Indian J. Anim. Res., 52(10) 2018: 1526-1530
Print ISSN:0367-6722 / Online ISSN:0976-0555

AGRICULTURAL RESEARCH COMMUNICATION CENTRE
www.arccjournals.com/www.ijaronline.in

Relationship between muscle fiber characteristics and meat quality parameters in Turkish native goat breeds

Emre Sirin*

Ahi Evran University, Faculty of Agriculture,
Department of Agricultural Biotechnology, 40250 Kirsehir, Turkey.
Received: 12-06-2018 Accepted: 16-08-2018 DOI: 10.18805/ijar.B-1004

ABSTRACT

This study was conducted to determine muscle fiber characteristics and their effect on some meat quality parameters in Longissimus dorsi (LD) and Semitendinosus (ST) muscles from kids of some Turkish native goat breeds. Male kids of Hair (n=6), Angora (n=6), Kilis (n=6) and Honamli (n=6) (pure breeds) were used as experimental animals. All kids were slaughtered at 3 months of weaning age and muscles samples were collected for determination of type I, IIA and IIB muscle fibers and some meat quality parameters. It was found that type IIA fiber number of Hair and Honamli kids were higher than those of other breeds in LD muscle. Similarly, Hair kids had higher number of ($P<0.05$) type IIA in ST muscle compared to other breeds. Generally, there were negative correlations between tenderness, pH and number of muscle fiber types in LD and ST muscles of all breeds ($P<0.05$). Also, there were positive correlations between intra muscular fat and number of muscle fiber types in LD muscles of all breeds ($P<0.05$). Conclusively, kids of Turkish native goat breeds had different muscle fiber characteristics which can affect meat quality.

Key words: Meat quality, Muscle fiber type, Turkish native goat.

INTRODUCTION

Meat quality has always been very important to the consumer, and it is a critical for the meat parameter industry today. Consumer demand for quality meat is increasing day by day all over the world. In order to produce high quality meat, meat quality characteristics and factors affecting them must be known (Joo *et al*. 2013).

Fresh meat quality can be directly influenced by muscle fiber characteristics such as muscle fiber composition, cross-sectional area (CSA) and metabolic activity properties due to the muscle fibers constitute the majority of the skeletal muscle mass structure (Kim *et al*. 2013). The skeletal muscle mass has different composition of myosin heavy chain isoforms such as type I, IIA and IIB in muscle fibers, which have shown different contractile or metabolic characteristics (Lee *et al*., 2010).

Differences in muscle fiber characteristics are influence by various factors including breed (Ryu *et al*., 2008), selection (Larzul *et al*., 1999), gender (Ozawa *et al*. 2000), hormone (Rehfeldt *et al*., 2004), growth performance (Kim, *et al*., 2013), diet (Jeong *et al*. 2012) and muscle location (Hwang *et al*. 2010).

The muscle fiber characteristics affect pH, color, water holding capacity, texture and intra-muscular fat ratio of consumable meat (Joo *et. al*. 2013). Differences in the muscle fibers composition and number, and myoglobin content of the muscle mass can change the preferable color stability of the fresh meat in pork (Kim *et al*. 2013) and beef (Renerre, 1990). The composition of muscle fibers is associated with water holding capacity in meat of different species (pig, Kim *et al*. 2013; sheep, Sirin *et al*. 2017). Meat tenderness is affected by heterogeneity of muscle fiber composition in different muscle (Maltin *et al*. 2003). Increasing muscle fiber diameter or CSA can cause tougher meat in pig (Karlsson *et al*. 1993) and cattle (Renand, 2001). The muscle fiber properties are associated with the muscle pH, which is regarded as an indication meat quality of pig (Choi *et al*. 2007; Joo et. al. 2013) and sheep (Sirin *et al*., 2017).

Goats were originally domesticated in southwest Asia (Ngambi *et al*., 2013). The goats are now reared all over the world. Goat breeding is widespread in Turkey due to the geographic-economic conditions of the country, the historical accumulation of agricultural experience, and the traditions and customs of the Turkish people (Bolacali *et al*., 2017). Turkey has about 10 million goats and 9 different breeds (Turkstat, 2016). Therefore, the goats are an important source for meat production. Turkey has local goat breeds, which have a variety of geographic and climatic conditions. The most commonly raised native goat breeds in Turkey are Hair, Kilis, Angora and Honamli. Hair goat constitutes approximately 92% of the goat population in the country (Atay and Gokdal, 2016). Numerous studies have examined the muscle fiber characteristics and meat quality of sheep, cattle and pig. However, no comparative study on the determination of meat quality and muscle fiber characteristics

