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Determination of Fatty Acid Composition and Total *Trans* Fatty Acids in Meat Products

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Abstract In this research, fatty acid composition and *trans* fatty acids of 22 selected meat products produced by Turkish companies were analyzed by capillary gas liquid chromatography (GLC). Total fat contents of the meat products ranged from 11.60-42.50%. Salami had the lowest fat content 11.60% and *sucuk* (*soudjuk*) the highest 42.50%. Major fatty acids were $C_{16:0}$, $C_{18:0}$, *trans* $C_{18:1}$, *cis* $C_{18:1}$, and $C_{18:2}$ in the samples. Total unsaturated fatty acid contents have changed from 38.73 to 70.71% of total fatty acids, and sausage had the highest percentage among the samples. The majority of samples contain *trans* fatty acids and the level ranged from 2.28 to 7.95% of the total fatty acids. The highest amount of total *trans* fatty acids was determined in *kavurma* (Cavurmas) (7.95%), and total *trans* fatty acids of meat products such as pastrami contained more than 5% of the total fatty acids.

Keywords: fatty acid composition, *trans* fatty acid, meat product, saturated fatty acid, unsaturated fatty acid

Introduction

Meat and meat products provide the majority of the nutrients required for human health. The significance of meat as a source of high biological value protein and micronutrients (including for example vitamins A, B_6, B_{12}, D, E, and iron) is well recognized (1,2). Meat fats play important roles in human nutrition. Beef also contains small amounts of the C20/22 poly unsaturated fatty acid (PUFA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA) and recent research has demonstrated that red meat is an important source of these fatty acids for human (3). The fatty acid profile of meat products has an impact on its nutritional value, shelf life, and palatability.

Meat fats from ruminants contain *trans* fatty acid and conjugated linoleic acid (CLA) isomers formed as metabolic intermediates by isomerization and reduction of PUFAs in rumen bacteria (3). The *trans* fatty acids may be further metabolized by rumen bacteria to saturated fatty acid (SFA), or taken up in rumen tissue lipids where some of the *trans* fatty acids isomers are converted to more UFAs by desaturases.

Arachidonic acid, conjugated linoleic acid, and γ-linolenic acid are found in low concentrations in foods and are usually not available in many nutrient databases. However, all these fatty acids may play an important role in the development of chronic diseases (4).

Trans fatty acids present in the diet arise from 2 origins. One is derived from bacterial biohydrogenation in the forestomach of ruminants, which is the source of *trans* fatty acids present in mutton and beef fats. The body fat of ruminants such as cattle and sheep should be contains *trans* fatty acids. As a result, food products produced from these animals which contain fat (e.g., butter) will contain *trans* fatty acids (5,6). The content of *trans* fatty acids range from 2 to 9% of bovine fat. *Trans*-11-octadecenoic acid produced as the main isomers although *trans*-9- and *trans*-10-octadecenoic acid are also produced. Thus, *trans* fatty acids occur in nature and cannot be considered to be foreign substances. Another origin is derived from the industrial catalytic hydrogenation of vegetable oils and fish oils (7).

The major sources of dietary *trans* fatty acids before the turn of the century were foods containing lipids from ruminant animals such as cows, sheep, and goats. However, currently these foods are only responsible for 10-20% of our total trans-fat intake (8,9)

Trans-fats can also be present in pork and poultry at low levels as a result of the animals consuming feeds that contain trans-fats (10). The amount of *trans* fatty acids in meat of nonruminant animals is generally low (11) and is depended on the presence of *trans* fatty acids in feeds. The main *trans* fatty acid group in all ruminants is 18:1 (12).

The two naturally occurring trans-fats from animal sources are conjugated linoleic acid (CLA) and vaccenic acid. CLA research with animal models has demonstrated beneficial effects such as protection against cancer, heart disease, and obesity. Vaccenic acid is a precursor to CLA and thus potentially offers health benefits as well.

The concentration of *trans* fatty acids in adipose tissue is approximately proportional to long-term dietary intake, and determination of the concentrations in storage fat is one method used to estimate *trans* fatty acid intake. *Trans*-18:1 isomers account for approximately 70% of the *trans* fatty acids found in adipose tissue, and *trans*-18:2 isomers (*trans, trans, trans, cis*, and *cis, trans*) account for about 20% (7). *Trans* isomers of $C_{18:1}$ (elaidic acid) are the most common *trans* fatty acids, accounting for 65% of the total *trans* fatty acids in the UK diet (7).

Raised plasma concentrations of low density lipoprotein (LDL) are considered to be a risk factor for coronary heart disease (CHD); in contrast, reduced concentrations of high density lipoprotein (HDL) are considered to increase risk.

