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Fatty Acid Content and Composition of Turkish Beef and Lamb at Retail

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Abstract: The fatty acid content and chemical composition of retail samples of beef and lamb meat were investigated. Fifty beef and lamb chops were purchased from different supermarkets in İstanbul on separate occasions. The average muscle fatty acid content was 2395 and 2257 mg/100 g of muscle for beef and lamb, respectively. Saturated and polyunsaturated fatty acid contents were 1000 and 940 mg/100 g, and 199 and 261 mg/100 g of muscle for beef and lamb, respectively. Overall results indicate that, particularly before the Sacrifice Holiday, concentrate-based feeding of livestock increases and this has an adverse effect on the n-6/n-3 ratio and P/S ratio of intramuscular fat in meat. Nonetheless, higher C18:1 and lower C16:0 contents in beef and lamb meat fat is favorable.

Key Words: Lamb, beef, fatty acid

Piyasada Satılan Sığır ve Kuzu Etlerinin Yağ Asidi İçeriği ve Kompozisyonu

Özet: Piyasadan satın alınan sığır ve kuzu etlerinin yağ asidi içeriği kompozisyonu incelendi. İstanbul'da yer alan değişik süper marketlerden farklı zamanlarda 50'şer adet sığır ve kuzu eti örneği toplandı. Ortalama yağ asidi miktarı, sığır etinde 2395 mg/100 g, kuzu etinde ise 2257 mg /100 g olarak bulundu. Doymuş ve uzun zincirli doymamış yağ asitlerinin sığır ve kuzu etindeki miktarı ise sırasıyla 1000 ve 940 mg/100 g, 199 ve 261 mg/100 g olarak belirlendi. Genel olarak sonuçlar gösterdi ki, kurban bayramı öncesi hayvanların daha çok konsantre yem ile beslenmeleri, etlerin intramüsküler yağındaki n-6/n-3 ve P/S oranlarını olumsuz olarak etkilemektedir. Buna rağmen sığır ve kuzu etlerindeki yüksek C18:1 ve düşük orandaki C16:0 içeriği bu etler için bir avantajdır.

Anahtar Sözcükler: Kuzu eti, sığır eti, yağ asidi

There is increasing concern in developed countries concerning the fat and fatty acid content of meat from farm animals, because some fatty acids negatively affect human health and can lead to cardiovascular disease. Some saturated fatty acids and polyunsaturated fatty acids (PUFAs), respectively, negatively and positively affect human health. Long chain n-3 PUFAs are particularly important for nerve tissue and the retina. Several studies of meat-producing domesticated animals have aimed at increasing PUFA content, in particular, n-3 long-chain fatty acids (1,2). Results of numerous studies confirm that fatty acid composition can be influenced by individual factors, such as diet (3,4), breed (5), age and weight (6), and level of fatness (7). Despite hydrogenation in the rumen, the fatty acid composition of ruminant meat can be modulated by diet. Effects attributed to breed are often due to the degree of fatness, live weight, age at slaughter, or production system (8). In

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most developed countries consumer demand for low fat levels and high levels of beneficial fatty acids directly influence the production of livestock. In contrast, such economic variables as the cost of livestock feed and consumer meat products primarily influence livestock production. Nonetheless, in general, the quantity and quality of animal feed, and the age at slaughter are the most important factors affecting the level of fat and fatty acids composition of meat.

The objective of the present study was to determine the fatty acids composition of muscle fat of typical cuts of beef sirloin steak and lamb chops available at retail outlets, and to compare them with other beef and lamb findings in the literature.

