TÜBİTAK

Research Article

Turk. J. Vet. Anim. Sci.
2010; 34(4): 349-357

doi:10.3906/vet-0805-27

Certain meat quality characteristics of Awassi and Turkish Merino × Awassi (F_1) lambs

Romedi ÇELİK[1,*], Alper YILMAZ[2]

[1]Department of Animal Breeding and Husbandry, Faculty of Veterinary Medicine, Dicle University, Diyarbakır - TURKEY

[2]Department of Animal Breeding and Husbandry, Faculty of Veterinary Medicine, İstanbul University, 34320 Avcılar, İstanbul - TURKEY

Received: 27.05.2008

Abstract: This study aimed to determine the meat quality characteristics of 2-way crossbred lambs that were obtained by mating Turkish Merino (Karacabey Merino) as a sire line with Awassi ewes, as compared to those of purebred Awassi lambs. In all, 8 male and 8 female single born lambs from each genotype (forming 4 groups and 32 lambs) were investigated. In Awassi purebred and Turkish Merino × Awassi (F_1) crossbred lambs mean pH values at 24 h were 5.84 and 5.80, drip losses were 2.35% and 2.69%, cooking losses were 31.41% and 30.94%, Warner-Bratzler shear force values were 3.42 kg and 2.63 kg, P:S ratios were 0.14 and 0.16, and (n-6/n-3) ratios were 3.70 and 4.66, respectively. The results of the present study show that meat of Turkish Merino × Awassi (F_1) lambs was more tender but less healthy than that of Awassi lambs, although the differences were probably not important enough to be significant at the market level.

Key words: Crossbreeding, fatty acid, drip loss, pH, cooking loss, texture

Türk Merinosu ve Türk Merinosu × İvesi (F_1) kuzuların bazı et kalitesi özellikleri

Özet: Araştırma, Türk Merinosu (Karacabey Merinosu) koçların baba hattı olarak İvesi koyunlarla birleştirilmesi yoluyla elde edilen ikili melez kuzuların et kalitesi ile ilgili özelliklerinin saf yetiştirilen İvesi kuzularla karşılaştırmalı olarak belirlenmesi amacıyla yapılmıştır. Her genotipten tek doğmuş sekiz erkek ve sekiz dişi kuzu (dört grup ve 32 kuzu) kullanılmıştır. İvesi ve Türk Merinosu × İvesi (F_1) kuzuların 24. saatteki pH değerleri 5,84 ve 5,80; damlama kaybı % 2,35 ve % 2,69; pişirme kaybı % 31,41 ve % 30,94; Warner-Bratzler pik kesme kuvveti 3,42 kg ve 2,63 kg; aşırı doymamış yağ asitlerinin doymuş yağ asitlerine oranı (A/D) 0,14 ve 0,16; omega 6 yağ asitlerinin omega 3 yağ asitlerine oranı (n-6/n-3) 3,70 ve 4,66 olarak hesaplanmıştır. Araştırma sonucunda, farklılıklar pazar düzeyinde etkili olmaya yeterli olacak kadar önemli olmamakla beraber, Türk Merinosu × İvesi (F_1) kuzuların etlerinin İvesi kuzulara göre daha yumuşak ancak daha az sağlıklı olduğu belirlenmiştir.

Anahtar sözcükler: Melezleme, yağ asidi, damlama kaybı, pH, pişirme kaybı, tekstür

* E-mail: romedi@dicle.edu.tr

Introduction

Meat is a quality food that contains all the nutrients necessary for the growth, livability, and physiologic functions of humans. The protein content is 17%-20%, fat content is 10%-27%, and ash (mineral components) content is 0.8%-1.3% in animals of different species. Meat protein is significant in that it contains sufficient quantities of essential amino acids (1).

