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Fatty Acid Composition of Beef Intermuscular, Sheep Tail, Beef Kidney Fats and Its Effects on Shelf Life and Quality Properties of Kavurma

M.İ. Aksu

ABSTRACT: The effects of beef intermuscular (BIF), beef kidney (BKF), and sheep tail fats (STF) and storage time on fatty acid composition, the thiobarbituric acid reactive substances (TBARS), free fatty acids (FFA), pH and L^*, a^*, and b^* values, and *Enterobacteriaceae* counts of sliced vacuum-packaged Kavurma were investigated. Kavurma was made from fresh beef which contained different amounts of melted BIF, BKF, STF, and salt as 10 groups. The Kavurma was sliced 3 to 4 cm thick and was vacuum packed and stored at 4 ± 0.5 °C for 360 d. Animal fat groups (BIF, STF, and BKF) had a statistically significant difference ($P < 0.01$) in terms of both fatty acid composition and total saturated and unsaturated fatty acids. Used animal fat types and levels in Kavurma production had a significant effect on unsaturated fatty acid composition (except for $C_{18:1n9t}$) ($P < 0.01$). $C_{18:1n9c}$ was the dominant fatty acid in all Kavurma groups, and the highest $C_{18:1n9c}$ was determined for 50% STF + 50% BKF (group 6). TBARS and FFA values were affected by the treatment ($P < 0.01$) and storage time ($P < 0.01$). The lowest TBARS value was found in group 10 (30% BIF + 35% STF + 35% BKF). There was a significant ($P < 0.01$) difference in FFA content in Kavurma between 0 and 180 and 360 d, and this value increased during storage time. The a^* values of Kavurma decreased during storage, and the greatest decrease was determined between days 0 and 180 of storage. *Enterobacteriaceae* counts were determined to be under the detectable level in all Kavurma groups during storage.

Keywords: Kavurma (cooked meat), beef intermuscular fat, beef kidney fat, sheep tail fat, fatty acid composition

Introduction

Kavurma is a traditional Turkish meat product, and it is produced in many regions such as the Middle East, Middle Asia, and some Mediterranean and Europe countries. It is still the most popular cooked meat product in Turkey (Kaya 1995; Kolsarici and Atici 1995; Gökalp and others 2004). Kavurma is a high-fat cooked meat product made from beef, water buffalo, or mutton meat, fat, and salt (Anonymous 2002; Aksu and Kaya 2005; Aksu 2007). The amount of moisture, animal fat, and salt in Kavurma is 40% to 50%, 15% to 35%, and 2.5% to 4.0%, respectively (Anonymous 2002). In recent years, Kavurma is generally sold the sliced, vacuum-packaged form (Aksu 2007). According to "Turkish Kavurma Standard," Kavurma has an average shelf life of 6 mo when stored at between +1 and +4 °C, and of 9 mo when stored at −18 °C (Anonymous 2002), but Aksu and Kaya (2005) reported that Kavurma with antioxidant can be stored at 4 °C for 10 mo.

Fat used in Kavurma production is the main effect on Kavurma properties and quality. Beef intermuscular and beef kidney fats at different levels are generally used in Kavurma. Also, in traditional Kavurma production, sheep tail fat can be used to increase aroma and flavor of Kavurma. Animal fats are important sources of fat in the Turkish diet, and sheep tail fat accounts for a large proportion of Turkish animal fat utilized (Unsal and Aktas 2003; Unsal and Yanlic 2005). Also, sheep tail is a concentrated fat source for meat products and other food, and is also used in the confectionery industry. Sheep tail fat content is approximately 94% of the fat utilized (Unsal and others 1995). Unsal and Aktas (2003) and Unsal and Yanlic (2005) reported that the fatty acid composition of sheep tail fat is lauric acid (0.20%), myristic acid (3.92% to 3.67%), palmitic acid (31.49% to 24.77%), palmitoleic acid (3.14% to 3.01%), margaric acid (4.32%), stearic acid (30.02% to 16.51%), oleic acid (44.43% to 28.37%), and linoleic acid (0.66% to 2.77%). Also, researchers reported that the melting point (°C), refractive index (50 °C), and iodine values of sheep tail fat are 34.30 to 43.2, 1.4540 to 1.4575, and 42.16 to 45.69, respectively.

The purpose of this study was to determine the effects of different animal fats (beef intermuscular, sheep tail, beef kidney fats) and/or their levels and/or storage period (0, 180, and 360 d) on the fatty acid composition, thiobarbituric acid-reactive substances (TBARS), free fatty acids (FFA), pH, CIE L^*, a^*, and b^* values, and *Enterobacteriaceae* counts of Kavurma sliced, vacuum packaged and stored at low temperature.

Materials and Methods

Beef meat (from round), melted beef intermuscular, sheep tail, beef kidney fats, and their combinations along with NaCl were used as the raw material for Kavurma production.

The beef meat, beef intermuscular, sheep tail, and beef kidney fats were obtained from a local slaughterhouse in Erzurum, Turkey. Fat tissues were ground once through a 3-mm plate, and then grounded fat tissues were melted at 60 °C in water bath. The fats obtained were stored at –20 °C in a jar until needed (Unsal and Aktas 2003; Aktaş and Gençcelep 2006).

