The Meat Quality and Sensory Characteristics of Turkish Native Sheep Genotypes

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ABSTRACT

Some meat quality and sensory characteristics were determined of Kıvırcık (n=10), Eşme Kıvırcık (n=10), Karya (n=8) and Çine Çaparı (n=9) lambs in this research. Carcass divided into two parts along the spine and the three different type of muscle samples were taken from the between 8th and 9th vertebrae, 12th and 13th vertebrae and leg part of the left side of the carcasses. Drip loss, cooking loss and shear force values of these muscles were identified. Additionally, pH0, pH24, color, fatty acid composition and sensory properties were determined in M. Longissimus dorsi samples. When muscle types are evaluated separately were a statistically significant factor in terms of dripping and cooking loss and shear force. While the highest dripping loss were reported in M. Longissimus dorsi (3.72%), the highest cooking loss were reported in M. Longissimus thoracis (22.67%) and the highest shear force were reported in M. semitendinosus (4.38 kg). Genotype and muscle interaction were found to be highly significant for only cooking loss. The analysis results for fatty acids indicated that there was an important difference between Kıvırcık, Eşme Kıvırcık, Karya and Çine Çaparı on C10:0, C12:0, C14:0, C15:0, C16:0, tC18:1, CLA, tC18:3, C20:1, C22:0 fatty acids in the study. Genotypes showed no effect to SFA (Saturated fatty acids), MUFA (Monounsaturated fatty acids), PUFA (Polysaturated fatty acids) and P/S ratio parameters. Karya lambs performed higher for odor and tenderness, and Kıvırcık lambs showed a higher score for juiciness, flavor and total acceptability in sensory evaluation.

Türkçe: Türkiye Yerli Koyun Genotiplerinin Et Kalitesi ve Duyusal Özellikleri

MAKALE BİLGİSİ

Araştırma Makalesi

Araştırmada Kıvırcık (n=10), Eşme Kıvırcık (n=10), Karya (n=8) ve Çine Çaparı (n=9) kuzularının bazı et kalitesi ve duyusal özellikleri belirlenmiştir. Karkas, omurga boyunca iki kısma bölünmüş ve karkasın sol kısmından 8.-9., 12.-13. kaburgalar arasından ve bu boşgelenin üç farklı kas öğesi alınmıştır. Bu kasılardan su kaybı, pişirme kaybı ve kesme kuvveti değerleri belirlenmiştir. İlaveten, M. Longissimus dorsi örneklerinde pH0, pH24, renk, yağ asidi bileşimi ve duyusal özellikleri ortaya konmuştur. Çalışmakta ki tipler ara bir çok şekilde değerlendirildiği; su kaybı, pişirme kaybı ve kesme kuvveti açısından istatistiksel olarak anlamlı etkiler ortaya çıkmıştır. Su kaybı açısından en yüksek değer M. Longissimus dorsi (%3,72) kasında görülürken, pişirme kaybı açısından en yüksek değer M. Longissimus thoracis (%22,67) kasında ve kesme kuvveti açısından en yüksek değer M. semitendinosus (4,38 kg) kasında belirlenmiştir. Genotip ve kas tipi interaksiyonu, sadece pişirme kaybı üzerine oldukça önemli etkide bulunmaktadır. Kıvırcık, Eşme Kıvırcık, Karya ve Çine Çaparı genotiplerini arasında yağ asitleri bazında, C10:0, C12:0, C14:0, C15:0, C16:0, tC18:1, CLA, tC18:3, C20:1, C22:0 açısından farklılıkların olduğu saptanmıştır. Genotip, SFA (doyum yağ asitleri), MUFA (tekli doymamış yağ asitleri), PUFA (çoklu doymamış yağ asitleri) ve P/S oranı parametreleri üzerinde etkili olmamıştır. Duyusal testlerde, Karya kuzuları koku ve yumuşaçılık için daha yüksek performans gösterirken, Kıvırcık kuzuları sululuk, lezzet ve toplam kabul edilebilirlik açısından daha yüksek puan almıştır.