Sheep meat is one of the most liked and consumed meats in the Southeast Anatolia region. Therefore, the most significant production of sheep is for meat. A large proportion of the meat produced from sheep is lamb meat (2); however, in recent years the preference of consumers has been changing rapidly. Today, consumers are conscious of their health and prefer to consume quality food (3). Therefore, successful production of foodstuffs is possible by taking the preferences and demands of the consumers into account. Currently, in EU countries researchers are focusing on the production of quality food, rather than on increasing production levels. One method of producing quality lamb meat is to take advantage of improved genotypes for these characteristics.

Turkish Merino was produced by crossbreeding the indigenous Kıvırcık breed with German Mutton Merino, in the form of upgrading to Merino, followed by careful selection. Turkish Merino was observed to be successful as a sire line in crossbreeding to improve meat production in different regions (4). Awassi is the dominant, fat tailed indigenous sheep breed in the Southeast Anatolia region of Turkey (1).

The present study aimed to determine the meat quality characteristics of 2-way crossbred lambs produced by mating Turkish Merino with Awassi ewes, as compared to those of purebred Awassi lambs. The goal was to improve the meat quality characteristics of lambs via crossbreeding.

Materials and methods

The present study was carried out at the Research and Practice Farm of Dicle University, Faculty of Veterinary Medicine, Diyarbakır, Turkey. The lambs used in the study were 2-way crossbred lambs produced by mating Turkish Merino (Karacabey Merino) rams with Awassi ewes; purebred Awassi lambs served as the control group.

After lambing, the lambs were kept together with their dams for 1 week. Later, the dams went to pasture during the daytime and when they returned in the evening they were kept together with their lambs until the next morning. During the suckling period the ewes were not milked; all the milk was left for the lambs. The lambs were weaned after a mean of 90 days, and after a 1 week period of adaptation to the feed they were fattened for 56 days. In all, 8 male and 8 female single born lambs from each genotype (forming 4 groups and 32 lambs) were fattened.

Throughout the fattening period the lambs were fed with lamb fattening feed containing 15% crude protein and 2800 kcal/kg of metabolic energy. The contents of the concentrate feed used in the study are shown in Table 1.

Analysis of the meat quality characteristics was carried out at the Carcass and Meat Quality Laboratory of İstanbul University, Faculty of Veterinary Medicine, Department of Animal Breeding and Husbandry.

The pH value of each lamb carcass was measured in the Longissimus dorsi (LD) and semimembranosus (SM) muscles, at 45 min and 24 h post-slaughter using a digital pH meter (Testo 205) equipped with a penetrating electrode and thermometer. To determine the water holding capacity characteristics for drip loss, pieces of approximately 50 g were cut from the LD and placed in plastic bags after being weighed. The meat pieces were tied with a piece of rope and hung without touching the surfaces of the plastic bag, and the plastic bags were tied securely after inflating. After keeping the plastic bags at 4 °C for 48 h, moisture on

Table 1. The contents of the concentrated feed used in the study.

Feed contents	%
Barley	20
Corn	17
Sunflower seed meal	13
Cotton seed meal	15
Bran	25
Limestone	3
Salt	1
Molasses	6

the meat surface was dried with paper towels. Then the meat pieces were weighed and the difference between the 2 measurements was determined. Drip loss was calculated as the percentage of weight loss from the initial weight (5).

For cooking loss measurement pieces of approximately 100 g that were cut from the LD, frozen below –18 °C, and thawed at 4 °C were weighed and put into plastic bags; the plastic bags were then vacuumed. The meat samples in the plastic bags were cooked for 1 h at 80 °C. The samples were then kept at 4 °C for 12 h. Afterwards, moisture on the meat surface was dried with paper towels and the samples were weighed. The difference between the 2 measurements was determined. Cooking loss was calculated as the percentage of the weight loss from the initial weight (5).

After the measurement of cooking loss, the same cooked meat samples were used to determine Warner-Bratzler (WB) shear force values. The cooked meat samples were cut into pieces 30 mm long, 10 mm wide, and 10 mm high, as rectangular prisms parallel to the meat fibers (6). The WB shear force value of each sample was determined using a cutting knife connected to an Instron 3343 single colon material test system (5).