Kavurma was manufactured according to formulation reported by Aksu and Kaya (2005) and Aksu (2007). Kavurma formulation

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included 70% beef meat, 28% melted animal fat (beef intermuscular, sheep tail, beef kidney fats), and 2% salt. The fat and/or fat combinations used in this study are listed in Table 1. In this study, 10 different groups of Kavurma were manufactured according to fat and/or fat combinations used or added such as detailed in Table 1. Produced Kavurmas were chilled (50 to 55 °C) and 3 kg were stuffed into a casing. The product was again chilled until internal temperature reached 4 °C. Then, Kavurma was sliced (3 to 4 cm thick) using a slicing machine. All meat products were vacuum-packaged automatically using Multivac A 300/16 (Sepp Haggenmüller, D 87787 Wolfertschwenden, Germany). A vacuum bag OPAEVOH/PE (water vapor transmission rate 15 g/m^2/24 h/38 °C, 90% RH, 1 atm; O_2 transmission rate 5 cm^3/m^2/24 h/23 °C, 50% RH, 1 atm; N_2 transmission rate 1 cm^3/m^2/24 h/23 °C, 50% RH, 1 atm; CO_2 transmission rate 23 cm^3/m^2/24 h/23 °C, 50% RH, 1 atm) was used in packaging (Aksu and Kaya 2005). The sliced-packaged Kavurma were stored at 4 ± 0.5 °C for 360 d.

Fatty acid compositions of melted beef intermuscular, sheep tail, and kidney fats used for Kavurma production were observed before from they were used. Fatty acid composition of manufactured Kavurma was also determined at 0 d of storage. TBARS, free fatty acids (FFA), pH, CIE L^*, a^*, and b^* values (fat and meat), and *Enterobacteriaceae* counts were evaluated at 0, 180, and 360 d of storage.

For fatty acid profile analysis, fat extracted by the ether method from each sample was used. Melted beef intermuscular, sheep tail, beef kidney fats, and fat from raw or cooked Kavurma were saponified with 5 mL 0.5 N NaOH with methanol in a boiling water bath for 10 min according to the method of Morrison and Smith (1964). Five milliliters of boron trifluoride-methanol were added and refluxed for 2 min. After adding 5 mL heptane, the mixture was again boiled for 1 min. The mixture was transferred to a 25-mL volumetric flask and the volume was adjusted with saturated NaCl to 25 mL. One milliliter of the heptane phase from the upper layer of the volumetric flask was used to determine the fatty acids composition (Aksu and Kaya 2002; Unsal and others 2004). Fatty acid methyl esters were analyzed by gas chromatography (Agilent 6890N Gas Chromatograph, Waldbronn, Germany) with a capillary column (DB23, 60 m × 250 μm × 0.15 μm), temperature (increasing from 100 to 200 °C with rate of 5 °C/min and from 200 to 250 °C with a rate of 4 °C/min), FID detector (H_2 and dry air) at 280 °C, helium gas (1.2 mL/min), and injection block temperature of 250 °C was utilized.

TBARS values of samples were determined according to the methods of Lemon (1975). According to the method, 1 g of sample was taken from each treatment and 6 mL TCA solution was added (7.5% TCA, 0.1% EDTA, 0.1% 1-propyl gallate, 1-propyl gallate was dissolved in 3 mL ethanol). The mixture was filtered over Whatman 1 (Whatman Ltd., U.K.) after homogenizing for 15 to 30 s.

Table 1—Formulation of used fats for Kavurma production.

Groups of Kavurma	Types of fat		
	Beef intermuscular fat (BIF) (%)	Sheep tail fat (STF) (%)	Beef kidney fat (BKF) (%)
1	100	—	—
2	—	—	100
3	30	20	50
4	20	10	70
5	90	10	—
6	—	50	50
7	—	30	70
8	—	20	80
9	50	—	50
10	30	35	35

Then, 1 mL 0.02M TBA solution (2.338 g/L thiobarbituric acid) was added on 1 mL filtrate. The mixture was kept in the boiling water bath for 40 min. It was cooled, and centrifuged at 2000 rpm for 5 min. Finally absorbance was measured at 532 nm (Shimadzu, UV 160, Kyoto, Japan) and was expressed as micromol malonaldehyde per kilogram meat. FFA values of samples were also determined according to the reported methods of Aksu (2007) and were expressed as gram oleic acid/100 g of fat. The pH values were measured with a pH meter (Schott L 6880, Lab Star pH, Mainz, Germany) (Gökalp and others 2000). CIE L^* (0, darkness; 100, lightness), a^* (+, redness; −, greenness), and b^* (+, yellowness; −, blueness) values of the Kavurma fat and meat were measured using a Minolta Model tristimulus colorimeter (Minolta Chroma Meter Measuring Head CR-200, Minolta, Osaka, Japan) and this was used to objectively measure CIE Lab L^*, a^*, and b^* values that were separately measured on the Kavurma meat and Kavurma fat surfaces immediately after opening of the package. The measurements were repeated on 2 randomly selected locations on the sample of each Kavurma group. The microbiological analysis of the samples was determined according to the methods of Baumgart and others (1993). Sample solutions for microbiological analyses were prepared by homogenizing 25 g Kavurma with 225 mL physiological saline water (0.85 NaCl%) in a Stomacher (Blender 400-BA 7021, Seward Medical, London, U.K.) for 2 min. The number of *Enterobacteriaceae* was determined by spreading 0.1 mL of the sample solution on Violet Red Bile Dextrose Agar, and anaerobically incubated at 30 °C for 2 to 3 d.

Statistical analysis

Statistical evaluations were performed with the SPSS (1996) using a completely randomized design procedure. The 1st model included effects of melted beef intermuscular (BIF), sheep tail (STF), and beef kidney fats (BKF) used for Kavurma production as the main effect on fatty acid composition. The 2nd model included effects of treatments (groups of Kavurma) as main effect on fatty acid composition of Kavurma groups. The 3rd model included effects of treatments and storage times (0, 180, and 360 d) as main effect on the other chemical and microbiological properties of all Kavurma groups, and their interactions. The differences among means were tested by Duncan's multiple range test according to $P < 0.05$ significance, and the results of statistical analysis are shown as mean value and standard error in tables.