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Introduction

Meat production is the most important source of income in the sheep industry in Turkey (Unal and Akçağma, 1996). There are several factors that affect the quality and quantity of meat production. Mainly, these may be classified as genetic and environmental factors such as breed, sex, climate, slaughter hygiene and procedure (Sanudo et al., 1998; Priola et al., 2001). Meat structure, biochemical changes in muscle occurred before and after slaughtering, technological and organoleptic properties of meat are influenced by these factors (Hopkins and Fogarty 1998; Gardener et al., 1999; Beriain et al., 2000).

In recent years, consumer's preference for meat with low fat content. Negative management and feeding conditions cause excessive fat in lamb, which this reduces consumer demand. Therefore, the implementation of efforts to improve the quality of meat, as well as to determine the current status of the local genotypes and breeds are also very important. Lamb meat quality is determined using some parameters such as carcass, meat and eating quality characteristics. Eating quality is evaluated with intramuscular adiposity associated with sensorial parameters such as softness and juiciness. For breeders, improving meat quality characteristics is difficult due to technological, financial and biological limitations. Lamb carcass is desirable to include a high proportion of polyunsaturated fatty acid, low fat, high parts of valuable carcass ratio, high-quality tenderness, color, juiciness and sensory characteristics (Sanudo et al., 1998; Priola et al., 2001).

Kırıçık, Eşme Kırıçık, Karya ve Çine Çaparı sheep genotypes are raised in Western Anatolia and Marmara part. From these genotypes, Kırıçık and Eşme Kırıçık sheep are known meat quality and production are raised in the Western part of Turkey. Kırıçık sheep is at risk of extinction (Ceyhan et al., 2007). Karya sheep, which are known for their high fertility and growth characteristics. Çine Çaparı sheep which is a regional native fat-tailed sheep genotype of Aydın province has rather decreased due to backcrossing with some genotypes. Kırıçık and Eşme Kırıçık, Karya and Çine Çaparı lambs.

Material and Method

The procedure approved by the Aydın Adnan Menderes University Local Ethics Committee, which conform with EU Directive 86/609/EEC for animal experiments (124-HEK/2009/53 Date: 02.09.2009).

Animals and Diets

Animal material for the study consisted of 37 Kırıçık (KIV), Eşme Kırıçık (EK), Karya (KR) and Çine Çaparı (CC) (Table 1) with an average age of five months that were grown in individual pens at the animal house facilities at Aydın Adnan Menderes University, Agriculture Faculty, Department of Animal Science. When the mean lamb age in the flock reached about 75 days, the lambs were weaned at same time. The fattening period continued for 70 days and each group of lambs were given ad-libitum concentrate feed (20.4% crude protein and 2728.3 kcal kg⁻¹ ME) during this time. The good quality wheat straw (100 g) and fresh clean water were provided until slaughter.

Table 1. Sample Size and Sampling Location of Animal Material

| Genotype | Location | N (head) |
|----------|----------|----------|
| KIV      | Bursa    | 10       |
| EK       | Eşme-Uşak| 10       |
| KR       | ADU-GSBP (Aydın)* | 8 |
| CC       | Aydın    | 9        |
| Total    |          | 37       |

KIV = Kırıçık, EK = Eşme Kırıçık, KR= Karya, CC= Çine Çaparı, *Adnan Menderes University Group Sheep Breeding Program Karya elite flock

Slaughter Procedures and Carcass Characteristics

Animals transported one day before slaughter to avoid transport stress and rested in paddock found in slaughterhouse at the end of the fattening period. Pre-slaughter live weight was recorded after the animals were fasted for 12 h with free access to water. After the slaughter, internal organs, skin and head were removed. After the hot carcass was weighed, it was maintained at 4°C for 24 h in cold storage and cold carcass weight was determined. M. Longissimus thoracis (MLT), M. Longissimus dorsi (MLD) and M. semitendinosus (MST) muscle samples were taken from the between 8th and 9th vertebrae, 12th and 13th vertebrae and leg part of the left side of the carcasses, respectively.