For fractioning the total lipids and obtaining the fatty acid methyl esters, LD tissue was broken well in a chloroform-methanol (2:1) mixture in a homogenizer. To prevent the auto-oxidation of polyunsaturated fatty acids 50 µL of butylated hydroxide-toluene, which was prepared in a ratio of 2% chloroform, was added to the extraction system. After the solvent evaporated under a nitrogen atmosphere, methanol with acid was added to the total lipid extracts of the lamb meat and was heated to 85 °C for 2 h. Thus, the fatty acids changed into methyl esters of fatty acids. After the solution was cooled, methyl esters were extracted using hexane.

After the density of the fatty acid methyl esters was increased under a nitrogen atmosphere, they were analyzed using gas chromatography. Fatty acid methyl esters were chromatographed by making a heat program. In the analysis a capillary colon (filling material: 78% cyanopropyl; length of colon: 30 m; inner diameter: 0.25 mm; thickness of film: 0.25 µm) Quadrex 007-23 was used. The heat of the colon started at 100 °C and ended at 60 °C; the waiting time at these temperatures was 1 min and the ramp was 5 °C/min. An HP 6890 gas chromatograph equipped with an FID detector was used. The heat of the detector block was 300 °C, the heat of the injector was 230 °C, and the injection was made without a split; helium was used as the carrying gas. The flow speed of gases was fixed as helium + makeup 30 mL/min, dry air 330 mL/min, and hydrogen 33 mL/min (7).

In order to determine the effects of genotype and sex on meat quality characteristics, least square procedures were performed using SPSS (8). The model used in the analyses included the fixed effects of genotype (Awassi and Turkish Merino × Awassi [F_1]), sex (male or female), and genotype × sex interaction.

Results

In terms of pH values in LD and SM at 45 min and 24 h post-slaughter, the differences between genotype and sex groups were not statistically significant. Additionally, in terms of drip loss and cooking loss, the differences between genotype and sex groups were not statistically significant. In terms of WB shear force values, there were no statistically significant differences between sex groups when the differences between genotype groups were significant on the side of Turkish Merino × Awassi (F_1) lambs ($P < 0.01$). The results for these characteristics, according to genotype and sex groups, are given in least square means, standard errors, and with significance controls in Table 2.

The differences in fatty acid composition between the 2 genotypes and sex groups were not significant. The results for fatty acid composition, according to genotype and sex groups, are presented in least square means and standard errors in Tables 3 and 4.

Discussion

Meat quality is regarded as the composition of desired and undesired characteristics of the muscle and fat tissues consumed. These are related to morphologic, physical, chemical, biochemical, microbiologic, hygienic, and organoleptic

Table 2. Least square means (LSM) and standard errors (SE) of some meat quality characteristics in Awassi and Turkish Merino × Awassi (F_1) lambs.

Traits	n	pH-LD 45 min		pH-LD 24 h		pH-SM 45 min		pH-SM 24 h		Drip loss (%)		Cooking loss (%)		WB Shear force (kg/cm^2)	
		LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE
Expected mean	32	6.84	0.03	5.82	0.02	6.85	0.03	6.07	0.04	2.52	0.11	31.18	0.77	3.02	0.13
Genotype		NS	NS	NS	NS	NS	NS	**							
Awassi	16	6.89	0.04	5.84	0.02	6.86	0.04	6.12	0.06	2.35	0.16	31.41	1.09	3.42	0.19
T.Merino × Awassi (F_1)	16	6.79	0.04	5.80	0.02	6.83	0.04	6.03	0.06	2.69	0.16	30.94	1.09	2.63	0.19
Sex		NS		NS		NS		NS		NS		NS		NS	
Male	16	6.87	0.04	5.82	0.02	6.86	0.04	6.06	0.06	2.43	0.16	32.45	1.09	3.28	0.19
Female	16	6.82	0.04	5.82	0.02	6.83	0.04	6.09	0.06	2.61	0.16	29.90	1.09	2.76	0.19
Genotype × Sex		NS		NS		NS		NS		NS		NS		NS	
Awassi-Male	8	6.89	0.05	5.82	0.03	6.86	0.05	6.07	0.08	2.45	0.23	31.53	1.54	3.72	0.26
Awassi-Female	8	6.90	0.05	5.86	0.03	6.87	0.05	6.17	0.08	2.25	0.23	31.30	1.54	3.11	0.26
T.Merino × Awassi (F_1)-Male	8	6.85	0.05	5.81	0.03	6.85	0.05	6.05	0.08	2.41	0.23	33.37	1.54	2.84	0.26
T.Merino × Awassi (F_1)-Female	8	6.74	0.05	5.78	0.03	6.80	0.05	6.01	0.08	2.98	0.23	28.51	1.54	2.41	0.26