Results and Discussion

Table 2 shows the mean values for fatty acid composition of melted beef intermuscular (BIF), sheep tail (STF), and beef kidney fats (BKF) used for Kavurma production, and differences for each animal fat. Typically, as shown in Table 2, fat groups (BIF, STF, and BKF) had a statistically significant difference ($P < 0.01$) in terms of total saturated and unsaturated fatty acids. The highest unsaturated fatty acid values were determined in sheep tail fat, and the lowest values were determined in beef kidney fat. However, the lowest polyunsaturated fatty acids were found in beef intermuscular fat. $C_{18:1n9c}$ acid was dominant in fatty acid composition of beef intermuscular and sheep tail fats. $C_{18:0}$ and $C_{18:1n9c}$ acids were also dominant of beef kidney fat (Table 2). Unsal and Yanlic (2005) reported that oleic acid was the dominant in fatty acid in sheep tail fats.

The saturated and unsaturated fatty acid compositions determined in Kavurma groups are presented Table 3 and 4. Palmitic ($C_{16:0}$) and stearic ($C_{18:0}$) acids were dominant in saturated fatty acid composition of all Kavurma groups (Table 3). The fat levels used had a significant effect ($P < 0.01$) on palmitic acid ($C_{16:0}$) and

the highest palmitic acid ($C_{16:0}$) was observed in 100% BIF (group 1) and 90% BIF–10% STF (group 5) (Table 3). As shown in Table 2, palmitic acid was the dominant acid in beef intermuscular fats. However, the lowest palmitic acid ($C_{16:0}$) was determined in group 2 (100% BKF).

The fat levels used had a significant effect on unsaturated fatty acid composition (except for $C_{18:1n9t}$) (Table 4). $C_{18:1n9c}$ was the dominant fatty acid in all Kavurma groups, and the highest amount was determined in 50% STF and 50% BKF (group 6) (Table 4). While the highest total USFA and PUFA amounts were also observed in this Kavurma group, the lowest $C_{18:1n9c}$ percentage was observed in group 2 using 100% BKF.

In the present study, the TBARS values were affected by the treatment (groups of Kavurma) ($P < 0.01$) and storage time ($P < 0.01$). Among Kavurma groups the highest TBARS values were observed in 100% BIF (group 1), 30% BIF + 20% STF + 50% BKF (group 3), 90% BIF +10% STF (group 5), and 90% BIF + 10% STF (group 8) ($P < 0.05$). There was no significant difference among 100% BKF (group 2), 20% BIF + 10% STF + 70% BKF (group 4), and 50% BIF + 50% BKF (group 9). The lowest TBARS value was found in group 10 (30% BIF + 35% STF + 35% BKF) (Table 5). The interaction of groups of Kavurma × storage time resulted in a significant effect on TBARS values of Kavurma groups ($P < 0.01$), and is shown in Figure 1. As can be seen in Figure 1, the greatest change in TBARS values of Kavurma occurred in groups 1, 2, and 10. For group 3, only 360 d was different from 0 and 180 days. However, at groups 4, 6, and 8, changes in TBARS values were lower than the other Kavurma groups during storage time. Cooking causes a dramatic increase in lipid oxidation in muscle, and can increase TBARS, peroxide, and free fatty acid values (Tims and Watts 1958; Kowale and others 1996). Thus, several researchers have shown that the supplementation of tocopherol and/or the other antioxidant in Kavurma process or other cooked meat products caused a significant increase in oxidative stability (Vural and Öztan 1989b; Liu and others 1994; Lynch and others 1999; Galvin and others 2000; Mikova 2001; Aksu and Kaya 2005; Aksu 2007). The mean values of these studies agree with previous reports indicating that TBARS values of Kavurma (Aksu and Kaya 2005). Aksu and Kaya (2005) were 6.74 ± 0.34 μmol malonaldehyde/kg in fresh Kavurma, and were 18.50 ± 0.77 μmol malonaldehyde/kg in Kavurma stored at 4 °C for 300 d. Vural and Öztan (1989b) reported that the TBA values of Kavurma stored at 0 °C at 0 d were 2.10 and at 180 d were 2.32 mg malonaldehyde/kg. Güngör (2000) determined that TBA values of the Kavurma samples were in the range of 0.125 to 2.56 mg malonaldehyde/kg of sample, and significantly increased with time during 6-mo storage. Kayaardi and others (2005) determined that TBA values of the Kavurma samples were significantly increased with time during 120 d of storage. Lipid oxidation can significantly differ among Kavurma samples, depending on raw material, ingredients properties, temperature, pH, processing, and cooking time of the meat product. In fatty products such as Kavurma, free fatty acids are very important quality criteria in determination of fat rancidity (Aksu 2007). When Kavurma groups were investigated in terms of FFA mean values (Table 5), values of group 2, 3, and 6 were determined to be relatively higher than the other Kavurma groups ($P < 0.01$). The lowest mean FFA value was observed in Kavurma with 90% BIF + 10% STF (group 8) (Table 5). Free fatty acid values were also significantly affected by storage time ($P < 0.01$). There was a significant ($P < 0.01$) difference in FFA content in Kavurma stored for 0 to 180 d and 360 d (Table 5), and this value increased during storage time. However, there was no statistically difference between 0 and 180 d of the storage period ($P > 0.05$). Also, group of Kavurma × storage time interaction had an effect ($P < 0.05$) on amount of FFA (Figure 2), and the greatest

Table 2—Fatty acid composition (percent) of intermuscular, sheep tail, and kidney fats used for Kavurma production.

