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RESEARCH ARTICLE

Effect of Feeding Regime on Fatty Acid Composition of *Longissimus dorsi* Muscle and Subcutaneous Adipose Tissue of Akkaraman Lambs [1]

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Summary

In this study, effect of feeding regime on fatty acid composition including conjugated linoleic acid (CLA) of *Longissimus dorsi* muscle and subcutaneous adipose tissue from lambs were investigated. From same flock, forty-five male Akkaraman suckling lambs, the most common lamb breeds in Turkey, were fed mainly maternal milk from birth to weaning and then were divided into three groups (only maternal milk-fed group, pasture-fed group and concentrate-fed group) at three months of age with an average live weight of 25 kg. *Longissimus dorsi* muscle from pasture fed-lambs contained significantly more total CLA, n-3 and n-3/n-6 ratio than other groups. In addition, pasture-fed lambs contained significantly more total saturated fatty acid (SFA), CLA, n-3 and n-3/n-6 ratio compared concentrate fed-lambs in subcutaneous adipose tissue. In conclusion, intramuscular muscle and subcutaneous adipose tissue fatty acid composition of lamb can be improved by pasture in the feeding regime.

Keywords: *Lamb, Pasture, Concentrate, Longissimus dorsi, Subcutaneous adipose tissue, Fatty acid composition, Conjugated linoleic acid*

Akkaraman Kuzuların *Longissimus dorsi* kası ve Subkutan Adipoz Dokusunun Yağ Asidi Bileşimi Üzerine Besleme Rejiminin Etkisi

Özet

Bu çalışmada, kuzuların *Longissimus dorsi* kası ve subkutan adipoz dokusunun konjuge linoleik asiti de (CLA) içeren yağ asidi bileşimi üzerine besleme rejiminin etkisi araştırılmıştır. Aynı sürüden, Türkiye'deki en yaygın koyun ırkı olan 45 erkek Akkaraman süt kuzusu doğumdan sütten kesime kadar başlıca anne sütü ile beslenmiş ve sonra üç aylık ve ortalama 25 kg ağırlığında iken 3 gruba ayrılmıştır (sadece anne sütü ile beslenen grup, mera ile beslenen grup ve konsantre yem ile beslenen grup). Mera ile beslenen kuzuların *Longissimus dorsi* kası, diğer gruplara göre önemli derecede fazla toplam CLA, n-3 ve n-3/n-6 oranı içermektedir. Bunun yanısıra, subkutan adipoz dokusunda merada beslenen kuzular konsantre yem ile beslenen kuzulara kıyasla önemli derecede daha fazla toplam doymuş yağ asidi (SFA), CLA, n-3 ve n-3/n-6 oranı içermektedir. Sonuç olarak, kuzuların intramuskular kası ve subkutan adipoz dokusunun yağ asidi bileşimi besleme rejiminde mera kullanılarak iyileştirilebilir.

Anahtar sözcükler: *Kuzu, Mera, Konsantre yem, Longissimus dorsi, Subkutan adipoz doku, Yağ asidi bileşimi, Konjuge linoleik asit*

INTRODUCTION

Ruminant fat has a higher SFA and a lower PUFA/SFA ratio than non-ruminant fat, due to hydrogenation of dietary unsaturated fatty acids in the rumen [1]. The amount of fat in the diet, and especially its content of saturated fatty acids, are considered major risk factors for coronary heart disease [2] nevertheless, a low intake of saturated fat

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and an increased PUFA/SFA ratio are associated with a lower risk of human coronary heart disease [3].

CLA is a collective term for different positional and geometric isomers of octadecadienoic acid and naturally occuring fatty acid found in ruminant fats. Two of the isomers (*c*9,*t*11 and *t*10,*c*12) are known to possess biological activity [4]. The major CLA isomer, 18:2 *c*9,*t*11, is produced in the rumen during the microbial biohydrogenation of dietary 18:2n-6 and in the tissues through delta 9 desaturation of 18:1*t*11 [5]. Among the fatty acids, great attention is given to n-3 fatty acids [6], and CLA which would have beneficial properties for human health [7]. Some isomers of CLA, in particular *c*9,*t*11 and *t*10,*c*12, have been associated with inhibition of carcinogenesis [8], reduction of atherosclerosis [9], stimulate the immune system [10] and reduction of body weights [11].

Diet has been shown to be one of the main factors influencing fatty acid composition of lambs' fat [12]. Pasture raised lambs have shown higher proportion of n-3 fatty acids, CLA, *trans*-octadecenoic fatty acid and lower n-6/n-3 ratio than lambs fed concentrate *ad libitum* [13]. The nutritional value of n-3 PUFAs in the human diet is well recognized and increased consumption of these fatty acids has been recommended and nutritional guidelines, therefore, recommend a higher consumption of n-3 PUFA, suggesting a n-6/n-3 ratio at 4/1 or lower for the total diet [2].

