GIDA
THE JOURNAL OF FOOD
E-ISSN 1309-6273, ISSN 1300-3070

Research / Araştırma
GIDA (2019) 44 (1): 173-183
doi: 10.15237/gida.GD18101

THE EFFECTS OF COOKING METHODS ON THE PROPERTIES OF BEEF *LONGISSIMUS DORSI*

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Received / Geliş: 26.09.2018; *Accepted* / Kabul: 24.01.2019; *Published online* / Online baskı: 22.02.2019

Aşçıoğlu,, Ç., Şevik, R. (2019). The effects of cooking methods on the properties of beef longissimus dorsi. GIDA (2019) 44 (1): 173-183 doi: 10.15237/gida.GD18101

Aşçıoğlu,, Ç., Şevik, R. (2019). Pişirme metodlarının sığır *longissimus dorsi* kasının özellikleri üzerine etkileri. *GIDA* (2019) 44 (1): 173-183 doi: 10.15237/gida.GD18101

ABSTRACT
The effects of different cooking methods (boiling, frying, oven-roasting and grilling) on certain properties of beef *longissimus dorsi* were studied. Cooking loss, moisture content, color, TBARS and the composition of fatty acids were determined. The highest cooking loss was observed with regards to boiling ($P < 0.05$). TBARS increased with boiling and oven- roasting ($P < 0.05$), whereas frying and grilling had no significant effect on TBARS ($P > 0.05$). Color indices were significantly changed through cooking ($P < 0.05$). Polyunsaturated fatty acid (PUFA) content increased in all cooking methods, while saturated fatty acids (SFA) content decreased in all treatments. The trans fatty acid (TFA) content increased after frying and oven-roasting, whereas boiling and grilling decreased the trans fatty acid content ($P < 0.05$). Grilling provided minimum cooking loss ($P < 0.05$) as well as the lowest TBARS value ($P < 0.05$), probably due to the structure of fire brick barbeque inhibiting the intense heat.
Keywords: Beef, cooking, grilling, fatty acids, *longissimus dorsi*

PİŞİRME METODLARININ SIĞIR *LONGISSIMUS DORSI* KASININ ÖZELLİKLERİ ÜZERİNE ETKİLERİ

ÖZ
Dört farklı pişirme metodunun (haşlama, kızartma, fırında pişirme ve ızgara) sığır *longissimus dorsi* kasının besinsel ve kalite kriterleri üzerine etkisi araştırılmıştır. En fazla pişirme kaybı haşlama işleminde meydana gelmiştir ($P < 0.05$). TBARS değerleri haşlama ve fırında pişirme işlemlerinde artarken ($P < 0.05$), kızartma ve ızgara işlemlerinin TBARS üzerine önemli etkisi olmamıştır ($P > 0.05$). Renk değerleri pişirme işlemi sonrası önemli derecede değişiklik göstermiştir ($P < 0.05$). Çoklu doymamış yağ asitleri (PUFA) miktarı tüm pişirme şekillerinde artarken, doymuş yağ asitleri (SFA) miktarı tüm uygulamalarda azalmıştır. Trans yağ asitleri kızartma ve fırında pişirme işlemleri ile artarken, haşlama ve ızgarada pişirme işlemleri sonucu azalmıştır ($P < 0.05$). Izgarada pişirme işlemi ile en düşük pişirme kaybı ve TBA değerleri tespit edilmiş ($P < 0.05$), bunun ateş tuğlalı ızgaranın şiddetli ısıyı bir miktar soğurması sonucu meydana gelmiş olabileceği sonucuna varılmıştır.
Anahtar kelimeler: Sığır, pişirme, ızgara, yağ asitleri, *longissimus dorsi*

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INTRODUCTION

Meat contains high bioavailable protein and micronutrients that provide essential requirements of human nutrition (FAO, 1992). It is a major source of minerals especially iron and zinc with high bioavailability (Cabrera et al., 2010). The cooking of meat is a compulsory process for the destruction of spoilage and and pathogenic organisms. It is also essential in order to improve palatability and to modify the texture and tenderness of meat (Bejerholm et al., 2014).