Fatty acids	Beef intermuscular fat	Beef kidney fat	Sheep tail fat	S-error	*P*
Saturated fatty acids (%)					
C 10:0	0.033 c	0.077 b	0.210 a	0.004	**
C 12:0	0.043 b	0.053 b	0.343 a	0.011	**
C 13:0	—	—	0.113		
C 14:0	2.833 b	2.143 c	3.390 a	0.006	**
C 15:0	0.283 c	0.456 b	0.900 a	0.004	**
C 16:0	27.670 a	19.770 c	21.900 b	0.061	**
C 17:0	1.893 c	2.480 b	3.507 a	0.013	**
C 18:0	23.287 b	33.603 a	13.643 c	0.072	**
C 20:0	0.470 c	0.767 b	0.833 a	0.009	**
C 22:0	—	—	0.037		
∑ SFA	56.510 b	59.349 a	44.571 c	0.039	**
Unsaturated fatty acids (%)					
C 14:1	0.973 c	0.457 b	1.473 a	0.007	**
C 16:1	1.595 b	1.533 b	4.290 a	0.146	**
C 17:1	0.413 b	0.400 b	1.577 a	0.005	**
C 18:1n9t	0.183 b	0.150 c	0.370 a	0.008	**
C 18:1n9c	37.403 b	33.500 c	40.263 a	0.074	**
C 18:2n6t	1.397 b	1.507 b	2.730 a	0.108	**
C 18:2n6c	1.190 c	2.230 b	3.230 a	0.037	**
C 18:3n6	0.074 c	0.180 b	0.323 a	0.006	**
C 18:3n3	0.093 b	0.827 a	0.870 a	0.020	**
C 20:1	0.143 a	0.0140 a	0.067 b	0.020	**
C 20:2	—	—	0.044	0.002	
C 20:3n3	—	—	0.087	0.004	
C 22:6n3	0.063 ± 0.006 b	0.055 ± 0.004 b	0.089 a	0.003	**
∑ USFA	43.490 b	40.655 c	55.429 a	0.040	**
∑ MUFA	40.693 b	35.737 c	48.040 a	0.139	**
∑ PUFA	2.797 c	4.918 b	7.389 a	0.085	**

**$P < 0.01$.
a–c, Means in the same line having the same letters are not significantly different at $P > 0.05$.
SFA = saturated fatty acids; USFA = unsaturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids.

Table 3—Saturated fatty acid composition (percent) of Kavurma groups.

	Groups of Kavurma											
Fatty acids	1	2	3	4	5	6	7	8	9	10	S-error	*P*
C 10:0	0.025 f	0.065 d	0.070 d	0.075 cd	0.040 e	0.100 a	0.069 ab	0.085 bc	0.045 e	0.075 cd	0.006	**
C 12:0	0.030 g	0.045 fg	0.070 bcd	0.065 cde	0.055 def	0.095 a	0.080 abc	0.085 ab	0.050 ef	0.075 bc	0.005	**
C 14:0	2.715 abcd	2.090 f	2.675 bcde	2.550 de	2.880 ab	2.810 abc	2.640 cde	2.885 a	2.510 de	2.470 e	0.061	**
C 15:0	0.260 g	0.375 e	0.445 d	0.435 d	0.335 f	0.585 a	0.535 b	0.500 bc	0.355 ef	0.495 c	0.011	**
C 16:0	27.645 a	20.215 e	23.980 b	22.810 c	27.320 a	22.250 cd	21.745 cd	24.220 b	24.290 b	21.460 d	0.332	**
C 17:0	1.140 g	1.810 f	2.275 c	2.305 c	1.960 e	2.655 a	2.565 a	2.435 b	2.2120 d	2.420 b	0.033	**
C 18:0	21.525 de	30.305 a	22.965 c	26.995 b	21.225 e	22.635 cd	25.840 b	21.600 de	26.820 b	26.495 b	0.401	**
C 20:0	0.390 d	0.960 a	0.930 a	1.000 f	0.195 e	0.515 c	0.485 c	0.530 c	0.125 ef	0.630 b	0.023	**
∑ SFA	53.730 de	55.965 ab	53.410 e	55.330 abc	54.010 de	51.645 f	54.865 bcd	52.700 ef	56.250 a	54.190 cde	0.381	**

**$P < 0.01$.
a–g, Means in the same line having the same letters are not significantly different at $P > 0.05$. SFA = saturated fatty acids; MUFA = mononunsaturated fatty acids.
PUFA = polyunsaturated fatty acids, Groups of Kavurma: (1) 100% BIF, (2) 100% BKF, (3) 30% BIF, 20% STF, and 50% BKF, (4) 20% BIF, 10% STF, and 70% BKF, (5) 90% BIF and 10% STF, (6) 50% STF and 50% BKF, (7) 30% STF and 70% BKF, (8) 90% BIF and 10% STF, (9) 50% BIF and 50% BKF, (10) 30% BIF, 35% STF, and 35% BKF; BIF = Beef intermuscular fat, STF = sheep tail fat, BKF = beef kidney fat.

Table 4—Unsaturated fatty acid composition (percent) of Kavurma groups.