In total, 50 samples each of beef sirloin steak and lamb chop were obtained from local supermarkets during February and March 2004 in İstanbul. Samples were selected from different animals. One chop was analyzed from each animal. When the chops were very small 2 chops were combined from 1 package. They were dissected into muscle, fat, and bone. Muscle tissue was blended separately in a small food processor. Samples were saponified and fatty acids were extracted, methylated, and analyzed by gas chromatography (9). Fatty acids were quantified using heneicosanoic acid methyl ester (catalogue no: H3265, Sigma-Aldrich Chemie GmbH, Eschenstrabe 5, 82024 Taufkirchen, Germany), which was added prior to saponification as an internal standard. Analyses were performed on a Perichrom 2100 gas chromatograph. Gas chromatographic conditions were as follows: injector temperature: 250 °C; detector temperature: 280 °C; silica capillary column (50 m × 0.2 mm); carrier gas: helium. Peaks were identified using standards (Sigma Chemical Co, Ltd). All results were expressed as a mean ± SE for all 50 samples. Meat samples were analyzed for ether extract (EE) and nitrogen (N). EE was determined using the Soxhlet (Kottermann, Germany) extraction procedure, with anhydrous diethyl ether as the non-polar solvent. N was analyzed using the Kjeldahl procedure with a Kjeltec-UDK 126 A (Velp Scientific, Italy) and the amount of N was multiplied by 6.25 to estimate crude protein (CP). Moisture was determined by oven drying for 24 h at 105 °C and crude ash by combustion at 550 °C for 6 h (10).

Chemical composition of the beef and lamb meat samples was analyzed. Mean values for beef and lamb, respectively, were as follows: moisture: 73.1% ± 0.54 and 72.9% ± 0.44; protein: 22.1% ± 0.58 and 23.4% ± 0.70; ash: 1.2% ± 0.1 and 1.09 % ± 0.13. Fatty acid content of muscle is shown quantitatively (mg/100 g of muscle) in Table 1 and fatty acid composition is shown qualitatively (percent of total fatty acids) in Table 2. Total fatty acid content in muscle lipid was 2.4% and 2.3% of the tissue weight in beef and lamb, respectively.

Mean total fatty acid concentration in beef from Turkey was 2395 mg/100 g of muscle. Foods below 5 g of fat/100 g are generally considered to be low-fat product (11). Accordingly, muscle tissue trimmed of any visible fat (less than 5% fat) would qualify for inclusion in a healthy diet. Mean total fatty acid content of beef muscle fat in EU countries was reported previously. Raes et al. (12) reported the average total fatty acid content of muscle fat in beef originating from 4 breeds in Belgium. Total intramuscular fatty acid concentration (mg/100 g of meat) was lowest in Belgian Blue and Limousin meat, as compared to Irish and Argentine meat. Values ranged from 865 to 3710 mg/100 g of meat. Enser et al. (13) reported a higher concentration, i.e. 3835 mg/100 g in muscle tissue of beef from the United Kingdom. Our fatty acids content data are lower than for US grain-finished beef (7). The main cause of the lower fatty acid content

Table 1. Fatty acid content of muscle fat from beef and lamb (mg per 100 g of muscle) (mean ± SE).

Fatty acid	Beef	Lamb
C14:0	72.5 ± 0.44	67.6 ± 1.18
C16:0	649 ± 25.7	546 ± 32.7
C16:1	85 ± 1.32	21.1 ± 1.35
C18:0	278 ± 12.7	326 ± 23.6
C18:1 trans	62.5 ± 1.25	88.8 ± 3.72
C18:1	1049 ± 67.8	946 ± 44.8
C18:2 n-6	116 ± 3.77	153 ± 6.50
C18:3 n-3	9.6 ± 0.51	15.5 ± 1.30
C20:4 n-6	48.7 ± 1.45	62.7±1.25
C20:5 n-3	6.9 ± 0.97	7.5 ± 0.55
C22:4 n-6	8.9 ± 0.86	11.3 ± 1.60
C22:5 n-3	7.7 ± 0.56	8.6 ± 0.86
C22:6 n-3	0.7 ± 0.01	2.5 ± 0.78
SFA	999.5 ± 44.8	939.6 ± 46.6
MUFA	1196.5 ± 55.5	1055.9 ± 61.2
PUFA	198.5 ± 6.58	261.1 ± 7.66
Total	2394.5 ± 78.3	2256.6 ± 88.3

Table 2. Fatty acid composition of muscle fat from beef and lamb (% by weight of total fatty acids) (mean ± SE).