*Corresponding author's e-mail: emre.sirin@ahievran.edu.tr

of goat breed has been reported. Hence, it is important to determine the differences in skeletal muscle fiber type and their effect on meat quality among Turkish native goat breeds. Since, muscle fiber characteritics can be used to improve meat quality of goats with breeding strategies (Büngera *et al*. 2009). The purpose of the current study was to determine muscle fiber characteristics and their correlation with some meat quality traits (cooking loss, intra muscular fat, tenderness, water holding capacity, pH and color) in Longissimus dorsi (LD) and Semitendinosus (ST) muscles from kids of Hair, Kilis, Angora and Honamli Turkish native goat breeds.

MATERIALS AND METHODS

A total of 24 kids of Hair (n=6), Kilis (n=6), Angora (n=6) and Honamli (n=6) breeds were used as experimental. All animals were sourced from the national sheep and goat breeding project in Tokat (Hair), Kilis (Kilis), Ankara (Angora) and Antalya (Homanlı) provinces of Turkey. All kids were slaughtered at 90 days of weaning age.

Following slaughter, approximate 50–75 g LD and ST muscles samples were taken from mid-sections of whole muscles from the right side of carcass within 30 min for histochemical analysis of muscle fibers. Subcutaneous fat and fascia were removed from these muscle samples and immediately frozen in liquid nitrogen and stored at -80 °C until ATPase staining of muscle fibers. All carcasses were chilled for 24 h at 4 °C. Following chilling, approximate 150 g of LD and ST muscle samples from the left side of carcass were taken from the central parts of the mid-section of the whole muscles and subcutaneous fat and fascia were removed from these muscle samples. These muscle samples were stored at 4 °C for determination of meat quality parameters.

Cooking loss (CL), intra muscular fat (IMF), tenderness, water holding capacity (WHC), pH and color values (L; lightness, a; redness and b; yellowness) of LD and ST muscles samples were measured as defined by Sen *et al* (2011). Type I, IIA and IIB muscle fibers composition in LD and ST muscles were determined using ATPase staining at pH 4.2 as defined by Broke and Keiser (1970) and Sen *et al*. (2016). Muscle fibers were scanned using a microscope at × 200 magnification with a digital camera linked to image analysis software (Laica Q Win V3.4 Processing-Analysis Software). Four areas were selected randomly from the three sections to determine composition of myofibre types and CSA of myofibre. CSA of myofibre was measured from ~20 fibers of each fiber type from each area counted. Images of muscle fibers from LD and ST muscles stained for ATPase (pH 4.2) are presented in Fig 1.

The effect of breed on muscle fiber characteristics analyzed as a complete randomized design using the general linear model procedure of Minitab Version 12.11. Relationships between the muscle fiber characteristics and meat quality parameters were determined with a Pearson correlation analysis at the 95% confidence interval. The differences in the mean values were compared by the Tukey's multiple comparison tests and results were computed as mean ± SEM. Statistical significance was considered at $P<0.05$.

RESULTS AND DISCUSSION

The numbers and CSA of myofibre types: The numbers and CSA of type I, IIA, IIB muscle fibers in LD muscle from Hair, Kilis, Angora and Honamli male kids are presented Table 1. There was no significant difference between kids born to Kilis, Homanli, Hair and Angora goat breeds in terms of type I muscle fiber number in LD muscle. However, type IIA and total muscle fiber number of Honamli and Hair kids were higher ($P<0.05$) than those of Kilis and Angora kids. Also, Angora kids had lower ($P<0.05$) type IIB muscle fiber number than those of Kilis, Honamli and Hair kids. Kilis, Homanli, Hair and Angora kids had similar type I, type IIB and average muscle fiber CSA in LD muscle, but Angora kids had higher ($P<0.05$) type IIA muscle fiber CSA than those of Kilis, Honamli and Hair kids.