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Therefore, it reveals that to reduce the possibility of CHD, diets should be ideally offered to maintain plasma concentrations of HDL cholesterol and to lower those of LDL cholesterol (7).

Trans fatty acids are found in numerous foods. The adverse effects of the *trans* fatty acids on the ratio of total cholesterol to HDL cholesterol double that of saturated fatty acids (13,14). Similar to saturated fatty acids, *trans* fatty acids also increase LDL cholesterol and lower HDL cholesterol therefore increasing the risk of heart diseases. Some epidemiological studies have also found a positive relationship between levels of *trans* fatty acid intake and the risk of cardiovascular disease (14). Therefore, the possible increase in risk for those diseases caused by a high *trans* fatty acid consumption should be carefully considered (15,16).

Concerns have been raised for several decades that consumption of *trans* fatty acids might have contributed to the 20^{th} century epidemic of coronary heart disease (17). Trans-fats have also been associated with an increased risk of coronary heart disease in epidemiologic studies (18). To promote cardiovascular health, diets should provide a very low intake of *trans* fatty acids (hydrogenated oils and fats). In practice, it is recommended that the intake of *trans* fatty acids should be less than 1% of daily energy intake (16).

The aim of this study was to determine the proximate compositions, the fatty acid composition and total *trans* fatty acid contents of meat products using by capillary gas liquid chromatography. The *trans* isomers of the samples were also evaluated in relation to health.

Materials and Methods

Materials Samples of meat products (made from beef) were purchased locally in Tekirdağ, Turkey. All samples were immediately transported at 4°C in cooling box and then subjected to analysis to determine the quality of the meat products in terms of proximate compositions, fatty acids and *trans* fatty acids.

Proximate composition Moisture, fat, protein, and ash contents in meat products were determined by AOAC methods (20).

Determination of fatty acid composition Fat extraction was carried out according to AOAC (20). Fatty acids methyl esters (FAME) were prepared after saponification, followed by esterification with the appropriate amount of methanolic boron trifluoride solution. The final concentration of the FAME was approximately 7 mg/mL in heptane (20).

Gas chromatogaphy (GC) analysis was performed using Agilent 6890 model gas chromatograph (Agilent Technologies, Palo Alto, CA, USA) equipped with a flame ionization detector (FID), a split injector (Chrompack, Middleburg, Netherlands) and Chemstation software. The column was CPTM-Sil 88 (Chrompack) 100 m in length, 0.25 mm i.d., 0.2 μm in film thickness. Both temperature of the injector and detector ports was set at 250°C. Hydrogen is used as a carrier gas at the flow rate of 1 mL/min. The GC was operated under temperature-programmed conditions from 45°C (4 min), ramped at 13°C/min to 175°C (27 min) and ramped at 4°C/min to 215°C (35 min). The GC was equipped with a split/splitless injector; an injection volume of 1 μL was employed, using a split ratio of 50:1.

Statistical analysis The data obtained from 3 replications were analyzed by analysis of variance (ANOVA) using the SPSS statistical package program, and differences among the means were compared using the Duncan's multiple-range test (21).

Results and Discussion

Proximate composition Total fat contents, and *cis* and *trans* fatty acids isomers of 22 selected meat products in Turkey were given in Table 1 and 2. Table 1 and 2 showed that their fat contents varied widely. As it is expected, salami and pastrami have contained the lowest amount of fat, 11.61 and 14.27%, respectively. The highest amount of fat was found in *sucuk* as 42.50%, and *kavurma* and *köfte* followed as 28.07 and 21.76%, respectively. Fat content of Turkish sausages range from 9 to 20%, protein 9 to 17%, moisture 52 to 69%, and salt 1.6 to 2.7% (22). Similar results were reported by Yılmaz *et al.* (22).

Fatty acid composition Since *sucuk* is very popular meat product, it is widely produced and consumed in Turkey. *Sucuk* contains high fat contents. *Sucuk* is a semidry fermented meat product (23). The highest total *trans* fatty acid content was determined with the *kavurma*. *Kavurma* is a traditionally cooked meat product made from beef or mutton, beef fat, and salt produced originally to conserve meat. Meats are diced and mixed with salt, and then cooked in animal fat using a double-sided steam cauldron. After cooking, the product is kept in almost anaerobic conditions and at low temperatures. *Kavurma* is also sold in slices or vacuum-packaged forms (24,25).

It is reported that beef contained 2.8-9.5% and lamb meat 4.3-9.2% *trans* fatty acids whereas pork (0.2-2.2%) and chicken (0.2-1.7%) and meat from other nonruminants were lower in *trans* fatty acids. With very few exceptions, sausages contained pork and showed low *trans* fatty acid levels (12). Veal samples were showed lower proportions of *trans* fatty acids (1.5-3.3%) compared with (2.8-9.5%) lamb and mutton generally contained slightly higher proportions of *trans* fatty acids than beef reaching levels of 8-9% (12).