Many biochemical and physical changes occur during cooking. Protein denaturation, color change, formation of new odors and flavors, lipid oxidation and texture modifications are all the results of the heating process (Boles, 2010). Water loss is also another critical result that is closely related to the cooking yield (Scussat et al., 2017).

Meat is a contradictive foodstuff with its variable fatty acid composition, which is correlated with the risk of coronary heart diseases, but also which has unique beneficial effects on biological functions (Vannice & Rasmussen, 2014). The ratio of polyunsatured fatty acids to saturated fatty acids is important. There is an increase observed in this ratio during cooking, which has been proven through with several studies (Ono et al., 1985; Gerber et al., 2009). The fatty acid composition of different lipid fractions may also be different. The storage component of the lipid is defined as being a neutral lipid fraction, and the membrane component of the cell is defined as being a polar lipid fraction. The presence of polyunsaturated fatty acids mainly in the membrane fraction causes various differences in fatty acid compositions. (Duckett & Wagner, 1998; Sweeten et al., 1990; Duckett et al., 1993). Proportional changes in the composition of fatty acids during cooking maybe explained with the lipid loss from the adipose tissue, which is mainly composed of triglycerides. Triglycerides consist of saturated fatty acids more than unsaturated fatty acids.

The main purpose of this study was to evaluate the impact of most common cooking methods on beef *longissimus dorsi*. Many studies concerning the effects of cooking on certain properties of different muscles of lamb (Bravo- Lamas et al., 2018), buffalo (Juarez et al., 2010) and pork (Li et al., 2016) have been done. However, presently, literature on the effects of cooking on the fatty acids in beef *longissimus dorsi* is scarce. Another aim was to determine the effects of an unusual grilling method, fire brick barbecue on beef *longissimus dorsi,* and to figure out the best cooking method for it.

MATERIAL AND METHOD

Meat Samples

24 Beef (*M. longissimus dorsi*) muscles were purchased from a national commercial meat processing plant in the region of Afyonkarahisar. Beef muscles were dissected from carcasses 48 h post-slaughter. Each muscle was cut into 2,5 cm slices as steaks and randomly divided into 5 groups. One group was used as raw (control), and the other 4 groups were subjected to the cooking methods immediately: boiling, pan frying, oven-roasting and grilling. No additional oil or other additives were used for any cooking method so that only the changes in the fatty acid profile could be analysed.

Cooking Treatments

All of the samples were cooked to a core temperature of 71 °C immediately upon the arrival at the food analysis laboratory. The slices were weighed both before and after cooking. Boiling was performed in a water bath with samples completely immersed until they reached the core temperature of 71 °C. Meat slices were fried for 4 minutes on each side in a Teflon pan preheated to 180 °C. Oven- roasting was conducted at 180°C in a commercial electric oven commonly used in private households. Grilling was done in a fire brick barbecue, fired with oak charcoal. The internal temperatures were viewed by thermocouples inserted into the approximate geometric centre of each cut. After the meat was cooked and left to rest, cooking losses were calculated, whereupon the steaks were minced, put into polyethylene bags, and stored at -18 °C until further analysis.

Cooking Loss and Color Measurements
All sampling was performed in triplicate and averaged. Moisture content of the samples was determined using the oven drying (Anonymous, 1995). After cooking, the meat samples were cooled at room temperature for 20 min, and the percentage of cooking loss was calculated as following the instructions outlined by Becker et al. (2016). Cooking loss was calculated as the percent weight difference between the raw and cooked samples. Color coordinates were determined using a Hunterlab model Minolta CR-400 (Osaka, Japan) chromometer. The color results were stated in terms of lightness (L*), redness (a*) and yellowness (b*) according to the standard conditions of the Commission International d'Eclairage (CIE). The values were measured in five locations within each slice, and the average values were calculated.

Lipid Oxidation Measurement
Lipid oxidation was assessed by measuring 2-thiobarbituric acid reactive substances (TBARS) according to the spectrophotometric method described by Byun et. al. (2001), with some modifications. The meat samples were extracted with perchloric acid. The absorbance of each sample was read at 538 nm by using Shimadzu UV-1800 Spectrophotometer (Shimadzu UV-1800 Spectrophotometer, Kyoto, Japan) differently. Results were expressed in terms of mg of malonaldehyde (MDA)/ kg of meat.