The numbers and CSA of type I, IIA, IIB muscle fibers in ST muscle from Kilis, Homanli, Hair and Angora male kids are presented Table 2. Hair kids had higher ($P < 0.05$) type IIA and total muscle fiber number in ST muscle compare to except for Honamli kids. However, there were

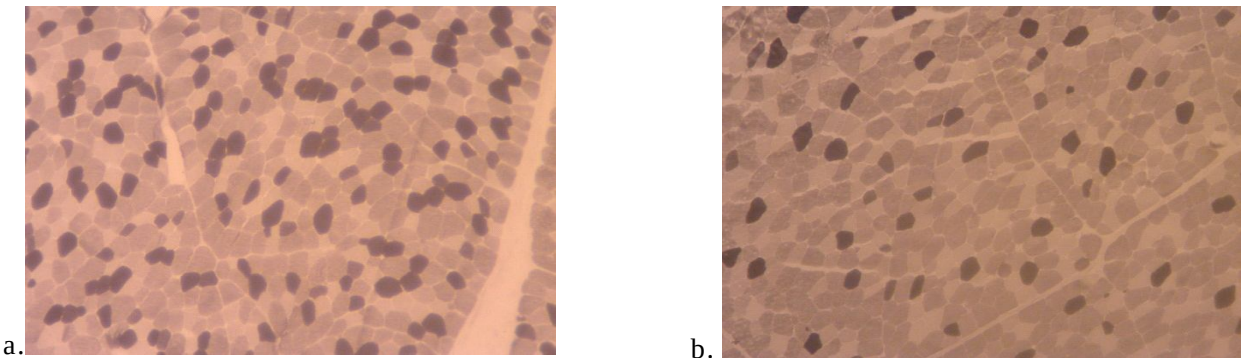

Fig 1: Pictures of myosin ATPase staining (pH 4.2) of (a) semitendinosus and (b) longissimus dorsi muscles. The darkest muscle fiber is type I, intermediate muscle fiber is type IIB and the lightest muscle fiber is type IIA.

Table 1: Numbers and cross-sectional areas of type I, IIA and IIB muscle fibers in Longissimus dorsi muscle.

		Number of muscle fibers (per mm^2)		
Breeds	**Type I**	**Type IIA**	**Type IIB**	**Total**
Kilis	214.3 ± 33.4	713.1 ± 87.3^b	754.1 ± 78.5^a	1681.5 ± 97.8^b
Honamli	178.3 ± 28.1	1449.0 ± 269.1^a	825.2 ± 43.0^a	2453.0 ± 300.2^a
Hair	305.6 ± 50.7	1637.0 ± 367.0^a	720.0 ± 75.8^a	2663.0 ± 414.2^a
Angora	219.4 ± 24.6	391.4 ± 67.2^b	581.9 ± 49.2^b	1193.0 ± 144.0^b
		Cross-sectional area (µm^2/per fiber)		
Breeds	**Type I**	**Type IIA**	**Type IIB**	**Average**
Kilis	59.38 ± 7.98	14.1 ± 3.3^b	14.6 ± 1.42	29.36 ± 2.72
Honamli	69.21 ± 7.69	8.9 ± 1.31^b	12.4 ± 1.7	30.19 ± 2.40
Hair	60.0 ± 12.50	9.5 ± 1.86^b	16.2 ± 2.48	28.56 ± 4.01
Angora	50.95 ± 5.73	38.3 ± 8.02^a	18.3 ± 1.47	35.84 ± 4.28

^{a,b} Different letters in the same column indicate significant difference (P<0.05).

Table 2: Numbers and cross-sectional areas of type I, IIA and IIB muscle fibers in Semitendinosus muscle.

		Number of muscle fibers (per mm^2)		
Breeds	**Type I**	**Type IIA**	**Type IIB**	**Total**
Kilis	270.2 ± 50.4	634.8 ± 50.1^c	676.0 ± 36.3	1311.0 ± 31.3^b
Honamli	232.2 ± 41.6	865.0 ± 144^b	780.0 ± 53.0	1878.2 ± 160.0^a
Hair	271.1 ± 20.2	1464.0 ± 140.0^a	652.1 ± 38.1	2388.2 ± 293.0^a
Angora	206.3 ± 14.3	523.1 ± 87.1^c	671.6 ± 40.7	1401.0 ± 59.4^b
		Cross-sectional area (µm^2/per fiber)		
Breeds	**Type I**	**Type IIA**	**Type IIB**	**Average**
Kilis	47.7 ± 6.7^{ab}	16.9 ± 1.6^a	15.2 ± 0.8	26.6 ± 2.5^{ab}
Honamli	68.8 ± 10.8^a	15.9 ± 3.4^a	26.3 ± 10.2	36.0 ± 7.5^a
Hair	38.9 ± 3.07^b	7.9 ± 0.5^b	15.8 ± 0.9	19.9 ± 0.8^b
Angora	51.0 ± 4.1^{ab}	25.8 ± 8.0^a	15.3 ± 0.8	31.4 ± 2.4^a

^{a,b,c} Differences between the meanings indicated by different letters in the same column were found significant difference (P<0.05).

