Emirates Journal of Food and Agriculture. 2015. 27(8): 636-642
doi: 10.9755/ejfa.2015.04.068
http://www.ejfa.me/

REGULAR ARTICLE

Meat quality and fatty acid composition of chios male lambs fed under traditional and intensive conditions

Sibel Soycan Önenç[1]*, Mürsel Özdoğan[2], Abdurrahman Aktümsek[3], Turgay Taşkın[4]

[1]Namık Kemal University, Agriculture Faculty, Animal Science Department, Tekirdağ, Turkey; [2]Adnan Menderes University, Agriculture Faculty, Animal Science Department, Aydın, Turkey; [3]Selçuk University Science Faculty, Biology Department, Konya; [4]Ege University, Agriculture Faculty, Animal Science Department, Izmir, Turkey

ABSTRACT

The study was conducted to compare the chemical composition, physicochemical characteristics, texture profile analysis (TPA) parameters and fatty acid composition of the meat of Chios male lambs fed under traditional and intensive conditions. A total of 34 lambs at the age of 3 months were used. The animals were randomly separated into traditional (T) and intensive (I) groups in equal numbers. The lambs in group T were fed on ration prepared in local style and grazed in olive grove for 8 h/day, while those in group I received 255 g alfalfa hay per animal and ad libitum mixed feed. The animals were slaughtered at 5 months of age. Significant differences were not found for chemical composition, physicochemical characteristics, and TPA parameters. Fatty acids such as C17: 0, C18: 0, C18: 1 Cc11, C18: 1 c9, C18: 2 c9c12, C18: 2 c9t11 and the total conjugated linoleic fatty acids in muscle differed significantly between the two groups. As a results of the study, it was found that Chios lambs fed intensively had particularly tender, vivid and bright meat however the contents of C18 fatty acid group and CLA were higher in lambs fed under traditional conditions.

Keywords: Chios lambs; Meat quality; Fatty acid composition; Traditional feeding; Intensive feeding

INTRODUCTION

Sheep farming has a multi-functional role by contributing beyond its productive function to include the management of rural areas, environmental sustainability, landscape conservation and regional development. In recent years, however, there have been substantial changes in response to numerous external factors, e.g., globalization, animal health and welfare concerns, environmental protection and consumer preferences (Boyazoglu, 2002).

The production of lamb meat in the region of Ege of Turkey is very important and traditionally based on lambs at the age of 4–6 months lambs. In this area, lamb production is constrained by the existing structure of sheep farming in the country and there is still a strong priority by the traditional consumer preferences for lamb meat. Besides, it is generally believed that Chios bred lambs has quality meat based on the lack of any negative feedback from either customers or markets so far (Önenç et al., 2009). In this regard, customers generally consider Chios lambs fed under traditonal conditions to have a good eating quality. As well known, meat quality of sheep is affected by breed, vegetation and feeding practices. Various aromatic compounds in natural vegetation during grazing may also affect the lamb meat quality (Kempt et al., 1981; Zervas et al., 1999; Özbey et al., 2000; Prioloa et al., 2002; Santos et al., 2008). It has been reported with previous studies (Esenbuğa et al., 2009; Yakan and Ünal, 2010) that there are important differences in animal feeding among geographical regions and even among districts. In addition, considering the expectations and demands of lamb customers, it is obvious that gourmet consumers prefer more delicious and healthier meat (Sarı et al., 2012). For that reason, many breeders have been revising their meat production methods, and endeavoring to update or improve the conventional methods in order to keep pace with market demands. These approaches include methods of lamb fattening within the extensive production system, performed according to regional conditions that can also be called "traditional" or "local" conditions.

***Corresponding author:**
S. Soycan-Önenç, Namık Kemal University, Agriculture Faculty, Animal Science Department, Tekirdağ, Turkey. Tel: +90 282 250 2186, Fax: +90282 250 9929. E-mail: ssonenc@nku.edu.tr

Received: 13 April 2015; **Revised:**13 May 2015; **Accepted:**15 May 2015; **Published Online:**15 May 2015

Non-breeding male Chios lambs commonly raised in Ege Region reach slaughter weight in early ages under intensive feeding conditions (Economides et al., 1990; Altınel et al., 1998, Zervas et al., 1999). However for healthier meat production with sensory attributes based on the changing consumer demands, producers prefer traditional feeding methods in animal production (Oliván et al., 2009).

The objectives of this study was to compare the traditional and intensive feeding conditions in terms of the meat quality of Chios lambs for the consumer.

