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The relationship between muscle fiber characteristics and some meat quality parameters in Turkish native sheep breeds

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ABSTRACT

This research was conducted to determine muscle fiber characteristics and its relationship with some meat quality traits in Longissimus dorsi (LD) and Semitendinosus (ST) muscles from lambs of some Turkish native sheep breeds. A total of 36 singleton male lambs were used as experimental pure breed animals of Karayaka (n = 6), Kıvırcık (n = 6), Middle Anatolian Merino (n = 6), Awassi (n = 6), Morkaraman (n = 6) and Akkaraman (n = 6) breeds. All experimental animals were fed the same diet until they reach to a target weight of 40 kg weight. After the feeding period all lambs were slaughtered and LD and ST muscle samples were collected for determination of some meat quality traits (tenderness, pH, water holding capacity, and colour) and ATPase staining of muscle fibers. Type IIB muscle fiber numbers of Morkaraman sheep were higher than those of other breeds in LD muscle ($P < 0.05$). Awassi lambs had higher number of ($P < 0.05$) type IIA fibers and total fiber numbers in ST muscle compared to other breeds. Diameter of type I muscle fiber of ST muscle from Kıvırcık lambs was higher than those of other breeds ($P < 0.05$). There were positive correlations between diameters of type I ($r = 0.513$; $P < 0.05$), type IIIA ($r = 0.476$; $P < 0.05$) and tenderness in LD and ST muscles of all breeds. Results of the present study showed that muscle fiber characteristics of lambs of different Turkish native sheep breeds differ and muscle fiber characteristics influence some meat quality traits.

1. Introduction

Meat quality is a very important issue for consumers and it is also important for the meat industry in terms of meat processability and production of meat products (Lee et al., 2010; Joo et al., 2013). In many developed/developing countries, the demand of consumers for high quality meat, which is delicious, nutritious, safe and healthy, is increasing day by day. Therefore, the meat industry has begun to work in order to meet this demand to provide continuous consumption of meat products (Joo et al., 2013). It is essential to understand the skeletal muscle tissue characteristics such as muscle fiber types, metabolic and contractile features to produce high quality meat and what factors affecting them which influence meat quality. The quality of the meat presented for consumption is affected by factors such as post mortem changes in muscle tissues, muscle structure, stromal tissue content, fat content, muscle fiber composition, chemical composition and interaction of chemical constituents, microbiological contamination level, pre-slaughter stress, product processing and storage (Sen et al., 2011; Joo et al., 2013). The majority of skeletal muscle is composed by muscle fibers and biological characteristics of muscle fibers are directly related to meat quality such as tenderness, pH and colour (Joo et al., 2013). Generally, skeletal muscle fibers are classified based on their major metabolic activities and contractile properties (Lee et al., 2010; Joo et al., 2013). Moreover type, number and diameter of muscle fibers have important effects on quality of the meat (Joo et al., 2013).

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Generally fibers in skeletal muscle tissue are classified into three types as follows; 1) slow-oxidative or type I; 2) fast oxido-glycolytic or type IIA; 3) fast glycolytic or type IIB (type IIX) muscle fiber (Furuichi et al., 2014). Characteristics of skeletal muscle tissue may vary depending on various factors such as breed (Ryu et al., 2008), sex (Ozawa et al., 2000), hormone level (Rehfeldt et al., 2004), growth term (Gondret et al., 2006), nutrition (Sen et al., 2016) and muscle location (Hwang et al., 2010). Muscle fiber composition of the skeletal muscle tissue is one of the intrinsic properties of muscle and this has impact on eating quality characteristics of meat such as colour, odor, flavor, juiciness, tenderness, and texture (Büngera et al., 2009). Also, metabolic and contractile characteristics of skeletal muscle tissue are determined by the composition of muscle fibers (Ryu et al., 2008; Ozawa et al., 2000). Therefore, the understanding of relationship between muscle fiber features and traits of meat quality would increase the high quality meat production. Manipulation of muscle fiber features may increase profitability of the meat industry. Consequently, total muscle fiber numbers in the muscle cross section area, muscle fiber diameter, muscle fiber type and composition, which influence post mortem meat quality, are important features for meat quality (Ryu et al., 2008).

Lamb meat production is a of major importance in meat production in Turkey, with approximately 32 million sheep (TurkStat, 2015). Additionally, Turkey has many local sheep breeds, which are well suited to a variety of geographic and climatic conditions. Although these breeds have low production levels, they constitute an important source of red meat production under harsh climate conditions. The most popular native sheep breeds in Turkey are Karayaka, Kıvırcık, Middle Anatolian Merino, Awassi, Morkaraman and Akkaraman, and male lambs of these breeds are used as fattening material for meat production. Although, there have been numerous studies on growth performance, carcass characteristics and meat quality of male lambs of these breeds, there is no comparative information about muscle fiber characteristics and its relationship with some meat quality traits. For this reason, detect of skeleton muscle fiber type differences among Turkish native sheep breeds is important; especially, whether muscle fiber differences observed could be exploited to improve meat quality and managing the meat quality through improved breeding strategies (Bünger et al., 2009).

