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EFFECT OF CULTIVATED PASTURE AND INTENSIVE FATTENING ON CARCASS TRAITS AND MEAT QUALITY OF AWASSI LAMBS

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ABSTRACT

The study aimed to evaluate the carcass trait, meat quality and fatty acid profile of Awassi lambs under cultivated pasture fattening with a concentrated feed (CPF) and intensive fattening (IF) system. A total of 76 male Awassi lambs (36 lambs in the CPF group and 40 in the IF group, 85 days average age) were distributed in complete random design into two experimental groups. The final body weight was lower, but the average daily gain was higher for the lambs on the CPF compared to the lambs on the IF system. There were no significant differences ($p>0.05$) between CPF and IF system for dressing percentage (50.31 and 51.51%) and shrinkage loss (3.45 and 2.50%), pelvic limb (34.9 and 30.3%), thoracic limb (20.8 and 18.3%), flank (9.4 and 7.6%), neck (4.4 and 5.9%), and LTL section area (15.6 and 13.0 cm^2), except for ribs (25.0 and 33.7%), which were higher in the intensive system. Also, meat pH and color value were not changed by the fattening systems. The fatty acid profile of the *longissimus thoracis et lumborum muscles* was assessed. The significant differences between groups were noted in margaric (1.00 and 1.80), heptadecenoic (0.51 and 0.99), eicosenoic (80.14 and 0.20), and linolenic fatty acids (0.21 and 0,19). In conclusion, the results of this study imply that carcass traits and meat quality were similar between CPF and IF systems in Awassi male lambs.

Keywords: Awassi lamb, carcass traits, cultivated pasture, fatty acid, intensive fattening, meat quality.

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INTRODUCTION

The public generally prefers lamb meat, sheep milk, and dairy products in Turkiye, as in most Mediterranean countries (Gürsoy 2006). According to TURKSTAT (2022), approximately 44 million sheep are kept in Turkiye. The total red meat produced is about 2.191 million tons, of which 26.8% is produced from sheep. The majority of the sheep population are low-productive domestic sheep breeds such as Akkaraman, Morkaraman, Awassi, and Kıvırcık. The Awassi sheep is a popular and widespread breed outside Europe due to their adaptability to tolerate environmental variations and ability to thrive in diverse feeding conditions ranging from steppe to high intensity systems (Ali *et al.* 2020).

Sheep meat quality is affected by many factors: feed content, feeding system, seasons, slaughter weight, slaughter ages, and breed (Al-Suwaiegh and Al-Shathri 2014, Carneiro *et al.* 2016, Yalcintan *et al.* 2017, Khadre and Karabacak 2018, Miguel *et al.* 2021, Obeidat 2021). Fats serve as the primary energy source for the body and offer valuable nutrients, including essential fatty acids that play a role in cell membrane structure, enhance the flavor of meat, and are crucial for a well-balanced diet when consumed in appropriate proportions (Murariu *et al.* 2023). The nutritional value of meat depends on the balance between saturated fatty acids (SFA) and polyunsaturated fatty acids (PUFA).

However, certain SFAs and trans-MUFAs have been found to have negative effects on blood lipid profiles and are associated with an increased risk of coronary events (Chikwanha *et al.* 2018). Consequently, consumers of red meat often prefer lamb meat obtained from grazing lambs, considering it to be healthier, more delicious, and more natural compared to meat produced through concentrated feeding systems (Font-i Furnols and Guerrero, 2014).

The Awassi lamb fattening system is based mainly on natural grassland, stubble, and fallow pastures in order to utilize natural resources as much as possible. Pasture-based systems may be a good option for indoor lamb production systems, and to use natural resources

and reduce production costs (Ekiz *et al.* 2013). There is an increasing demand for safe meat production, however, the on-farm cost of feedstuffs is quite high. The EU Common Agricultural Policy is stimulating market interest in pasture production systems (Demirel *et al.* 2006). Consumers prefer the meat of grazed lambs which is much healthier, tastier, and more natural than meat from concentrate-based production systems (Font-i-Furnols and Guerrero 2014). The concentrate supplementation of grazing lambs enhanced the animal's performance and carcass yield. The feeding system did not affect meat and fat color, fat consistency, or meat proportions (Carrasco *et al.* 2009).