NS = $P > 0.05$; ** = $P < 0.01$

LD = Longissimus dorsi; SM = Semimembranosus

Table 3. Least square means (LSM) and standard errors (SE) of percentages of saturated and monounsaturated fatty acids measured from musculus longissimmus dorsi in Awassi and Turkish Merino × Awassi (F_1) lambs.

Traits	n	C16: 0		C18: 0		SFA		C16: 1n-7		C18: 1n-9		MUFA	
		LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE
Expected mean	26	25.20	0.88	6.55	0.37	31.76	0.83	1.63	0.19	32.80	1.05	34.43	1.00
Genotype		NS		NS		NS		NS		NS		NS	
Awassi	14	26.80	1.20	6.26	0.50	33.06	1.12	1.96	0.26	32.86	1.42	34.82	1.36
T.Merino × Awassi (F_1)	12	23.60	1.30	6.85	0.54	30.45	1.22	1.31	0.29	32.73	1.54	34.04	1.48
Sex		NS		NS		NS		NS		NS		NS	
Male	11	25.34	1.34	6.55	0.56	31.89	1.26	1.83	0.30	32.84	1.60	34.67	1.53
Female	15	25.07	1.15	6.56	0.48	31.63	1.08	1.44	0.25	32.75	1.37	34.19	1.30
Genotype × Sex		NS	NS	NS	NS	NS	NS						
Awassi-Male	6	27.84	1.81	6.13	0.76	33.97	1.70	2.22	0.40	31.09	2.15	33.31	2.06
Awassi-Female	8	25.77	1.57	6.39	0.66	32.16	1.47	1.70	0.34	34.63	1.87	36.33	1.78
T.Merino × Awassi (F_1)-Male	5	22.83	1.98	6.97	0.83	29.80	1.86	1.44	0.44	34.59	2.36	36.03	2.25
T.Merino × Awassi (F_1)-Female	7	24.37	1.68	6.73	0.70	31.10	1.57	1.18	0.37	30.86	1.99	32.04	1.90

NS = $P > 0.05$
SFA = Saturated fatty acids; MUFA = Monounsaturated fatty acids

Table 4. Least square means (LSM) and standard errors (SE) of percentages of polyunsaturated fatty acids measured from musculus longissimmus dorsi in Awassi and Turkish Merino × Awassi (F_1) lambs.