Akkaraman is the most widespread sheep breed in central Anatolia and accounts for 40-50% of sheep population in Turkey [14]. Akkaraman sheep is one of the fat-tailed breeds and approximately 87% of the sheep population in Turkey is fat-tailed breeds [15].

The objective of the study was to characterise the effects of different feeding regime, (maternal milk, pasture and concentrate) on fatty acid composition of *Longissimus dorsi* muscle and sub-cutaneous adipose tissue, especially n-3 fatty acids and CLA, of Akkaraman lambs.

MATERIALS and METHODS

Animals and Diets

Forty-five male Akkaraman suckling lambs, born in the same farm, were fed mainly maternal milk and a small amount of lamb starter during first three months from birth to weaning and then the suckling lambs were divided into three equal groups at three months of age with an average live weight of 25 kg. One group of the suckling lambs (only maternal milk-fed group) was directly slaughtered after weaning. After one week adaptation period, other group of the suckling lambs was allowed to graze a natural pasture (pasture group) everyday from weaning to slaughter. These lambs were slaughtered at three months after weaning. The other group (concentrate group) was fed concentrate *ad libitum* together with 150 g/day alfalfa from weaning to slaughter. These lambs were slaughtered at three months after weaning. Ingredients and chemical composition and fatty acid composition of the concentrate feed are presented in *Table 1* and *2*.

Muscle and Subcutaneous Adipose Tissue Sampling

When the all lambs were slaughtered, carcasses were immediately transferred to cooler at 4°C. After 24 h conservation period, 10 g *Longissimus dorsi* muscle and subcutaneous adipose tissue samples were collected from each carcass. *Longissimus dorsi* and sub-cutaneous adipose tissue samples were taken between the 12th-13th ribs and 9th-11th ribs, respectively. Samples were vacuum packaged, frozen and stored at -27°C until analysis.

Fatty Acid Analysis

Total lipids of lambs and concentrate feed were extracted with chloroform/methanol (2:1 v/v) according to Folch et al.[16] method. Fatty acid methyl esters (FAMEs) were prepared by transmethylation, using KOH 2 mol/L in methanol and n-heptane, according to method 5509 of the ISO [17].

The FAMEs were analyzed on a HP (Hewlett Packard, Palo Alto, CA.) Agilent 6890N model gas chromatograph (GC), equipped with a flame ionization detector (FID) and fitted with a HP-88 capillary column (100 m, 0.25 mm i.d. and 0.2 µm). Chromatographic conditions were performed according to Ledoux et al.[18] method modified as follows:

Table 1. *Ingredients and chemical composition of the concentrate feed (%)*
Tablo 1. *Konsantre yemin içeriği ve kimyasal bileşimi*

Ingredients	**%**
Corn	50
Bran	18.2
Soybean meal	4
Sodium chloride	1
Sunflower seed meal	21.6
Vegetable oil	2.15
Marble powder	2.8
*Vitamin and mineral premix	0.25
Chemical Composition	
Moisture	8.3
Ash	6.96
Crude protein	14.14
Starch	4.56
Sugars	36.85
Crude fat	4.5
Crude cellulose	9.81
Calculated metabolizable energy (kcal/kg)	2505

** In per 10 kg feed,* ***Vitamin A:*** *12.500.000 IU;* ***Vitamin*** B_3***:*** *2.500.000 IU;* ***Vitamin E:*** *20.000 mg;* ***Vitamin*** B_1***:*** *5.000 mg;* ***Niacin:*** *20.000 mg;* ***Choline chloride:*** *10.000 mg;* ***Manganese:*** *30.000 mg;* ***Iron:*** *50.000 mg;* ***Zinc:*** *50.000 mg,* ***Copper:*** *8.000 mg;* ***Cobalt:*** *1.000 mg;* ***Iodine:*** *1.500 mg;* ***Selenium:*** *500 mg;* ***Magnesium:*** *20.000 mg;* ***Phosphor:*** *50.000 mg;* ***Sodium bicarbonate:*** *400.000 mg*

Table 2. *Fatty acid composition of concentrate feed [a] (g/100 g total fatty acids)*

Tablo 2. *Konsantre yemin yağ asidi bileşimi [a](g/100 g toplam yağ asidi)*

Fatty Acids	Concentrate Feed
C 14:0	0.08±0.01 [b]
C 15:0	0.03±0.00
C 16:0	12.33±0.03
C 17:0	0.09±0.02
C 18:0	3.18±0.03
C 20:0	0.47±0.08
Σ SFA [c]	**16.18± 0.09**
C 16:1n-7	0.11±0.02
C 17:1n-8	0.07±0.01
C 18:1n-9	26.80±0.07
C 20:1n-9	0.35±0.03
Σ MUFA [c]	**27.32±0.03**
C 18:2n-6	51.81±0.15
C 18:3n-6	0.27±0.05
C 18:3n-3	4.02±0.01
C 20:5n-3	0.24±0.04
C 22:5n-6	0.04±0.01
C 22:5n-3	0.14±0.01
Σ PUFA [c]	**56.51±20.15**
Σ n-3	**4.40±0.05**
Σ n-6	**52.12±0.11**
n-3/n-6	**0.08±0.00**
n-6/n-3	**11.85±0.14**

