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Fatty acid profile and sensory properties of lamb meat from males of five indigenous breeds

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Abstract. The objective of this study was to determine meat quality characteristics, fatty acid profiles, and sensory characteristics of 50 single-birth male lambs from five breeds: Artlı ($n = 10$), Çepni ($n = 10$), Hemşin ($n = 10$), Karayaka ($n = 10$), and Of ($n = 10$). At the beginning of the experiment, the average age and weight of the lambs were 120 ± 5 d and 30.7 ± 0.68 kg respectively. After 60 d of intensive fattening, the average live weight before slaughter was 40.96 kg $\pm$ 0.76 kg. All evaluations were performed on samples from the longissimus thoracis et lumborum (LTL) muscle. There was no difference between breeds in terms of the pH values of the hot carcasses, whereas the cold carcass pH values were higher ($P < 0.001$) in Hemşin animals than in the other breeds. Meat chemical properties (such as organic matter; dry matter; and fat, measured as the ether extract), physical properties (such as cooking loss; drip loss; and water-holding capacity, WHC), and instrumental values (such as colour, L^* and b^* values, chewiness, hardness, and resilience) were significantly affected by breed differences. Additionally, the differences between breeds were found to be significant in terms of the fatty acid composition and the evaluation of organoleptic properties, such as sensory characteristics, flavour, and juiciness of cooked (boiled or roasted) meat. The results show that lamb meat's physical, chemical, and sensory properties vary by breed. The differences found in the composition and presence of meat fatty acids between and within breeds can be used as a source of variation for future genetic improvement strategies.

1 Introduction

Most sheep meat production comes from local breeds. These local breeds, which adapt very well to the environment and management (such as climate, care and feeding, and disease resistance) conditions of the place where they are bred, are also crucial in terms of genetic diversity and the development of new gene combinations (Cadavez et al., 2020).

Everyday habits of the consumers, the quality of the meat, and the sensory characteristics of the meat are influential factors in the choice of mutton and lamb meat. It has been shown in many studies that breed or genotype (Kuchtik et al., 2012; Jandasek et al., 2014; Flakemore et al., 2017) affects the meat quality and sensory characteristics, which in turn influences consumption preferences (Cam et al., 2021). Türkiye (Turkey) has a considerable wealth of approximately 40 domestic and newly developed sheep breeds. For centuries, new sheep genotypes have been developed in areas in which different breeds overlap, or they have naturally come about in specific areas where different breeds occur in close proximity to one another. The purebred Artlı, Çepni, and Of sheep genotypes, which have been selectively bred for centuries in Trabzon Province in the Black Sea region of Türkiye, are among the newly registered breeds.

The notable characteristics of the five sheep breeds focused upon in this work (Artlı, Çepni, Of, Hemşin, and Karayaka) are briefly outlined in the following. The most notable characteristic of the Artlı breed is its uniquely formed

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tail: it is 6–7 cm long and turns inward at the tip. Moreover, Artlı sheep have a high maternal ability. The Çepni breed is more agile than other breeds in the region, but it has a more intensely gregarious social instinct and better grazing ability. The Of breed, in contrast, is larger than other sheep breeds in the region, has a higher milk yield, and is more resistant to harsh winter conditions. While the Karayaka sheep breed is predominantly reared in the Black Sea region, Hemşin sheep are reared in the Artvin Province and its surroundings, in the easternmost areas of the Black Sea region. In the classification of sheep breeds reared in Türkiye according to their tail structures, the Hemşin, Çepni, and Of breeds are in the long-tailed medium-fat group, whereas Karayaka is in the long thin-tailed group.

Generally, consumers argue that some meat sheep breeds are better than others, which affects consumer preference and price. Therefore, this study aimed to reveal the five above-mentioned indigenous lamb meat breeds' fatty acid composition and organoleptic characteristics.

2 Material and methods

2.1 Animal and experimental design

A total of 50 lambs from five breeds (Artlı, Çepni, Hemşin, Karayaka, and Of), each represented by 10 lambs, were examined in this study. The lambs were purchased from private sheep farms within 300–600 km of the Ondokuz Mayıs University Agricultural Research and Application Center (41°21′39.1" N, 36°11′02.1" E), where the feeding study was also conducted. Artlı, Çepni, and Of sheep, bred in Trabzon Province, have been newly registered as regional breeds (Official Turkish Newspaper, 10 September 2020, issue no. 31240). For this study, unrelated lambs were selected from registered sheep farms (involved in the breeding project coordinated by the General Directorate of Agricultural Research and Policies of the Republic of Türkiye Ministry of Agriculture and Forestry) based on their ages (120 ± 5 d) and were single-birth lambs from 3- and 4-year-old ewes. Lambs used in the experiment were selected from farms with similar environmental factors, such as feeding and rearing practices. The lambs remained with their mothers until weaning, which resulted in approximately 110 d spent under their original environmental rearing conditions. All lambs were sheared off during the pretrial adaptation process, and all procedures for health were followed. An approximate 10 d adaptation period was applied in order to get the lambs used to the new shelter and feeding environment at the end of the 10 d training period.

The mean weight of the lambs was 30.7 ± 0.68 kg at the start of the experiment. The animals were weighed for 3 consecutive days, and the average was taken as the fattening onset live weight. The animals were left without water for 12 h before each weighing. Thus, they were subjected to a 60 d (from July to August) intense fattening period in individual pens, which had respective areas of approximately 1.50 m × 1.20 m. The feed was supplied with as much concentrate as the animals could eat and with about 450 g of quality roughage. The concentrate contained the following: 1.99 metabolisable energy (ME, measured as megacalories per kilo of dry matter, Mcal kg^{-1} DM), 13.69 % crude protein, 8.86 % crude ash, 8.51 % crude fibre, 1.91 % fat (measured as ether extract), 0.3 % sodium. The roughage contained the following: 1.78 metabolisable energy (ME, Mcal kg^{-1} DM), 4.8 % crude protein, 31.7 % crude fibre, 0.99 % fat (measured as ether extract), and 6.43 % ash. Mineral blocks and freshwater were always available in the pens. Daily feed was offered twice, at 08:00 and 16:00 LT (local time).

After the fattening period, the lambs underwent a dry fasting period for 13 h. Following this, their weights were determined using a 50 g sensitive scale before slaughter. The lambs' average live weight was 40.96 ± 0.76 kg. The lambs were slaughtered, their blood was drained, and they were skinned and eviscerated in an authorised private abattoir located 15 km from the experimental research station. The carcasses were then chilled at +4 °C for 24 h.

A specialist divided the chilled carcasses into two equal parts along the dorsal line after the meat had rested for 24 h. Meat quality and sensory traits were determined on the left half of the carcasses. All meat samples were collected from the longissimus thoracis et lumborum (LTL) muscle after the carcass had rested (+4 °C for 24 h), and they were stored at −20 °C until the analysis. A total of 50 lambs (10 lambs from each breed in the fattening study) represented all five of the above-mentioned breeds. Every sample was analysed for meat quality using two replicates, and the study results present the average values.