Major fatty acids in the samples were $C_{16:0}$, $C_{18:0}$, *trans* $C_{18:1}$, *cis* $C_{18:1}$, and $C_{18:2}$, and the other fatty acids were around or less than 1% in the samples. Total unsaturated fatty acid contents ranged from 38.73-70.71% of the total fatty acids and major proportion of them was composed of monounsaturated fatty acids. On the other hand, total unsaturated fatty acid contents of the sausage was relatively high (70.71%) compared with the others and large percentage of unsaturated fatty acids of this sample was composed of polyunsaturated fatty acids, mainly $C_{18:2}$. All the samples contain *trans* fatty acids and the level ranged from 1.37-7.95% of the total fatty acids. The highest amount of total *trans* fat was determined in *kavurma* (7.95%), and pastrami contained more than 10% of the total fatty acids. The predominant *trans* isomers found in all samples were *trans* $C_{18:1}$ monounsaturated fatty acid, ranging between 1.21-5.94% of the total fatty acids. As *trans* polyunsaturated fatty acids, *trans* $C_{18:2}$ was

Table 1. Proximate and fatty acid composition (as % total fatty acids) of emulsified meat products (salami and sausage)[1)]

	Salami					Sausage				
Brand	1	2	3	4	5	1	2	3	4	5
Proximate composition (%)										
Moisture	64.09±2.69	66.67±1.98	63.01±2.04	56.90±1.72	62.07±2.52	62.34±1.75	61.83±2.05	61.17±2.52	66.74±3.01	61.14±2.71
Fat	13.92±1.01	11.60±0.35	15.46±1.11	20.23±0.72	16.48±0.81	17.81±0.51	16.73±1.14	18.02±0.78	13.19±0.58	15.32±0.62
Protein	17.51±1.42	17.87±1.03	16.57±1.29	19.45±0.41	18.32±1.07	16.41±0.62	15.34±0.89	16.04±0.69	15.22±1.07	18.34±0.88
Ash	2.76±0.31	3.07±0.21	3.86±0.41	2.54±0.31	2.70±0.41	2.24±0.16	2.64±0.26	3.15±0.42	3.39±0.33	3.17±0.54
Fatty acid composition										
C8:0	0.06±0.01	0.05±0.01	0.04±0.01	0.07±0.02	0.08±0.02	0.05±0.01	0.04±0.01	0.02±0.01	0.03±0.01	0.02±0.01
C10:0	0.07±0.02	0.08±0.02	0.21±0.06	0.10±0.02	0.13±0.03	0.19±0.03	0.07±0.02	0.04±0.01	0.06±0.02	0.05±0.01
C12:0	0.07±0.02	0.03±0.01	0.02±0.01	0.08±0.01	0.06±0.01	0.02±0.01	0.03±0.01	0.01±0.01	0.04±0.01	0.03±0.01
C14:0	3.23±0.76	1.70±0.03	1.43±0.65	2.88±0.79	2.91±0.37	1.40±0.62	1.31±0.21	0.75±0.11	1.30±0.32	1.44±0.24
C14:1	1.18±0.06	0.41±0.13	0.33±0.04	0.94±0.22	0.97±0.11	0.38±0.06	0.37±0.06	0.13±0.02	0.44±0.6	0.43±0.02
C15:0	0.43±0.09	0.33±0.05	0.25±0.02	0.51±0.11	0.47±0.08	0.27±0.04	0.19±0.03	0.14±0.03	0.24±0.06	0.25±0.02
C15:1	0.28±0.02	0.13±0.03	0.10±0.02	0.29±0.03	0.24±0.02	0.15±0.03	0.14±0.02	0.04±0.01	0.11±0.03	0.12±0.01
C16:0	26.09±1.47	22.45±2.26	22.02±2.31	25.51±1.24	25.45±2.31	22.22±1.89	19.46±1.56	19.22±1.31	19.76±1.54	21.08±1.76
C16:1	4.31±0.88	2.87±0.25	3.22±1.01	3.74±0.53	4.48±0.79	3.11±0.88	3.19±0.78	2.84±0.08	3.10±0.08	3.87±0.72
C16:1 *trans*	0.11±0.02	0.10±0.02	0.13±0.02	0.11±0.01	0.11±0.02	0.10±0.02	0.29±0.09	0.11±0.02	0.39±0.06	0.14±0.02