MATERIALS AND METHODS

The study was conducted using seventeen pairs of male twins at 3 months of age which were not kept for breeding and had been raised in a commercial Chios sheep farm in Ege region. All the lambs had the same male parent. A total of 34 animals were randomly distributed into traditional (T) and intensive (I) groups at equal numbers. Initial body weights means were 31.80±1.44 kg and 34.72±1.21 kg respectively for traditional and intensive group, Traditional group was fed two times a day (morning and evening) with local style prepared rations and allowed to graze for 8 hours every day under olive trees. Intensive group was fed with 255 dry alfalfa per animal and ad libitum commercial mixed feed on a daily basis. All the animals consumed ad libitum water.

The nutrient requirements of the lambs in the intensive group were met by considering a 15% higher amount of daily dry matter intake reported by the NRC, (1985). The component contents of mixed feeds used in the experiment is given in Table 1 and the nutrient composition and energy values of the rations are given in Table 2. Proximate analysis of the feeds were carried out in accordance with standard methods described by AOAC, (2011).

Table 1: Composition (%) of the feed in traditional and intensive group

Component	T	I
Corn	30.00	30.00
Barley	25.00	-
Wheat	-	4.00
Sun flower seed meal	28.00	-
Canola pulp	-	3.50
Flaxseed pulp	-	5.50
Corn gluten feed	-	6.00
Fermentation waste dried maize solution (DDGS)	-	9.00
Wheat bran	5	19.00
Wheat flour for feed	-	16.00
Molasses	-	3.00
Limestone	3.00	2.80
Salt	0.80	1.00
Vitamin- mineral mixture[1]	0.20	0.20

[1]: Each kg of feed contains Vit. A 15000 IU, Vit D3 3000 IU, Vit E 30000 mcg, Mn 50000 mcg, Zn 50000 mcg, Fe 50000 mcg, Cu 10000 mcg, I 800 mcg, Co 150 mcg, and Se 150 mcg, T: Traditional group, I: Intensive group

At the end of the trial, lambs were slaughtered at 5 months of age. Final body weights means were 46.85±1.70 kg and 49.99±1.75 kg for traditional and intensive group, respectively. Prior to slaughtering, the lambs were subjected to a 12 h fasting period. The animals were transported by light duty vehicles from the farm to the abattoir. After 1 h transport and 2 h lairage time, they were slaughtered., After slaughter the carcasses were kept at +4°C for 24h. Meat samples were taken from *M. Longissimus dorsi* (MLD) muscle between the 12th and 13th ribs for chemical composition, physicochemical characteristics, texture profile analysis and fatty acid composition analyses. They were packaged in vacuum bags, subjected to a vacuum process and stored at -18°C until the analysis.

Analyses

The pH of the carcass was measured directly on the MLD between the 12th and 13th ribs at 24 hours post mortem using a pH meter (Testo205). L * (lightness), a * (redness) and b * (yellowness) values were measured on the cross-sectional area of *M. longissimus dorsi* by spectrocolorimeter (Konica Minolta CR-400). Glycogen levels in the muscle samples (mg/g tissue) were determined according to Roe et al., (1961). The amount of collagen in muscle (g/100 g tissue) was determined using the Reddy and Enwemeka, (1996) method and calculated according to Edward and O'Brien, (1980).

Tissue protein (%) was determined using the Bradford method as reported by Bradford (1976). Myoglobin was determined according to Hornsey, (1956) method. Myoglobin value (mg/g tissue) was measured with a spectrophotometer (Shimadzu UV-1700). The water content of the meat (%) was calculated based on the dry matter basis as described in the AOAC (2011) while the water holding capacity (%) was determined by the compression method of Grau and Hamm, (1956) (Barton-Gade et al., 1993). Thawing loss (%) was

Table 2: Chemical composition and energy contents of experimental feeds

Nutrient, %	T Roughage-concentrate feed mixture	I Commercial feed mixture	Alfalfa hay
Dry matter	84.70	86.30	90.21
Crude protein	8.50	17.50	12.09
Crude cellulose	24.00	7.10	28.70
Ca	0.50	1.21	1.45
P	0.30	0.63	0.26
ME, kcal/kg	1933.20	2484.00	1518.00

T: Traditional group, I: Intensive group

calculated by quantifying the water released from the meat (Honikel, 1997).

Cooking loss was determined in 1.5 cm thick meat samples of similar geometry, individually placed inside polyethylene bags in a water bath at 75 °C for 20 min until an ultimate temperature of 70 °C was reached and then cooled for 60 min. They were then taken from the bags, dried with paper and weighed (Campo, 1999). The weight loss, expressed as a percentage of the initial weight, was the cooking loss. After measurements of cooking loss, the same samples were used for determination of the texture parameters.