Table 3: Significant Pearson correlation coefficients between muscle fiber and meat quality traits for the pooled data of LD and ST muscles of all kids#.

LD	**pH**	**L**	**b**	**WHC**	**CL**	**Tenderness**
Type I number			.496*		.468*	
Type IIA number				.438*		-.457*
Type IIB number	-.424*	.454*	.411*			-.579*
Total fiber number			.515*	.455*		-.484*
Type I CSA						.525*
Type IIA CSA	.639*	-.626*	-.647	-.497*	-.482*	.655*
ST	**pH**	**L**	**WHC**	**CL**	**Tenderness**	**IMF**
Type I number				-.511		
Type IIA number			.424*			
Type IIB number	-.481*	-.433*				
Total fiber number		-.501*				
Type IIA CSA			-.534*	-.464*	428*	
Type IIB CSA			.510*	-.565*		-.472*

Nonsignificant Pearson correlation coefficients between muscle fiber and meat quality traits have not been shown in the table. P<0.05*

no significant difference between kids born to Hair, Kilis, Angora and Homanli goat breeds in terms of type I and IIB muscle fiber number in ST muscle. Hair kids had lower (P<0.05) type I and IIA muscle fiber CSA than those of Honamli kids. Similarly, Hair kids had lower (P<0.05) average muscle fiber CSA than those of Honamli and Angora kids.

Compositions of muscle fiber type, size and total number of fibers in skeletal muscle tissue are affected by factor of breed in different species (Renand *et al*. 2001; Kim *et al*. 2013; Sirin *et al*. 2017). Studies related to muscle fiber characteristics carried out in sheep (Sirinet *et al*. 2017) and pig breeds (Ryu *et al*. 2008). However, there has been no comparative information about muscle fiber characteristics and meat quality in goat. Previous studies showed that Berkshire pig breed has more type I fiber than that of Yorkshire and Landrace pig breeds in LD muscle (Ryu *et al*. 2008). Wimmers *et al*. (2008) reported that high muscularity in different pig breeds was highly correlated with high ratio in myosin heavy chain transcripts of type IIB muscle fiber. Consequently, with regard to breeds within a species, there is a strong relationship between muscle fiber composition and growth performance.

These results may indicate that the muscle development of kids may be affected by breed. Perhaps, these differences among kids from Turkish goat breeds may also be due to maternal nutrition level during gestation, because the number of skeletal muscle fibers especially type II muscle fibers are affected from environmental factors, especially maternal mal-nutrition during gestation (Dwyer *et al*. 1994; Fahey *et al*. 2005; Sen *et al*. 2016). Moreover, decreasing in the number of secondary muscle fibers (IIA and IIB) is caused by the low level of maternal nutrition (Wigmore and Stickland, 1983).

Correlations between muscle fiber characteristics and meat quality traits: Significant Pearson correlation coefficients between muscle fiber and meat quality traits of LD and ST muscles of all kids were observed and are presented in Table 3. It can be seen that there were positive and negative correlations between type I, IIA and IIB muscle fiber characteristics (muscle fibers number and CSA) and meat quality parameters (CL, IMF, tenderness, WHC, pH, Lab color values) at different levels (P<0.05 and P<0.01).

The analysis of Pearson correlation coefficients on the pooled data of LD muscle for all breeds showed that there were positive correlations between type I muscle fiber number and CL and b color value (P<0.05), type IIA muscle fiber number and WHC and tenderness (P < 0.05), type IIB muscle fiber number and l and b color values and tenderness (P<0.05), total muscle fiber number and b color value, WHC and tenderness (P<0.05). There was negative correlation between type IIB muscle fiber number and pH (P<0.05). There were positive correlations between type I muscle fiber CSA and tenderness (P<0.05), type IIA muscle fiber CSA and pH (P<0.05) type IIA muscle fiber CSA and tenderness (P<0.05). There were negative correlations between type IIA muscle fiber CSA and l and b color values, WHC, CL (P<0.05).