2.2 Meat pH

The pH was measured manually at the exact location of the LTL muscle using a portable pH meter (CyberScan PC 510) with a solid-type pH electrode immediately after carcass dressing (within 30 min) and after the carcasses had been rested at 4 °C for 24 h. The pH meter was calibrated at +4 °C using pH 4 and 7 buffers, and the electrode was rinsed with distilled water between each measurement. The electrode was immersed and kept in the meat until stable values were obtained on the pH meter's display screen. Three measurements were recorded from the different sites on the LTL muscles, and pH values were calculated according to the average of these values (Ramírez and Cava, 2007).

2.3 Chemical analyses

Dry matter (DM) content was determined from homogenised 6 g meat samples that had been dried for 5 h at 105 °C. The crude protein (CP) content was calculated as the nitrogen content multiplied by 6.25, using the Kjeldahl method

(Jandesek et al., 2014). Ash content was measured gravimetrically after a homogenised sample (2 g) was burned in a muffle furnace at 550 °C for 8 h. Organic matter (OM) was calculated by subtracting the ash fraction from the dry matter fraction (AOAC, protocol no. 920 153). The intramuscular fat (IMF) of the LTL muscle and subcutaneous adipose tissue samples were partially thawed at +4 °C and trimmed to remove any external adipose (in muscle) and connective tissue. Meat samples used for fatty acid analysis were minced with an electric coffee grinder and homogenised with a vortex mixer for 10 min at +4 °C. IMF was determined gravimetrically after spiking 50 g of the LTL muscle sample with 5 mL of an internal standard solution (2.5 mg C15 : 0 mL^{-1} isooctane; Merck) and extraction with petrol ether in a Soxhlet extractor for 6 h (Komprda et al., 2012). Data for ash, IMF (ether extract), and crude protein are given as percentages on a dry matter basis. LTL area (cm^3) was determined by tracing photographic images using a digital planimeter on the cut surface of the LTL muscle at the interface between the 12th and 13th ribs (Najafi et al., 2020).

2.4 Meat colour

Meat colour (Centre Internationale de l'Eclariage – L*a*b*) was evaluated 24 h post-mortem on a fresh cut surface of LTL muscle (after 0 min) and after blooming in ambient air for 45 min using a reflectance chroma meter (CR-300 reflectance chroma meter, Konica Minolta, Japan) with illuminate C and an 11 mm measurement diameter. The instrument was calibrated against a standard white plate, and six measurements were made on each sample (Xin et al., 2018). The parameters L* (lightness), a* (redness), and b* (yellowness) were recorded. Hue angle was calculated as (arctan (b*/a*)), and chroma, or the saturation index, was calculated as (a*2+b*2) 0.5 (Sabbioni et al., 2019).

2.5 Meat cooking loss and drip loss

Drip loss was collected by suspending 50 g of the LTL muscle, collected 24 h post-mortem, in a plastic bag while avoiding contact with the bag. The samples were suspended for 48 h at 2 °C. At 72 h post-slaughter, the meat sample was removed from the plastic bag, blotted dry, and weighed again. The drip loss value of the meat was the percentage difference between the final value and the initial weight of the meat (Bond and Warner, 2007).

Respective 40 g samples were also taken from the LTL muscle of each carcass, placed vacuum bags, and cooked in a hot water bath (70 °C) for 40 min to determine the cooking loss of meat for each sample. Afterward, the samples were held under tap water (for about 30 min) until they dropped to room temperature (25 °C), and they were then removed from the bags and weighed without pressing (Mitchaothai et al., 2007). Thus, the cooking loss value of the meat was recorded as the percentage difference between the final value and the initial weight.

2.6 Meat water-holding capacity

Meat samples taken from the LTL muscles were minced, mixed with 0.6 M NaCl solution, and homogenised using a vortex mixer at +4 °C and 350–400 rpm for 10 min. The results were recorded as the amount of water absorbed in millilitres per 100 g of meat (Souza et al., 2013).

2.7 Instrumental tenderness

For the texture analysis, the samples used to measure cooking loss were utilised. Samples were taken in 2 cm ×2 cm, 2.5–3 cm long sections parallel to the muscle fibres. Instrumental tenderness was evaluated using a Warner–Bratzler shear force (WBSF) blade connected to an INSTRON 3343 single-column universal testing system (INSTRON, California) for texture analysis. The force applied to the meat in the INSTRON device was set to 50 kg, and the blade speed was set to 200 mm min^{-1}. The peak shear force (shear force, measured as kilograms per square centimetre, kg cm^{-2}) and force–time graph values obtained from these measurements were recorded on a computer. The animals' LTL muscle peak shear force values were determined by calculating the average measurement obtained from repeated samples (Souza et al., 2013; Fabre et al., 2018) immediately after cutting (0 min) and 45 min after cutting. The instrumental meat texture parameters such as adhesiveness, chewiness, cohesiveness, hardness, springiness, resilience, and WBSF (tenderness) were obtained automatically from the INSTRON 3343 device (Ropka-Molik et al., 2014).

2.8 Fatty acid profiles

Meat samples for the analysis of physical and chemical properties, fat, and sensory parameters were taken from the LTL muscles of 10 animals from each breed. Meat samples taken for fatty acid were minced with an electric coffee grinder and homogenised using a vortex mixer for 10 min at +4 °C. The ISO 12966-2 (2011) method was applied to determine meat samples' fatty acid methyl ester (FAME) contents (Supelco 37-component FAME mix, Bellefonte, PA, USA) (Sabbioni et al., 2019). The meat fatty acid content in each sample was measured, and the test was replicated.

Meat quality characteristics according to breed were also evaluated in terms of nutrient content (CP; fat – ether extract; and crude ash, CAs) and in terms of health (fatty acid profiles). Various parameters were evaluated – such as the atherogenic index (AI); the thrombogenic index (TI); the polyunsaturated fatty acid / saturated fatty acid ratio (PUFA / SFA); the polyunsaturated fatty acid / monounsaturated fatty acid ratio (PUFA / MUFA); the monounsaturated fatty acid ratio / saturated fatty acid ratio (MUFA / SFA); the PFAn-3 / PUFAn-6 ratio; and desired fatty acids (DFAs), which was calculated using the $n6/n3$ ($\sum\omega6/\sum\omega3$) ratio – in order to determine the differences in fatty acid profiles between breeds (Cadavez et al., 2020).

2.9 Meat sensory traits

Sensory evaluations were made on 200 g samples taken from the LTL muscles on the left half of the carcasses' lumbar region. All samples were coded using four digits (containing the breed information) after extracting the outer fat, and they were wrapped individually (for each animal) in aluminium foil and stored at −24 °C until analysis. A total of 1 d before the evaluation panel, the samples were thawed at +4 °C and cooked with boiling water, as described above (Olfaz et al., 2005), or roasted on an electric grill until the intramuscular temperature reached 80 °C. After cooking, the meat subsamples (2 cm × 2 cm × 2.5 cm subsamples, average weight of 20 g) were prepared for the panel, using the same amount and size for the boiled and roasted meat. All of the samples were then wrapped in aluminium foil again in order to preserve their digital numbers. Following this, the samples were kept in a 75 °C water bath in closed glass beakers in order to keep the temperature constant at 65–70 °C. Samples with a constant temperature and the exact same sample size, colour, and shape were presented to the panelists on identical plates (Souza et al., 2022).