*[a] Average of three lots analyzed, [b] Values reported are mean ± SD, [c] **SFA:** Saturated fatty acid, **MUFA:** Monounsaturated fatty acid, **PUFA:** Polyunsaturated fatty acid*

injector and detector temperatures were 250 and 280ºC, respectively. The oven was programmed at 60ºC initial temperature and 1 min initial time. Thereafter the temperature increased at 20ºC/min to 190ºC held for 60 min then increased at 1ºC/min to 220ºC and held for 10 min at 220ºC. Total run time was 107.5 min. Carrier gas was helium (1 ml/min). GC analysis of FAMEs was performed at three replications.

Identification of fatty acids and *trans* isomers were carried out by comparing sample FAME peak relative retention times with those obtained for Alltech, Nu-Check Prep. Inc. USA and Accu standards. Linoleic acid conjugated methyl ester (mixture of *cis*- and *trans*-9,11- and -10,12-octadecadienoic acid methyl esters, catalog number O5632) was purchased from Sigma-Aldrich (St Louis, MO, USA). Results were calculated using FID response area and were expressed as gram per 100 g total fatty acid methyl esters. The results are offered as mean ± SD.

Statistical Analysis

The results were submitted to analysis of variance (ANOVA), at 0.05 significance level, using SPSS 10.0. The mean values were compared with Duncan test[19,20].

RESULTS

Slaughter traits and total lipid levels in *Longissimus dorsi* muscle and subcutaneous adipose tissue of Akkaraman lambs are presented in *Table 3* and *4*, respectively. Fatty acid composition of *Longissimus dorsi* muscle and subcutaneous adipose tissue fat from lambs fed on different diets containing maternal milk, concentrate or pasture are given in *Table 5* and *6*, respectively.

Total SFA was 52.09, 47.59 and 46.30 g/100 g total fatty acids in intramuscular muscle and 54.70, 50.77 and 41.79 g/100 g total fatty acids in subcutaneous adipose tissue from pasture, maternal milk and concentrate-fed lambs, respectively. Total SFA in pasture, concentrate or maternal milk-fed lamb's subcutaneous adipose tissue was significantly affected by feeding regime. Total SFA in pasture or concentrate-fed lamb's muscle was affected by feeding regime. C 16:0 palmitic acid, C 18:0 stearic acid and C 14:0 myristic acid were the major SFA from maternal milk, pasture and concentrate fed-lambs in *Longissimus dorsi* muscle and subcutaneous adipose tissue. Total SFA, palmitic acid, stearic acid, myristic acid and C 12:0 lauric acid were higher from pasture-fed lambs than concentrate-fed lambs muscle and subcutaneous adipose tissue.

Total MUFA was 37.15, 37.35 and 41.16 g/100 g total fatty acids in *Longissimus dorsi* muscle and 39.84, 33.44 and 41.99 g/100 g total fatty acids in subcutaneous adipose tissue of maternal milk-fed, pasture-fed and concentrate-fed lambs, respectively. Muscle and subcutaneous adipose tissue from animals fed on concentrate diets had higher C 18:1 oleic acid than those of pasture-fed.

Total PUFA was 4.30 g/100 g total fatty acids in

Table 3. *Comparison of the slaughter traits of maternal milk, concentrate and pasture-fed Akkaraman lambs*

Tablo 3. *Anne sütü, konsantre yem ve mera ile beslenen Akkaraman kuzuların kesim özelliklerinin karşılaştırılması*

Slaughter Traits	Maternal Milk Group (n=15) Mean ± SE*	Concentrate Group (n=15) Mean ± SE*	Pasture Group (n=15) Mean ± SE*
Age at slaughter (days)	90	180	180
Live weight at slaughter (kg)	25.18±0.75	46.08±0.75	35.07±0.55
Hot carcass weight (kg)	12.44±0.49	24.05±1.60	17.20±0.94

** SE = standard error of the mean*

Table 4. *Total lipid levels in longissimus dorsi muscle and subcutaneous adipose tissue of Akkaraman lambs*
Tablo 4. *Akkaraman kuzuların longissimus dorsi kası ve subkutan adipoz dokusunun total lipid seviyeleri*

Groups	**Total Lipid (%)**	
	***Longissimus dorsi* Muscle Mean ± SD ***	**Subcutaneous Adipose Tissue Mean ± SD**
Maternal milk-fed group	6.2±0.36	69.8±1.39
Concentrate-fed group	14.2±0.75	70.5±1.30
Pasture-fed group	3.8±0.08	59.5±1.13