Meat Quality Analysis

The pH and fresh meat color (L*, a*, b*) were performed directly in the M. longissimus dorsi muscle between 12th and 13th vertebrae. Carcass pH was measured using a digital pH meter at 0 minutes after slaughter (pH0) and 24 hours post slaughter (pH24). Lightness (L*), redness (a*) and yellowness (b*) values were obtained using colorimeter (Minolta CR 400) for determining of color properties.

In this study, some meat properties in MLD, MLT and MST muscle samples are examined for the meat quality characteristics. Cooking loss (%) and drip loss (%) were performed by the method described by Hofmann. et al. (2003). Drip loss was calculated as the percentage of weight loss from the starting weight (Honikel, 1998). To determine the water holding capacity, approximately 50 g portion of MLD were cut and weighed. After, this muscle sample placed in plastic bags. The meat sample was hung in closed polyethylene package (left to the effect of gravity) and kept at 4°C degrees for 48 hours. At the end of the dwell time, the piece of meat was weighed again and the result obtained was proportional to the initial weight. shear force values were obtained using a Zwik/Roell texture analysis tester equipped with a V-shaped blade (60° angle). Firstly, the muscle samples were cooked for 35 min at 75°C in a waterbath. After, samples were cooled to room temperature, they were blotted dry using paper towel. From each muscle type six 1 cm² subsamples were cut parallel to muscle fiber and these samples tested using texture analyser.

Fatty Acid Composition Analysis

The composition of fatty acid in the muscle sampled from M. Longissimus dorsi was performed by gas chromatography (Tokuşoğlu, 2005). Fatty acids between C10:0-C24:0 and conjugated linoleic acid (CLA) have
been determined in this research. Additionally, SFA (saturated fatty acids), MUFA (monounsaturated fatty acids), PUFAs (polyunsaturated fatty acids) and P/S ratio values were calculated.

**Sensory Assessment**

The *M. Longissimus dorsi* muscle (100 g) sampled from all studied genotypes for sensory analyses were packaged under vacuum at 4 °C 24 h after slaughter. After this step, the samples were frozen and stored at -18°C until panel evaluation. One day prior to panel test, frozen samples were thawed at 4°C for 24 h. Samples were cooked in an electric oven at 180°C until the internal temperature reached 80°C. Cooked samples were cut into 1 cm³ thick slices and were served to panelists. Training was provided to the panelists prior to evaluation. Sensory properties of cooked samples were assessed by 29 semi-trained male and female panelist with an average age of 22 years old using a nine-point category scale (scale 1: extreme poor, scale 9: excellent) described by Sanudo et al. (1998).

**Statistical Analysis**

Univariate SAS (1999) program was used to control the obtained data. GLM and CORR procedures in SAS were used for analysis. When a statistical significance was detected (P<0.05) for sensory characteristics, paired comparisons between means were carried out using Tukey’s test.

**Results and Discussion**

**pH and color**

The results about of pH and color measurements are given in Table 2. There was a significant difference between genotypes in terms of pH₀ (P<0.05) in the study. Genotypes showed no significance pH₂₄ and color parameters. The highest L value was observed from Eşme Kıvırcık lambs while the highest a* and b* values were seen in Kıvırcık lambs. pH has a considerable influence on meat tenderness, color, taste and juiciness. After slaughtering, muscle glycogen is degraded to lactic acid and as a consequence the pH level of the muscle decreases. Meat quality is affected by this pH decline. The desirable pH value at 24 h after slaughter is between 5.50 and 5.80. It is known as the acceptable quality range. (Young and West, 2001; Öztan, 2005; Sanudo et al., 2007; Yagoubi et al., 2018). The pH values at pre-rigor mortis and 24 h after slaughter ranged from 6.29 to 6.44 and 5.77 to 6.02 in MLD muscle respectively (Table 2). pH₂₄ values obtained in this study were higher than previous similar researches (Sanudo et al. 1998; Diaz et al. 2003; Martinez 2005; Sanudo et al., 2007; Sanudo et al., 2009). Results for pH₂₄ in the present study were in agreement with Romedi and Yılmaz (2010). Many of research were reported different pH₂₄ value for different genotypes and breeds (Hopkins and Fogarty, 1998; Hoffman et al., 2003; Sanudo et al., 2003; Ügurlu et al., 2017). The differences between the previous literature and the present study were mainly due to non-comparative aspects such as managements and genotype differences. Considering the pH value obtained from the study can be said that within normal meat pH values. In this respect, these results indicated that the lambs did not stressed pre-slaughter.