Sensory evaluations were conducted in a well-lit and well-aired room by experienced panelists, 18 members of which were 25- to 55-year-old non-smoking men and women who had eaten lunch. The panelists' seating arrangements were planned so that they would not affect one another. They were allowed to drink water and eat bread at the end of each test. After a 1 min break, the next sample was evaluated. Panelist evaluations were made 3.5 h after lunchtime during a single session. The evaluation was carried out without any panelist knowledge regarding which plates contained boiled meat and which contained roasted meat. Each panelist evaluated the boiled and roasted samples from each of the five breeds. Thus, each panelist evaluated 20 (2 boil or roasted samples × 5 breeds × 2 replicates) samples for each parameter and 360 samples (20 × 18) overall. For each sensory feature, two repetitions were made, and these values were averaged, as there was no difference between the repeats. The sensory characteristics of the meat, such as the appearance, juiciness, flavour, odour, and overall liking, were evaluated using a nine-point hedonic scale: the scale ranged from 1 (dislike extremely) to 9 (like extremely).

2.10 Statistical analysis

The experiment was conducted using a completely randomised design with five treatments (breeds) and 12 replicates, resulting in 50 experimental units. The parametric test's suitability for all data was checked using Smirnow and Levene tests in the IBM SPSS Statistics 25.0 software (IBM SPSS Statistic Corp.) package.

The effect of breed on meat quality was tested using a generalised linear model (GLM) in SPSS. The breed was taken as a fixed factor, and breed and cooking style (boiling or roasting) were considered fixed factors for sensory analysis.

All data are presented as the mean ± standard error of the mean. A Duncan multiple comparison test was used to compare means; a Pearson correlation was calculated between the meat quality parameters; and a principal component analysis (PCA) of the meat sensory characteristics, including appearance, juiciness, odour, flavour, and overall liking, was performed using XLSTAT® statistical software (version 16.02.27444; Addinsoft, Paris, France).

3 Results and discussion

The meat's physical, chemical, and instrumental properties, determined via the analysis of lamb meat samples taken from LTL muscles of five breeds of lambs, are presented in Table 1.

The $pH_{30\,min}$ values, measured using the hot carcass 30 min after slaughter, were not affected by breed variations, and the $pH_{24\,h}$ values, measured using the resting carcass after the carcass had been kept at +4 °C for 24 h, were only significantly affected in the Hemşin breed ($P<0.005$). These results are consistent with those of Jandasek et al. (2014) and Gonzales-Barron et al. (2021), who reported that the breed did not influence $pH_{24\,h}$ and pH_{48h} values. Considering the cold-meat pH values, the difference in pH values between breeds may be due to the temperament of animals, as Hemşin and Of lambs exhibited more nervous behaviour during care and feeding (Cam et al., 2021). A logical explanation for the pH difference in aged meat between breeds would be the difference in the glycogen-binding abilities of the meat muscle fibres of the breeds. However, there is no consensus in the literature regarding the effects of breed on meat pH. Some studies (Jandasek et al., 2014; Hajji et al., 2016; Gonzales-Barron et al., 2021) declare that the breed could affect meat pH, whereas the others (Esenbuga et al., 2009; Komprda et al., 2012; Cam et al., 2021) report the opposite or confusing results. In summary, the pH values of only Hemşin lambs were different from the others (except for Of lambs), and all pH values were found to be within acceptable limits (Gonzales-Barron et al., 2021) in terms of meat processing and quality. The fact that the final pH value of the Hemşin breed was higher than that of the other breeds used in the study may be because the former has a more timid temperament.

In this study, the correlations (0.59, 0.43, −0.47, 0.41) between the final pH value of the meat and the respective cooking loss, drip loss, water-holding capacity (WHC), and instrumental tenderness of meat were determined to be significant ($P<0.01$). These relationships increase the importance

Table 1. The physical and chemical quality characteristics of the lamb meat for each of the respective breeds.

	Artlı	Çepni	Hemşin	Karayaka	Of	P value
pH1	6.31 ± 0.06	6.36 ± 0.07	6.51 ± 0.11	6.32 ± 0.04	6.33 ± 0.06	0.237
pH2	5.44 ± 0.05^{b}	5.35 ± 0.02^{b}	5.63 ± 0.09^{a}	5.34 ± 0.03^{b}	$5.48 \pm 0.06^{a,b}$	0.005
OM	22.5 ± 0.2^{c}	$24.8 \pm 0.4^{a,b}$	$23.3 \pm 0.3^{b,c}$	25.8 ± 0.9^{a}	22.8 ± 0.4^{c}	0.001
CAs	1.09 ± 0.01	1.05 ± 0.02	1.06 ± 0.02	1.08 ± 0.02	1.03 ± 0.03	0.263
DM	23.6 ± 0.2^{c}	$25.8 \pm 0.4^{a,b}$	$24.4 \pm 0.3^{b,c}$	26.9 ± 0.9^{a}	23.8 ± 0.3^{c}	0.001
Fat (EE)	0.57 ± 0.07^{c}	1.63 ± 0.17^{a}	$1.51 \pm 0.05^{a,b}$	$1.32 \pm 0.27^{a,b}$	1.14 ± 0.12^{b}	0.001
CP	18.9 ± 0.2	18.9 ± 0.2	18.6 ± 0.2	18.3 ± 0.3	18.8 ± 0.2	0.249
CoL	25.5 ± 0.8^{b}	22.5 ± 0.9^{c}	27.9 ± 0.5^{a}	$24.1 \pm 0.7^{b,c}$	$24.2 \pm 1.0^{b,c}$	0.001
DrL	2.86 ± 0.23^{a}	3.26 ± 0.20^{a}	1.87 ± 0.18^{b}	2.77 ± 1.13^{a}	2.08 ± 1.33^{b}	0.001
WHC	$8.60 \pm 0.36^{a,b}$	9.03 ± 0.31^{a}	7.76 ± 0.21^{b}	$8.44 \pm 0.20^{a,b}$	7.84 ± 0.29^{b}	0.015
LTA	19.2 ± 0.8	21.5 ± 1.3	18.6 ± 1.3	20.5 ± 1.0	21.2 ± 1.0	0.280

* Samples were taken from 10 animals per breed. The abbreviations/variables listed in the table are as follows: pH1 – hot carcass pH values, pH2 – cold carcass pH values, OM – organic matter (%), DM – dry matter (%), CP – crude protein (%), CAs – crude ash (%), CoL – cooking loss (%), DrL – drip loss (%), WHC – water-holding capacity (%), LTA – longissimus thoracis muscle area (cm^2), and EE – ether extract (%). [a,b,c] According to the Duncan multiple comparison test, means in rows without a common superscript differ significantly ($P < 0.05$).

of the final pH value in terms of meat consumption preference and quality. Cam et al. (2021) reported that the cooking losses of meat depend on the amount of water-soluble protein and the fat content of the meat. However, there is no consensus in the literature about the effect of the breed on the cooking loss of meat (Jandasek et al., 2014; Hajji et al., 2016).