Traits	n	C18: 2n-6		C18: 3n-3		C20: 3n-6		C20: 4n-6		C20: 5n-3		PUFA		P:S		n-6/n-3	
		LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE
Expected mean	26	2.5	0.10	0.66	0.09	0.37	0.04	0.66	0.04	0.38	0.03	4.59	0.16	0.15	0.01	4.18	0.42
Genotype		NS		NS		NS		NS		NS		NS		NS		NS	
Awassi	14	2.5	0.13	0.7	0.12	0.4	0.05	0.61	0.05	0.39	0.04	4.58	0.22	0.14	0.01	3.7	0.58
T.Merino × Awassi (F_1)	12	2.6	0.14	0.61	0.13	0.33	0.06	0.7	0.05	0.38	0.04	4.59	0.23	0.16	0.01	4.66	0.62
Sex		NS	NS	NS	NS	NS	NS	NS	NS								
Male	11	2.5	0.15	0.72	0.13	0.38	0.06	0.61	0.05	0.36	0.04	4.54	0.24	0.15	0.01	3.69	0.65
Female	15	2.6	0.12	0.59	0.11	0.35	0.05	0.71	0.05	0.4	0.04	4.63	0.21	0.15	0.01	4.67	0.55
Genotype × Sex		NS		NS		NS		NS		NS		*		NS		NS	
Awassi-Male	6	2.5	0.20	0.89	0.18	0.45	0.08	0.61	0.07	0.42	0.06	4.89	0.33	0.15	0.02	2.81	0.87
Awassi-Female	8	2.4	0.17	0.52	0.15	0.35	0.07	0.62	0.06	0.35	0.05	4.28	0.28	0.14	0.01	4.58	0.75
T.Merino × Awassi (F_1)-Male	5	2.4	0.21	0.55	0.19	0.31	0.09	0.62	0.08	0.31	0.06	4.2	0.36	0.15	0.02	4.56	0.95
T.Merino × Awassi (F_1)-Female	7	2.7	0.18	0.67	0.16	0.35	0.07	0.79	0.07	0.45	0.05	4.98	0.3	0.16	0.02	4.75	0.81

NS = $P > 0.05$; *= $P < 0.05$

PUFA = Polyunsaturated fatty acids; P:S = Polyunsaturated fatty acids to saturated fatty acids ratio; n-6/n-3 = omega-6 to omega-3 ratio

characteristics, and cooking methods. For instance, appearance, marbling, dryness, hardness, softness, taste, smell, color, moisture content, and tenderness can be considered organoleptic characteristics. Generally, these characteristics can be the result of the structure or a function (pH), whereas it can also be the result of a combination of more than one structure and function (color, taste) of meat (9).

As an indication of glycolysis, the pH in the lamb carcasses 45 min after slaughter ranged between 6.05 and 6.85. The degree of pH decline in meat after slaughter is affected by stress, electrical stimulation, cooling, and the amount of glycogen deposits. These are factors that can be controlled; however, their effects on the decrease in pH cannot be calculated. Individual factors like sex, genotype, season, and age also affect pH (10).

The pH in the LD of Awassi and Turkish Merino × Awassi (F_1) lambs at 45 min was similar to that in Irish lambs (10) and was higher than that in Talavera, Manchega, Serra da Estrela, and Merino Branco lambs (6,11,12); pH at 24 h was similar to that in Manchega, Texel × Merino, Border Leicester × Merino, Merino, Talavera, and Irish lambs (6,10,11,13), and was higher than that in Serra da Estrela and Merino Branco lambs (12). Pre-slaughter handling was reported to be one of the reasons for the differences between genotypes (14). The similarity in the pH at 45 min and 24 h post-slaughter among the lamb genotypes and sexes in the present study might have been due to the fact that all the lambs were kept in similar pre-slaughter conditions.

Dripping is generally described as the liquid that leaks from the cuts of meat in the days after slaughter. The dripping liquid has a protein percentage nearly half of the sarcoplasmic protein in the muscles. Proteins have water-holding capacity of 10% of muscle weight. Dripping is increased by both the denaturation of proteins and the water produced by denaturation. The basic mechanism of dripping is the contraction (shortening) of the myofibrillar frame (9).

Drip loss in Awassi and Turkish Merino × Awassi (F_1) lambs was higher than that in Mutton Merino, Dormer × Merino, Dormer × Dohne Merino, Dormer × Mutton Merino, Suffolk × Merino, Suffolk × Dohne Merino, Suffolk × Mutton Merino, Dohne Merino, Dormer, and Suffolk lambs (3,15), and was lower than that reported in lambs in India (16). Cooking loss in Awassi and Turkish Merino × Awassi (F_1) lambs was lower than that in Mutton Merino (15); was similar to that in Texel × Merino, Border Leicester × Merino, and Merino lambs (13); and was higher than that in Dormer × Merino, Dormer × Dohne Merino, Dormer × Mutton Merino, Suffolk × Merino, Suffolk × Dohne Merino, Suffolk × Mutton Merino, Dohne Merino, Dormer, Suffolk lambs, and lambs in India (3,16). The differences in drip loss and cooking loss between different studies might be due to differences in meat pH, the muscle used, and cooking temperature and duration (14). In the present study the differences between lamb genotypes and sexes, in terms of drip loss and cooking loss, might not have been significant due to the similar meat pH values in the lambs.