** SD= standard deviation of the mean*

concentrate-fed lambs, 5.46 g/100 g total fatty acids in pasture-fed lambs and 10.44 g/100 g total fatty acids in maternal milk-fed lambs muscle. Total PUFA was higher in pasture-fed lamb muscle than concentrate-fed lamb but no significant differences were observed between pasture and concentrate-fed lambs. In subcutaneous adipose tissue, total PUFA was 4.96, 3.32 and 3.69 g/100 g total fatty acids in concentrate, pasture and maternal milk-fed lambs, respectively. Total PUFA in subcutaneous adipose tissue was significantly higher in concentrate-fed lambs than pasture ones. The high value of C 18:2 linoleic acid in concentrate feed (51.81 g/100 g total fatty acids) increased this fatty acid and total PUFA in subcutaneous adipose tissue of concentrate-fed lambs.

Pasture feeding significantly enhanced total CLA in Akkaraman lambs muscle and subcutaneous adipose tissue compared to concentrate-fed lambs. C18:2 *c*9,*t*11 (rumenic acid) and total CLA was more than three times higher in muscle of pasture-fed lambs than in concentrate-fed lambs. Rumenic acid and total CLA was more than two times higher in subcutaneous adipose tissue of pasture-fed lambs than in concentrate-fed lambs.

For n-3 fatty acids and n-3/n-6 ratio, significant differences were observed between muscle and adipose tissue of pasture and concentrate groups. Concentrate-fed lambs muscle and subcutaneous adipose tissue had higher n-6/n-3 ratio and pasture feeding decreased this ratio.

DISCUSSION

In all feeding regime, the predominant fatty acids in intramuscular fat and subcutaneous adipose tissue fat were palmitic acid and stearic acid as SFA, oleic acid as MUFA and linoleic acid as PUFA. These results were similar to those reported by Osorio et al.[21], Wistuba et al.[22] and Lee et al.[23] on the fatty acid composition of ruminants subcutaneous adipose tissue and Demirel et al.[24], Fisher et al.[25], French et al.[1] and Nuernberg et al.[26] for both pasture and concentrate-fed lambs muscle. Juarez et al.[27] also reported similar results for fatty acid composition of subcutaneous fat of suckling and light lambs. Talpur et al.[28] also reported that fatty acid composition of goat's muscle, reared on naturally grown grasses, were primarily composed of oleic acid (31.50-33.38%), follewed by palmitic acid (19.84-22.05%) and stearic acid (22.25-24.91%).

Velasco et al.[29] reported higher values of SFA (66.32-63.71%) for subcutaneous fat of lambs raised under pasture or drylot compared to our results. Talpur et al.[28] also reported similar values of SFA (51.13%) for muscle tissue of Pateri goats. In accordance with our results, palmitic acid, stearic acid and myristic acid were the major SFA in all lambs. These results agreed with Aurousseau et al.[30], Demirel et al.[24], Scerra et al.[31] and Nuernberg et al.[26] for lamb muscle and Velasco et al.[29] for subcutaneous fat who reported that palmitic acid, stearic acid and myristic acid were major SFA of in pasture and drylot lambs. Lee et al.[23] also reported similar results of these fatty acids for subcutaneous fat from lambs raised on pasture with a grain suplement. Similar to our results, Nuernberg et al.[26] found that total SFA, palmitic acid, lauric acid and myristic acid were higher in muscle of pasture kept lambs and Demirel et al.[24] found that palmitic acid, myristic acid and stearic acid were higher in muscle of lambs fed-grass hay than those of fed-concentrate.

The values of total MUFA in our study were similar to those reported by Diaz et al.[32] on the *Longissimus dorsi* muscle fatty acid content of Spain and Uruguayan lambs fed concentrate (42.58%) and grazing (37.90%), respectively. Similarly, Velasco et al.[29] reported that drylot lambs displayed higher levels of MUFA than raised at pasture in the subcutaneous fat. In our study, total MUFA from pasture and concentrate lamb's meat was affected by feeding regime. Similarly, Cividini et al.[33] found lower percentage of MUFA in *Longissimus dorsi* of pasture lambs than in stable lambs and statistical differences were observed. Velasco et al.[29] also reported that drylot lambs displayed more MUFA than their raised at pasture. In our study, oleic acid in lambs fed on concentrate diets was higher than those of pasture -fed in both muscle and subcutaneous adipose tissue. Similar result was reported other researches between pasture and stable or drylot-fed lambs' intramuscular fat [29,33]. These results agreed with Velasco et al.[29], who reported that drylot lambs displayed a greater pro-portion of oleic acid than lambs grazing at pasture in the subcutaneous fat.