In this study, although the effect of breed was not found to be insignificant in terms of the CAs and CP contents in meat samples taken from LTL muscle, the impact of breed on the fat (ether extract), DM, and OM contents was found to be significant ($P<0.001$). The values obtained in terms of raw ash and dry matter were consistent with the findings of Komprda et al. (2012). Additionally, some studies (Cadavez et al., 2020) have reported that the CAs and CP content of meat varies according to breed, whereas other work (Esenbuga et al., 2009; Komprda et al., 2012; Cadavez et al., 2020; Echegaray et al., 2021) has reported that breed has no effect. The genetic similarity or dissimilarity of the breeds under study may be the cause of these dilemmatic results.

Approximately 85 %–88 % of the total fatty acids in the samples were determined, and the remaining 12 %–15 % were considered unknown or undetectable volatile compounds (Souza et al., 2022). The IMF content, which affects the eating and nutrition quality of the meat (Li et al., 2021), and consumer preferences vary depending on the species from which the meat is obtained and the breed within the species. When evaluated from this perspective, it was determined that the IMF content in Artlı lambs was the lowest (0.57 %, $P<0.001$), whereas is was highest in Çepni lambs (1.63 %) (see in Table 1). However, fat composition is more important than IMF with respect to meat quality and nutritional value.

Meat colour is a critical evaluation criterion that affects consumers' meat purchase preferences (Cam et al., 2021). Although there may be individual differences in the evaluation of meat by panelists in terms of colour, the margin of error decreases with the instrumental colour evaluation of meat. After the meat had been rested for 24 h, instrumental colour evaluations were carried out on the LTL muscles via two respective measurements at 0 and 45 min. It was determined that redness value did not differ between the breeds, whereas the yellowness value differed after 45 min. Brightness values differed according to breed and at 0 and 45 min (Table 2). Different results have been reported in previous studies of instrumental flesh colour values. Mateo et al. (2018) stated that the brightness value of the meat was not affected by breed, whereas the redness and yellowness values were affected. Faria et al. (2012), Mateo et al. (2018), and Cam et al. (2021) also reported that the breed was not influential on the instrumental colour values of meat. However, Juárez et al. (2009) and Gonzales-Barron et al. (2021) reported that breed affected instrumental colour values. These different results between studies in terms of colour may be due to the similarity or dissimilarity in muscle fibres (such as the ability to store fat and glycogen between muscle fibres) that make up the breeds' meat. The instrumental colour and quality parameters are presented in Table 2.

Khliji et al. (2010) and Atsbha et al. (2021) stated that 95 % of consumers prefer it when the brightness value of meat is above 44; they also found that consumer desire decreased when the brightness value dropped below 34 and that the meat was then considered "dark meat". Although Hemşin, a breed used in this study, showed lower values than the other breeds based on the instrumental brightness values, it was determined that all of the breeds used in this work had brightness values above the aforementioned threshold.

Table 2. Instrumental meat quality characteristics in five local lamb breeds ($n = 10$).

Par	Artlı	Çepni	Hemşin	Karayaka	Of	P value
a^{*1}	20.9 ± 1.4^{a}	$20.2 \pm 1.2^{a,b}$	$17.0 \pm 0.5^{b,c}$	$19.8 \pm 1.7^{a,b}$	$19.5 \pm 0.9^{a,b}$	0.228
a^{*2}	22.6 ± 1.3^{a}	$20.1 \pm 1.8^{a,b}$	18.2 ± 0.6^{b}	$20.8 \pm 1.0^{a,b}$	$19.7 \pm 1.3^{a,b}$	0.192
b^{*1}	7.26 ± 0.07	7.33 ± 0.21	7.34 ± 0.50	7.59 ± 0.14	7.5 ± 0.25	0.912
b^{*2}	7.04 ± 0.11^{b}	7.21 ± 0.12^{b}	8.08 ± 0.41^{a}	6.99 ± 0.08^{b}	7.94 ± 0.29^{a}	0.004
L^{*1}	51.5 ± 0.02^{a}	51.9 ± 0.08^{a}	45.2 ± 2.27^{b}	51.8 ± 0.09^{a}	50.4 ± 0.89^{a}	0.001
L^{*2}	51.9 ± 0.02^{a}	52.0 ± 0.10^{a}	42.9 ± 1.31^{b}	52.0 ± 0.02^{a}	51.5 ± 1.24^{a}	0.001
Gum	47.0 ± 2.33	46.9 ± 5.02	58.4 ± 1.98	47.4 ± 5.26	51.4 ± 3.21	0.175
Coh	0.44 ± 0.01	0.45 ± 0.01	0.49 ± 0.02	0.45 ± 0.02	0.46 ± 0.02	0.321
Chew	45.6 ± 3.09^{b}	44.3 ± 3.94^{b}	59.9 ± 4.90^{a}	45.3 ± 2.66^{b}	$49.4 \pm 4.95^{a,b}$	0.039
Spr	0.47 ± 0.02	0.48 ± 0.04	0.51 ± 0.02	0.47 ± 0.03	0.48 ± 0.02	0.755
Adh	-0.04 ± 0.01	-0.04 ± 0.00	-0.07 ± 0.00	-0.04 ± 0.01	-0.05 ± 0.01	0.237
Hard	72.1 ± 2.32^{b}	74.5 ± 2.70^{b}	82.9 ± 1.94^{a}	73.68 ± 2.55^{b}	75.1 ± 2.67^{b}	0.034
WBSF	6.20 ± 0.43^{b}	$6.85 \pm 0.40^{a,b}$	8.04 ± 0.49^{a}	$6.52 \pm 0.59^{a,b}$	$7.02 \pm 0.70^{a,b}$	0.170
Res	0.33 ± 0.00^{a}	0.35 ± 0.00^{a}	0.24 ± 0.00^{b}	0.35 ± 0.01^{a}	0.27 ± 0.00^{b}	0.001
H	0.35 ± 0.03	0.35 ± 0.02	0.41 ± 0.03	0.39 ± 0.04	0.37 ± 0.02	0.527
C	22.2 ± 1.31^{a}	$21.5 \pm 1.11^{a,b}$	18.6 ± 0.40^{b}	$21.2 \pm 1.53^{a,b}$	$20.9 \pm 0.84^{a,b}$	0.226

The abbreviations/variables listed in the table are as follows: Par – parameter, a – redness; b – yellowness, L – lightness, Gum – gumminess, Coh – cohesiveness, Chew – chewiness, Spr – springiness, Adh – adhesiveness, Hard – hardness, WBSF – Warner–Bratzler shear force (kg cm^{-2}), Res – resilience, H – hue angle, and C – chroma values.
The superscript numbers "1" and "2" refer to the colour values at 0 min and 45 min respectively.
^{a,b,c} According to the Duncan multiple comparison test, means in rows without a common superscript differ significantly ($P < 0.05$).