C17:0	1.08±0.02	0.85±0.12	0.76±0.23	1.26±0.06	1.16±0.02	0.72±0.04	0.69±0.11	0.48±0.03	0.72±0.03	0.73±0.23
C17:1	0.58±0.03	0.33±0.05	0.28±0.04	0.50±0.05	0.62±0.03	0.23±0.02	0.51±0.09	0.17±0.04	0.23±0.02	0.30±0.08
C18:0	18.73±1.69	14.21±1.41	12.68±0.89	23.47±1.92	17.37±1.11	12.08±1.12	11.23±1.02	8.03±0.98	12.91±1.11	12.08±0.72
C18:1 *cis*	27.26±2.21	28.12±2.35	30.69±2.84	27.03±1.75	30.49±2.71	28.44±2.19	32.07±2.08	30.43±2.14	26.03±2.31	32.57±2.72
C18:1 *trans*	3.64±0.06	4.50±0.87	2.02±0.34	3.53±0.19	2.57±0.98	1.21±0.49	2.09±0.04	2.81±1.11	2.37±0.97	2.01±0.29
C18:2 *cis*	9.63±0.08	20.68±1.72	22.77±2.31	7.11±0.92	9.98±1.08	21.07±1.92	23.09±0.91	30.94±2.91	24.59±2.23	21.52±1.29
C18:2 *trans*	1.99±0.05	0.82±0.11	0.52±0.06	1.43±0.04	1.29±0.02	2.33±0.78	1.41±0.77	0.18±0.02	1.67±0.09	0.11±0.02
C18:3 *cis*	0.23±0.05	1.32±0.15	1.30±0.78	0.40±0.06	0.54±0.03	1.73±0.43	2.56±0.68	2.50±0.03	4.66±0.91	1.98±0.05
C18:3 *trans*	ND[1)]	0.01±0.01	0.01±0.01	ND	ND	ND	0.02±0.01	0.01±0.01	0.02±0.01	0.02±0.01
C20:0	0.15±0.03	0.15±0.02	0.21±0.04	0.22±0.08	0.24±0.05	0.19±0.04	0.17±0.02	0.19±0.02	0.27±0.02	0.27±0.02
C20:1	0.25±0.08	0.10±0.02	0.29±0.07	0.24±0.05	0.30±0.06	0.29±0.05	0.05±0.01	0.05±0.01	0.08±0.01	0.13±0.03
C20:2	0.16±0.05	0.18±0.04	0.19±0.05	0.20±0.08	0.15±0.03	0.17±0.02	0.18±0.03	0.15±0.02	0.20±0.02	0.17±0.01
C22:0	0.31±0.06	0.23±0.03	0.21±0.04	0.22±0.04	0.22±0.03	0.19±0.04	0.21±0.03	0.26±0.02	0.16±0.03	0.25±0.06
C24:0	0.13±0.03	0.19±0.02	0.10±0.01	0.05±0.01	0.04±0.02	0.08±0.01	0.16±0.01	0.15±0.01	0.12±0.02	0.11±0.02
C24:1	0.03±0.01	0.16±0.03	0.22±0.06	0.11±0.02	0.13±0.02	0.18±0.02	0.47±0.05	0.35±0.06	0.50±0.02	0.43±0.03
Total *trans*	**5.74^{a}**	**5.43^{c}**	**2.69^{bc}**	**5.07^{a}**	**3.97^{b}**	**3.64^{b}**	**3.61^{b}**	**2.93^{bc}**	**2.45^{c}**	**2.28^{c}**
Total saturated	**50.35^{a}**	**40.27^{b}**	**37.93^{b}**	**54.37^{a}**	**48.13^{a}**	**37.21^{b}**	**33.56^{b}**	**29.29^{c}**	**35.61^{b}**	**36.31^{b}**
Totalmonounsaturated	**37.64^{ab}**	**36.72^{ab}**	**37.28^{ab}**	**36.49^{ab}**	**39.91^{a}**	**37.59^{ab}**	**39.18^{ab}**	**36.93^{ab}**	**33.25^{b}**	**39.00^{ab}**
Total polyunsaturated	**12.01^{c}**	**23.01^{b}**	**24.79^{b}**	**9.14^{c}**	**11.96^{c}**	**25.20^{b}**	**27.26^{b}**	**33.78^{a}**	**31.14^{a}**	**24.69^{b}**
Total unsaturated	**49.65^{bc}**	**59.73^{ab}**	**62.07^{a}**	**45.63^{c}**	**51.87^{b}**	**62.79^{a}**	**66.44^{a}**	**70.71^{a}**	**64.39^{a}**	**63.69^{a}**
Total unsaturated/ total saturated	**0.99**	**1.48**	**1.64**	**0.84**	**1.08**	**1.69**	**1.98**	**2.41**	**1.81**	**1.75**

[1)]All values are expressed as mean±SD of triplicate determination; ND, not detected; [a,b]Means within the same row with different letters are significantly different (p<0.05).

