنتجات الثانوية الزراعية–الصناعية، وبالأخص تفل العنب، كان أكثر فعالية في تحسين أداء النمو وزيادة الربحية مقارنة بحملان غذيت عليقة السيطرة او التي احتوت تفل الزيتون

الكلمات المفتاحية: حملان العواسي، صفات الذبيحة، تفل العنب، النمو، تفل الزيتون