As a general idea, meat preferences for consumers change according to the habits taken on by family and friends. In terms of colour saturation (the C index), the difference between the Hemşin and Artlı breeds was significant. Various findings have been reported in the literature with respect to the effect of breed on meat colour indices (Komprda et al., 2012; Cam et al., 2021; Gonzales-Barron et al., 2021).

Instrumental texture values such as the gumminess, cohesiveness, chewiness, springiness, adhesiveness, hardness, Warner–Bratzler shear force, and resilience of meat also reveal more objective results than panelist evaluations. In this study, differences between the breeds were significant in terms of meat's instrumental chewiness, hardness, and resilience values (Table 2). In terms of the WBSF values, it was found that the difference between the Artlı and Hemşin breeds was significant in the Duncan multiple comparisons. In the literature, there are contradictory findings in this respect (Elmore and Mottram, 2009; Gonzales-Barron et al., 2021), with many publications stating that the breed is influential in terms of the instrumental tenderness value of meat.

The Pearson correlations between IMF, pH, water-holding capacity (WHC), cooking loss (CoL), drip loss (DrL), and various instrumental quality values of meat are shown in Table 3. The tenderness value of meat, which can vary depending on the collagen content, the maturation process, exposure to stress before slaughter, and muscle contractions after slaughter, is a critical meat quality criterion (Cam et al., 2021).

It was determined that the relationships between the IMF content, the meat's final pH values, and instrumental tenderness were significant. This result is consistent with Li et al. (2021). Gagaoua et al. (2016) also reported that the final pH values of the meat were correlated with physical and instrumental quality criteria. Furthermore, this study found that the effect of breed on the meat fatty acid composition was significant (Table 4).

The highest to lowest values in terms of the SFA composition were determined in the Of, Karayaka, Çepni, Hemşin, and Artlı breeds in this study. This work determined that myristic acid (C14:0) and palmitic acid (C16:0) were the highest in the Çepni, Of, and Karayaka breeds. These cholesterolemic fatty acids were the lowest in the fat-tailed Artlı breed. However, C18:0, which is stated to reduce cholesterol due to the easy conversion of C18:0 to C18:1, was detected, with the highest to lowest ratios being found in Of, Karayaka, Çepni, Hemşin, and Artlı lambs. Artlı and Hemşin lambs differed from other breeds in that they contained lower SFAs in their meat ($P < 0.001$).

In terms of the MUFA and PUFA ratios, the highest to lowest values were found in the meat of Artlı, Hemşin, Çepni, Karayaka, and Of lambs. It was also found that PUFAs differed according to breed ($P < 0.001$) and that some PUFAs could not be detected in the meat of some animals in these breeds. Significant differences were found between lamb breeds in terms of the fatty acid content of the meat. These differences might also be due to nutritional differences in the lambs during the fetal and neonatal periods. In this context,

Table 3. The Pearson correlations between intramuscular fat, pH, water-holding capacity, cooking loss, drip loss, and various instrumental quality values of meat.

	pH	WHC	CoL	DrL	WBSF	Hard	Res	Chew
IMF	−0.09	0.20	−0.00	0.09	0.31*	0.08	−0.11	−0.05
$pH_{24\,h}$		−0.47**	0.59**	0.43**	0.41**	0.50**	0.50**	0.49**
WHC			−0.20	0.87**	−0.08	−0.30	0.28	−0.18
CoL				−0.38*	0.13	0.13	−0.43**	0.30
DrL					−0.19	−0.30	0.47**	−0.31
WBSF						0.35*	−0.23	0.32*
Hard							−0.21	0.37*
Res								−0.52**

The abbreviations/variables listed in the table are as follows: IMF – intramuscular fat, pH – meat pH value after 24 h rest, WHC – water-holding capacity, CoL – cooking loss, DrL – drip loss, WBSF – Warner–Bratzler shear force, Hard – hardness, Res – resilience, and Chew – chewiness. "*" denotes significance at the $P<0.05$ level, and "**" denotes significance at the $P<0.01$ level.

Osorio et al. (2008) reported significant differences in fatty acid profiles between lambs fed with their mother's milk and those fed on milk replacement feeds. The diet fatty acid composition affects the nutritional value, organoleptic properties, and the consumer preferences for meat (Turner et al., 2014). As there was no difference in the diet offered to the animals in our study, the differences in fatty acid content were attributed to breed disparities.

Some index values developed depending on the presence of SFAs, MUFAs, and PUFAs for the health evaluation of meat are shown in Table 5.

The thrombogenic index, the atherogenic index, PUFA / SFA, the ratio of low cholesterolemic fatty acids / high cholesterolemic fatty acids (h / H), and other indexes, which were calculated based on the fatty acid composition and content obtained from the LTL muscle of lambs, are biomarkers of the nutritional value and cardiovascular health risk potential of the meat. However, it is clear from the MUFA, PUFA, and other indexes that the meat of these five breeds is of similar quality to that of other breeds (Costa et al., 2021; Gonzales-Barron et al., 2021). Additionally, some PUFAs and SFAs were not found in some animals within the breed in terms of the fatty acid profile, which infers that such animals could possibly be selectively bred in order to ensure genetic improvements in terms of the fatty acid profile.

Differences in the fatty acid profile between breeds may be due to the presence or absence of an enzyme such as stearoyl-CoA desaturase, which converts SFAs to unsaturated fatty acids, or to the presence or absence of breed-specific enzymes (Kuchtik et al., 2012; Boughalmi and Araba, 2016). Changes in the rumen environment depending on breed and differences in the activity of converting enzymes, such as stearoyl-CoA desaturase, may have played a role in the differences in the fatty acid content between breeds (Kuchtik et al., 2012; Boughalmi and Araba, 2016). Additionally, the effects of the different animal tail structures on the subcutaneous, visceral environment and IMF accumulation might also have altered the fatty acid profile. However, it is noteworthy that the PUFA content is low in these breeds of lambs. The most plausible explanation for the low MUFA and PUFA values in samples taken from LTL muscles of the male lambs used in this study is that 12 %–15 % of the undetectable part in the proportional values was not added. Thus, this work reveals the need for further research into how dietary composition adjustments may affect the PUFA composition values.

The cooking method is essential to provide the meat's smell, taste, and appearance with features that will attract the taste and trust of consumers. Additionally, the cooking method is also crucial in the emergence of volatile fatty acids, which effectively provide the smell and taste of meat. The cooking method also affects the nutritional value of meat by decreasing the number of water-soluble proteins.

According to the panelist evaluations, there was no difference in the general acceptability, colour, flavour, odour, or juiciness of the lamb meat according to the cooking method within the breeds. In contrast, significant differences in the earlier characteristics were detected between the breeds according to the analysis of variance and the Duncan multiple comparison test (Table 6, Fig. 1).

Sensory characteristics, such as the amount and composition of intramuscular fat, tenderness, and meat flavour, are important criteria for consumer preference and general acceptability of meat (Cadavez et al., 2020). The compounds that make up the flavour and smell of meat are due to the oxidation of fatty acids in meat during cooking or processing. PUFAs containing two or more double bonds are important in the emergence of sensory and aromatic properties specific to meat sheep and goat species (Elmore and Mottram, 2009). The tenderness, juiciness, flavour, and colour are considered common determinants of meat quality. Jandasek et al. (2014) reported several contrasting studies that state significant or non-significant correlations between the final pH values of meat and the sensory properties.