Table 2. Proximate and fatty acid composition (as % total fatty acids) of meat products[1)]

	Pastrami			*Sucuk* (*Soudjuk*)			*Kavurma* (*Cavurmas*)			Köfte (Meatball)		
Brand	1	2	3	1	2	3	1	2	3	1	2	3
Proximate composition (%)												
Moisture	37.31±2.21	43.72±2.53	45.56±3.29	34.60±1.76	48.03±2.71	27.65±1.42	39.02±2.74	39.37±2.51	39.60±2.41	56.38±3.52	53.92±3.91	56.22±2.11
Fat	14.89±1.98	14.27±1.82	15.51±1.03	35.43±1.59	27.34±1.39	42.50±3.72	26.24±2.17	21.43±1.75	28.07±1.54	18.07±1.87	21.76±2.74	16.01±1.04
Protein	35.86±2.01	34.42±2.01	32.75±2.27	25.22±1.01	19.13±1.73	24.43±2.04	26.66±2.36	23.80±1.30	23.48±1.72	22.07±1.81	20.85±1.03	23.45±1.72
Ash	9.16±0.78	7.39±0.91	5.62±0.45	4.32±0.52	3.71±0.48	5.04±1.06	4.94±0.74	4.87±0.51	4.96±0.71	2.44±0.62	2.54±0.32	2.86±0.34
Fatty acid composition												
C8:0	0.04±0.01	0.05±0.01	0.04±0.01	0.04±0.01	0.04±0.01	0.05±0.02	0.13±0.03	0.05±0.01	0.13±0.02	0.06±0.01	0.06±0.02	0.06±0.02
C10:0	0.04±0.01	0.06±0.01	0.04±0.01	0.05±0.01	0.19±0.04	0.05±0.01	0.23±0.03	0.07±0.01	0.23±0.02	0.06±0.02	0.06±0.01	0.06±0.01
C12:0	0.11±0.02	0.06±0.02	0.06±0.02	0.05±0.01	0.05±0.01	0.08±0.01	0.07±0.02	0.09±0.02	0.07±0.01	0.09±0.02	0.06±0.01	0.07±0.02
C14:0	2.66±0.33	2.98±0.32	2.39±0.21	2.17±0.26	1.65±0.29	2.69±0.22	3.96±048	2.81±0.87	3.99±0.51	2.85±0.31	2.96±0.52	2.69±0.42
C14:1	0.90±0.21	0.76±0.11	0.59±0.09	0.65±0.09	0.49±0.11	1.04±0.09	0.99±0.17	1.10±0.31	0.90±0.11	0.95±0.19	0.99±0.11	1.09±0.31
C15:0	0.49±0.06	0.35±0.08	0.29±0.04	0.39±0.04	0.34±0.06	0.49±0.09	0.56±0.11	0.55±0.04	0.58±0.09	0.52±0.03	0.41±0.06	0.41±0.04
C15:1	0.42±0.08	0.27±0.03	0.27±0.02	0.21±0.03	0.17±0.03	0.30±0.04	0.30±0.09	0.34±0.08	0.29±0.03	0.33±0.02	0.23±0.03	0.28±0.02
C16:0	29.41±2.01	25.55±2.36	25.39±1.78	22.37±2.07	21.70±2.01	25.13±2.41	26.22±1.92	24.64±1.82	27.50±2.04	24.96±1.97	26.75±2.01	24.15±1.83
C16:1	3.54±0.72	2.59±0.44	3.06±0.51	3.03±0.08	3.05±0.92	4.01±0.45	4.32±0.81	4.10±0.72	4.10±0.49	3.49±0.42	4.40±0.91	4.02±0.42
C16:1 *trans*	0.12±0.03	0.12±0.03	0.11±0.01	0.14±0.02	0.11±0.01	0.11±0.01	0.12±0.01	0.12±0.02	0.88±0.22	0.13±0.02	0.11±0.01	0.10±0.01
C17:0	1.23±0.04	1.04±0.04	0.93±0.09	1.20±0.09	0.90±0.09	1.33±0.09	1.42±0.09	1.23±0.03	1.55±0.09	1.38±0.09	1.17±0.04	1.23±0.09
C17:1	0.82±0.05	0.24±0.02	0.37±0.02	0.41±0.02	0.27±0.04	0.58±0.04	0.69±0.08	0.59±0.09	0.64±0.11	0.52±0.04	0.66±0.03	0.57±0.07
C18:0	22.06±1.11	30.80±2.81	24.32±1.31	20.57±1.72	16.21±1.01	23.98±2.01	17.74±1.05	23.61±2.09	18.94±1.09	27.07±2.31	19.59±1.39	23.71±1.82