Fatty acid profile
The content of fatty acid methyl esters (FAMEs) was determined using gas chromatography (GC). Fatty acid methyl esters were obtained using the AOAC Official Method (1992). Ten grams of each sample were homogenized, and the lipid was extracted using 100 ml of chloroform:methanol (2:1, v/v). The solvent was removed by evaporation under vacuum. The residual chloroform was then removed using nitrogen. Extracted fat was saponified with 0,5 mol /L methanolic sodium hydroxide and then methylated with 12 % (v/v) boron trifluoride (BF_3) in methanol according to the method outlined by Morrison & Smith (1964). The obtained fatty acid methyl esters were then seperated and analyzed by gas chromatography (Agilent 7890A GC) equipped with an automatic liquid sampler, a split injector, a flame ionization detector (GC- FID) and a fused silica capillary column (100 m x 0,25 mm i.d.) with a 0,20 µm film thickness. 1 µL aliquot of the sample was injected into a split at a division ratio of 1/50. The GC was operated under with the oven temperature being at 90 °C / 7 min and injector being at 250 °C, detector at 250 °C. The identification and quantification of the methyl esters of the fatty acids were achieved by comparing them with both the retention times and concentrations of methyl esters of standard fatty acids. The results were reported as % of each cooking sample.

Based on the FAME results, the atherogenic (AI) and thrombogenic indexes (TI) were also calculated according to Ulbricht & Southgate (1991) as shown in following equations: (1) and (2).

$$AI = \frac{C12{:}0 + (4 * C14{:}0) + C16{:}0}{\left(\sum[PUFA) + (\sum[MUFA)\right]} \quad (1)$$

$$TI = \frac{C14{:}0 + C16{:}0 + C18{:}0}{\left(0{,}5 * \sum[MUFA) + (0{,}5 * \sum n-6) + \left(3 * \sum[n-3) + \left(\frac{n-3}{n-6}\right)\right]\right]} \quad (2)$$

Statistical Analysis

One way analysis of variance (ANOVA) was performed using IBM SPSS Statistics 19.0 programme (IBM Corporation, Somers, NY, USA) in order to determine significant differences between groups. Duncan's multiply range test was applied when a significant effect (P <0.05) was detected. Analytical values were realized in triplicate. The data is presented as mean± standard deviation. The effect of cooking on the changes within a meat cut was evaluated using the paired T-test; differences were considered significant at a value of $P < 0.05$.

RESULTS

Thermal treatments induced the water loss observed in all of the treated steaks. The highest lost was obtained in boiled steaks, whereas the lowest was obtained in oven-cooking samples. The results for cooking loss, moisture and color indices are displayed in table 1. The boiled steaks had more cooking loss compared to steaks cooked using the other 3 methods. This might be attributed to the slower cooking rate of boiling. Similar results were found by Obuz et al. (2004) who reported highest cooking loss for steaks cooked in water bath. Slight but not significant differences obtained between other methods. Cooking loss was lowest in grilled meat, probably crust formation prevented the water from escaping (Aaslyng, 2003). The cooking losses obtained here are in agreement with those reported in similar studies (Alfaia et al., 2010; Jensen et al., 2014; Oz et al.,2017). Aaslyng et al. (2003) stated that cooking loss is not only composed of liquid but also soluble matters such as myofibrillar and sarcoplasmic proteins, collagen, lipids, salt, polyphosphates and flavour compounds get lost from meat with water during thermal treatment (Gerber et al., 2009). The basic moisture transport hypothesis by Godsalve et al. (1977) is still effectual, which indicates that protein denaturation occurs as a result of thermal treatment. Denaturation decreases the capacity of the proteins to hold water, and protein network shrinks. The shrinking network forms a mechanical force on the interstitial water, and the excess water is expelled to the surface of the meat. Cooking methods had a significant effect on the water content of samples. The moisture contents of the cooked samples ranged between 59.0 and 60.6 %. Obtained results basically agree with similar previous studies, even in both the same and different kind of meats for both raw and cooked samples (Jensen et al., 2014; Lorenzo et al., 2015; Roseland et al., 2015; Yıldız-Turp, 2016).