The effect of cultivated pasture is not well documented in the literature and their comparison of the carcass, meat quality characteristics, and fatty acid content. Therefore, the aim of this study was to investigate the effect of cultivated pasture fattening with concentrated feed consisting of a mixture of wheat grasses, legumes, and an intensive fattening system by evaluating carcass traits, meat quality, and fatty acid content of the *longissimus thoracis et lumborum musculus* (LTL) of lambs.

MATERIALS AND METHODS

Experimental site: The study was conducted at the Memuta dairy sheep farm, located in the Central Anatolian region of Turkiye at an altitude of 1086 m and at 37∘50′14.2″ N and 34∘10′39.0″ E. The long-term average annual precipitation is 329.2 mm, generally distributed in spring and autumn, with a dry summer and some precipitation in the form of snow in winter. The average annual temperature of Konya province is 11.7°C. The highest temperature in July was 40.6°C and the lowest in January was -20.6°C.

Animal care: The study was approved by Niğde Governorate, Provincial Directorate of Agriculture and Forestry of Turkiye (protocol code: E30110456-325.04.02-1061418 and April 2021).

Animal management and experimental design: The lambs remained indoors with ewes for one week and were fed on colostrum and the complement of 1cm^3 selenium injected intramuscularly (Yeldif, Ceva, Turkiye; Sodium Selenite -1 mg, Vit E -60 mg, Vit B1 -40 mg per 1ml). After this period, the lambs were kept with the ewes for 40 days. During this period, the ewes were milked, and the lambs were suckled. Two weeks after birth, the lambs were fed with the starter feed and alfalfa hay (Table 1). The nutrient requirements of the lambs were met by feeding a concentrate mix and alfalfa hay according to NRC (2007) guidelines. Chemical analyses were performed according to the procedures described by AOAC (2016). Lambs were subjected to an adaptation period of three weeks according to the feeding systems. During the adaptation period, four lambs from the CPF group were excluded from the experiment due to growth restrictions and health problems.

Table 1. Ingredients and chemical composition of starter feed for Awassi lambs.

Ingredients	%
Barley	15.00
Maize	25.50
Sunflower meal, (CP: 35%)	3.70
Cottonseed meal, (CP: 26%)	6.00
Soybean meal, (CP: 44%)	43.00
Wheat Barn	5.00
Mineral Premix	1.80
Chemical composition	
Dry matter	90.67
Crude protein	17.09
Crude cellulose	5.52
Ether extract	2.48
ADF	21.00
NDF	28.00
ME (kcal/kg DM)	2747.86

CP: crude protein, ADF: acid detergent fiber, NDF: Neutral detergent fiber, ME: metabolizable energy

Cultivated pasture-based grazing fattening (CPF) system: Lambs were grazed in groups on pasture during the day and kept in a semi-open sheepfold at night. The CPF lambs were given concentrate feed (Table 3) at 1.5% of their live weight and had access to fresh water both in the pasture and in the sheepfold. The chemical composition of cultivated pasture is shown in Table 2.

Table 2. The chemical composition of cultivated pasture for Awassi lambs.

Chemical composition	%
CP grass	14.40
CP legumes	19.02
ADF grass	32.00
ADF legumes	35.81
NDF grass	61.84
NDF legumes	45.75

CP: Crude protein, ADF: acid detergent fiber, NDF: Neutral detergent fiber

Cultivated pasture establishment: An area of 30 hectares was planned for cultivating pasture for sheep. The cultivated pasture was set up with a mixture of six different perennial species of grass: perennial ryegrass (*Lolium perenne* L.), smooth bromegrass (*Bromus inermis*), tall fescue (*Festuca arundinacea* Schreb), and three legume species: white clover (*Trifolium repens* L.), alfalfa (*Medicago sativa* L.), and sainfoin (*Onobrychis sativa*). The NIRS system (FOSS, Denmark) was used to measure the quality of cultivated pasture forage.

Intensive fattening (IF) system: The lambs in the IF group were fed a finisher diet for 56 days. The ingredients and chemical composition of the diet are shown in Table 3.

Table 3. Ingredients and chemical composition of finisher feed for Awassi lambs.