Texture Profile Analysis was performed on the meat samples (1 cm^3). The samples (five repetitions) were cut in parallel to the direction of the muscle fiber and TPA parameters, including hardness, chewiness, resilience and gumminess were determined according to the procedure suggested by Bourne, (1982). Full-scale load was set at 50 kg and chart drive and crosshead speeds were 5 mm/sec.

For determining fat and fatty acids contents, muscle samples were minced into a homogeneous mixture before analyzing. Fat in minced meat was extracted by homogenization with a standard chloroform: methanol mixture (2:1, v/v) as reported by Christie, (1992). The resulting fats were then subjected to an esterification process (Christie, 1992). Analysis of fatty acid methyl esters (FAME) was performed using an Agilent 6890N (Hewlett Packard) model gas chromatograph (GC), ion detector (FID) and HP-88 capillary column (100 m, 0.25 mm i.d. and 0.2 μm). The injector and detector temperatures of the device were increased to 250 and 280 °C, respectively. The initial oven temperature of 60°C was increased by 20 °C/min for 6.5 min and kept at 190° C for 60 minutes. Then, it was increased by 1°C/min to 220 °C, at which it was held for 10 min. The total running time was 107.5 min. Helium (1 mL/min) was used as a carrier gas. Prior to analysis of the samples, fatty acid standards (Alltech) were analyzed by GC in order to identify the peak retention times. The results were calculated as percentages (%) of the total fatty acid methyl esters. Each sample was repeated 3 times, and the results for fatty acid content were averaged.

The data were analysed using the "General Linear Model" procedure of SPPS, (1999). The model used accounted for the effects of group. The t-test was used to locate differences between means at the 5% level of probability.

RESULTS AND DISCUSSION

Chemical composition of MLD muscle in Chios lambsis given in Table 3. As shown in the table, there were no significant differences for dry matter, glycogen, protein, collagen and myoglobin in the MLD muscle between the two groups. When examining the results of the chemical analyses performed on MLD muscle of the lambs in this study, it was seen that changes in the feeding system did not affect the levels of dry matter, protein, collagen or myoglobin. However, glycogen level was higher in group I compared to group T although significant differences were not found. Our findings, like those of (Zervas and Tsiplakou, 2011; Carrasco et al., 2009; D'Alessandro et al., 2012) confirm that feeding does not affect muscle chemical parameters such as glycogen, protein, collagen and myoglobin.

Physicochemical characteristics and colour parameters for traditional and intensive groups are given in Table 4. Significant differences were not found for the examined characteristics between the two groups.

Although feeding system in this study appeared to have no effect on thawing loss, cooking loss, pH_{24}, a number of studies have reported that these parameters do change along with changes in feeding system (Skapetas et al., 2006; Rodriguez et al., 2008; Santos et al., 2008). However, our findings are in agreement with the findings of Cerdeno et al., (2006) who found no significant differences neither in meat pH value nor in colour between different feeding practices. Likewise Ripoll et al., (2008) reported that the final pH was not significantly different among lambs with 4 different grazing and feeding systems, contrary to the findings of Diaz et al., (2002). Besides other factors, the development of meat colour after the oxygenation of the meat surface is believed to be dependent on the final pH of the muscle, with meat lightness, being generally lower in meat with high ultimate pH (Confort and Egbert, 1985,

Table 3: Chemical composition of MLD muscle in Chios lambs[1]

	T	I	P value
Dry matter, %	23.12±0.889	23.48±0.678	0.070
Glycogen, mg/100 g tissue	73.14±19.27	78.28±25.86	0.197
Protein, %	24.24±2.96	23.25±0.76	0.502
Collagen, g/100 g tissue	0.18±0.013	0.17±0.019	0.962
Myoglobin, mg/g tissue	0.14±0.012	0.16±0.008	0.762

[1]: Least squares mean and standard errors, T: Traditional group, I: Intensive group

Table 4: Physicochemical characteristics of MLD muscle in Chios lambs[1]

	T	I	P value
Thawing loss, %	10.45±1.53	13.27±1.89	0.282
Cooking loss, %	34.13±1.28	30.42±1.94	0.149
pH_{24}	5.88±0.056	5.74±0.022	0.618
L*	62.04±0.87	65.28±1.06	0.377
a*	4.36±0.38	3.88±0.46	0.717
b*	6.38±0.79	3.90±0.97	0.948
c*	9.84±1.94	13.88±2.38	0.827

[1]: Least squares mean and standard errors, T: Traditional group, I: Intensive group