Normally, meat stored in a refrigerator increases in tenderness. Stress before slaughter can cause meat parts that are expected to be tender to become tough. Generally, the effects of genotype and sex on tenderness are less than those of other factors. However, techniques such as vitamin D injection or treatment before slaughter, transportation, and different techniques before slaughter (including electrical stunning at the time of slaughter), thawing of meat after freezing, and keeping the meat are all significant factors that affect the tenderness of meat. Ultimate meat pH also affects tenderness. At very high and very low pH levels meat has a tender character (17).

The WB shear force value of meat is a texturally significant meat quality characteristic and is important for consumer acceptability. In terms of this trait, the meat of Turkish Merino × Awassi (F_1) lambs was more tender than that of Awassi lambs, showing that crossbreeding with Turkish Merino improved the tenderness level of meat in crossbred lambs. The WB shear force value of Turkish Merino × Awassi (F_1) lambs in the present study was similar to that of Texel × Merino, Border Leicester × Merino, and Merino lambs (13), and was lower than that in 3 different indigenous breeds (Churra, Castellana, and Manchega) in Spain, Merino Branco, Manchega, Mutton Merino, Awassi, Red Karaman, Tuj, and Awassi × Tuj (F_1) lambs (6,13,18-20).

In determining the nutrient value of meat the lipids in the muscles are important. For human health and nutrition, fatty acid composition and in particular some specific fatty acids in the diet play a significant role. In the human diet the amount of fat and especially the proportion of saturated fatty acids have been considered major risk factors in coronary heart illnesses, and the ratio between polyunsaturated (PUFA) and saturated (SFA) fatty acids is one of the indexes for the nutritional evaluation of fat (21). This ratio is relatively low in ruminants (22,23). Recently, nutrition scientists have focused on the type of PUFA in the diet and the proportion of ω-3, which consists of α-linolenic acid (18:3) to ω-6, which consists of linoleic acid (18:2). This ratio is a risk factor for cancer and heart attacks, and especially for the formation of blood clots that cause heart attacks. The primary source of ω-6 is corn and soybean oil, which contain high quantities of linoleic acid. High quantities of ω-3 are found in flaxseed, walnut, and especially in planktons and fatty fish (24). In ruminant meat, particularly those fed in pasture, the ω6/ω3 PUFA proportion is beneficially low (22,23).

The (P:S) results related to fatty acid composition in the Awassi and Turkish Merino × Awassi (F_1) lambs were similar to the results in Kıvırcık (25), lambs in Germany and England (26), and Manchega (27) lambs, and were lower than those in Chios (25), Spanish Merino, Rasa Aragonesa, and Welsh Mountain (28) lambs.

In terms of fatty acid composition, the (n-6/n-3) levels in the Awassi and Turkish Merino × Awassi (F_1) crossbred lambs were higher than those in Welsh Mountain and early slaughter lambs from Britain and Spain (28); were similar to those in Merino Branco, Ile de France × Merino Branco, Rasa Aragonesa, Kıvırcık, Chios, and Manchega lambs (21,25,27,28); and were lower than those in Spanish Merino (28). The (n-6/n-3) fatty acid composition should be low for healthy nutrition. The results obtained in the Awassi and Turkish Merino × Awassi (F_1) lambs were generally similar to the results of other studies; however, these results were higher than those of early slaughter lambs from Britain and Spain, showing that this characteristic might increase with age. The differences in fatty acid composition between studies might be due to differences in the feeding systems used. Although it was not statistically significant, Awassi lambs had a numerically lower (n-6/n-3) ratio (3.7) than the Turkish Merino × Awassi (F_1) crossbred lambs (4.7), indicating that Awassi lambs might produce healthier meat than crossbred lambs.