Ingredient	%
Barley	21.70
Maize	40.40
Sunflower meal, (CP: 35%)	6.00
Cottonseed meal, (CP: 26%)	10.00
Soybean meal, (CP: 44%)	13.00
Wheat Barn	7.10
Mineral Premix	1.80
Chemical composition	
Dry matter (DM)	91.02
Crude ash	7.20
Crude cellulose	5.89
Ether extract	2.83
ADF	7.70
NDF	13.70
Crude protein	15.81
ME (Kcal/Kg DM)	2815.32

CP: Crude protein, ADF: acid detergent fiber, NDF: Neutral detergent fiber, ME: metabolizable energy

Carcass Characteristics and Meat Quality: On the 56th day, the lambs were first starved for 12 hours and then slaughtered according to the Islamic method. During the slaughtering process the live weight, empty body weight (excluding the gastrointestinal tract) and hot carcass, organs (including head, skin, feet, lungs and trachea, liver, heart, spleen, pancreas, gastrointestinal tract, diaphragm, and testicles) were weighted and store 4°C. After 24 h of slaughter, carcasses were weighed again and in order to determine cold carcass weight, dressing percentage sharing losses each carcass. As described by Colomer-Rocher *et al.* (1987), hot carcasses included kidneys and perinephric-pelvic fat. The dressing percentage and shrinkage loss were calculated according to the presented formulas:

$$Dressing\ percentage = \frac{cold\ carcass\ weight\ \times\ 100}{live\ weight}$$

$$Shrinkage\ loss = \frac{(hot\ carcass\ weight - cold\ carcass\ weight)\ \times\ 100}{hot\ carcass\ weight}$$

The tail was removed, and the pelvic fat from the two halves was removed and weighed to obtain the contents of the kidney knob and pelvic fat. The chilled carcasses were classified for fatness and conformation using the SEUROP scale as described by (Johansen *et al.* 2006). *Longissimus thoracis et lumborum* (LTL) muscle section area and backfat thickness were measured as described by (Boggs *et al.* 1993).

A pH-meter equipped with a penetrating electrode and a thermometer (Hanna Instruments, HI–9025, Merck, Germany) was used to determine the pH immediately after slaughter carcass dressing (pH30min) and at 24 h post-slaughter (pH24h) pH in the LTL.

Meat color was assessed by lightness (L^*), redness (a^*), and yellowness (b∗) systems Li *et al.* (2022) using a colorimeter, the Minolta Chroma Meter CM-700d (Konica Minolta Holdings, Japan). The color was measured on the fresh muscle surface immediately after cutting. Chroma (C^*) and hue angle (H^*) were calculated with the following formulas Miguel *et al.* (2021).

$$C^* = [(a^*)^2 + (b^*)^2]\frac{1}{2}$$

$$H^* = arctan\ (\frac{b^*}{a^*})\ \times 57.29$$

Meat fatty acid composition: To determine the fatty acid content, the connective tissue was removed from the meat to avoid contamination by intramuscular and leaking fat. A 150 g portion of the respective muscle tissue was taken. A 10 g sample was vacuum-packed and frozen at -20°C until analysis. Subcutaneous fat samples were obtained from the ribs and the *longissimus thoracis et lumborum muscle* of each carcass to assess the fatty acid composition. The fatty acid composition of the *longissimus thoracis et lumborum muscle* was analyzed using gas chromatography (GC). The GC system used in the analysis was equipped with a flame ionization detector (FID) and a capillary column with dimensions of 60 m × 0.25 mm i.d. The capillary column had a film thickness of 0.25 µm and was composed of DB-23, which is a stationary phase made up of 50% cyanopropyl and 50% dimethyl polysiloxane. The injector temperature was set. to 250°C. The oven temperature was programmed as follows: starting at 110°C (held for 6 minutes), increasing to 165°C at a rate of 11°C/min (held for 13 minutes), further increasing to 195°C at a rate of 15°C/min (held for 22 minutes), and finally reaching 230°C at a rate of 7°C/min (held for 7 minutes). Helium was used as the carrier gas at a flow rate of 0-7 ml/min. The injection volume was fixed at 3 µl, and the split ratio was set at 1:50. Each fatty acid methyl ester was reported as a percentage of the total peak area of the chromatogram, excluding the solvent peak. The analyzed fatty acids were further categorized into saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), unsaturated fatty acids (UFA), n-3 PUFA, and n-6 PUFA (Papaloukas *et al.* 2016).