Young et al., 1999). This has been proposed as a possible explanation for the lower lightness (lower L*values) often observed in meat from pasture-fed animals compared to that from concentrate-fed ones (Priolo et al., 2002). In the present study, no differences in lightness were observed between meat from intensive-fed animals and meat from traditional-fed lambs. However, in the present study, traditional fed lambs had pale and dark meat colour compared to intensive group. These results, together with the lack of difference in meat redness (a*) and saturation (C*) between treatments, confirm previous findings showing that, in lambs (Luciano et al., 2009), differences in meat colour between concentrate- and pasture-fed animals are not evident when animals are allowed to grow at comparable rates. Moreover, it is also evident that colour differences of one CIE-LAB coordinate can be discerned by most normal observers (Hunter and Harold, 1987) and consumers can detect one CIELAB unit change in colour coordinates (Zhu and Brewer, 1999). Thus colour development in two groups could be detected by eye.

In this study, minor variation between both groups for meat quality parameter may be associated with shorter fattening period and age of animals. However, many studies have demonstrated differences in carcass and meat quality between older lambs under intensive feeding and pasture-based systems (Carrasco et al., 2009, Luciano et al., 2009, Barbut, 2014). Animals fattened under these two different systems had significantly different carcass fat and meat colour (Barwick, 1980, Priolo et al., 2002, Rodriguez et al., 2008), fatness status (Santos et al., 2002; Santos et al.,2008) and meat flavor (Saňudo et al., 2000). Our results related to meat colour disagree with the results of (Peña et al. (2005), Komprda et al. (2012), Juarez et al. (2009), Aguayo-Ulloa et al. (2013), Ripoll et al.(2012).

As shown in Table 5, texture parameters were lower in intensively fed lamb compared to the traditional fed lambs. These results show that the way of feeding of group I prevents glycogen level in muscle and so improves meat texture. Likewise, Immonen et al., (2000) reported lower shear force values in meats of high and intermediate glycogen contents compared to meats of low glycogen content.

Table 5: Texture profile analysis parameters of MLD muscle in Chios lambs[1]

	T	I	P value
Hardness, kg	6.80±0.554	5.54±0.882	0.212
Chewiness, kg	1.54±0.141	1.26±0.274	0.336
Resilience	0.39±0.013[a]	0.33±0.023[b]	0.226
Gumminess	3.76±0.276	3.24±0.491	0.333

[1]: Least squares mean and standard errors, T: Traditional group, I: Intensive group

The meat hardness, chewiness, resilience and gumminess values did not differ between groups. But, cooked meat from the MLD were better in intensive group, with their lower values indicating the meat was more tender, and less force was needed to cut it.

Less tender meat in group T is thought to be associated with higher daily movement activity. Therefore, higher muscle activity due to larger grazing fields appears to affect the textural measurements rather than feeding. Previous studies on this subject also reported the effect of physical activity on textural properties of meat (Martinez-Cerezo et al., 2005; Miranda-de la Lama et al., 2009; Majdoub-Mathlouthi et al., 2013).

Fatty acid composition of the MLD muscle in Chios lambs is shown in Table 6. The majority of the fatty acids with a chain length from 10 to 18 carbons did not differ in both groups.

Table 6: Fatty acid composition (%) of MLD muscle in Chios lambs[1]

	T	I	P value
C10:0	0.090±0.042	0.083±0.017	0.638
C11:0	0.015±0.008	0.011±0.003	0.180
C12:0	0.124±0.100	0.082±0.041	0.238
C13:0	0.014±0.006	0.011±0.003	0.232
C14:0	1.573±0.950	1.360±0.471	0.533
C15:0	0.229±0.074	0.269±0.028	0.130
C16:0	16.864±2.460	16.664±1.338	0.825
C16:1	0.203±0.071	0.171±0.024	0.196
C17:0	0.642±0.076	0.966±0.096	0.001
C18:0	16.764±0.946	15.057±1.168	0.002
C20:0	0.199±0.048	0.163±0.030	0.063
C22:0	0.579±0.103	0.635±0.082	0.198
C18:1	17.365±4.282	18.614±2312	0.428
C18:1 c11	1.149±0.134	1.833±0.338	0.001
C18:1, c9	2.976±0.592	3.420±0.324	0.050
C18:2 c9c12	0.225±0.032	0.130±0.061	0.001
C18:2, c9t11	0.608±0.123	0.432±0.124	0.005
C18:2 t10	0.037±0.014	0.051±0.016	0.063
C18:2	22.019±4.784	22.030±1.747	0.995
C18:3	0.491±0.144	0.459±0.076	0.537
C20:4	10.933±2.808	10.561±1.096	0.701
C22:3	1.241±0.779	1.426±0.439	0.522
C22:4	0.999±0.331	0.806±0.155	0.113
C22:5	0.281±0.139	0.267±0.101	0.800
C22:5	1.412±0.139	1.342±0.161	0.315
C22:6	0.270±0.049	0.297±0.061	0.294
Others	2.696±0.396	2.863±0.173	0.238
Σ CLA	0.645±0.117	0.483±0.113	0.006
Σ Trans	3.724±0.647	3.972±0.400	0.317
Σ SFA	37.259±3.028	35.455±1.650	0.115
Σ MUFA	19.744±4.676	21.893±2.397	0.212
Σ PUFA	38.626±8.156	38.200±2.888	0.878
Total	99.998±0.009	100.00±0.009	0.247