	Groups of Kavurma											
Fatty acids	1	2	3	4	5	6	7	8	9	10	S-error	*P*
C 14:1	0.945 a	0.530 d	0.750 bc	0.675 bc	0.960 a	0.790 bc	0.670 c	0.970 a	0.765 bc	0.795 b	0.036	**
C 16:1	3.220 a	2.500 cd	2.365 de	2.195 ef	3.135 a	2.865 b	2.140 f	2.600 c	2.420 cd	2.025 f	0.066	**
C 17:1	0.440 g	0.385 h	0.585 d	0.480 f	0.515 e	0.820 a	0.650 c	0.715 b	0.405 h	0.605 d	0.011	**
C 18:1n9t	0.160	0.100	0.135	0.130	0.105	0.105	0.120	0.125	0.105	0.130	0.012	NS
C 18:1n9c	37.585 abc	35.735 c	37.825 abc	36.820 abc	37.585 abc	38.610 a	36.180 bc	38.060 ab	35.515 b	36.370 bc	0.661	*
C 18:2n6t	1.500 c	2.095 b	2 .530 a	1.370 c	1.680 c	2.150 ab	2.470 ab	2.150 ab	2.485 ab	2.255 ab	0.114	**
C 18:2n6c	1.517 f	1.995 d	2.165 cd	2.315 b	1.700 e	2.615 a	2.560 a	2.200 bc	1.740 e	2.360 b	0.054	**
C 18:3n6	0.055 def	0.035 f	0.090 bc	0.095 bc	0.045 ef	0.075 cd	0.070 cde	0.075 cd	0.105 b	0.200 a	0.08	**
C 18:3n3	0.065 f	0.075 f	0.095 ef	0.660 b	0.215 d	0.105 ef	0.120 e	0.105 ef	0.415 c	0.725 a	0.012	**
C 20:1	0.105 b	0.035 d	0.065 bcd	0.105 b	0.085 abc	0.050 d	0.110 a	0.055 cd	0.055 cd	0.090 ab	0.009	**
C 22:6n3	—	—	0.035 b	—	—	0.045 ab	0.045 ab	0.045 ab	0.045 ab	0.050 a	0.004	**
∑ USFA	46.117 bcd	44.035 e	46.590 abc	44.870 de	46.000 bcd	48.535 a	45.135 de	47.305 ab	43.755 e	45.820 cd	0.464	**
∑ MUFA	42.540 a	39.413 c	41.800 ab	40.355 bc	42.340 a	42.560 a	39.870 c	42.525 a	39.265 c	40.015 c	0.527	**
∑ PUFA	3.580 c	4.625 b	4.790 b	4.515 bc	3.660 c	5.980 a	5.270 ab	4.785 b	4.495 bc	5.805 a	0.285	**

NS = nonsignificant.
**$P < 0.01$.
a–h, Means in the same line having the same letters in the same sections are not significantly different at $P > 0.05$. USFA = unsaturated fatty acids; MUFA = mononunsaturated fatty acids; PUFA = polyunsaturated fatty acids.
Groups of Kavurma: (1) 100% BIF, (2) 100% BKF, (3) 30% BIF, 20% STF, and 50% BKF, (4) 20% BIF, 10% STF, and 70% BKF, (5) 90% BIF and 10% STF, (6) 50% STF and 50% BKF, (7) 30% STF and 70% BKF, (8) 90% BIF and 10% STF, (9) 50% BIF and 50% BKF, (10) 30% BIF, 35% STF, and 35% BKF; BIF = beef intermuscular fat, STF = sheep tail fat, BKF = beef kidney fat.

change in FFA values occurred in group 3. Aksu (2007) reported that the amount of FFA in the fat depends on the hydrolytic activity of the lipases, the microbial metabolic processes, and the oxidative reactions that worked on the free fatty acids released in the lipolysis. These reactions are directly related to both the raw material and the production process. Aksu (2007) observed that mean FFA values of control and Kavurma samples with added 50 and 100 mg/kg tocopherol, stored at 4 or 10 °C for 90 d, were 0.30, 0.27, and 0.25 oleic acid/100 g of fat, and this value increased during storage from 0.25 to 0.29 oleic acid/100 g of fat. Additionally, Güngör (2000) determined that the FFA values of Kavurma stored at 4 °C for 180 d was 0.67 and 1.18 mg KOH/g fat. According to the Kavurma standard (Anonymous 2002) the FFA value of Kavurma should be a maximum of 2% as oleic acid.

The difference among Kavurma groups in pH was significant ($P < 0.01$) (Table 5), and the highest value occurred to group 10 with a mean value of 6.28. The lowest pH was found in group 8 with a mean value of 6.07. The pH values of 360-d-stored samples increased from 6.11 to 6.21 during storage ($P < 0.01$). However, there were no significant differences in pH between 180 and 360 d of storage time ($P > 0.05$). The maximum pH value is 6.4 according to Turkish Kavurma Standard (Anonymous 2002). Several researchers have found that pH values of Turkish Kavurma were 6.06 to 6.45 (Vural and Öztan 1989a, 1989b; Tiryakioğlu and Yücel 1995; Cetin 2000; Aksu and Kaya 2005; Aksu 2007).

Enterobacteriaceae counts were determined under the detectable level (<2.00 log CFU/g) in all Kavurma groups during

Table 5—Means and standard errors for TBARS value, free fatty acid, and pH values of Kavurma groups with different animal fat at 0, 180, and 360 d of storage.

	TBARS[a]	FFA[b]	pH	*Enterobacteriaceae* counts log CFU/g
Groups of Kavurma (GK)				
1	16.98 a	0.25 cd	6.21 ab	<2.00
2	11.28 c	0.30 a	6.17 b	<2.00
3	18.23 a	0.29 ab	6.09 cd	<2.00
4	11.56 c	0.25 cd	6.15 bc	<2.00
5	17.43 a	0.21 f	6.18 b	<2.00
6	15.02 b	0.30 a	6.22 ab	<2.00
7	14.99 b	0.26 cd	6.16 bc	<2.00
8	18.41 a	0.23 e	6.07 d	<2.00
9	11.55 c	0.25 cd	6.09 cd	<2.00
10	7.49 d	0.27 bc	6.28 a	<2.00
S-error	0.584	0.007	0.024	
P	**	**	**	
Storage time (ST) (d)				
0	12.35 c	0.24 b	6.11 b	<2.00
180	13.59 b	0.25 b	6.17 a	<2.00
360	16.93 a	0.28 a	6.21 a	<2.00
S-error	0.320	0.004	0.013	
P	**	**	**	
GK × ST	**	*	NS	

[a] μmol malonaldehyde/kg, [b] g oleic acid/100 g of fat, NS = nonsignificant. $^{*}P < 0.05$, $^{**}P < 0.01$. a–e, Means in the same line having the same letters in the same sections are not significantly different at $P > 0.05$, Groups of Kavurma: (1) 100% BIF, (2) 100% BKF, (3) 30% BIF, 20% STF, and 50% BKF, (4) 20% BIF, 10% STF, and 70% BKF, (5) 90% BIF and 10% STF, (6) 50% STF and 50% BKF, (7) 30% STF and 70% BKF, (8) 90% BIF and 10% STF, (9) 50% BIF and 50% BKF, (10) 30% BIF, 35% STF, and 35% BKF; BIF = beef intermuscular fat, STF = sheep tail fat, BKF= beef kidney fat.