The purpose of the current study was therefore to determine muscle fiber characteristics and its relationship with some meat quality traits in Longissimus dorsi (LD) and Semitendinosus (ST) skeletal muscles from lambs of Karayaka, Kıvırcık, Middle Anatolian Merino, Awassi, Morkaraman and Akkaraman Turkish native sheep breeds.

2. Materials and methods

2.1. Animals

This experiment was conducted at the Agricultural Research Unit of Gaziosmanpasa University, Tokat, Turkey (40°31′N, 36°53′E, 650 m above sea level). A total of 36 singleton male lambs were used as experimental pure breed animals of Karayaka (n = 6), Kıvırcık (n = 6), Middle Anatolian Merino (n = 6), Awassi (n = 6), Morkaraman (n = 6) and Akkaraman (n = 6) breeds. Weaning age of lambs was at day 90 and they had similar weaning weights (approximately 20 kg). After weaning all lambs were subjected to a fattening period for approximately 125 ± 7 days and they were slaughtered upon reaching a target weight of 40 kg weight. The lambs were fed a diet composed of approximately 100 g/day alfalfa hay and concentrate feed. The nutrient contents of the diet during fattening period are given in Table 1. Water and mineral stone were freely available during fattening period.

Table 1
The nutrient contents of concentrate and alfalfa hay.

Nutrient Content	Concentrate	Alfalfa hay
Dry Matter (%)	93.10	94.02
Crude Protein (%)	15.21	15.01
ADF (%)	29.41	59.75
NDF (%)	30.22	58.22
Crude Oil (%)	2.23	0.74
Crude Ash (%)	8.58	10.30
Metabolisable Energy (kcal/kg)	2690.00	1878.00

2.2. Muscle sample collection

Following slaughter, the carcasses of all lambs were chilled for 24 h at 4 °C. Within 30 min of slaughter muscle samples (approximate 50 g) were isolated from the mid-sections of LD and ST muscles. Fat and connective tissue were removed from muscle samples and immediately frozen in liquid nitrogen. Afterwards all muscle samples were stored at −80 °C until ATPase staining of muscle fibers. For determination of meat quality traits, approximately 100–150 g muscle samples were collected from the central parts of the mid-section of the whole LD and ST muscles from the left side of the carcasses after 24 h chilled storage. These samples were trimmed of subcutaneous fat and fascia before storage at 4 °C for meat quality analysis.

2.3. Meat quality analyses and histochemical determination of muscle fiber type composition

All meat quality parameters (tenderness, pH, water holding capacity, and colour) were analyzed as described by Sen et al. (2011). Muscle fibers characteristics of LD and ST muscles were analyzed using myosin ATPase staining at pH 4.2 described by Broke and Keiser (1970) and Sen et al. (2016). Muscle fibers were counted using a microscope (Nikon Eclipse E600, Nikon Corporation, Tokyo, Japan) linked to an image analysis software (Laica Q Win V3.4 Processing-Analysis Software). Pictures of stained muscle fibers from LD and ST muscles are presented in Fig. 1.

2.4. Statistical analysis

To analyze the data for muscle fiber types and diameter Kolmogorov-Smirnov one sample test was performed to examine the normality. Data did not distribute normally. Levene variance homogeneity test was performed to obtain the information about homoscedasticity and results showed that variances were not homogeneous. Then, non-parametric permutation tests were applied to the data. To compare the means posterior pairwise permutation tests were used (Onder, 2007; Onder and Cebeci, 2009). Data analyses were utilized with NPMANOVA software written by Anderson (2000).Relationships between muscle fiber characteristics and some meat quality traits were determined with a Pearson correlation analysis at the 95% confidence interval.

3. Results

3.1. Muscle fibers number

The numbers of type I, IIA, IIB and total muscle fibers in mm^2 muscle area of LD and ST muscles from Karayaka, Kıvırcık, Middle Anatolian Merino, Awassi, Morkaraman and Akkaraman male lambs are presented in Fig. 2. Type I, IIA and total muscle fiber numbers in LD muscle were similar between lambs of different breeds, but type IIB muscle fiber numbers of Morkaraman lambs were higher than those of other breeds in LD muscle ($P < 0.05$). Type IIA and total muscle fiber numbers of ST muscle in Awassi