[1]: Least squares mean and standard errors, T: Traditional group, I: Intensive group

However, heptadecanoic (C17: 0), octadecanoic (C18: 0), cis-11-octadecanoic (C18: 1 c11), cis-9-octadecanoic (C18: 1 c9), cis-9 cis-12-octadecadienoic (C18:2 c9, 12), cis-9 trans-11-octadecadienoic (C18: 2 c9t11) acid and total conjugated linoleic acid (CLA Σ) levels differed significantly. The levels of heptadecanoic ($P < 0.01$), cis-11-octadecenoic ($P < 0.01$) and cis-9-octadecenoic ($P < 0.05$) acids in traditional group were statistically lower than that those in intensive group while the levels of octadecanoic ($P < 0.01$), cis -9, cis-12-octadecadienoic ($P < 0.01$), cis-9, trans-11-octadecadienoic ($P < 0.01$) acids and total conjugated linoleic acid ($P < 0.01$) were significantly higher in traditional group compared to intensive group.

According to previous research that yielded similar results, grain and roughage rich in polyunsaturated fatty acids have significant effects on tenderness and flavour of ruminant meats (Rousset-Akrim et al., 1997; Fisher et al., 2000; D'Alessandro et al., 2012). Meat from lambs fattened traditional has less odor and tenderness as compared to those with intensively fattening (Priolo et al., 2002; Resconi et al., 2009; Juarez et al., 2009). Another finding on this subject associated the presence of n-3 or n-6 PUFA in meat of lambs fed with roughage or grain. In Turkey, people have different taste preferences against lamb meat. As a result, some people have higher levels of n-6 PUFA. Strong odor and tenderness can vary depending on the meat composition.

In this study, it was observed that some fatty acids in the MLD muscle such as heptadecanoic (C17: 0), octadecanoic (C18: 0), cis-11-octadecenoic (C18: 1 c11), cis-9-octadecenoic (C18: 1 c9), cis-9 cis-12-octadecadienoic (C18: 2 c9,12), cis-9, trans-11-octadecadienoic (C18: 2 c9t11) and total conjugated linoleic acid (CLA Σ) were changed by feeding practices. Variation in the group T were likely to due to their grazing in fields with olive trees. In previous studies, it has been reported that certain fatty acids and the CLA group are likely to change depending on feeding differences or pasture-based feeding (Auroussea et al., 2007; Lind et al., 2009). Thus, some fatty acids taken with feed can be directly subjected to conversion in the rumen (conversion to CLA fatty acids) while some fatty acids of the C18: 0, C18: 1 and C18: 2 groups are not converted in the rumen but rather retained in muscle and fat tissues (Griinar et al., 2000; Díaz et al., 2002; Loor and Herbein, 2003; Manso et al., 2009, Vasta et al., 2008). On the other hand, Petrova et al., (1994) reported that the fatty acids taken with intense feeding ration did not stay long enough in the rumen for bio-hydrogenation; therefore the fatty acid composition of meat could be affected by that of the ration.

CONCLUSION

This study showed that chemical properties of MLD muscle, textural parameters and the levels of certain fatty acids varied under traditional and intensive conditions. However, the effects of feeding practice on meat quality and color parameters as well as certain muscle chemical properties were not statistically significant. Textural attributes of lamb fed intensive appeared lower than those of the lam fed traditional.

It was found that the fatty acid composition of MLD muscle in Chios lambs statistically changed due to different feed resources. It is noteworthy that C18 fatty acid group changed and fatty acids of CLA group were particularly higher in the group T.

ACKNOWLEDGEMENTS

This study was financed under a project supported by the Ege University Research Fund (project no: 2008-ZRF-036).

Author contributions

S.S.Ö.: Did chemical composition, physicochemical characteristics, texture profile analysis of meat and wrote article, M.Ö: Designed the study, collected data, supported in providing literature, A.A.: Did the fatty acid composition analysis, T.T.: Conducted the research work and proofreading and corrected the article.