Meat color varies according to myoglobin and metmyoglobin as a result of chemical reaction of myoglobin depend on oxidation and pH in meat. Increasing of pH, affecting enzyme activity, leads to the darker color of the meat. The color of the meat is affected by many factors such as genetic and environment (Priola et al., 2001; Öztan, 2005). For this reason, it is difficult to make an assessment in terms of color values. Although the L (brightness) and a* (redness) in our study were similar when compared to previous studies, b* (yellowness) values were, in fact, lower than those (Diaz et al. 2003; Tejeda et al., 2008; Ekiz et al., 2009; Esenbuğa et al., 2009). Low b* values defined as yellowness index are expected due to low fat content of MLD muscle.

**Drip Loss, Cooking Loss and Shear Force**

Muscle type was a statistically significant factor for shear force, cooking loss and drip loss (Table 3, P<0.01). The coefficients for the regression of cold carcass weight on the same characteristics were seen to be non-significant.

The highest of the drip loss, cooking loss and shear force value were seen in MLD (3.72%), MLT (22.67%) and MST (4.38 kg), respectively. The interaction between genotype and muscle type was statistically significant in terms of cooking loss (P<0.001). A comparison in terms of genotypes, cooking loss of MLT muscle in Çine Çapar was higher than the other studied genotypes. The analysis results indicated that the highest shear force value was obtained from MST in Eşme Kıvırcık. MLD muscle sampled from Çine Çapar was more tender than the other studied genotypes. Phenotypic correlation coefficients between drip loss, cooking loss and shear force are given in Table 4. All coefficient of correlation were found to be positive and significant (P<0.001) except between drip loss and shear force. The largest correlations were between shear force and cooking loss (r = 0.411; P < 0.001). The correlation between drip loss and cooking loss was calculated important (r = 0.351; P < 0.001).

| Table 2. The Least Squares Mean and Standard Errors of pH and Color Parameters |
|-----------------|-----------------|-----------------|----------|--------|--------|
| Factors        | N   | pH₀  | pH₂₄ | L     | a*    | b*    |
|----------------|-----|------|------|-------|-------|-------|
| CC             | 9   | 6.44±0.051a | 6.02±0.111 | 37.79±1.513 | 14.49±0.844 | -1.12±0.504 |
|EK             | 10  | 6.31±0.048a | 5.86±0.106 | 38.42±1.435 | 15.46±0.800 | -0.68±0.478 |
|KR             | 8   | 6.46±0.054a | 5.84±0.118 | 36.35±1.605 | 16.55±0.895 | 0.20±0.535 |
|KIV            | 10  | 6.29±0.048a | 5.77±0.106 | 38.12±1.435 | 17.06±0.800 | 0.40±0.478 |
|General        | 37  | 6.37±0.025 | 5.87±0.055 | 37.67±0.749 | 15.89±0.418 | -0.30±0.250 |

CC= Çine Çapari, EK= Eşme Kıvırcık, KR= Karya, KIV= Kıvırcık, *a,b,c In the same column, means with different letters differ significantly. *P<0.05