It was determined that Awassi and Turkish Merino × Awassi lambs had similar pH values at 45 min and 24 h, drip loss and cooking loss percentages, and (C16: 0), (C16: 1), (C18: 0), (C18: 1), (C18: 2 n-6), (C18: 3 n-3), (C20: 3 n-6), (C20: 4 n-6), (C20: 5 n-3), (SFA), (MUFA), (PUFA), (P:S), and (n-6/n-3) results, in terms of fatty acid composition; however, the meat of Turkish Merino × Awassi (F_1) crossbred lambs was more tender.

In terms of the characteristics that determine the quality of meat, although flavor, which is also important for acceptability, was not evaluated in the present study, as Turkish Merino × Awassi (F_1) crossbred lambs had better tenderness results than Awassi and some genotypes in other studies, it can be considered that the meat obtained from Turkish Merino × Awassi (F_1) lambs might have a positive effect on consumer demand.

Acknowledgements

This study was based on the PhD thesis of the first author and was supported by İstanbul University Research Fund, project no: T-385/08032004.

References

1. Yalçın, B.C.: Genel Zootekni. İstanbul Üniv. Vet. Fak. Yayın. No: 1, İstanbul. 1981.
2. Akçapınar, H.: Koyun Yetiştiriciliği. 2. Baskı, İsmat Matbaacılık, Ankara. 2000.
3. Hoffman, L.C., Muller, M., Cloete, S.W.P., Schmidt, D.: Comparison of six crossbred lamb types: sensory, physical and nutritional meat quality characteristics. Meat Sci., 2003; 65: 1265-1274.

4. Yılmaz, A., Özcan, M., Ekiz, B., Akgündüz, M.: Investigations on the possibility of improving the meat production by crossbreeding Turkish Merino, Chios and Kıvırcık sheep breeds 2. Fattening, slaughter and carcass characteristics of lambs. Turk. J. Vet. Anim. Sci., 2002; 26: 1333-1340. (article in Turkish with an abstract in English)

5. Honikel, K.O.: Reference methods for the assessment of physical characteristics of meat. Meat Sci., 1998; 49: 447-457.

6. Vergara, H., Molina, A., Gallego, L.: Influence of sex and slaughter weight on carcass and meat quality in light and medium weight lambs produced in intensive systems. Meat Sci., 1999; 52: 221-226.

7. Bligh, E.G.H., Dyer W.J.: A rapid method of total lipid extraction and purification. Can. J. Biochem. Physiol., 1959; 37: 911-917.

8. Özdamar, K.: Biostatistics with SPSS. 4th edn., Kaan Publ., Eskişehir. 2001. (book in Turkish)

9. Murray, A.C.: The evaluation of muscle quality. In: Jones, S.D.M., Ed., Quality and Grading of Carcasses of Meat Animals. CRC Publications, Canada. 1995; 84-107.

10. McGeehin, B., Sheridan, J.J., Butler, F.: Factors affecting the pH decline in lamb after slaughter. Meat Sci., 2001; 58: 79-84.

11. Díaz, M.T., Velasco, S., Cañeque, V., Lauzurica, S., Ruiz De Huidobro, F., Pérez, C., González, J., Manzanares, C.: Use of concentrate or pasture for fattening lambs and its effect on carcass and meat quality. Small Ruminant Res., 2002; 43: 257-268.

12. Santos-Silva, J., Vaz Portugal, A.: The effect of weight on carcass and meat quality of Serra da Estrela and Merino Branco lambs fattened with dehydrated lucerne. Anim. Res., 2001; 50: 289-298.