REFERENCES

Aguayo-Ulloa, L. A., G. C. Miranda-de la Lama, M. Pascual-Alonso, K. Fuchs, J. L. Olleta, M. M. Campo, M. M. Alierta, M. Villarroel and G. A. Maria. 2013. Effect of feeding regime during finishing on lamb welfare, production performance and meat quality. Small Rumin. Res. 111: 147-156.

Altınel, A., M. Evrim, M. Özcan, H. Başpınar and F. Deligözlü. 1998. Studies on possibility of producing high quality lambs by crossbreeding among Sakız, Kıvırcık and German black headed mutton sheep. Turk. J. Vet. Anim. Sci. 22: 257-265.

AOAC. 2011. Official Methods of Analysis, 18th ed. Revision. 4. Association of Official Analytical Chemists, Washington, D. C.

Aurousseau, B., D. Bauchart, X. Faure, A. L. Galot, S. Prache, D. Micol and A. Priolo. 2007. Indoor fattening of lambs raised on pasture: (1) Influence of stall finishing duration on lipid classes and fatty acids in the longissimus thoracis muscle. Meat Sci. 76: 241-252.

Barbut, S. 2014. Review: Automation and meat quality-global challenges. Meat Sci. 96: 335-345.

Barton-Gade, P. A., D. Demeyer, K. O. Honikel, R. L. Joseph, E. Puolanne, M. Severini, F. Smulders and E. Tonberg. 1993. Reference methods for water holding capacity in meat and meat products: Procedures recommended by an OECD working group. 39th International Congress of Meat Science and Technology, Calgary, File S4 Po2, WP.

Barwick, S. A. 1980. Carcass measurements and their association with yield of cuts and tenderness of lamb. Wool Technol. Sheep Breed. 28: 19-23.

Bourne, M. C. 1982. Food Texture and Viscosity: Concept and Measurement. 2nd ed. Academic Press Inc., London, UK.

Boyazoglu, J. 2002. Livestock research and environmental sustainability with special reference to the Mediterranean basin. Small Rumin. Res. 45: 193-200.

Bradford, M. M. 1976. A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principles of protein-dye binding. Anal. Biochem. 72: 248-254.

Campo, M. M. 1999. Influencia de la Raza Sobre la Textura y las Caracteristicas Sensoriales de la Carne Bovina a lo Largo de la Maduracion. Tesis Doctoral. Universidad de Zaragoza Facultad de Veterinaria. España.

Carrasco, S., B. Panea, G. Ripoll, A. Sanz and M. Joy. 2009. Influence of feeding systems on cortisol levels, fat colour and instrumental meat quality in light lambs. Meat Sci. 83: 50-56.

Cerdeno, A., C. Vieira, E. Serrano, P. Lavín and A. R. Mantecón. 2006. Effects of feeding strategy during a short finishing period on performance, carcass and meat quality in previously-grazed young bulls. Meat Sci. 72: 719-726.

Christie, W. W. 1992. Gas Chromatography and Lipids: A Practical Guide. The Oily Press, Ayr., Scotland. Pp. 64-128.

Cornforth, D. P. and W. R. Egbert. 1985. Effect of rotenone and pH on the color of prerigor muscle. J. Food Sci. 50: 34-35, 44.

D'Alessandro, A. G., G. Maiorano, B. Kowaliszyn, P. Loiudice and G. Martemucci. 2012. How the nutritional value and consumer acceptability of suckling lambs meat is affected by the maternal feeding system. Small Rumin. Res. 106: 83-91.

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

Economides, S., A. Koumas, E. Georghiades and M. Hadjipanayiotou. 1990. The effect of barley-sorghum grain processing and form of concentrate mixture on the performance of lambs, kids and calves. Anim. Feed Sci. Tech. 31(1-2): 105-116.

Edward, C. A. and W. D. O'brien. 1980. Modified assay for determination of hydroxyproline in a tissue hydrolyzate. Clin. Chim. Acta. 104: 161-167.

Esenbuga, N., M. Macit, M. Karaoglu, V. Aksakal, M. I. Aksu, M. A. Yoruk and M. Gul. 2009. Effect of breed on fattening performance, slaughter weight and meat quality characteristics of Awassi and Morkaraman lambs. Livest. Sci. 123: 255-260.

Fisher, A. V., M. Enser, R. I. Richardson, J. D. Wood, G. R. Nute, E. Kurt, L. A. Sinclair and R. G. Wilkinson. 2000. Fatty acid composition and eating quality of lamb types derived from four diverse breed x production systems. Meat Sci. 55: 141-147.

Grau, R. and R. Hamm. 1956. Determination of water binding in meat by the pressing method. Fleischwirtschaft. 8: 733-736.