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Meat content constitutes a significant proportion of the water (70-80%) as with all other foods. It is desirable to keep the water in the meat structure due to economic and technological properties. Also, removing water from the tissue has adverse effects on sensory properties of meat such as tenderness and juiciness (Hamm, 1986; Honikel, 1988). Drip and cooking loss are affected by genotype, sex, meat chemical composition, muscle type, surface area of meat, cooking temperature and duration. The average of the cooking losses obtained in this study was 19.91%. This value was lower than the reports Lanza et al. (2003), Ekiz et al. (2009) and Uğurlu et al. (2017) at the same muscle and cooking temperature. Shear force value measured in this research was lower than previous studies (Abdullah and Rasha, 2009; Çelik and Uğurlu et al. 2010). High oleic acid (C18:1), known mono-unsaturated fatty acid, value led to an increase MUFA value. In addition, the low PUFA caused to low P/S ratio. This situation is explained by the intensive feeding of the animal notwithstanding the pasture during the trial. Although fatty acid composition obtained from studied genotypes was similar to literature, it is reasonable to mention some differences from the literature (Marmer et al., 1984; Enser et al., 2000; Wood et al., 2003; Demirel et al., 2006; Vatansever and Demirel, 2009). The differences between the previous literature and the present study were mainly due to the many factors such as breed, feeding, age that affect fatty acid composition. SFA, MUFA, PUFA and P/S ratio showed no significance in terms of genotype used in this study.

The fatty acid composition associated with meat flavor and nutritional value is an important factor in the meat quality. Although fatty acid composition obtained from studied genotypes was similar to literature, it is reasonable to mention some differences from the literature (Marmer et al., 1984; Enser et al., 2000; Wood et al., 2003; Demirel et al., 2006; Vatansever and Demirel, 2009). The differences between the previous literature and the present study were mainly due to the many factors such as breed, feeding, age that affect fatty acid composition. SFA, MUFA, PUFA and P/S ratio showed no significance in terms of genotype used in this study.

### Fatty Acid Composition

The results of the analysis performed according to fatty acid composition are represented Table 5. Although some fatty acids such as C10:0, C12:0, C14:0, C15:0, C16:0, tC18:1, CLA, tC18:3, C20:1, C22:0 were statistically significant in terms of genotypes. The results indicated that genotypes showed no significance effect on total fat ratio, SFA, MUFA, PUFA and P/S. The mean values for C16:0, C18:0, C18:1 and CLA, which is one of the most important in the total fatty acids, were 24.12%, 17.57%, 38.98% and 0.40%, respectively. The mean values of SFA, MUFA, PUFA and P/S ratio were 48.37%, 47.87%, 3.80% and 0.08, respectively.

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### Table 3. Least Squares Mean and Standard Errors for Shear Force, Cooking Loss and Drip Loss According to Muscle Types and Genotypes

| Factors                  | N  | Drip Loss% | Cooking Loss% | Shear Force (kg cm²) |
|--------------------------|----|------------|---------------|---------------------|
| Muscle                   |    |            |               |                     |
| M. semitendinosus        | 39 | 3.68±0.542 | 3.68±0.542    | 3.68±0.542          |
| M. longissimus thoracis   | 39 | 3.68±0.542 | 3.68±0.542    | 3.68±0.542          |
| Interaction (Genotype × Muscle) |    |            |               |                     |
| CC × M. semitendinosus   | 27 | 3.68±0.542 | 3.68±0.542    | 3.68±0.542          |
| CC × M. longissimus thoracis | 27 | 3.68±0.542 | 3.68±0.542    | 3.68±0.542          |

### Table 4. Phenotypic Correlation Coefficients between Drip Loss, Cooking Loss and Shear Force

| N  | Drip Loss | Cooking Loss |
|----|-----------|--------------|
| 111| 0.351**   | (0.180-0.506)|
| 111| 0.131**   | (0.054-0.309)|

***P<0.001, **P<0.01, *P<0.05, NS=Non-significant
Palmitic acid, stearic acid, and oleic acid and P/S ratio results in this study were in agreement when compared to Kivrıkç and Sakız lambs (Demirel et al., 2006; Vacca et al., 2008; Romedi and Yılmaz, 2010). Additionally, stearic acid and oleic acid were significantly higher than reported values by Vacca et al. (2008). Although the MUFA values in our study were higher, PUFAs and P/S ratio were, in fact, lower than values reported by Vatansever and Demirel (2009). Mean CLA, SFA, MUFA and PUFAs were lower than noticed by Diaz et al. (2005).