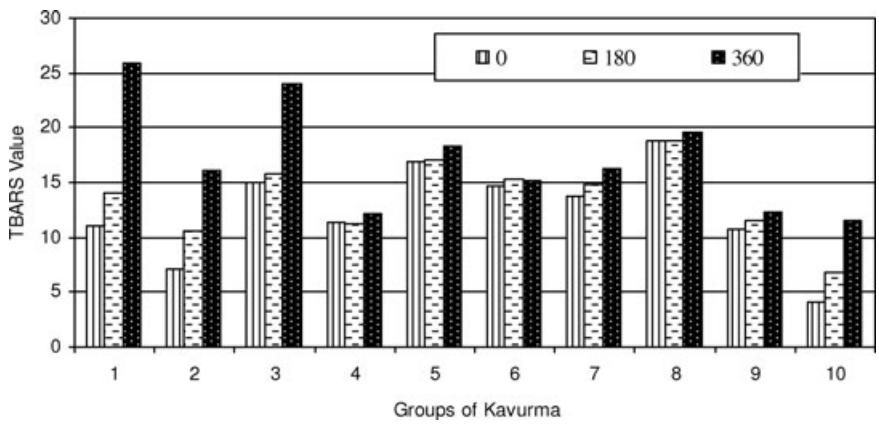

Figure 1—Effect of treatment and storage time on the TBARS value (μmol malonaldehyde/kg) of Kavurma groups. Groups of Kavurma: (1) 100% BIF, (2) 100% BKF, (3) 30% BIF, 20% STF, and 50% BKF, (4) 20% BIF, 10% STF, and 70% BKF, (5) 90% BIF and 10% STF, (6) 50% STF and 50% BKF, (7) 30% STF and 70% BKF, (8) 90% BIF and 10% STF, (9) 50% BIF and 50% BKF, (10) 30% BIF, 35% STF, and 35% BKF; BIF = beef intermuscular fat, STF = sheep tail fat, BKF = beef kidney fat.

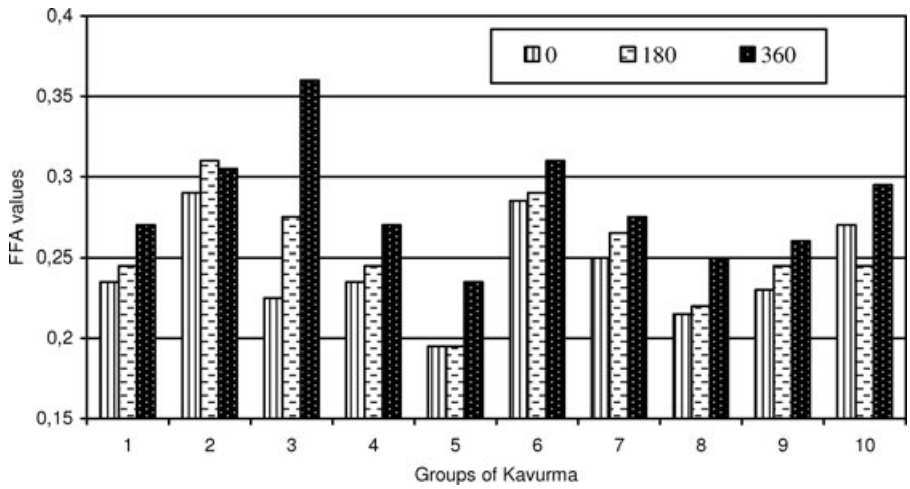

Figure 2—Effect of treatment and storage time on the FFA value (g of oleic acid/100 g of fat) of Kavurma groups. Groups of Kavurma: (1) 100% BIF, (2) 100% BKF, (3) 30% BIF, 20% STF, and 50% BKF, (4) 20% BIF, 10% STF, and 70% BKF, (5) 90% BIF and 10% STF, (6) 50% STF and 50% BKF, (7) 30% STF and 70% BKF, (8) 90% BIF and 10% STF, (9) 50% BIF and 50% BKF, (10) 30% BIF, 35% STF, and 35% BKF; BIF = beef intermuscular fat, STF = sheep tail fat, BKF = beef kidney fat.

storage (Table 5). This is because cooking temperature for Kavurma (105 °C for 120 to 130 min) is sufficient to destroy pathogens and other spoilage bacteria. In a study, in Kavurma samples that were regular (large casings of 4 to 5 kg) or vacuum packaged collected from different retail locations in Erzurum, Turkey, *Escherichia coli*, *Salmonella*, or *Staphylococcus aureus* were not determined (Cetin 2000).

Color values of fresh Kavurma fat and meat (0 d) and stored at 4 ± 0.5 °C for 360 d are given in Table 6. Color properties of fat and meat of Kavurma were generally affected with treatments. The effects of storage time on L^* ($P < 0.05$) and b^* ($P < 0.01$) values of Kavurma fat and L^* ($P < 0.05$), a^* ($P < 0.01$), and b^* ($P < 0.05$) of Kavurma meat were found statistically significant (Table 6). Kavurma groups × storage time interaction had a significant effect on L^* ($P < 0.01$; Figure 3) and b^* ($P < 0.05$; Figure 4). Values of Kavurma fat had an effect on a^* values for Kavurma meat ($P < 0.05$; Figure 5). L^* values of Kavurma fat at the groups 1, 2, 3, and 10 increased during storage, and the greatest change occurred to group 1 (Figure 3). As an important result of this study, a^* values of Kavurma meat decreased during storage (Figure 5), and the greatest decrease was determined between days 0 and 180 of storage. Aksu and Kaya (2005) and García-Segovia and others (2007) reported that color measurement in cooked meat can provide reliable information about eating quality attributes, and color is an important factor for the shelf life and consumer acceptance of cooked meat products. This is because the myoglobin is the primary heme pigment responsible for meat color, but there are other species as DeoxyMb, MetMb, OxyMb, and sulfmyoglobin (SulfMb) contributing to color changes during the cooking of meat. During cooking, 3 forms of myoglobin interconvert and are degradated through oxygenation and oxidation and reduction reactions, ultimately influencing the appearance of cooked meat color (Liu and Chen 2001; Liu and others 2003; García-Segovia and others 2007). Also, Lawrie (1998) reported that the color complexes in cooked meat are composed of denaturated hemoproteins and the reactions where in the protein may be other several denatured proteins present, and not