Similar to our results, Realini et al.[34] also reported that pasture-fed beef contained a higher percentage of PUFA than concentrate-fed cattle. In addition, drylot lambs dis-

Table 5. *Fatty acid composition of longissimus dorsi muscle of lambs fed with maternal milk, concentrate and pasture (g/100 g total fatty acids)*
Tablo 5. *Anne sütü, konsantre yem ve mera ile beslenen kuzuların longissimus dorsi kasının yağ asidi bileşimi (g/100 g toplam yağ asidi)*

Fatt Acids	**Maternal Milk Group**	**Concentrate Group**	**Pasture Group**
C 10:0	0.35±0.12 [a, y]	0.20±0.04 [b]	0.25±0.05 [b]
C 11:0	0.03±0.02 [a, z]	0.01±0.01 [b]	0.02±0.01 [b]
C 12:0	0.71±0.22 [a]	0.16±0.06 [c]	0.50±0.19 [b]
C 13:0	0.07±0.03 [a]	0.02±0.01 [b]	0.03±0.01 [b]
C 14:0	6.44±1.69 [a]	2.88±0.61 [c]	5.14±1.05 [b]
C 15:0	0.78±0.19 [a]	0.52±0.13 [b]	0.66±0.08 [a]
C 16:0	24.48±2.27 [ab]	22.89±2.13 [b]	25.39±0.67 [a]
C 17:0	1.31±0.24 [b]	1.96±0.62 [a]	1.24±0.09 [b]
C 18:0	12.93±1.67 [b]	17.35±2.46 [a]	18.29±0.65 [a]
C 19:0	0.33±0.09 [a]	0.14±0.02 [b]	0.31±0.06 [a]
C 20:0	0.09±0.03 [b]	0.11±0.02 [b]	0.19±0.04 [a]
C 21:0	0.05±0.04 [a]	0.04±0.03 [a]	0.05±0.03 [a]
C 22:0	0.02±0.01 [ab]	0.01±0.01 [b]	0.03±0.02 [a]
Σ SFA [t]	**47.59±4.59 [b]**	**46.30±3.04 [b]**	**52.09±1.51 [a]**
C 14:1n-5	0.28±0.09 [b]	0.17±0.04 [c]	0.36±0.06 [a]
C 15:1n-5	0.17±0.04 [a]	0.07±0.03 [b]	0.20±0.02 [a]
C 16:1n-7	2.82±0.50 [a]	1.65±0.25 [b]	1.94±0.13 [b]
C 17:1n-8	0.82±0.14 [a]	0.86±0.28 [a]	0.46±0.03 [b]
C 18:1n-9	31.44±2.39 [c]	37.04±3.25 [a]	33.85±1.57 [b]
C 18:1n-7	1.56±0.39 [a]	1.34±0.47 [a]	0.52±0.15 [b]
C 20:1n-9	0.04±0.01 [a]	0.01±0.01 [b]	0.01±0.00 [b]
C 22:1n-9	0.02±0.01 [a]	0.01±0.00 [b]	0.02±0.01 [ab]
Σ MUFA [t]	**37.15±2.73 [b]**	**41.16±3.02 [a]**	**37.35±1.56 [b]**
C 18:2n-6	6.50±3.85 [a]	3.74±1.22 [b]	3.24±0.19 [b]
C 18:3n-6	0.10±0.04 [a]	0.02±0.01 [c]	0.04±0.02 [b]
C 18:3n-3	0.33±0.08 [b]	0.16±0.08 [c]	1.23±0.20 [a]
C 20:2n-6	0.09±0.03 [a]	0.06±0.02 [b]	0.09±0.03 [a]
C 20:3n-6	0.19±0.16 [a]	0.03±0.01 [b]	0.05±0.01 [b]
C 20:3n-3	0.03±0.02 [a]	0.02±0.01 [b]	0.02±0.01 [ab]
C 20:4n-6	2.27±2.34 [a]	0.10±0.07 [b]	0.33±0.04 [b]
C 20:5n-3	0.02±0.01 [b]	0.01±0.01 [b]	0.04±0.03 [a]
C 22:2n-6	0.08±0.07 [a]	0.02±0.01 [b]	0.07±0.03 [a]
C 22:3n-3	0.03±0.02 [a]	0.05±0.03 [a]	0.04±0.03 [a]
C 22:4n-6	0.25±0.21 [a]	0.03±0.02 [b]	0.04±0.02 [b]
C 22:5n-6	0.09±0.08 [a]	0.03±0.02 [b]	0.04±0.02 [b]
C 22:5n-3	0.36±0.32 [a]	0.02±0.01 [b]	0.20±0.03 [a]
C 22:6n-3	0.09±0.08 [a]	0.02±0.01 [b]	0.05±0.01 [ab]
Σ PUFA [t]	**10.44±7.12 [a]**	**4.30±1.33 [b]**	**5.46±0.16 [b]**
CLA *c*9, *t*11	0.73±0.19 [b]	0.29±0.13 [c]	0.87±0.06 [a]
CLA *t*10, *c*12	0.03±0.02 [ab]	0.02±0.01 [b]	0.03±0.02 [a]
CLA *c*11, *t*13	0.02±0.01 [a]	0.01±0.01 [a]	0.02±0.01 [a]
Σ CLA [t]	**0.78±0.17 [b]**	**0.32±0.12 [c]**	**0.92±0.07 [a]**
C 14:1*t*9	0.18±0.06 [a]	0.07±0.03 [b]	0.18±0.03 [a]
C 16:1*t*9	0.39±0.08 [a]	0.17±0.09 [b]	0.38±0.09 [a]
C 18:1 *t*9	0.02±0.01 [a]	0.02±0.01 [a]	0.02±0.01 [a]
C 18:1 *t*11	3.09±0.84 [b]	7.53±2.51 [a]	3.33±0.44 [b]
C 18:2 *t*9, *t*12	0.20±0.04 [a]	0.05±0.02 [c]	0.10±0.09 [b]
C 18:2 *t*9, *c12*	0.16±0.06 [a]	0.08±0.02 [b]	0.17±0.03 [a]
Σ TFA [t]	**4.05±0.92 [b]**	**7.92±2.54 [a]**	**4.18±0.49 [b]**
Σ n-3	**0.86±0.49 [b]**	**0.28±0.09 [c]**	**1.58±0.23 [a]**
Σ n-6	**9.58±6.65 [a]**	**4.02±1.28 [b]**	**3.89±0.23 [b]**
n-3/n-6	**0.09±0.02 [b]**	**0.07±0.03 [b]**	**0.41±0.08 [a]**
n-6/n-3	**11.14±2.21 [b]**	**14.36±8.57 [a]**	**2.46±0.51 [c]**