13. Hopkins, D.L., Fogarty, N.M.: Diverse lamb genotypes. 2. Meat pH, colour and tenderness. Meat Sci., 1998; 49: 477-488.

14. Ekiz, B., Yilmaz, A., Ozcan, M, Kaptan, C., Hanoglu, H., Erdogan, I., Yalcintan, H.: Carcass measurements and meat quality of Turkish Merino, Ramlic, Kivircik, Chios and Imroz lambs raised under an intensive production system. Meat Sci., 2009; 82: 64-70.

15. Sheridan, R., Hoffman, L.C., Ferreira, A.V.: Meat quality of Boer goat kids and Mutton Merino lambs. 2. Sensory meat evaluation. Anim. Sci., 2003; 76: 73-79.

16. Sen, A.R., Santra, A., Karim, S.A.: Carcass yield, composition and meat quality attributes of sheep and goat under semiarid conditions. Meat Sci., 2004; 66: 757-763.

17. Anonymous: The Meat Tenderness Debate [web page on the Internet] 18.11.2005, The Natural Food Hub: http://www.naturalhub.com, 2005.

18. Bessa, R.J.B., Portugal, P.V., Mendes, I.A., Santos-Silva, J.: Effect of lipid supplementation on growth performance, carcass and meat quality and fatty acid composition of intramuscular lipids of lambs fed dehydrated lucerne or concentrate. Livest. Prod. Sci., 2005; 96: 185-194.

19. Esenbuga, N., Yanar, M., Dayioglu, H.: Physical, chemical and organoleptic properties of ram lamb carcasses from four fat-tailed genotypes. Small Ruminant Res., 2001; 39: 99-105.

20. Sañudo, C., Campo, M.M., Sierra, I., María, G.A., Olleta, J.L., Santolaria, P.: Breed effect on carcass and meat quality of suckling lambs. Meat Sci., 1997; 46: 357-365.

21. Santos-Silva, J., Bessa, R.J.B., Santos-Silva, F.: Effect of genotype, feeding system and slaughter weight on the quality of light lambs: II. Fatty acid composition of meat. Livest. Prod. Sci., 2002; 77: 187-194.

22. Oriani, G., Maiorano, G., Filetti, F., Di Cesare, C., Manchisi, A., Salvatori, G.: Effect of age on fatty acid composition of Italian Merino suckling lambs. Meat Sci., 2005; 71: 557-562.

23. Wood, J.D., Richardson, R.I., Nute, G.R., Fisher, A.V., Campo, M.M., Kasapidou, E., Sheard, P.R., Enser, M.: Effects of fatty acids on meat quality: a review. Meat Sci., 2004; 66: 21-32.

24. Kaya, Y., Duyar, H.A., Erdem, M.E.: The importance of fish fatty acids on human health. Ege Üniv. Su Ürün. Derg., 2004; 21: 365-370. (article in Turkish with an abstract in English)

25. Demirel, G., Ozpinar, H., Nazli, B., Keser, O.: Fatty acids of lamb meat from two breeds fed different forage: concentrate ratio. Meat Sci., 2006; 72: 229-235.

26. Díaz, M.T., Álvarez, I., De La Fuente, J., Sañudo, C., Campo, M.M., Oliver, M.A., Font i Furnols, M., Montossi, F., San Julián, R., Nute, G.R., Cañeque, V.: Fatty acid composition of meat from typical lamb production systems of Spain, United Kingdom, Germany and Uruguay. Meat Sci., 2005; 71: 256-263.

27. Díaz, M.T., Velasco, S., Pérez, C., Lauzurica, S., Huidobro, F., Cañeque, V.: Physico-chemical characteristics of carcass and meat of Manchega-breed suckling lambs slaughtered at different weights. Meat Sci., 2003; 65: 1085-1093.

28. Sañudo, C., Enser, M.E., Campo, M.M., Nute, G.R., María, G., Sierra, I., Wood, J.D.: Fatty acid composition and sensory characteristics of lamb carcasses from Britain and Spain. Meat Sci., 2000; 54: 339-346.