Fatty acid	Beef	Lamb
C14:0	3.0 ± 0.12	2.9 ± 0.20
C16:0	27.1 ± 0.39	24.2 ± 0.26
C16:1	3.6 ± 0.12	0.93 ± 0.19
C18:0	11.6 ± 0.22	14.4 ± 0.26
C18:1 trans	2.6 ± 0.0.14	3.9 ± 0.12
C18:1	43.8 ± 0.20	41.9 ± 0.21
C18:2 n-6	4.8 ± 0.10	6.8 ± 0.12
C18:3 n-3	0.40 ± 0.03	0.7 ± 0.03
C20:4 n-6	2.0 ± 0.14	2.8 ± 0.14
C20:5 n-3	0.28 ± 0.06	0.33 ± 0.06
C22:4 n-6	0.37 ± 0.06	0.50 ± 0.03
C22:5 n-3	0.32 ± 0.06	0.38 ± 0.03
C22:6 n-3	0.02 ± 0.0	0.11 ± 0.06
SFA	41.7 ± 0.22	41.5 ± 0.20
MUFA	50.0 ± 0.29	46.7 ± 0.21
PUFA	8.19 ± 0.14	11.6 ± 0.25

of intramuscular fat of Belgian Blue and Limousin beef compared to other breeds is probably breed differences. Meat from these 2 breeds is very lean and probably originated from animals raised on high concentrate diets. Individual fatty acid content in the study also shows that the examined samples originated from animals fed concentrate diets. The lower intramuscular fat content (to some extent) can probably be explained by the fairly young age at which beef in Turkey is slaughtered. On the basis of data regarding butchering it was determined that 70% of beef consumed in Turkey comes from young bulls (< 22 months and age), which significantly affected the total fatty acid content of intramuscular fat in previous studies (14). It was verified that the content of PUFAs and triglyceride varies with age. Saturated and monounsaturated fatty acid contents will vary with the fat content of muscle. C16:0 + C18:0 + C18:1 represented 75% of the total fatty acids. The C18:0 level was much lower than that of Irish, Argentine (12), and English beef (13), whereas the amount of oleic acid was quite high as a result of greater de novo synthesis from dietary carbohydrate. The linoleic acid level in beef fat was higher than in English and Argentine beef, and lower than in Belgian Blue. Hence, we observed lower concentrations of this fatty acid in local beef than in Irish and Limousin beef reported by Raes et al. (12) and Enser et al. (13), but similar to results reported by Enser et al. (4) for concentrate-fed beef. As such, the results of the present study are in line with our expectation that some concentrates had been used to finish the animals in February and March. The results show lower concentrations of C18:2 n-6 as compared to the results reported by Raes et al. (12), and higher concentrations than those reported by Enser et al. (13). The concentration of C18:3 in the fat of beef muscle was 9.6 mg/100 g of muscle (0.40%) in the present study, 26 mg/100 g of muscle (0.70%) in Enser et al.'s study (13), and 11.7 mg/100 g of muscle (1.3%) in Belgian beef (12). All these results are higher than the present study's when expressed on a weight or percentage basis and these results suggest that the animals were fed primarily with concentrates shortly before slaughter. The level of C20:4 n-6 in intramuscular fat was also high as a result of synthesis from C18:2 n-6. Compared to other studies of meat at retail, the level of C20:4 n-6 was quite high in the present study; however, the result presented by Enser et al. (4) for concentrate-fed bulls is similar to our results (44 vs. 48.7 mg/100 g of meat).

Mean total fatty acid concentration was 2257 mg/100 g of muscle for lamb from Turkey. The major saturated fatty acids were palmitic (C16:0) and stearic acid (C18:0), and the measured amounts were 546 and 326 mg/100 g, respectively. Compared to results from other countries, the estimated amount of palmitic and stearic acid was lower than in German lambs and higher than in Spanish and Uruguayan lambs (15). The oleic acid level was higher than in the intramuscular fat of Spanish and Uruguayan lambs, and lower than that of German and British lambs.