Table 1. Cooking loss (%), moisture content (g/100 g meat) and color values of raw and cooked beef *longissimus dorsi*

	Raw	Boiling	Frying	Oven-Roasting	Grilling
Cooking Loss	-	$42{,}76^{a}$	$37{,}81^{b}$	$35{,}8^{b}$	$35{,}69^{b}$
Moisture	75.27^{c} ±0.3	$59.35^{a,b}$±0.79	$59.8^{a,b}$±0.68	60.6^{b}± 1.07	59.0^{a}± 0.55
L^{*}	40.91^{c}± 1.95	54.06^{a}± 1.50	53.37^{a}± 2.16	54.45^{a}± 1.46	49.24^{b}± 1.61
a^{*}	10.33^{a}± 0.17	2.09^{c}± 0.15	5.04^{b}± 2.16	2.46^{c}± 0.15	6.24^{b}± 0.51
b^{*}	6.0^{b}± 1.91	15.6^{a}± 0.47	14.04^{a}± 0.19	14.04^{a}± 0.23	13.61^{a}± 1.46

a,b,c ; different superscript letters in the same trait indicate significant statistical differences (P <0.05)

Color is an important property of meat and meat products especially for consumer acceptability (Tian et al., 2016). The heat process causes the denaturation of globin, which then precipitates with other meat proteins. Between 55 °C and 65 °C denaturation of myoglobin and other proteins begin in meat, after then most denaturation has occured by 75 °C or 80 °C (King & Whyte, 2006). Maillard molecules begin to form along with the melanoid pigments, which are associated with the grilled-meat color above the 85 °C threshold (Kondjoyan et al., 2014). L*, a* and b* mean values of both the raw and cooked samples are shown in Table 1. L* and b* values of samples increased with cooking, while a* values decreased. Decrease in a* values could be explained with the

denaturation of myoglobin as a result of temperature increase. Grilled samples displayed a more intense reddish color as well as a less intense lightness. The formation of dark color due to the browning reaction caused lower lightness value for grilling. Significantly higher a* value in grilling had indicated that more myoglobin degradation occurred during boiling, frying and roasting. Significant increase in L* values of cooked meat possibly occured because of less myoglobin in the surface and also increased light scattering due to protein denaturation (Warner, 2014). Higher L* and b* values and lower a* values observed in previous similar studies (Lorenzo et al., 2015; Oz et al., 2017; Becker et al., 2016). Becker et al. (2016) has attributed higher b* values to the formation of metmyoglobin, and following the heat denaturation of globin in metmyoglobin. This denatured globin hemichrome is the pigment responsible for the dull-brown color of cooked meat (Suman & Joseph, 2014). Potentially increased b* values and decreased a* value might be due to denatured globin hemichrome. All cooking methods had led to similar effects on L* and b* values, that there were no significant differences between cooking methods. These findings are in aggrement with a similar study in beef *longissimus dorsi* (Tian et al., 2016), whereby increased L* and b* values were attributed to the migration of water from the center to the meat surface during cooking.