Joo *et al*. (2013) reported that muscle fiber characteristics were related with fresh meat quality. Maltin *et al*. (2003) reported that the meat tenderness affected by the composition of muscle fiber types in different muscles. Previous studies showed that increasing muscle fiber diameter, especially type IIB muscle fiber, exhibit tougher meat in pig (Karlsson *et al*. 1993) and cattle (Renand, 2001). Similarly, Hwang *et al*. (2010) reported that meat tenderness can be improved by increasing the ratio of type I muscle fibers and decreasing the ratio of type IIB muscle fibers in muscle composition in cattle. Moreover, Sirin *et al*. (2017) reported positive correlations between type I and type IIA muscle fiber diameter and tenderness in LD and ST muscles in sheep. Kovanen *et al*. (1984) also reported that type I (slow-twitch) muscle fibers have more collagen, which leads to a decrease in tenderness of meat. In the present study also, it has been found that the tenderness decreased as the number of muscle fibers increased and also tenderness increased as the CSA of muscle fibers increased in all kid breeds. These observations were in agreement with the argument of previous studies.

Muscle fiber characteristics as fiber composition and area may influence pH, meat color and WHC in meat (Joo *et al*. 2013; Sirin *et al*. 2017). Previous studies reported that composition and size of muscle fiber were strongly related to meat quality parameters in meat producing species (Renerre, 1990; Choi *et al*. 2007; Kim *et al*. 2013; Sirin *et al*. 2017). This study indicated that muscle fiber characteristics have a significant effect on meat quality traits in different levels. The understanding of the impact of muscle fiber characteristics on meat quality traits can provide useful information for improving muscle growth and meat quality in goat breeds. Consequently, the results observed in the present study suggested that muscle fiber characteristics of Turkish native goat breeds might be used as an important indicator of the fresh meat quality.

CONCLUSION

Muscle fiber characteristics and its effects on some meat quality parameters were first determined in Kilis, Honamli, Hair and Angora Turkish native goat breeds. In conclusion, the results of the present study suggest that breed is an important factor affecting skeletal muscle fiber characteristics in goat. Differences in muscle fiber characteristics may influence kid meat production and quality. Determination of skeletal muscle fiber characteristics in different goat breeds will help improve meat quality of Turkish goat breeds with breeding strategies.

REFERENCES

Atay, O. and Gokdal, O. (2016). Some production traits and phenotypic relationships between udder and production traits of Hair goats. *Indian J. Anim. Res*., **50** (6) : 983-988.

Bolacali, M. Ozturk, Y. Yýlmaz, O. Kucuk, M. and Karslı, M. A. (2017). Effect of genotype and non-genetic factors on growth traits and survival rates in Turkish indigenous Hair goats and their first cross with Boer bucks. *Indian J. Anim. Res*., **51**: 975-981.

Broke, M.M. Keiser, K. (1970). Muscle fiber type; How many and what kind. *Arc. Neuro*. **23:** 369–370.

Büngera, L, Navajasa, E.A. Stevensonb, L. Lambea, N.R. Maltin, C.A. Simma, G. Fisherd, A.V. and Change, K.C. (2009). Muscle fibre characteristics of two contrasting sheep breeds: Scottish Blackface and Texel. *Meat Sci*., **81**: 372–381.

Choi, Y.M. Ryu, Y.C. and Kim, B.C. (2007). Influence of myosin heavy- and light chain isoforms on early postmortem glycolytic rate and pork quality. *Meat. Sci*. **76**: 281–288.

Dwyer, C.M. Stickland, N.C. and Fletcher, J.M. (1994). The influence of maternal nutrition on muscle fiber number development in the porcine fetus and on subsequent postnatal growth. *J Anim. Sci*. **72**: 911–917.

Fahey, A.J. Brameld, J.M. Parr T. Buttery, P.J. (2005). The effect of maternal undernutrition before muscle differentiation on the muscle fiber development of the newborn lamb. *J. Anim. Sci*. **83**: 2564–2571.

Hwang, Y.H. Kim, G.D. Jeong, J.Y. Hur, S.J. Joo, S.T. (2010). The relationship between muscle fiber characteristics and meat quality traits of highly marbled Hanwoo (Korean native cattle) steers. *Meat Sci*. **86**: 456–461.

Jeong, J.Y. Kim, G.D. Ha, D.M. Park, M.J. Park, B.C. Joo, S.T. and Lee, C.Y. (2012). Relationships of muscle fiber characteristics to dietary energy density slaughter weight, and muscle quality traits in finishing pigs. *Journal of Animal Science & Technology*, **54:** 175–183.

Joo, S.T. Kim, G.D. Hwang, Y.H. and Ryu, Y.C. (2013). Control of fresh meat quality through manipulation of muscle fiber characteristics. *Meat Sci*. **95**: 828–836.