Nutritional indices: The fatty acid composition of meat was used to calculate an index of healthy fat consumption. The calculation of this ratio was based on the formula by Chen and Liu (2020).

$$h/H\ = \frac{(C18{:}1\ n-9\ cis\ +\ \sum PUFA\ )}{(C12{:}0\ +\ C14{:}0\ +\ C16{:}0)}$$

The atherogenicity index (AI) and thrombogenicity index (TI) were calculated according to the formula proposed by Ulbricht and Southgate (1991):

$$AI = \frac{[C12{:}0 + (4 \times C14{:}0) + C16{:}0]}{\sum UFA}$$

$$TI = \frac{(C14{:}0 + C16{:}0 + C18{:}0)}{[(0.5 \times \sum MUFA) + (0.5 \times n-6\,PUFA) + (3 \times n-3\,PUFA) + (n-3/n-6)]}$$

The health-promoting index (HPI) was calculated according to the formula proposed by Chen *et al.* (2004):

$$HPI = \frac{\sum UFA}{[C12{:}0 + (4 \times C14{:}0) + C16{:}0]}$$

The desirable fatty acid (DFA) index was calculated according to the formula of Rhee et al. (2003):

$$DFA = \sum UFA + C18{:}0$$

Statistical analysis: Data was entered into a spreadsheet program, which was used to perform all necessary transformations. Statistical analysis was performed by a General Linear Model univariate with SPSS software package release 22.0 (Watkins 2021). The fattening systems (CPF and IF) as the fixed factors were used. The fattening initial weight was added to the model as covariance. Differences with p≤0.05 were considered as significant (a, b) and p≤0.01 as highly significant (A, B).

RESULTS

Carcass characteristics and quality: The initial weight showed a significant difference between the fattening systems but there were no significant differences seen between the birth weight, final weight, and daily live weight gain of Awassi lambs (Table 4).

The proportion of joints obtained from half-left carcasses in Awassi lambs fed in CPF and IF systems are given in Table 5. The differences in terms of ribs were significantly higher in IF than in the CPF group (p≤0.05). No statistical differences were found between the groups in terms of pelvic limb, thoracic limb, flank, neck, dressing percentage, shrinkage loss rates, LTL cross-sectional area, backfat thickness, and SEUROP fat score.

Table 4. Effect of the fattening system on growth and fattening performance of Awassi lambs.

Growth results (kg)	CPF (n=36)	IF (n=40)	SEM	p-value
Birth Weight, kg	4.76	4.72	0.241	0.121
Weaning Weight, kg	20.64	20.62	1.820	0.943
Initial Weight, kg	22.96^{A}	25.38^{B}	1.246	0.010
Initial age, day	85 days	85 days		
Final Weight, kg	38.51	40.30	1.229	0.102
Final age, day	141 days	141 days	-	-
Daily Live Weight Gain, kg/d	0.278	0.267	0.008	0.290
Average Feed intake, kg/d	Pasture*	1.27		

SEM: standard error of mean, ^{A,B}: significant differences at the level of p≤0.01

* Lambs were fed 1.5% of their live weight in concentrated feed, CPF: Cultivated pasture-based grazing fattening, IF: Intensive fattening.

Table 5. The proportion of joints obtained from half-left carcasses in Awassi lambs fattened under an CPF and IF system.

Item, Unite	CPF	IF	SEM	p-value
Dressing percentage (%)	50.31	51.54	0.782	0.471
Shrinkage loss (%)	3.45	2.50	0.336	0.193
Pelvic limb (%)	34.9	30.6	1.26	0.980
Thoracic limb (%)	20.8	18.3	0.37	0.909
Flank (%)	9.4	7.6	0.64	0.600
Neck (%)	4.4	5.9	0.67	0.324
Ribs (%)	25.0^{a}	33.7^{b}	1.46	0.019
LTL section area (cm^2)	15.6	13.0	1.2	0.310
Backfat thickness (mm)	3.9	3.6	0.47	0.640
SEUROP fat conformation	2.2	2.6	0.158	0.242

SEM: standard error of mean, ^{a,b}: significant differences at the level of p≤0.05, CPF: Cultivated pasture-based grazing fattening, IF: Intensive fattening.