C18:1 *cis*	23.25±1.43	17.59±1.27	25.07±1.09	21.85±1.87	22.65±2.81	35.62±2.71	29.20±2.91	25.68±2.31	21.13±2.41	28.02±2.08	33.74±3.01	31.86±2.85
C18:1 *trans*	4.17±0.32	4.71±0.91	3.93±0.98	3.15±0.72	2.47±0.82	1.90±0.28	3.89±0.83	3.87±1.01	5.94±1.01	1.93±0.43	1.57±0.52	2.02±0.82
C18:2 *cis*	2.40±0.22	4.00±0.4	3.24±0.09	13.36±1.03	20.42±1.89	2.02±0.18	4.09±0.72	2.49±0.09	1.79±0.09	2.54±0.82	2.35±0.33	2.72±0.09
C18:2 *trans*	0.82±0.09	0.78±0.09	1.87±0.04	1.07±0.28	1.93±0.62	1.26±0.09	1.14±0.48	1.53±0.43	1.13±0.03	0.97±0.21	0.64±0.31	0.66±0.19
C18:3 *cis*	0.55±0.08	0.13±0.02	0.15±0.02	1.14±0.09	1.12±0.08	0.22±0.03	0.08±0.01	0.11±0.01	0.04±0.01	0.16±0.01	0.18±0.06	0.25±0.03
C18:3 *trans*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:0	0.19±0.02	0.18±0.03	0.15±0.03	0.23±0.04	0.27±0.09	0.24±0.06	0.20±0.03	0.22±0.21	0.20±0.04	0.19±0.04	0.21±0.03	0.22±0.04
C20:1	0.18±0.03	0.27±0.04	0.24±0.04	0.19±0.05	0.13±0.03	0.28±0.08	0.10±0.02	0.28±0.09	0.01±0.01	0.21±0.02	0.16±0.02	0.33±0.05
C20:2	0.24±0.04	0.18±0.02	0.16±0.02	0.19±0.03	0.15±0.03	0.18±0.03	0.17±0.02	0.19±0.04	0.16±0.03	0.25±0.03	0.15±0.03	0.18±0.05
C22:0	0.17±0.02	0.13±0.02	0.18±0.02	0.24±0.06	0.19±0.04	0.23±0.04	0.18±0.01	0.23±0.03	0.18±0.04	0.10±0.03	0.26±0.03	0.19±0.04
C24:0	0.04±0.01	0.07±0.01	0.06±0.01	0.09±0.02	0.14±0.05	0.06±0.02	0.18±0.02	0.03±0.01	0.59±0.09	0.08±0.02	0.23±0.04	0.05±0.02
C24:1	0.15±0.02	0.09±0.01	0.09±0.01	0.21±0.02	0.35±0.09	0.05±0.02	0.02±0.01	0.07±0.01	0.03±0.01	0.14±0.03	0.06±0.01	0.08±0.01
Total *trans*	**5.11**^{b}	**5.61**^{b}	**5.91**^{b}	**4.36**^{bc}	**4.52**^{bc}	**3.27**^{c}	**5.15**^{b}	**5.52**^{b}	**7.95**^{a}	**3.03**^{c}	**2.32**^{c}	**2.78**^{c}
Total saturated	**56.44**^{ab}	**61.27**^{a}	**53.85**^{ab}	**47.40**^{ab}	**41.68**^{c}	**54.33**^{ab}	**50.89**^{ab}	**53.53**^{ab}	**53.96**^{ab}	**57.36**^{ab}	**51.76**^{ab}	**52.84**^{ab}
Totalmonounsaturated	**39.55**^{ab}	**33.64**^{c}	**40.73**^{ab}	**36.84**^{b}	**34.69**^{bc}	**43.89**^{a}	**43.63**^{a}	**42.15**^{a}	**42.92**^{a}	**35.72**^{bc}	**41.92**^{a}	**40.35**^{ab}
Total polyunsaturated	**4.01**^{b}	**5.09**^{b}	**5.42**^{b}	**15.76**^{a}	**23.63**^{a}	**3.68**^{b}	**5.48**^{b}	**4.32**^{b}	**3.12**^{b}	**3.92**^{b}	**3.32**^{b}	**3.81**^{b}
Total unsaturated	**43.56**^{b}	**38.73**^{c}	**46.15**^{ab}	**52.60**^{ab}	**58.32**^{a}	**47.57**^{ab}	**49.11**^{ab}	**46.47**^{ab}	**46.04**^{ab}	**42.64**^{bc}	**48.24**^{ab}	**47.16**^{ab}
Total unsaturated/ total saturated	**0.77**	**0.63**	**0.86**	**1.11**	**1.40**	**0.88**	**0.96**	**0.87**	**0.85**	**0.74**	**0.93**	**0.89**