[y] *Values reported are mean ± SD.* [z] *abc values for each sample with different letters in the same fraction are significantly different at P<0.05*
[t] ***SFA:*** *Saturated fatty acid,* ***MUFA:*** *Monounsaturated fatty acid,* ***PUFA:*** *Polyunsaturated fatty acid,* ***TFA:*** *Trans fatty acid,* ***CLA:*** *Conjugated linoleic acid*

Table 6. *Fatty acid composition of subcutaneous adipose tissue of lambs fed with maternal milk, concentrate and pasture (g/100 g total fatty acids).*
Tablo 6. *Anne sütü, konsantre yem ve mera ile beslenen kuzuların subkutan adipoz dokusunun yağ asidi bileşimi (g/100 g toplam yağ asidi)*

Fatty Acids	Maternal Milk Group	Concentrate Group	Pasture Group
C 10:0	0.46±0.09 a y	0.21±0.04 c	0.28±0.10 b
C 11:0	0.04±0.01 a z	0.04±0.02 a	0.01±0.00 b
C 12:0	0.95±0.23 a	0.29±0.14 b	0.46±0.29 b
C 13:0	0.10±0.04 a	0.07±0.03 b	0.05±0.03 b
C 14:0	8.36±1.11 a	3.07±0.57 c	5.13±1.90 b
C 15:0	0.97±0.17 b	1.34±0.40 a	0.84±0.16 b
C 16:0	26.40±1.36 a	21.70±2.11 b	22.43±1.69 b
C 17:0	1.44±0.21 b	3.01±1.00 a	1.64±0.13 b
C 18:0	11.56±2.64 b	11.65±4.54 b	23.18±3.18 a
C 19:0	0.37±0.09 a	0.26±0.06 b	0.28±0.06 b
C 20:0	0.07±0.02 b	0.10±0.03 b	0.33±0.14 a
C 21:0	0.02±0.01 b	0.05±0.02 a	0.05±0.03 a
C 22:0	0.01±0.00 b	0.02±0.01 a	0.02±0.01 a
Σ SFA t	**50.77±3.37 b**	**41.79±3.13 c**	**54.70±1.28 a**
C 14:1n-5	0.40±0.09 b	0.36±0.10 b	0.50±0.12 a
C 15:1n-5	0.20±0.02 b	0.16±0.08 c	0.26±0.04 a
C 16:1n-7	3.52±0.54 a	2.42±0.53 b	1.82±0.28 c
C 17:1n-8	0.98±0.28 b	1.83±0.55 a	0.46±0.13 c
C 18:1n-9	33.44±2.36 a	35.60±3.44 a	29.74±0.96 b
C 18:1n-7	1.24±0.27 b	1.56±0.46 a	0.64±0.14 c
C 20:1n-9	0.05±0.02 a	0.05±0.03 a	0.01±0.00 b
C 22:1n-9	0.01±0.00 a	0.03±0.01 a	0.01±0.00 a
Σ MUFA t	**39.84±3.07 a**	**41.99±3.93 a**	**33.44±1.21 b**
C 18:2n-6	2.82±0.44 b	4.17±0.58 a	2.05±0.49 c
C 18:3n-6	0.08±0.02 a	0.03±0.01 b	0.03±0.01 b
C 18:3n-3	0.26±0.05 b	0.22±0.03 b	0.73±0.41 a
C 20:2n-6	0.06±0.02 b	0.08±0.03 a	0.06±0.02 b
C 20:3n-6	0.04±0.01 a	0.04±0.02 a	0.02±0.01 b
C 20:3n-3	0.02±0.01 b	0.03±0.02 ab	0.03±0.02 a
C 20:4n-6	0.16±0.04 a	0.10±0.04 b	0.08±0.03 b
C 20:5n-3	0.02±0.01 a	0.03±0.02 a	0.02±0.01 a
C 22:2n-6	0.02±0.01 b	0.03±0.02 a	0.02±0.01 ab
C 22:3n-3	0.05±0.04 b	0.07±0.05 ab	0.10±0.06 a
C 22:4n-6	0.05±0.02 a	0.07±0.04 a	0.02±0.01 b
C 22:5n-6	0.02±0.01 b	0.03±0.01 a	0.01±0.01 b
C 22:5n-3	0.08±0.02 b	0.04±0.01 c	0.12±0.05 a
C 22:6n-3	0.02±0.01 a	0.03±0.02 a	0.02±0.01 a
Σ PUFA t	**3.69±0.50 b**	**4.96±0.67 a**	**3.32±0.67 b**
CLA *c*9, *t*11	0.96±0.20 a	0.56±0.16 b	1.08±0.29 a