The mean values of non-carcass components are given in Table 6. Lambs from the CPF group had a lower head, feet, skin, lungs, trachea, heart, and stomach rate than the IF group. However, the differences were not statistically significant.

Table 6. Non-carcass components of lamb in CPF and IF systems.

Item, Unite	CPF	IF	SEM	p-value
Head, %	6.6	6.9	0.30	0.696
Feet, %	3.3	3.4	0.16	0.760
Skin, %	11.5	12.0	0.58	0.666
Lungs and trachea, %	2.5	2.7	0.13	0.513
Liver, %	2.4	2.4	0.06	0.733
Heart, %	0.6	0.7	0.05	0.111
Spleen, %	0.2	0.2	0.02	1.000
Omental and mesenteric fat, %	0.8	0.8	0.05	0.583
Stomachs, %	23.9	26.1	0.77	0.196

SEM: standard error of mean, CPF: Cultivated pasture-based grazing fattening, IF: Intensive fattening.

Table 7 shows the LTL of Awassi lambs' colorimetric parameters measured after 24 h slaughter. The lamb fattening system did not affect the pH value of LTL of Awassi lambs after 24 h of cooling at 4℃. The CPF lamb carcass pH value measured at 30 minutes was higher than the IF group. The meat pH value measured after 24 h was found to be lower than the value of the IF group. This affected the result of differences between pH0h - pH24h measurements, which was a statistically significant difference ($p \leq 0.05$). Lamb fattening systems did not affect the color characteristics of LTL after slaughter.

Table 7. Values of pH, color characteristics of the LTL of lambs CPF and IF systems.

Item	CPF	IF	SEM	p-value
pH^{30min}	7.4	6.9	0.10	0.064
pH^{24h}	5.6	5.7	0.04	0.172
pH^{0h} - pH^{24h}	1.8^{a}	1.2^{b}	0.09	0.020
L^{*}	48.2	45.7	0.88	0.192
a^{*}	8.7	8.0	0.45	0.211
b^{*}	12.1	10.8	0.55	0.617
C^{*}	14.8	13.5	0.62	0.337
H^{*}	35.1	36.3	1.06	0.596

SEM: standard error of mean, ^{a,b}: significant differences at the level of $p \leq 0.05$, CPF: Cultivated pasture-based grazing fattening, IF: Intensive fattening.

Fatty acid composition and indices: The lamb fattening system influenced the concentration of margaric fatty acid, heptadecenoic fatty acid ($p \leq 0.05$), and eicosenoic fatty acid ($p \leq 0.01$), which was statistically higher in the IF group. The lamb fattening system also affected the concentration of linolenic fatty acid, which was statistically higher ($p \leq 0.01$) in the CPF group. On the other hand, CPF and IF systems did not affect the relation between FA, TI, and AI (Table 8).

Table 8. Effect of the different lamb fattening systems on meat fatty acids profile and relationships between groups of fatty acids, atherogenic index, and thrombogenic index.

Item	CPF	IF	SEM	p-value
SFA (%)				
Lauric acid (C12:0)	0.72	1.61	0.319	0.215
Myristic acid (C14:0)	4.51	4.35	0.387	0.841
Pentadecanoic acid (C15:0)	0.48	0.50	0.030	0.789
Palmitic acid (C16:0)	30.84	29.57	0.689	0.383
Margaric acid (C17:0)	1.00^{a}	1.80^{b}	0.131	0.028
Stearic acid (C18:0)	20.71	19.20	1.017	0.480

Arachidic acid (C20:0)	0.92	1.00	0.194	0.836
MUFA (%)				
Palmitoleic acid (C16:1)	1.47	1.65	0.204	0.661
Heptadecenoic acid (C17:1)	0.51 [a]	0.99 [b]	0.071	0.016
Oleic acid (C18:1)	36.74	38.28	1.452	0.613
Eicosenoic acid (C20:1)	0.14 [A]	0.20 [B]	0.000	0.001
PUFA (%)				
Linolenic acid (18:3)	0.21 [A]	0.19 [B]	0.040	0.001
Linoleic acid (C18:2)	2.07	2.80	0.302	0.260
Total FA				
UFA	33.58	43.58	3.885	0.234
MUFA	31.30	40.60	3.828	0.260
PUFA	2.28	2.98	0.299	0.272
SFA	59.12	58.02	0.726	0.146
Relations among fatty acids, and thrombogenic and atherogenic indexes				
h/H	0.90	1.20	0.11	0.250
AI	0.50	0.55	0.55	0.366
TI	1.35	1.21	0.061	0.121
HPI	2.09	2.34	0.34	0.376
DFA	54.28	62.78	4.02	0.580
MUFA/SFA	0.53	0.72	0.08	0.570
PUFA/SFA	0.04	0.05	0.01	0.463