Griinari, J. M., B. A. Corl, S. H. Lacy, P. Y. Chouinard, K. V. V. Nurmela and D. E. Bauman. 2000. Conjugated linoleic acid is synthesized endogenously in lactating dairy cows. J. Nutr. 130: 2285-2291.

Honikel, K. O. 1997. Reference methods supported by OECD and their use in mediterranean meat products. Meat Sci. 59(4): 573-582.

Hornsey, H. C. 1956. The colour of cooked cured pork. I. Estimation of the nitric oxide-haem pigments. J. Sci. Food Agric. 7: 534-540.

Hunter, R. S and R. W. Harold. 1987. The Measurement of Appearance. New York, Wiley-Interscience.

Immonen, K. and E. Puolanne. 2000. Variation of residual glycogenglucose concentarion at ultimate pH values below 5.75. Meat Sci. 55: 279-283.

Juarez, M., A. Horcada, M. J. Alcalde, M. Valera, O. Polvillo and A. Molina. 2009. Meat and fat quality unweaned lambs as affected by slaughter weight and breed. Meat Sci. 83: 308-313.

Kempt, J. D., M. Mahyuddin, D. G. Ely, J. D. Fox and W. G. Moody. 1981. Effect of feeding systems, slaughter weight and sex on organic properties, and fatty acid composition of lamb. Turk. J. Vet. Anim. Sci. 51: 321-330.

Komprda, T., J. Kuchtik, A. Jarosova, E. Drackova, L. Zemanek and B. Filipcik. 2012. Meat quality characteristics of lambs of three organically raisedbreeds. Meat Sci. 91: 499, 505.

Lind, V., J. Berg, L. O. Eik, J. Mølmann, E. Haugland, M. Jørgensen and M. Hersleth. 2009. Meat quality of lambs: Pre-slaughter fattening on cultivated or mountain range pastures. Meat Sci. 83: 706-712.

Loor, J. J. and J. H. Herbein. 2003. Dietary canola or soybean oil with two levels of conjugated linoleic acids (CLA) alter profiles of 18:1 and 18:2 isomers in blood plasma and milk fat from dairy cows. Anim. Feed Sci. Tech. 103(1-4): 63-83.

Luciano, G., F. J. Monahan, V. Vatsa, L. Biondi, M. Lanza and Priolo, A. 2009. Dietary tannins ımprove lamb meat colour stability. Meat Sci. 81: 120-125.

Majdoub-Mathlouthi, L., B. Said, A. Say and K. Kraiem. 2013. Effect of concentrate level and slaughter body weight on growth performances, carcass traits and meat quality of Barbarine lambs fed oat hay based diet. Meat Sci. 93: 557-563.

Manso, T. R. Bodas, T. Castro, V. Jimeno and A. R. Mantecon. 2009. Animal performance and fatty acid composition of lambs fed with different vegetable oils. Meat Sci. 83: 511-516.

Martinez-Cerezo, S., C. Sañudo, B. Panea, I. Medel, R. Delfa, I. Sierra, J. A. Beltran, R. Cepero and J. L. Olleta. 2005. Breed, slaughter weight and ageing time effects on physico-chemical characteristics of lamb meat. Meat Sci. 69: 325-333.

Miranda-de la Lama, G. C., M. Villarroel, J. L. Olleta, S. Alierta, C. Sañudo and G. A. Maria, 2009. Effect of the pre-slaughter logistic chain on meat quality of lambs. Meat Sci. 83: 604-609.

NRC. 1985. Nutrient requirements of sheep. 6th Revised ed. National Academy Press, Washington, D. C.

Özbey, O., F. Esen and M. H. Aysöndü. 2000. Production characteristics of Kıvırcık x (Chios x Red Karaman) F1 and Chios x (Kıvırcık x Red Karaman) F1 crossbreed lambs II. Fattening performance and carcass characteristics. Yüzüncü Yıl Univ. Vet. Faculty. J. 11: 34-40.

Oliván, M., V. Sierra, P. Castro, A. Martinez, R. Celeya and K. Osoro. 2009. Carcass and meat quality from yearling bulls managed under organic or conventional systems. 60th Annual meeting of the european federation of animal science – EAAP 2009. Session 05. 24 August, Barcelona, Spain, p. 38.

Önenç A., K. Metin, T. Taşkın, S. Kayaardı, F. Kıral, H. Akşit, Z. B. B. Ateşlier and Ö. Koç. 2009. A study on the evaluation of carcass and meat quality of common , slaughtered cattle and sheep breeds in Turkey under EUROP classification system (TÜBİTAK Project No: 106O722).