[1)]All values are expressed as mean±SD of triplicate determination; ND, not detected; [a,b]Means within the same row with different letters are significantly different ($p<0.05$).

detected in majority of the samples ranging from 0.11 to 2.33%, however, *trans* $C_{18:3}$ was found in some samples, ranging from 0.01 to 0.02%. Among meat products, Karabulut (26) contained the lowest *trans* fatty acids.

Linoleic acid showed the greatest individual variation ranging from 1.79 to 30.94%. Oleic acid was the only one that accounted for the highest percentage of the fatty acid profile (17.59-35.62%).

Total saturated fatty acids (SFA) were significantly higher in pastrami ($p<0.05$), followed by brands *kavurma* and *köfte*. Among the saturated fatty acids, palmitic acid (16:0) presented the highest value ranging from 19.22 to 29.41%, followed by stearic (18:0), that varied from 8.03 to 30.80%. The content of polyunsaturated fatty acids (PUFA) ranged from 3.12 to 33.78%, being significantly higher in sausages ($p<0.05$). Yılmaz (27,28) and Yılmaz and Dağlıoğlu (29) obtained similar results in fibre added of meatball samples in respect to fatty acid composition.

Based on published data, the estimated intake of *trans* $C_{18:1}$ in Western countries varies between 2 and 12 g/day or 5-7% of total fatty acids. The variation in intake between individuals is also very large (30). The available information is not sufficient to give any particular consumption rate of *trans* fatty acids for Turkish people. Based on food available data of foods since 1984, the estimated per capita consumption of dietary *trans* fatty acids from vegetable and animal sources is 8.1-12.8 g/day (31). According to the TRANSFAIR study (12) which was based on market basket analysis of the diets in 14 European countries, mean daily intakes of trans fatty acids in European countries range from minimal intakes for Greece (1.4 g/day), Portugal (1.6 g/day), Italy (1.6 g/day), and Spain (2.1 g/day) to values for Finland (2.1 g/day), Germany (2.2 g/day), France (2.3 g/day), Sweden (2.6 g/day), Denmark (2.6 g/day), United Kingdom (2.8 g/day), Norway (4.0 g/day), Belgium (4.1 g/day), The Netherlands (4.3 g/day), and Iceland (5.4 g/day).

If the only source of *trans* fatty acid in the diet is ruminant products, *trans* fatty acid consumption would drop to less than 2 g/day or less than 1% of energy. The impact of changes in legislation restricting use of *trans* fatty acid in food products and requiring *trans* fatty acid content on food labels awaits future studies (32). Many foods contain *trans* fatty acids in changing amounts. However, there is not any information about fatty acids and *trans* fatty acids on the labels of many food products (15). Several countries now have regulations requiring that *trans* fatty acid be listed on products' labels.

In conclusion, our results indicate that analyzed samples contain considerable amounts of fat and *trans* fatty acids. There were wide variations of either total fat or *trans* fatty acids percentages among the samples. It's obvious that it should be paid attention on consuming of meat products, considering the effect of *trans* fatty acids on human health. The *trans* fatty acid content of their products are significant in the view point of the FDA's recent regulation that makes it obligatory to include *trans* fatty acid contents in the nutritional labeling of foods. Regulation on mandatory labeling of product vary from country to country, but rarely include details of fatty acid composition especially *trans* fatty acids. If fatty acids and *trans* fatty acids contents are written in the labels of food products, consumers can be provided with better knowledge on foods.