SEM: standard error of mean, [a,b] : significant differences at the level of $p \leq 0.05$, [A,B] : significant differences at the level of $p \leq 0.01$. CPF: Cultivated pasture-based grazing fattening, IF: Intensive fattening. SFA: Saturated fatty acids, MUFA: Monounsaturated fatty acids, PUFA: polyunsaturated fatty acids.

DISCUSSION

Different sheep breeds and fattening systems influenced the dressing percentages and shrinkage loss (Ekiz *et al.* 2013, Kocak *et al.* 2016, Uğurlu *et al.* 2017). The values of dressing percentages obtained in our study were similar to those reported by Khadre and Karabacak (2018) and Khalaf and Oray (2021) for Awassi lambs.

There were no differences in the rates of the head, feet, skin, lungs, trachea, heart, and stomach between experimental groups. Also, Ekiz *et al.* (2013) showed no differences among production systems in terms of percentages of the head, feet, heart, empty intestines, and gastrointestinal tract content in Kivircik sheep. Contrary results were reported by Ekiz *et al.* (2020) for concentrate-based and pasture-based systems in Kivircik sheep, where the production system affected the percentages of non-carcass components of lamb. However, some of the parameters of Ekiz *et al.* (2020) study are in agreement with our study, which shows the role of cultivated pasture and intensive production systems had a non-significant effect on organ characteristics.

Thoracic limb, ribs, and pelvic limb had higher percentages in all treatments, whereas neck and flank had lower value, these result findings are in agreement with data reported by other authors (Aurousseau *et al.* 2007, Khadre and Karabacak 2018, Khalaf and Oray 2021). The carcass dressing method and age of slaughter are different in these reports than in our results, which explains the slightly different results. However, Gallo *et al.* (2019) found that cut proportion was not influenced by the fattening system. Similarly, Kocak *et al.* (2016) found that the percentages of the neck, shoulder, flank, long leg, tail, and kidneys are not influenced by the production systems. In our study, the LTL area was higher in the CPF group than in the IF system. Moreover, the LTL area from CPF was higher than those obtained by other authors (Esenbuga *et al.* 2009, Obeidat 2021) from growing Awassi lambs. The differences in the results could be explained by the year effect and the age of the animal.

The pH value of meat is one of the most important criteria used in determining its quality. The increase in lactic acid as a result of the anaerobic glycosides formed in the muscles coupled with the decrease in the oxygen level after slaughter causes the pH value of the meat to be decreased. The pH value of the meat falls between 5.6 and 6.2 in the first half an hour after slaughter. As a result of the decrease in the pH level, the meat becomes more juicy and crunchy. According to Peña *et al.* (2009) eventual meat pH levels (pH24h) between 5.5 and 5.8 might be classified as a good enough quality range. According to this aspect, the final meat pH levels determined in the current investigation appear to be within permissible limits. The results show that the fattening system did not affect the pH level. The pH value measured after 24 hours was similar to the studies of other authors (Carneiro *et al.* 2016, Miguel *et al.* 2021, Obeidat 2021) and was within the range of 5.5 and 5.8 for

good quality range meat, regardless of fed system, gender, and seasons of lamb rearing.