In this work, the results of the sensory panel evaluations of the boiling and roasting styles of meat from the five breeds

Table 4. The least squares mean ± standard error of the mean values for the fatty acid composition (% total fatty acid) of the LTL muscles in the five local lamb breeds.

FA	Artlı	Çepni	Hemşin	Karayaka	Of	*P* value
SFA	41.9 ± 1.20^{d}	55.9 ± 1.60^{b}	49.3 ± 0.97^{c}	$59.2 \pm 0.9^{a,b}$	60.2 ± 1.87^{a}	0.001
C6:0	0.02 ± 0.00^{b}	0.03 ± 0.00^{a}	0.032 ± 0.00^{a}	0.04 ± 0.00^{a}	0.04 ± 0.03^{a}	0.088*
C8:0	0.02 ± 0.00^{c}	$0.04 \pm 0.01^{b,c}$	$0.05 \pm 0.01^{b,c}$	0.15 ± 0.02^{a}	0.07 ± 0.01^{b}	0.001
C10:0	$0.23 \pm 0.01^{b,c}$	0.27 ± 0.02^{b}	0.21 ± 0.02^{c}	0.33 ± 0.02^{a}	0.32 ± 0.03^{a}	0.001
C11:0	0.03 ± 0.00	0.04 ± 0.01	0.02 ± 0.00	0.03 ± 0.00	0.02 ± 0.00	0.289
C12:0	0.16 ± 0.02^{b}	0.29 ± 0.04^{a}	0.17 ± 0.01^{b}	0.27 ± 0.03^{a}	$0.24 \pm 0.05^{a,b}$	0.009
C13:0	0.05 ± 0.01	0.03 ± 0.00	0.04 ± 0.00	0.05 ± 0.01	0.07 ± 0.03	0.358
C14:0	2.85 ± 0.17^{b}	4.23 ± 0.27^{a}	3.21 ± 0.11^{b}	4.17 ± 0.23^{a}	4.20 ± 0.41^{a}	0.000
C15:0	$1.14 \pm 0.09^{a,b}$	0.92 ± 0.05^{b}	$0.99 \pm 0.06^{a,b}$	$1.18 \pm 0.09^{a,b}$	$0.97 \pm 0.05^{a,b}$	0.043
C16:0	20.5 ± 0.70^{d}	26.2 ± 0.74^{b}	23.3 ± 0.70^{c}	29.1 ± 0.72^{a}	$27.3 \pm 0.70^{a,b}$	0.001
C17:0	3.21 ± 0.20^{a}	$2.81 \pm 0.21^{a,b}$	2.68 ± 0.15^{b}	3.28 ± 0.17^{a}	2.70 ± 0.14^{b}	0.031
C18:0	13.1 ± 0.83^{d}	20.5 ± 0.8^{b}	18.1 ± 0.69^{c}	20.5 ± 0.51^{b}	24.0 ± 0.88^{a}	0.001
C20:0	0.08 ± 0.01^{c}	0.13 ± 0.01^{b}	0.12 ± 0.07^{b}	0.12 ± 0.00^{b}	0.16 ± 0.01^{a}	0.001
C21:0	0.65 ± 0.08^{a}	0.52 ± 0.14^{a}	0.61 ± 0.1^{a}	0.07 ± 0.00^{b}	0.07 ± 0.02^{b}	0.001
C22:0	0.01 ± 0.00^{c}	$0.02 \pm 0.00^{a,b}$	$0.02 \pm 0.00^{b,c}$	0.03 ± 0.00^{a}	0.03 ± 0.00^{a}	0.001
C23:0	Nd	Nd	0.02 ± 0.01	Nd	Nd	
C24:0	Nd	Nd	0.04 ± 0.00	Nd	0.03 ± 0.00	0.771
MUFA	41.3 ± 0.61^{a}	30.6 ± 1.79^{c}	36.0 ± 0.78^{b}	25.9 ± 1.37^{d}	25.1 ± 1.76^{d}	0.001
C14:1	0.10 ± 0.01^{a}	$0.09 \pm 0.01^{a,b}$	$0.07 \pm 0.01^{b,c}$	0.06 ± 0.01^{c}	0.55 ± 0.01^{c}	0.001
C16:1	1.31 ± 0.07^{a}	1.00 ± 0.07^{b}	1.02 ± 0.04^{b}	$0.91 \pm 0.03^{b,c}$	0.77 ± 0.04^{c}	0.001
C18:1n9c	34.4 ± 0.84^{a}	24.70 ± 1.42^{b}	28.00 ± 0.93^{b}	21.5 ± 1.24^{c}	20.4 ± 1.40^{c}	0.001
C18:1n9t	5.44 ± 0.45^{b}	$4.88 \pm 0.37^{b,c}$	6.87 ± 0.39^{a}	3.56 ± 0.16^{d}	$3.90 \pm 0.37^{c,d}$	0.001
C20:1	0.12 ± 0.01^{a}	0.07 ± 0.01^{b}	0.09 ± 0.01^{b}	0.08 ± 0.02^{b}	0.07 ± 0.01^{b}	0.001
PUFA	3.27 ± 0.26^{a}	1.57 ± 0.38^{c}	2.35 ± 0.32^{b}	0.34 ± 0.07^{d}	0.52 ± 0.12^{d}	0.000
C18:2n-6	2.65 ± 0.24^{a}	1.31 ± 0.31^{b}	2.02 ± 0.27^{a}	0.25 ± 0.07^{c}	0.56 ± 0.11^{c}	0.001
C18:3n-6	0.04 ± 0.00	0.04 ± 0.00	0.03 ± 0.01	Nd	Nd	0.602
C18:3n-3	0.40 ± 0.04^{a}	$0.16 \pm 0.06^{a,b,c}$	$0.37 \pm 0.08^{a,b}$	0.06 ± 0.00^{c}	$0.12 \pm 0.00^{b,c}$	0.002
C20:2n-6	0.03 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	Nd	Nd	0.122
C20:3n-6	0.03 ± 0.01	0.02 ± 0.00	0.02 ± 0.00	Nd	Nd	0.442
C20:3n-3	0.01 ± 0.00	Nd	0.02 ± 0.00	Nd	Nd	0.134
C20:4n-6	0.05 ± 0.00	0.07 ± 0.01	0.08 ± 0.04	Nd	0.01 ± 0.00	0.435
C22:2n-6	Nd	Nd	Nd	Nd	0.07 ± 0.00	
UDM %	13.53	11.93	12.35	14.56	14.18	

The abbreviations listed in the table are as follows: FA – fatty acid, SFA – saturated fatty acid, MUFA – monounsaturated fatty acid, PUFA – polyunsaturated fatty acid, Nd – not detected, and UDM – undetectable matter.
[a,b,c,d] According to the Duncan multiple comparison test, means in rows without a common superscript differ significantly ($P < 0.05$).

are similar to the values of some existing studies (Santos et al., 2022; Flakemore et al., 2017). Panelists favoured boiled meat over roasted meat in terms of juiciness and general acceptability. According to the panelist evaluations, roasting the meat significantly affected flavour (taste and aroma), whereas boiling considerably impacted juiciness. The values given by the panelists for the sensory properties of meat are similar to the assessments reported by Souza et al. (2022).