Table 6—Means and standard errors for L^*, a^*, and b^* values of meat and fat of Kavurma groups with different animal fat at 0, 180, and 360 d of storage.

	Kavurma fat			Kavurma meat		
	L	*a**	*b**	*L*	*a**	*b**
Groups of Kavurma (GK)						
1	74.76 c	−2.41 b	5.88 e	39.87 bc	5.53 bc	6.91 a
2	74.81 c	−2.97 cd	8.55 bc	41.04 bc	6.20 bc	6.58 ab
3	74.45 c	−1.93 a	11.38 a	37.78 c	5.78 bc	5.18 bc
4	79.10 a	−3.19 def	7.49 cd	40.93 bc	5.77 bc	5.18 bc
5	77.20 abc	−2.90 cd	6.93 de	45.56 a	7.21 ab	6.55 ab
6	75.58 bc	−3.50 ef	8.91 b	42.69 ab	6.19 bc	4.80 c
7	77.76 ab	−3.58 f	7.40 cd	43.37 ab	6.15 bc	5.21 bc
8	78.51 a	−3.20 def	6.56 de	45.59 a	9.17 a	5.72 abc
9	77.32 abc	−2.63 bc	6.93 de	43.19 ab	5.02 c	4.99 bc
10	74.85 c	−3.14 de	8.36 bc	42.23 ab	5.96 bc	6.60 ab
S-error	0.881	0.131	0.391	1.073	0.530	0.503
P	**	**	**	**	*	*
Storage time (ST) (days)						
0	76.87 a	−3.00	7.48 b	41.50	8.95 a	7.69 a
180	75.32 b	−2.91	8.42 a	42.83	5.58 b	5.02 b
360	77.12 a	−2.93	7.62 b	42.34	4.07 c	4.60 b
S-error	0.482	0.072	0.214	0.276	0.290	0.276
P	*	NS	**	*	**	*
GK × ST	**	NS	*	NS	*	NS

NS = nonsignificant, $^*P < 0.05$, $^{**}P < 0.01$. a–e, Means in the same line having the same letters in the same sections are not significantly different at $P > 0.05$. Groups of Kavurma: (1) 100% BIF, (2) 100% BKF, (3) 30% BIF, 20% STF, and 50% BKF, (4) 20% BIF, 10% STF, and 70% BKF, (5) 90% BIF and 10% STF, (6) 50% STF and 50% BKF, (7) 30% STF and 70% BKF, (8) 90% BIF and 10% STF, (9) 50% BIF and 50% BKF, (10) 30% BIF, 35% STF, and 35% BKF; BIF = beef intermuscular fat, STF = sheep tail fat, BKF = beef kidney fat.

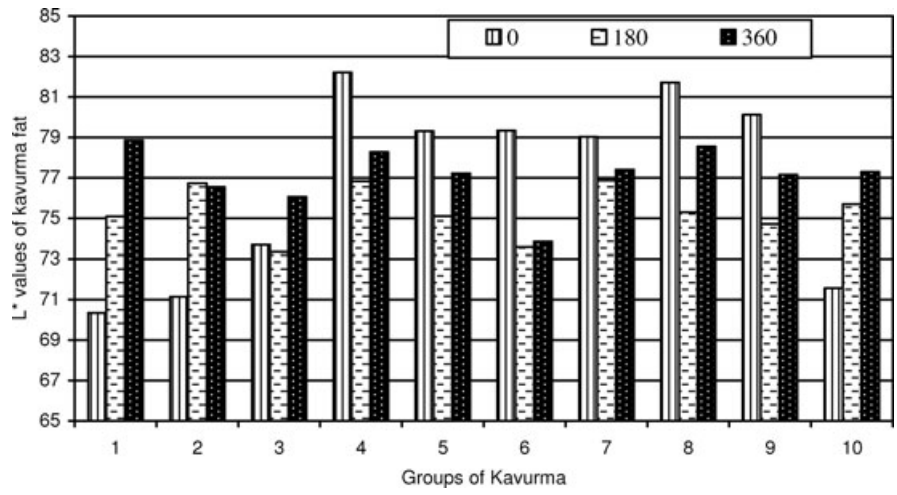

Figure 3—Effect of treatment and storage time on the L^* value of Kavurma fat. Groups of Kavurma: (1) 100% BIF, (2) 100% BKF, (3) 30% BIF, 20% STF, and 50% BKF, (4) 20% BIF, 10% STF, and 70% BKF, (5) 90% BIF and 10% STF, (6) 50% STF and 50% BKF, (7) 30% STF and 70% BKF, (8) 90% BIF and 10% STF, (9) 50% BIF and 50% BKF, (10) 30% BIF, 35% STF, and 35% BKF; BIF = beef intermuscular fat, STF = sheep tail fat, BKF = beef kidney fat.