Meat color is a significant feature that consumers use to assess the quality and freshness of meat at the moment of purchase (Teke *et al.* 2018). Pale or pink lamb meat is favored by people in the European Mediterranean regions (Ekiz *et al.* 2020). Dark meats are usually rejected by consumers, which associate a dark color with old meat or mature animal origin, and therefore with tough flesh (Carneiro *et al.* 2016). In the presented study, the feeding system had no statistically significant effects on the meat color characteristics. Values of whiteness were higher than those obtained by other authors for Awassi lamb's *longissimus muscles* (Khadre and Karabacak 2018, Obeidat 2021). Similarly, Ekiz *et al.* (2012) reported lower meat lightness characteristics of LTL muscle of lambs kept in different production system ranges. On the other hand, Miguel *et al.* (2021) evaluated lambs of different slaughter ages and sex got results of meat lightness consistent with ours. Similarly, Yalcintan *et al.* (2017) reported that the meat's lightness was consistent with ours. The LTL redness value obtained in this study was 8.0 for IF and 8.7 for CPF systems, both values were lower compared to data obtained by other authors (Khadre and Karabacak 2018, Miguel *et al.* 2021, Obeidat 2021, Yalcintan *et al.* 2017). In our study, the yellowness value in CPF and IF lambs were 12.1 and 10.8, respectively. Khadre and Karabacak (2018) reported yellowness of Awassi lamb meat around 4.0, Papaloukas *et al.* (2016) around 5.0, Ekiz *et al.* (2021) around 2.0-3.0, which is much lower compared to our results. The high yellowness values in the current study could be explained by the amount of fat in the color measurement area. If the measurement area is characterized by a high value of fat, the yellowness will be lower, while high values of yellowness will be recorded due to the lower fat presence (Elizalde *et al.* 2021). On the other hand, our results present lower values of yellowness compared to those obtained by Obeidat (2021) around 18.0 value.

Costa *et al.* (2009) reported that the genotype of the animal and provided diet have a significant effect on meat quality. In the presented study, the main constituents of the fatty acid composition were oleic, palmitic, and stearic acids, constituting approximately 70% of the total FA, which is consistent with the FA composition reported by other authors (Flakemore *et al.* 2017, de Almeida Rego *et al.* 2017). Similarly, Ekiz *et al.* (2013) evaluated the effects of different production systems on lamb performance and reported that oleic, palmitic, and staric acids were the most abundant FA in all growing systems. Except for margaric acid, heptadecenoic acid, eicosenoic acid, and linolenic acid, the different lamb fattening strategies showed no significant effect on percentages of particular FA. These findings are consistent with the earlier studies that evaluated the FA composition of lambs fed in pasture-based vs. concentrate-based systems (Ricardo *et al.* 2015). Oleic acid, recognized for its hypocholesterolemic effect, was the predominant MUFA, which was also observed by Ekiz *et al.* (2013). Concerning the MUFA detected in the meat fat, oleic acid is the MUFA with the highest expression levels in ruminants. Similarly, Ekiz *et al.* (2010) observed variations in oleic acid concentration for the LTL muscles of Kivircik lambs in different production systems. However, in the obtained studies, the fattening system did not influence the concentration of oleic acid. Murariu *et al.* (2023) observed that MUFA ranged between 35.18 - 36.36% in Karagül sheep.

Aurousseau *et al.* (2007) showed the FA profile of the muscles was more favorable for the lambs raised on grazing. Their fatty acid ratios, CLAs, n-3, n-6 FA, and n-6/n-3 ratio were improved and beneficial for consumption. Moreover, Elizalde *et al.* (2021) reported that lamb meat from steppe pasture contained higher levels of palmitic, stearic, and oleic acid than lamb meat from the highland. In the present study, the fattening system affected linolenic acid concentration, which was higher in the CPF system. Likewise, Aghwan *et al.* (2014) observed different levels of C18:3 between treatments with different levels of concentrate, which confirms that linolenic acid amount depends on the type of diet. Interestingly, Elizalde *et al.* (2021) reported that the C18:3 concentration was much higher in the steppe pasture compared to the highland pasture. This difference may be explained by the wide range of botanical species of grasses on steppe land and high rainfall, which can make grasses greener and more nutritious (Ponnampalam *et al.* 2012). Al-Suwaiegh and Al-Shathri (2014) and Junkuszew *et al.* (2020) showed the relationship between the lambs' age and meat linolenic acid concentration. Junkuszew *et al.* (2020) evaluated ewes and lamb meat and found a significant difference in SFA, MUFA, PUFA, and DFA between treatments. The adult animal meat had a more desirable n-6/n-3 ratio than the lamb meat. These results suggested that the consumption of adult animal meat can be a healthier diet than young lamb meat.