Table 7 shows the relationship between general acceptability (overall liking), appearance (colour), odour, aroma (flavour), and juiciness values according to panelist evaluations, regardless of the cooking method or breed. The relationships between all traits were reliable and significant. Regarding general acceptability, the panelist evaluations of the boiled and roasted meat of the five lamb breeds were consistent or better than those reported by Flakemore et al. (2017). In this work, no relationship was found between sensory characteristics and the amount of intramuscular fat. The panelists' evaluations revealed that all sensory properties were associated with the general acceptability of meat, independent of the cooking method. It was determined that the strongest relationship existed between the meat's flavour (taste and aroma) and its appearance with respect to general acceptability. Despite differences between breeds in terms of the meat's water-holding capacity, cooking loss, and intra-

Table 5. Index values calculated depending on the saturated and unsaturated fatty acid content of five breeds of lamb ($n = 50$).

Fatty acids	Artlı	Çepni	Hemşin	Karayaka	Of	P value
PUFA / SFA	0.08 ± 0.01^{a}	0.03 ± 0.01^{c}	0.05 ± 0.01^{b}	0.01 ± 0.00^{d}	0.01 ± 0.00^{d}	0.001
PUFA / MUFA	0.08 ± 0.01^{a}	0.04 ± 0.01^{b}	0.01 ± 0.00^{c}	0.02 ± 0.00^{c}	0.06 ± 0.01^{a}	0.001
MUFA / SFA	1.00 ± 0.04^{a}	0.57 ± 0.05^{c}	0.44 ± 0.03^{d}	0.44 ± 0.04^{d}	0.74 ± 0.03^{b}	0.001
AI	0.75 ± 0.03^{c}	1.52 ± 0.16^{b}	0.99 ± 0.05^{c}	$1.95 \pm 0.03^{a,b}$	2.10 ± 0.31^{a}	0.001
TI	2.20 ± 0.19^{a}	1.76 ± 0.17^{a}	1.20 ± 0.50^{b}	0.83 ± 0.04^{b}	2.18 ± 0.26^{a}	0.001
DFAs	57.6 ± 0.89^{a}	$52.8 \pm 1.46^{b,c}$	$56.5 \pm 1.28^{a,b}$	46.7 ± 1.59^{d}	$49.7 \pm 1.39^{c,d}$	0.001
$\omega6/\omega3$	6.83 ± 0.25^{b}	8.50 ± 0.32^{a}	5.56 ± 0.29^{c}	4.17 ± 0.07^{d}	5.33 ± 0.10^{c}	0.001
h / H	3.45 ± 0.09^{a}	$2.73 \pm 0.09^{c,d}$	3.04 ± 0.10^{b}	2.47 ± 0.08^{e}	$2.61 \pm 0.08^{d,e}$	0.050

The abbreviations/variables listed in the table are as follows: SFA – saturated fatty acid; MUFA – monounsaturated fatty acid; PUFA – poly unsaturated fatty acid; AI – atherogenic index, calculated as ((C12:0) +4× (C14:0) + (C16:0)) / (ΣMUFA+ΣPUFA); TI – thrombogenic index, calculated as ((C14:0 + C16:0 + C18:0)) / ((0.5 × ∑MUFA) + (0.5 × ∑PUFAn-6) + (3 × ∑PUFAn-3) + (∑PUFAn-3) / (∑PUFAn-6)); DFAs – desirable fatty acids, calculated as (MUFA + PUFA + C18:0); the $\Sigma\omega6/\Sigma\omega3$ ratio, calculated as (C18:2 + C18:3 + C20:2 + C20:4 + C22:5 + C22:6) / (C18:3 + C20:3 + C20:5 + C21:5 + C22:6); and h / H – the ratio of low cholesterolemic fatty acids / high cholesterolemic fatty acids, calculated as (18:1n9c + 18:2ω6 + 20:4ω6 + 18:3ω3 + 20:5ω3 + 22:5w3 + 22:6ω3) / (14:0 + 16:0) (Costa et al., 2021).
^{a,b,c,d,e} According to the Duncan multiple comparison test, means in rows without a common superscript differ significantly ($P < 0.05$).

Table 6. Panelists' sensory evaluation results for boiled (B) and roasted (R) lamb meat from the five breeds ($n = 50$).

Breed	Cooking method	Colour	Odour	Flavour	Juiciness	Overall liking
A	B	$6.83 \pm 0.31^{a,b}$	$7.11 \pm 0.28^{a,b}$	$6.78 \pm 0.25^{b,c}$	$7.11 \pm 0.30^{a,b}$	$6.94 \pm 0.34^{a,b}$
	R	$6.94 \pm 0.25^{a,b}$	$6.94 \pm 2.74^{a,b}$	$6.28 \pm 0.29^{b,c}$	$6.94 \pm 0.24^{a,b}$	$6.89 \pm 0.18^{a,b}$
C	B	$7.17 \pm 0.25^{a,b}$	$7.06 \pm 0.27^{a,b}$	$6.94 \pm 0.25^{b,c}$	$7.22 \pm 0.24^{a,b}$	$6.89 \pm 0.27^{a,b}$
	R	$7.06 \pm 0.24^{a,b}$	$7.17 \pm 0.23^{a,b}$	$7.11 \pm 0.27^{a,b}$	$6.94 \pm 0.29^{a,b}$	6.61 ± 0.28^{b}
K	B	6.33 ± 0.29^{b}	6.56 ± 0.29^{b}	7.44 ± 029^{a}	$6.50 \pm 0.31^{b,c}$	6.33 ± 0.18^{b}
	R	$6.67 \pm 0.33^{a,b}$	$6.89 \pm 0.27^{a,b}$	6.17 ± 0.29^{c}	$6.67 \pm 0.29^{a,b,c}$	6.44 ± 0.27^{b}
H	B	7.33 ± 0.32^{a}	7.50 ± 0.22^{a}	7.28 ± 0.26^{a}	$7.00 \pm 0.19^{a,b}$	$7.11 \pm 0.28^{a,b}$
	R	$6.39 \pm 0.41^{a,b}$	$6.89 \pm 0.33^{a,b}$	7.28 ± 0.35^{a}	$7.11 \pm 0.28^{a,b}$	$7.00 \pm 0.19^{a,b}$
O	B	$7.11 \pm 0.29^{a,b}$	$7.28 \pm 0.20^{a,b}$	$6.83 \pm 0.32^{b,c}$	7.50 ± 0.27^{a}	7.56 ± 0.33^{a}
	R	$7.17 \pm 0.26^{a,b}$	$7.39 \pm 0.28^{a,b}$	$6.67 \pm 0.23^{b,c}$	6.00 ± 0.24^{c}	6.28 ± 0.28^{b}
P value		0.212*	0.216*	0.082*	0.237*	0.191*
B		6.96 ± 0.13	7.10 ± 0.16	7.06 ± 0.12^{B}	7.07 ± 0.12^{A}	6.97 ± 0.19^{A}
R		6.84 ± 0.14	7.06 ± 0.12	7.70 ± 0.15^{A}	6.73 ± 0.12^{B}	6.64 ± 0.37^{B}
P value		0.588	0.793	0,047	0.049	0.083*

The abbreviations listed in the table are as follows: A – Artlı, C – Çepni, K – Karayaka, H – Hemşin, O – Of, B – boiled, and R – roasted.
^{A,B} and ^{a,b,c} denote the presence or absence of a significant difference: values within a column without a common superscript letter differ significantly (P <0.05). "*" denotes that, although there was no difference between the sensory evaluations according to the analysis of variance, there were differences in the Duncan multiple comparison test.

muscular fat content, the results from this work are inconsistent with the reports of Souza et al. (2022).