CLA *t*10, *c*12	0.01±0.00 a	0.03±0.01 b	0.01±0.00 a
CLA *c*11, *t*13	0.01±0.00 b	0.02±0.01 a	0.03±0.02 b
Σ CLA t	**0.98±0.20 a**	**0.61±0.16 b**	**1.12±0.29 a**
C 14:1*t*9	0.23±0.03 a	0.21±0.14 a	0.26±0.05 a
C 16:1*t*9	0.49±0.06 a	0.31±0.25 b	0.51±0.05 a
C 18:1 *t*9	0.02±0.01 b	0.02±0.01 b	0.03±0.01 a
C 18:1 *t*11	3.55±0.88 c	9.89±3.14 a	6.25±2.45 b
C 18:2 *t*9, *t*12	0.27±0.05 a	0.07±0.03 c	0.19±0.12 b
C 18:2 *t*9, *c12*	0.17±0.05 a	0.16±0.05 a	0.18±0.04 a
Σ TFA t	**4.73±0.90 c**	**10.65±3.13 a**	**7.42±2.39 b**
Σ n-3	**0.45±0.11 b**	**0.41±0.11 b**	**1.03±0.47 a**
Σ n-6	**3.24±0.47 b**	**4.54±0.62 a**	**2.29±0.45 c**
n-3/n-6	**0.14±0.03 b**	**0.09±0.02 b**	**0.46±0.21 a**
n-6/n-3	**7.20±1.52 b**	**11.07±2.90 a**	**2.22±0.86 c**

[y] Values reported are mean ± SD. [z] abc values for each sample with different letters in the same fraction are significantly different at P<0.05
*[t] **SFA:** Saturated fatty acid, **MUFA:** Monounsaturated fatty acid, **PUFA:** Polyunsaturated fatty acid, **TFA:** Trans fatty acid, **CLA:** Conjugated linoleic acid*

played fewer PUFA than raised at pasture [29] and Cividini et al.[33] reported higher percentages of PUFA in *Longissimus dorsi* of pasture lambs than in stable lambs. Linoleic acid was major PUFA and higher in concentrate-fed lambs than pasture-fed lambs in *Longissimus dorsi* muscle and sub-cutaneous adipose tissue. These results were similar to those reported by Diaz et al.[32] for *Longissimus dorsi* of lambs fed concentrate and grass. Grazing lambs on pasture led to a significant increase of C 18:3 n-3 α-linolenic acid in the muscle and subcutaneous adipose tissue of Akkaraman lambs as they consumed grass which is rich in α-linolenic acid. The percentage of α-linolenic acid in pasture-fed lambs was more than eight times higher in *longissimus dorsi* muscle and three times higher in subcutaneous adipose tissue than those concentrate-fed. The higher concentration of α-linolenic acid found in grass-fed lambs agreed with the results of other authors for muscle [13,24,26,32] and subcutaneous tissue [29]. These results matched with Noci et al.[35] who reported that the response of α- linolenic acid to pasture-feeding was a consistent increase in subcutaneous adipose tissue, where a 76% increase was observed in beef heifers fed pasture compared with those fed concentrate and silage. Pasture in green seasons may meet highly the nutritional requirements of the lambs and sheep [36].