The PUFA/SFA and n-6/n-3 fatty acid ratios are regarded as important indicators for the nutritional assessment of fatty meat (Frunză *et al.* 2023). Aghwan *et al.* (2014) reported that a higher PUFA:SFA ratio is important for reducing the risk of cancer and cardiovascular diseases. In the evaluation of meat lipids, the PUFA/SFA ratio holds significant importance, and sheep meat is characterized by a PUFA/SFA ratio ranging from 0.04 to 0.05. Our findings indicated lower values compared to the recommended PUFA/SFA ratio for safe consumption of meat, which should be above 0.4. However, our research revealed higher values compared to other studies conducted by Frunză *et al.* (2023) (ranging from 1.61 to 186), Lee *et al.* (2023) on Korean

native black goats (ranging from 0.44 to 0.57), and de Carvalho *et al.* (2022) on Santa Inês crossbred lambs (ranging from 0.12 to 0.15). Costa *et al.* (2009) reported that PUFA:SFA ratios were influenced by sheep genotypes and diets with different energy concentrations. At the same time, there was a decrease in SFA, atherogenic index (AI) and thrombotic index (TI). These changes in fatty acid composition have a positive effect on meat eaters, as they contribute to a healthier fatty acid profile in meat. Uribe-Martínez *et al.* (2023) conducted a study to investigate the effects of adding chia seeds (*Salvia hispanica* L.) to the diet of fattening lamb based on their nutritional requirements. The study aimed to analyze the biometric parameters and fatty acid profiles in the obtained meat. This change in fatty acid composition was statistically significant ($p < 0.0001$). Zhang *et al.* (2022) found that a UFA/SFA value of 0.69 for grass finishing and 0.74 for concentrate finishing after grass weaning for Hulunbuir sheep.

To ensure a protective potential for coronary artery health, the AI and TI of atherogenicity and thrombogenicity should be less than 1.0 and 0.5, respectively (Fernandes *et al.* 2015). Both indexes are used to evaluate the nutritional value of food, based on the lipid fraction levels, which are related to cardiovascular diseases in the human population (Oliveira *et al.* 2008). Our results are in agreement with Alshamiry *et al.* (2023) who found that AI values ranged from 0.74, 0.63 and 0.74 and TI values ranged from 1.61, 1.48 and 1.49 in different feeding regimes for Awassi lambs. de Carvalho *et al.* (2022) reported that AI values of 0.58, 0.57, 0.54 and 0.55 and TI values of 1.43, 1.41, 1.37 and 1.32 for Santa Inês crossbred lambs. Murariu *et al.* (2023) found that the TI values ranged from 0.78 to 1.22 and the AI values from 0.44 to 0.67 in Karakul sheep. Khaldari *et al.* (2022) reported that TI value between 1.67-1.72 and AI value between 0.96-0.79 in Lori-Bakhtiari and Romanov crossbred sheep breeds. In this study, it was observed that lamb meat in both groups presented the expected values for AI. However, the TI value was found to be higher than the normal values.

The h/H index considers the functional activity of fatty acids on lipoprotein metabolism responsible for plasma cholesterol transport. It is associated with an increased risk of developing cardiovascular disease, with a higher value indicating a lower risk (Carneiro *et al.* 2021). This index serves as a tool to assess the cholesterol-lowering effects of lipids, providing information on their impact on cholesterol levels (Murariu *et al.* 2023). The reference for meat products is the value of 2.0. Products with h/H values above 2.0 mostly consist of hypocholesterolemic FA, thus representing products with a nutritionally desirable FA composition that reduces the risk of cardiovascular disease (Frota *et al.* 2010). Murariu *et al.* (2023), reported that the values of h/H range between 2.17 and 2.67 for Karakul sheep and de Carvalho *et al.* (2022) found that the h:H indices between 1.93, 1.92, 2.00 and 1.97 values for Santa Inês crossbred lambs. The obtained data presents an h/H ratio of around 0.9-1.2, which confirms the results obtained by other authors (Khaldari *et al.* 2022). Higher h/H values are considered nutritionally beneficial for human health. The type of fattening system did not affect the h/H index. An improvement would be noted if components with a high level of PUFA were added to the diet.

Conclusion: The results of this study imply that carcass traits and meat quality were similar between cultivated pasture-based grazing fattening and intensive fattening systems in Awassi male lambs. The significant difference between fattening methods was noted in margaric, heptadecenoic, eicosenoic, and linolenic fatty acids. However, these differences did not effect on healthy index as the h/H ratio, TI, and AI.

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