Peña, F., T. Cano, V. Domenech, Ma J. Alcalde, J. Martos, A. Garcia-Martinez, M. Herrera and E. Rodero. 2005. Influence of sex, slaughter weight and carcass weight on non-carcass and carcass quality in segurena lambs. Small Rumin. Res. 60: 247-254.

Petrova, Y., V. Banskalieva and V. Dimov. 1994. Effect of feed on distribution of fatty acids at Sn-2-position in triacylglycerols of different adipose tissue in lambs. Small Rumin. Res. 13: 263-267.

Priolo, A., D. Micol, J. Agabriel, S. Prachea and E. Dransfieldb. 2002. Effect of grass or concentrate feeding systems on lamb carcass and meat quality. Meat Sci. 62: 179-185.

Reddy, G. K. and C. S. Enwemeka. 1996. A simplified method for the analysis of hydroxyproline in biological tissues. Clin. Biochem. 29: 225-229.

Resconi, V. C., M. M. Campo, M. F. Furnols, F. Montossi and C. Sañudo. 2009. Sensory evaluation of castrated lambs finished on different proportions of pasture and concentrate feeding systems. Meat Sci. 83: 31-37.

Ripoll, G., M. Alberti and M. Joy. 2012. Influence of alfalfa grazing-based feding systems oncarcass fat clour and meat quality of light lambs. Meat Sci. 90: 457-464.

Ripoll, G., M. Joy, F. Muñoz and P. Albertí. 2008. Meat and fat colour as a tool to trace grass-feeding systems in light lamb production. Meat Sci. 80: 239-248.

Rodriguez, A. B., R. Bodas, N. Prieto, R. Landa, A. R. Mantecón and F. J. Giráldez. 2008. Effect of sex and feeding system on feed ıntake, growth and meat and carcass characteristics of fattening assaf lambs. Livest. Sci. 116: 118-125.

Roe, J. H., J. M. Bailey, R. R. Gray and J. N. Robinson. 1961. Complete removal of glycogen from tissues by extraction with cold trichloroacetic acid solution. J. Biol. Chem. 236: 1244-1246.

Rousset-Akrim, S., O. A. Young. and J. Berdagué. 1997. Diet and growth effects in panel assessment of sheepmeat odour and flavour. Meat Sci. 45: 169-181.

Santos, V. A. C., I. A. Mendes and R. J. B. Bessa. 2002. The Effect of genotype, feeding system and slaughter weight on the quality of light lambs. 1. Growth carcass composition and meat quality. Livest. Prod. Sci. 76: 17-25.

Santos, V. A. C., S. R. Silva and J. M. T. Azevedo. 2008. Carcass composition and meat quality of equally mature kids and lambs. J. Anim. Sci. 86: 1943-1950.

Sañudo, C., M. Alfonso, A. Sánchez, A. Delfa and A. Teixeria. 2000. Carcass and meat quality in light lambs from different fat classes in the eu carcass classification system. Meat Sci. 56: 89-94.

Sarı, M., A. R. Aksoy, M. Tilki, İ. Kaya and S. Işık. 2012. Effect of different fattening methods on slaughter and carcass characteristics of Tuj male lambs. Arch. Tierzucht. 55: 480-484.

Skapetas, B., E. Sinapis, J. Hatziminaouglou, A. Karalazos and J. Katanos. 2006. Effect of age at slaughter on carcass characteristics and carcass composition in lambs of mountain grek breeds. Czech J. Anim. Sci. 51: 311-317.

SPSS. 1999. Spss for Windows, Advanced Statistics Release 10. SPSS, Chigago, USA.

Vasta, V., A. Nudda, A. Cannas, M. Lanza and A. Priolo. 2008. Alternative feed resources and their effects on the quality of meat and milk from small runinants. Anim. Feed Sci. Tech. 147: 223-246.

Yakan, A. and N. Ünal. 2010. Meat production traits of a new sheep breed called Bafra in Turkey 2. Meat quality characteristics of lambs. Trop. Anim. Health. Prod. 42: 743-750.

Young, O. A., A. Priolo, N. J. Simmons and J. West. 1999. Effects of rigor attainment temperature on meat blooming and colour on display. Meat Sci. 52: 47-56.

Zervas, G., I. Hadjigeorgiou, G. Zabeli, K. Koutsotolis and C. Tziala. 1999. Comparison of a grazing – with an indoor-system of lamb fattening in Greece. Livest. Sci. 61: 245-251.

Zervas, G. and E. Tsiplakou. 2011. The effect of feding systems on the characteristics of products from small ruminants. Small Rumin. Res. 101: 140-149.

Zhu, L. G. and M. S. Brewer. 1999. Relationship between instrumental visual color in a raw, fresh beef and chicken model system. J. Muscle Foods. 10: 131-146.