In this study, both boiled and roasted meat of Karayaka and Artlı lambs were scored lower by panelists than other breeds. According to principal component analysis (PCA), it was determined that the boiled and roasted meat from the Karayaka and Of breeds are included in the same areas: roasted and boiled meat from the Of breed are both located in the positive area, whereas roasted and boiled meat from Karayaka lambs are both located in the negative area. With respect to the Hemşin and Çepni lambs, boiled and roasted meat from both breeds are located in the positive and negative areas, according to the PCA, respectively. The roasted meat of the Artlı breed was included in the negative area, but the boiled meat was in the positive region (Fig. 1).

4 Conclusion

This work evaluated the fatty acid composition of five local lamb breeds raised in the Black Sea region of Türkiye, in terms of various cardiovascular health index values, and found result similar to those of many breeds worldwide. Specifically, lamb meat tenderness and aroma could be more critical in future alternatives for human nutrition. The fat-

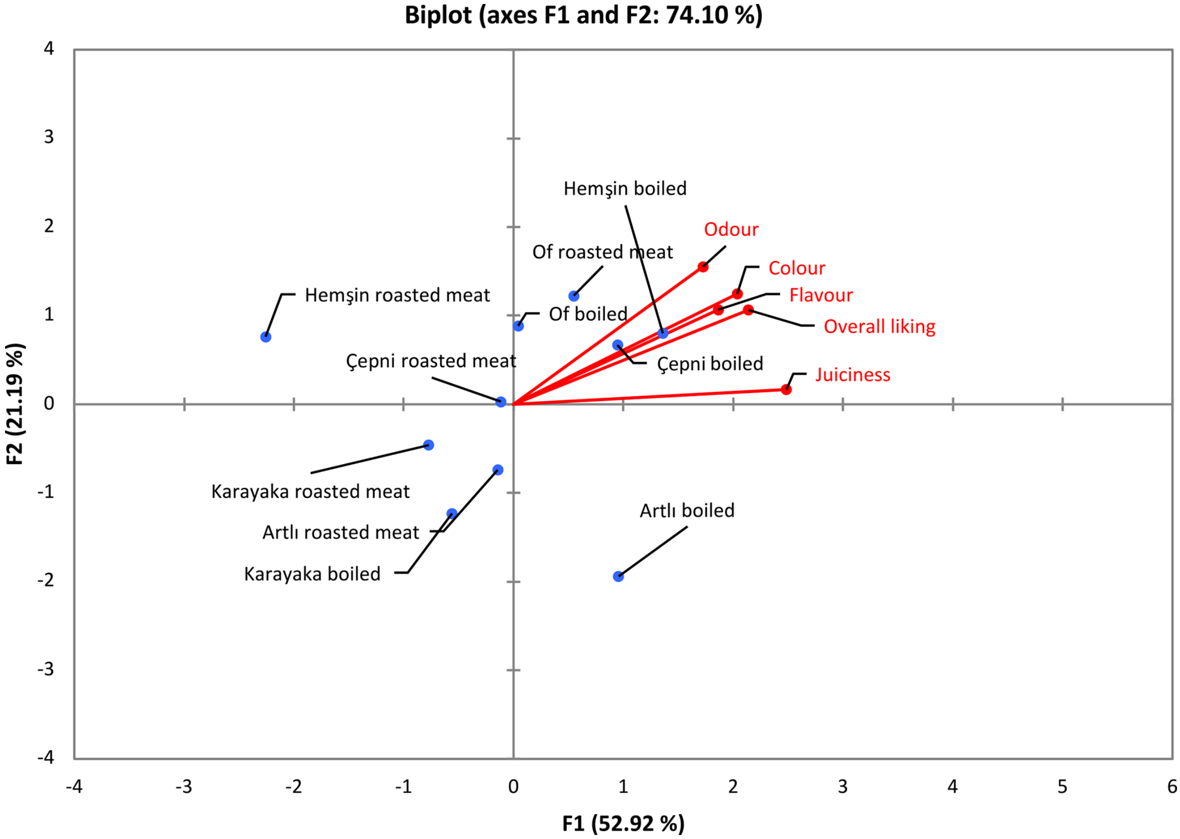

Figure 1. The distribution of genotypes and the sensory characteristics of meat according to the cooking status based on a principal component analysis.

Table 7. Pairwise Pearson correlations (95 % confidence intervals for ρ) between sensory parameters regardless of breed and cooking style.

Parameters*	Odour	Flavour	Juiciness	Overall liking
Appearance	0.62 (0.53, 0.71)	0.64 (0.54, 0.72)	0.41 (0.28, 0.53)	0.74 (0.66, 0.80)
Odour	–	0.60 (0.50, 0.69)	0.39 (0.25, 0.50)	0.63 (0.53, 0.71)
Flavour		–	0.47 (0.35, 0.58)	0.75 (0.68, 0.81)
Juiciness			–	0.48 (0.36, 0.59)

* All correlations were significant ($P<0.001$).

tailed Artlı breed had more preferential values in terms of health compared with the other four breeds.

The general findings of this study showed that breed influenced the physical and chemical properties, the fatty acid content, the fatty acid composition, and the instrumental quality of the meat. Furthermore, it was found that the breed and cooking method influenced the meat's sensory properties.

Ethical statement. This study was performed with ethical approval from the Ondokuz Mayıs University Local Ethical Committee for Animal Studies (OMU-HADYEK, Samsun, Türkiye; approval no. 2017/025).

Data availability. The original data from the paper are available from the corresponding author upon reasonable request.

Author contributions. LM was responsible for conceptualising the study, carrying out the investigation, writing the original draft of the paper, and creating figures. MAC developed the methodology, carried out the validation, supervised the study, undertook project administration, acquired funding, and reviewed and edited the paper. MO undertook the formal analysis, investigation, and data curation as well as acquiring resources. KK carried out the investigation, wrote the original draft of the paper, and created figures. HT was responsible for carrying out the investigation and data curation as well as acquiring resources. UK contributed to writing the original draft of the paper and carrying out the formal analysis and investigation.

Competing interests. The contact author has declared that none of the authors has any competing interests.

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