Karlsson, A. Enfalt, A.C. Essen-Gustavsson, B. Lundstrom, K. Rydhmer, L. Stern, S. (1993). Muscle histochemical and biochemical properties in relation to meat quality during selection for increased lean tissue growth rate in pigs. *J. Anim. Sci*. **71**: 930–938.

Kim, G.D. Jeong, J.Y. Jung, E.Y. Yang, H.S. Lim, H.T. and Joo, S.T. (2013). The influence of fiber size distribution of type IIB on carcass traits and meat quality in pigs. *Meat Sci*. **94**: 267–273.

Kovanen, V. Suominen, H. Heikkinen, E. (1984). Mechanical properties of fast and slow skeletal muscle with special reference to collagen and endurance training. *J. Biomech*. **17**: 725–735.

Larzul, C. Le Roy, P. Gogue, J.,Talmant, A. Jacque, B. Lefaucheur, L. (1999). Selection for reduced muscle glycolytic potential in Large White pigs. II. Correlated responses in meat quality and muscle compositional traits. *Genetics, Selection, Evolution*, **31**: 61–76.

Lee, S.H. Joo, S.T. and Ryu, Y.C. (2010). Skeletal muscle fiber type and myofibrillar proteins in relation to meat quality. *Meat Sci*. **86**: 166–170.

Maltin, C. Balcerzak, D. Tilley, R. Delday, M. (2003). Determinants of meat quality: Tenderness. *Proc. Nutr. Soc*. **62**: 337–347.

Ngambi, J.W. Alabi, O.J. Alabi, D. N. J. and Norris, D. (2013). Role of goats in food security, poverty alleviation and prosperity with special reference to Sub-Saharan Africa: a review. *Indian J. Anim. Res*., **47** (1): 1 – 9

Ozawa, S. Mitsuhashi, T. Mitsumoto, M. Matsumoto, S. Itoh, N. and Itagaki, K. (2000). The characteristics of muscle fiber types of longissimus thoracis muscle and their influences on the quantity and quality of meat from Japanese Black steers. *Meat Sci*. **54**: 65–70.

Rehfeld, C. Fiedler, I. Stickland, N.C. (2004). Number and size of muscle fibres in relation to meat production. Pas, MFW te; Everts ME, Haagsman HP. Muscle development of livestock animals, 1–38. Wallingford, UK: CABI Publishing.

Renand, G. Picard, B. Touraille, C. Berge, P. and Lepetit, S. (2001). Relationship between muscle characteristics and meat quality traits of young Charlois bulls. *Meat Sci*. **59**: 49–60.

Renerre M. (1990): Factors involved in the discoloration of beef meat. Inter. *J. Food Sci. Tech*. **25**: 613–630.

Ryu, Y.C. Choi, Y.M. Lee, S.H. Shin, H.G. Choe, J.H. Kim, J.M. Hong, K.C. and Kim, B.C. (2008). Comparing the histochemical characteristics and meat quality traits of different pig breeds. *Meat Sci*. **80**: 363–369.

Sen, U. Sirin, E. Aksoy, Y. Ensoy, U. Ulutas, Z. and Kuran, M. (2016). The effect of maternal nutrition level during mid-gestation on post-natal muscle fiber composition and meat quality in lambs. *Anim. Prod. Sci*. **56**: 834–843.

Sen, U. Sirin, E. Ulutas, Z. and Kuran, M. (2011). Fattening performance, slaughter, carcass and meat quality traits of Karayaka lambs. Trop. *Anim. Health Prod*. **43**: 409–416.

Sirin, E. Aksoy, Y. Uğurlu, M. Çicek, U. Önenç, A. UlutaŞ, Z. Şen, U. Kuran, M. (2017). The relationship between muscle fiber characteristics and some meatquality parameters in Turkish native sheep breeds. *Small Ruminant Research* **150**: 46–51.

TurkStat (Turkish Statistical Institute). (2016). Livestock Statistics. http://www.tuik.gov.tr (accessed November 19, 2016).

Wigmore P.M.C. and Stickland, N.C. (1983). Muscle development in large and small pig fetuses. *J. Anat*. **137:** 235–245.

Wimmers, K. Ngu, N.T. Jennen, D.G.J. Tesfaye, D. Murani, E. Schellander, K. and Ponsuksili, S. (2008). Relationship between myosin heavy chain isoform expression and muscling in several diverse pig breeds. *J. Anim. Sci*. **86:** 795–803.