When results were presented as percent by weight of total fatty acids (Table 2), the proportion of C18:1 was 41.9; this value ranged from 35.8 to 40.5 in Spanish, German, UK, and Uruguayan lambs. Results of the present study show that intramuscular fat of Turkish lambs had a higher proportion of C18:1 than the intramuscular fat of lambs from other countries.

Intramuscular fat of Turkish lambs had 153 mg/100 g of C18:2 n-6. This value is similar to the intramuscular fat of German and Spanish lambs, but higher than that of British and Uruguayan lambs. Nevertheless, intramuscular fat of Turkish lambs had the lowest C18:3 n-3 levels, as compared to lambs from other countries, except Spanish lambs.

Mean arachidonic acid level was 62.7 mg/100 g of muscle, which is similar to that of Spanish lambs (15) and higher than that of British lambs (13). Additionally, the mean value of 2% arachidonic acid was much lower than the mean value of 3.99% for Spanish lambs (15). This difference arises from differences in the fat content of lamb muscle. As was the case with C20:4 n-6, fatty acid percentages can be misleading when meats differ in total fatty acid content. This is because at low fat levels the contribution made by phospholipids is proportionally greater and they are more unsaturated than triacylglycerols, which themselves increase in proportion as total lipid increases (4). Arachidonic acid was positively correlated with linoleic acid, as C18: 2 in the diet is a precursor of arachidonic acid (16). Both of those fatty acid levels were higher in Turkish lambs. Concentrate diets are known to increase available soluble carbohydrates, resulting in lower ruminoreticular pH, which, in turn, inhibits lipolysis and biohydrogenation (17). This is in agreement with our observation of an increase in C18:2 n-6 and decrease in 18:0 compared to lambs from other countries. Concentrations of C20:5 n-3, C22:5 n-3, and C22:6 n-3 synthesized from C18:3 n-3 were also lower than those previously reported for lambs (13,15).

With respect to the fatty acid ratios, the polyunsaturated fatty acid/saturated fatty acid (P/S) ratio was low due to high saturated fatty acids content. The P/S ratios of muscle fat from beef and lamb (0.20 and 0.28) were lower than the recommended levels (0.45). Compared to results from other countries, the P/S ratio was higher (0.28) than in German, British, and Uruguayan lambs, with values of 0.20, 0.19, and 0.21, respectively. The incremental effect of saturated fatty acids on plasma cholesterol is twice as effective at raising plasma cholesterol as the hypocholesterolemic effect of polyunsaturated fatty acids. While C14:0 and C16:0 are the most effective at raising plasma cholesterol, C18:0 and fatty acids with 10 or less carbon atoms appear to have no cholesterol-raising effects (18). Because C16:0 contributes substantially to the total amount of saturated fatty acids in animal fat, a decrease in C16:0 and an increase in C18:0 or C18:1 n-9 are favorable changes, with regard to current nutritional guidelines. Enser et al. (4) reported higher P/S ratios in animals fed concentrate containing high levels of linoleic acid than in animals fed grass. On the other hand, intramuscular fat from beef had a more unfavorable n-6/n-3 PUFA ratio. The recommended ratio is 4 (19). The ratios for beef and lamb were 8.4 and 6.6, respectively.

In conclusion, as a result of inadequate pasture, concentrate feed becomes necessary in Turkey to ensure high productivity, despite its high cost. In particular, before the Sacrifice Holiday (which every year occurs about 11 days earlier than the previous year), concentrate-based feeding of livestock increases. Increasing percentages of concentrate feed in rations have an effect on the n-6/n-3 ratio and P/S ratio of meat. Nonetheless, the observed lower level of n-3 long chain PUFA, higher level of C18:1, and lower level of C16:0 content in beef and lamb meat are favorable. Further studies are needed to observe seasonal effects on fatty acid composition of beef and lamb meat raised in Turkey.

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