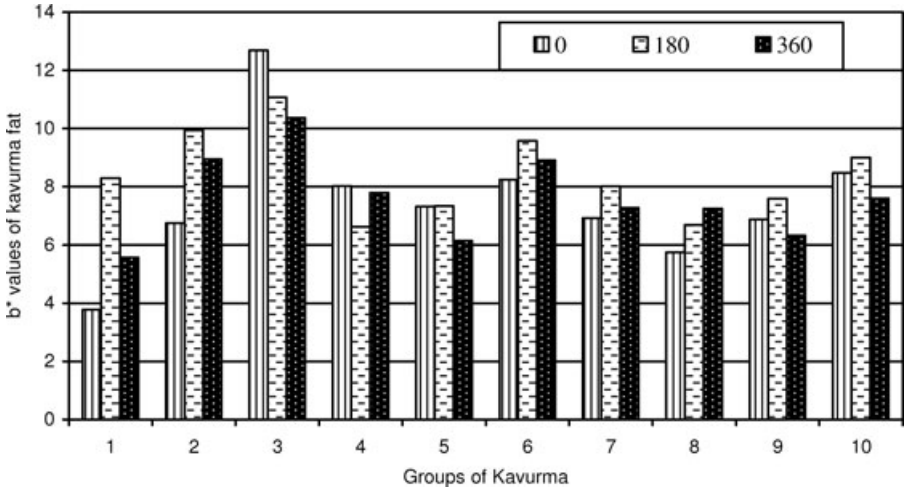

Figure 4 — Effect of treatment and storage time on the *b value of Kavurma fat. Groups of Kavurma: (1) 100% BIF, (2) 100% BKF, (3) 30% BIF, 20% STF, and 50% BKF, (4) 20% BIF, 10% STF, and 70% BKF, (5) 90% BIF and 10% STF, (6) 50% STF and 50% BKF, (7) 30% STF and 70% BKF, (8) 90% BIF and 10% STF, (9) 50% BIF and 50% BKF, (10) 30% BIF, 35% STF, and 35% BKF; BIF = beef intermuscular fat, STF = sheep tail fat, BKF = beef kidney fat.**

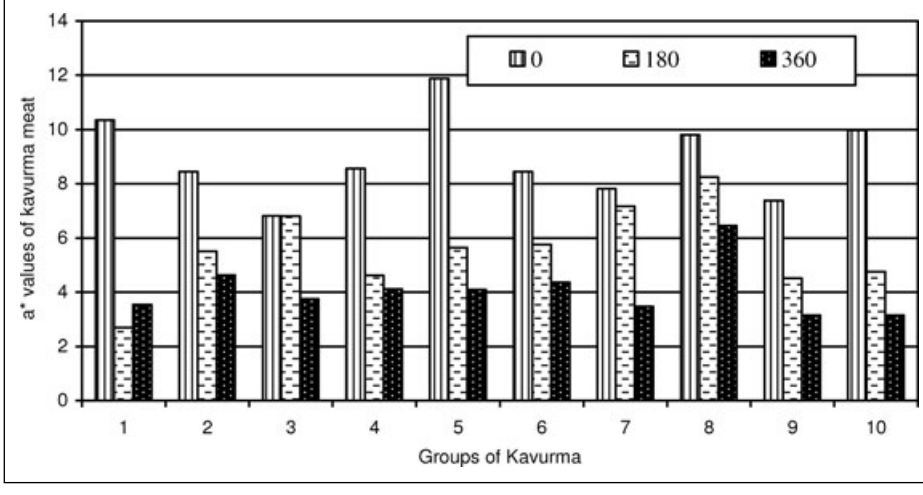

Figure 5 — Effect of treatment and storage time on the *a value of Kavurma meat. Groups of Kavurma: (1) 100% BIF, (2) 100% BKF, (3) 30% BIF, 20% STF, and 50% BKF, (4) 20% BIF, 10% STF, and 70% BKF, (5) 90% BIF and 10% STF, (6) 50% STF and 50% BKF, (7) 30% STF and 70% BKF, (8) 90% BIF and 10% STF, (9) 50% BIF and 50% BKF, (10) 30% BIF, 35% STF, and 35% BKF; BIF = beef intermuscular fat, STF = sheep tail fat, BKF = beef kidney fat.**

only globin. Aksu and Kaya (2005) reported that a^* values of sliced Kavurma, vacuum-packaged and stored for 300 d at 4 °C of decreased during storage from 8.15 ± 1.61 to 4.34 ± 1.38. This fact is supported by the results of the present study. Also, Kayaardi and others (2005) determined that color values of the Kavurma samples were significantly decreased during a 120-d storage period.

Conclusions

Many people have limited their dietary intake of fat due to health concerns, and they are interested in replacing or reducing dietary fat (Candoğan and Kolsarici 2003a), which is economical and contributes to textural and organoleptical properties of meat products (Candoğan and Kolsarici 2003b). Sheep tail fat contains levels of unsaturated and polyunsaturated fatty acids than beef intermuscular and beef kidney fats. Therefore, the positive effects for consumer health could be improved by producing Kavurma with simultaneous reduction in beef intermuscular and beef kidney fats and partial replacement with sheep tail fat. Also, the quality of Kavurma could be considerably improved in terms of saturated/unsaturated or saturated/PUFA ratios by using sheep tail fat in Kavurma production. It is known that lipid oxidation seems to be the main cause of deterioration of cooked meat products during refrigerated storage, causing a decrease in PUFA and an increase in MUFA and SFA percentages (Estevez and others 2004). There is no problem in term of lipid oxidation in all Kavurma groups during storage according to TBARS and FFA values determined in this study during storage. Sliced and vacuum-packaged Kavurma with different added animal fat in terms of color values and *Enterobacteriaceae* count showed acceptability properties at 4 ± 1 °C for 360 d. In addition, sheep tail fat was used to increase aroma and flavor in traditional meat products, and so, in future studies, there is a need to determine the volatile compounds of Kavurma samples with different levels of sheep tail fat.

[Correction added after online publication 21 January 2009: Acknowledgments removed.]

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