### Sensory Evaluation

Aricmertic means of the sensory properties (odor, tenderness, juiciness, flavor, and acceptability) given for the MLD muscle are summarized in Table 6. The least squares mean and standard error for sensory characteristics according to genotypes are given in Table 7. High coefficient of variation was seen in all genotypes for all studied parameters. Although, the highest score for odor (5.59) and tenderness (6.41) was observed in Karya lambs, the highest juiciness (5.69) and flavor (6.07) scores were

| Variable          | Genotype | N  | X±SE | CV (%) |
|-------------------|----------|----|-----|--------|
| Odor              | EK       | 29 | 4.79±0.352 | 39.58 |
|                   | CC       | 29 | 4.17±0.268 | 34.54 |
|                   | KR       | 29 | 5.59±0.300 | 28.91 |
|                   | KIV      | 29 | 5.45±0.342 | 33.84 |
| Tenderness        | EK       | 29 | 6.10±0.307 | 27.12 |
|                   | CC       | 29 | 5.79±0.327 | 30.39 |
|                   | KR       | 29 | 6.41±0.308 | 25.86 |
|                   | KIV      | 29 | 6.28±0.354 | 30.38 |
| Juiciness         | EK       | 29 | 5.17±0.340 | 35.45 |
|                   | CC       | 29 | 5.38±0.278 | 27.85 |
|                   | KR       | 29 | 5.17±0.314 | 32.71 |
|                   | KIV      | 29 | 5.69±0.341 | 32.24 |
| Flavour           | EK       | 29 | 5.24±0.296 | 30.45 |
|                   | CC       | 29 | 5.07±0.276 | 29.32 |
|                   | KR       | 29 | 6.03±0.274 | 24.45 |
|                   | KIV      | 29 | 6.07±0.289 | 25.65 |
| Overall Acceptability | EK   | 29 | 5.14±0.292 | 30.65 |
|                   | CC       | 29 | 4.93±0.248 | 27.06 |
|                   | KR       | 29 | 6.07±0.243 | 21.54 |
|                   | KIV      | 29 | 5.97±0.395 | 35.70 |
observed in Kıvırcık lamb. There was a significant difference between genotypes for odor (P<0.05), flavor (P<0.05) and overall acceptability (P<0.05) in the present study. The results showed that the highest tenderness value obtained from Kıvırcık lamb was found to be parallel to the assessment of sensory characteristics.

Therefore, many different methods have been developed for sensory evaluation; scoring system is usually used in meat and meat products. Eating quality and flavour are associated with many chemical and physical properties of the meat. For example, juiciness and tenderness depend not only on the fat content, but also on the ability to water holding capacity. Tenderness, juiciness and flavour are complex features and they are influenced by many factors in the production and processing processes. There are also well-trained panelists are needed to evaluate these characteristics in sensory tests (Warriss, 2000).

Many factors such as attention, detection capability, prejudice and trend, habits, age and sex of panelists effect on sensory tests (Sanudo et al., 1998; Öztan, 2005). Sensory analysis is reported to be highly subjective (Risvik, 1994). High variation in all sensory parameters was determined in the present study. This result was expected considering these measurements is biased. The higher scores are given to Kıvırcık meat samples by the panelist in terms of juiciness and flavour, although there were no significant differences between other genotypes. The studied genotypes showed that they have a significant potential for high-quality lamb meat production in Turkey. In addition, taking into account that, according to (Safari et al., 2001), tenderness, flavour and juiciness are the most important sensory properties in overall acceptability, the MLD muscle of Karya lambs was more acceptable than the others.

The score of odor, tenderness, flavor and overall acceptability was found to be lowest in Çine Çağrısı lambs. Sanudo et al. (1997) reported that the breed has a significant effect on meat color, cooking loss, tenderness and juiciness of meat for the Churra, Castellana, Spanish Manchega and Awassi crossbred lambs. Therefore, there were non-significant differences between genotypes for tenderness and juiciness in this study. This result was in agreement previous study except tenderness in Merino, Ramlıç Kıvırcık, Sakız and İmroz breeds (Ekiz et al., 2009) researches.

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