References

1. Biesalski HK. Meat as a component of a healthy diet are there any risks or benefits if meat is avoided in the diet? Meat Sci. 70: 509-524 (2005)
2. Williamson CS, Foster RK, Stanner SA, Buttriss JL. Red meat in the diet. Nutr. Bull. 30: 323-355 (2005)
3. Howe P, Meyer B, Record S, Baghurst K. Dietary intakes of long chain ω-3 polyunsaturated fatty acids: Contribution of meat sources. Nutrition 22: 47-53 (2006)
4. Baylin A, Siles X, Donovan-Palmer A, Fernandez X, Campos H. Fatty acid composition of Costa Rican foods including *trans* fatty acid content. J. Food Compos. Anal. 20: 182-192 (2007)
5. Sommerfeld M. *Trans*-unsaturated fatty acids in natural products and processed foods. Prog. Lipid Res. 22: 221-233 (1983)
6. Schakel SF, Harnack L, Wold C, Van Heel N, Himes JH. Incorporation of *trans*-fatty acids into a comprehensive nutrient database. J. Food Compos. Anal. 12: 323-331 (1999)
7. Sadler MJ. *Trans* fatty acids. pp. 230-237. In: Encyclopedia of Food Science, Food Technology, and Nutrition. Macrae R, Robinson RK, Sadler MJ (eds). Academic Press Inc., London, UK (1998)
8. Lichtenstein AH, Appel LJ, Brands M, Carnethon M, Daniels S, Franch H, Franklin B, Kris-Etherton P, Harris W, Howard B, Karanja N, Lefevre M, Rudel L, Sacks F, Van Horn L, Winston M, Wylie-Rosett J. Diet and lifestyle recommendations revision 2006: A scientific statement from the American Heart Association Nutrition Committee. Circulation 114: 82-96 (2006)
9. Strovas JD. Development of a knowledge survey and food composition database regarding *trans*-fatty acids. MS thesis, Texas Tech University, Lubbock, TX, USA (2007)
10. Yılmaz I, Geçgel U. Effects of gamma irradiation on *trans* and fatty acid composition in ground beef. Food Control 18: 635-638 (2007)
11. Pfalzgraf A, Timm M, Steinhart H. Amounts of *trans*-fatty acids in food. Z. Ernahrungswiss. 33: 24-43 (1993)
12. Aro A, Antoine JM, Pizzoferrato L, Reykdal O, Van Poppel G. *Trans* fatty acids in dairy and meat products from 14 European countries: The transfair study. J. Food Compos. Anal. 11: 150-160 (1998)
13. Fritsche J, Steinhart H. Contents of *trans* fatty acids (TFA) in German foods and estimation of daily intake. Fett-Lipid 99: 314-318 (1997)
14. Litin L, Sacks F. *Trans* fatty acid content of common foods. New Eng. J. Med. 329: 1969-1970 (1993)
15. Tavella M, Peterson G, Espeche M, Cavallero E, Cipolla L, Perego L, Caballero B. *Trans* fatty acid content of a selection of foods in Argentina. Food Chem. 69: 209-213 (2000)
16. Mensink RP, Katan MB. Effect of dietary *trans* fatty acids on high-density and low-density lipoprotien cholesterol levels in healthy subjects. New Eng. J. Med. 323: 439-445 (1990)
17. Booyens J, Louwrens CC, Katzeff IE. The role of unnatural dietary *trans* and *cis* unsaturated fatty acids in the epidemiology of coronary artery disease. Med. Hypotheses 25: 175-182 (1988)
18. Willet WC, Ascherio A. *Trans* fatty acids: Are the effects only marginal? Am. J. Public Health 84: 722-724 (1994)
19. WHO. Diet, nutrition, and prevention of chronic diseases. Technical Report Series 916. Food and Agriculture Organization of United Nations and The World Health Organization, Geneva, Swizerland (2003)
20. AOAC. Official Methods for the Analysis AOAC. 16^{th} ed. Method 923.03. Association of Official Analytical Chemists, Arlington, VA, USA (1995)
21. Soysal I. Principles of Biometric Analysis. Zir. Fak. Yay. No: 95: 1-257 Tekirdag (1992)
22. Yılmaz I, Şimşek O, Işıklı M. Fatty acid composition and quality characteristics of low-fat cooked sausages made with beef and chicken meat, tomato juice, and sunflower oil. Meat Sci. 62: 253-258 (2002)
23. Kayaardı S, Gök V. Effect of replacing beef fat with olive oil on quality characteristics of Turkish *soudjouk* (*sucuk*). Meat Sci. 66: 249-257 (2003)
24. Anonymous. Kavurma (TS 978), Turkish Standard. Ankara, Turkey. pp. 1-12 (2002)

25. Aksu MI, Kaya M. The effect of α-tocopherol and butylated hydroxyanisole on the colour properties and lipid oxidation of *kavurma*, a cooked meat product. Meat Sci. 71: 277-283 (2005)
26. Karabulut I. Fatty acid composition of frequently consumed foods in Turkey with special emphasis on *trans* fatty acids. Int. J. Food Sci. Nutr. 58: 619-628 (2007)
27. Yılmaz I. Effects of rye bran addition on fatty acid composition and quality characteristics of low-fat meatballs. Meat Sci. 67: 245-249 (2004)
28. Yılmaz I. Physicochemical and sensory characteristics of low fat meatballs with added wheat bran. J. Food Eng. 69: 369-373 (2005)
29. Yılmaz I, Dağlıoğlu O. The effect of replacing fat with oat bran on fatty acid composition and physicochemical properties of meatballs. Meat Sci. 65: 819-823 (2003)
30. Mensink RP, Katan MB. *Trans* monounsaturated fatty acids in nutrition and their impact on serum lipoprotein levels in man. Prog. Lipid Res. 32: 111-112 (1993)
31. Hunter J, Applewhite T. Reassessment of *trans*-fatty acid availability in the U.S. diet. Am. J. Clin. Nutr. 54: 363-369 (1991)
32. Craig-Schmidt Mc. World-wide consumption of *trans* fatty acids. Atherosclerosis 7: 1-4 (2006)