The predominant CLA isomer of three CLA isomers in *Longissimus dorsi* muscle and subcutaneous adipose tissue was rumenic acid. Similar result was found by several researches for intramuscular muscle [28,32] and sub-cutaneous adipose tissue [27,35,37]. Santos Silva et al.[13] who reported that pasture raised intramuscular fat of muscle of lambs showed higher proportion of CLA than concentrate-fed lambs also reported similar results of our findings. The total CLA value of Akkaraman lamb muscle was found 0.92 g/100 g total fatty acids, higher than in other grass-fed ruminants reported by other authors [13,28] and lower than those by Aurousseau et al.[38]. The value of rumenic acid (0.87 g/100 g total fatty acids) in this experiment was the close to that reported for pasture-fed lambs' muscle [31]. Diaz et al.[32] also reported similar values of CLA (0.94%) for Uruguayan heavy lambs and in German lambs *Longissimus dorsi* muscle (0.97%). The total CLA value of Akkaraman lamb adipose tissue was found 1.12 g/100 g total fatty acids, higher than in other grass-fed ruminants reported by other author [39]. The value of rumenic acid (1.08 g/100 g total fatty acids) in subcutaneous adipose tissue of pasture-fed lambs was the close to that reported for pasture-fed ruminants grazing for 99 day (1.11%) [35]. The result of rumenic acid in our study agreed with Aurousseau et al.[30], who reported that rumenic acid was twice higher in grass-fed lambs compared to stall fed ones. Steen and Porter [40] who reported that subcutaneous fat tissue from grass-fed cattle contained three times as much CLA as those from concentrate-fed cattle also reported similar results of our findings. Increasing the duration of grazing led to a linear increase in the concentration of CLA in subcutaneous adipose tissue [35]. However, Dannenberger et al.[37] reported that no diet effect (pasture vs. concentrate) was observed for rumenic acid in subcutaneous fat of beef cattle.

Fatty acid profile was effective in the identification of lamb feeding systems. From the nutritional aspect, fat from lambs raised on pasture seems to be more adequate, than lambs raised in confinement with concentrate because of their higher proportion on n-3 PUFA and CLA and lower n-6/n-3 ratio [13]. In addition, Aurousseau et al.[38] stated that fatty acid composition of the lipids from muscles of grazed lambs was more favourable to the health of the consumers than that of stall fed lambs, according to improved CLA, α- linolenic acid, long chain n-3 PUFA content and linoleic acid/α- linolenic acid ratio. Similarly, in our study, pasture feeding increased total n-3 and n-3/n-6 ratio. These results were similar to those reported by De la Fuente et al.[41] who reported that cattle grazing on pasture accumulated a 4 to 5-hold higher concentration of total n-3 PUFA in their meat compared to those that were only fed on concentrate. In our study, concentrate-fed lambs muscle had higher n-6/n-3 ratio (14.36) and pasture feeding decreased this ratio to 2.46. This ratio was 2.22 in pasture-fed lambs' subcutaneous adipose tissue compared with 11.07 in concentrate-fed lambs. These results were similar to those reported by Santos-Silva et al.[13], Aurousseau et al.[30], Demirel et al.[24] and Nuernberg et al.[26] on the muscle fatty acid content from grazed ruminants. These results were similar to those reported by Velasco et al.[29] for subcutaneous fat in pasture vs. drylot lambs. Nuernberg et al.[26] also reported similar results for adipose tissue of Skudde lambs fed grass and concentrate. Decrease in the n-6 fatty acids, increase in n-3 fatty acids and low ratio of n-6/n-3 fatty acids in muscle of grass fed lambs are beneficial for human nutrition [26]. In our study, the n-6/n-3 ratio, in *longissimus dorsi* (2.46) and subcutaneous adipose tissue (2.22) from pasture fed lambs, was below the recommended level of 4 for human consumption [2].

In conclusion, intramuscular muscle and subcutaneous adipose tissue fatty acid composition of lambs was effected by feeding regime. *Longissimus dorsi* muscle from concentrate fed-lambs displayed a higher total MUFA, total TFA and total n-6/n-3 ratios and subcutaneous adipose tissue from concentrate fed-lambs displayed a higher total MUFA, total PUFA, total TFA, total n-6 and n-6/n-3 compared with those pasture and maternal milk-fed. Moreover, pasture fed-lambs showed significantly more CLA, total n-3, n-3/n-6 ratio than other groups in muscle. In subcutaneous adipose tissue, pasture-fed lambs contained significantly more total SFA, total CLA, total n-3 and n-3/n-6 ratio compared with concentrate fed-lambs. In conclusion, intramuscular muscle and subcutaneous adipose tissue fatty acid composition of lambs can be improved by including pasture in the feeding regime.

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