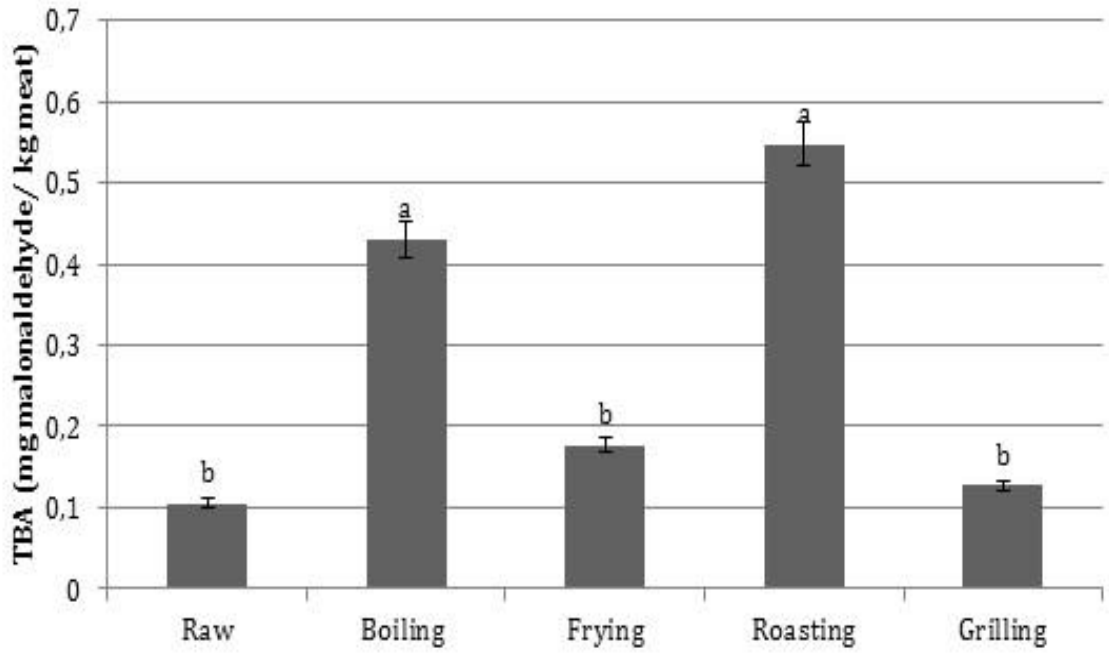

Figure 1. Thiobarbituric acid substances (TBARS) content (mg malonaldehyde/ kg meat) of beef *longissimus dorsi*.

a,b ; different superscript letters indicate significant statistical differences (P <0.05)

TBARS content is an important parameter to determine lipid oxidation. The oxidation of meat lipids may cause the development of off-flavours besides carcinogenic malondialdehyde. Boiling and roasting increased the TBARS significantly, however frying and grilling had no significant effect on lipid oxidation. Several authors found similar results, for beef *longissimus lumborum* (Temgilimoglu-Metin & Kızıl, 2017), for pork (Broncano et al., 2009), for buffalo (Juarez et al., 2010) and for foal meat (Lorenzo et al., 2015) with similar cooking procedures.

Table 2. Mean fatty acid composition (expressed as g/100 g of fatty acids) with standard error of the mean of raw and cooked beef *longissimus dorsi*

Fatty acids(%)	Raw	Boiling	Frying	Oven-Roasting	Grilling
C14:0	3.379^{a}±0.20	2.603^{b}±0.20	2.867^{a,b}± 0.12	3.383^{a}±0.19	3.356^{a}±0.52
C14:1	0.443^{a,b}±0.030	0.319^{b}±0.06	0.496^{a,b}±0.04	0.591^{a}±0.11	0.586^{a}±0.25
C15:0	0.231^{a}±0.087	0.448^{a}±0.30	0.366^{a}±0.20	0.810^{a}±0.63	1.139^{a}±1.07
C16:0	30.764^{a}±0.19	28.182^{b}±0.15	28.443^{b}±1.17	28.518^{b}±1.13	28.384^{b}±0.28
C16:1	3.404^{a,b}±0.32	3.014^{a,b}±0.26	3.155^{a,b}±0.35	2.406^{b}± 1.18	3.584^{a}±0.22
C17:0	0.183^{b}±0.04	0.343^{a,b}±0.22	0.319^{a,b}±0.22	1.043^{a}±0.31	0.734^{a,b}±0.43
C17:1	0.567^{a}±0.01	0.569^{a}±0.07	0.560^{a}±0.08	0.568^{a}±0.21	0.657^{a}±0.13
C18:0	19.618^{a,b}±0.05	21.162^{a}±1.87	21.650^{a}±2.11	17.426^{b}±0.77	18.165^{a,b}±2.77
C18:1n-9t	1.290^{a,b}±0.06	1.146^{b}±0.03	1.508^{a,b}±0.48	1.685^{a}±0.24	1.187^{b}±0.05
C18:1n-9c	35.278^{a}±0.05	36.680^{a}±0.99	34.584^{a}±1.88	35.575^{a}±1.01	34.907^{a}±2.59
C18:2n-6t	0.129^{b}±0.08	0.147^{a,b}±0.05	0.152^{a,b}±0.025	0.174^{a}±0.02	0.132^{b}±0.05
C18:2n-6c	2.934^{c}±0.05	3.734^{b,c}±0.87	4.106^{b,c}±0.91	5.715^{a}±0.45	4.826^{a,b}±1.16
C20:0	0.151^{a}±0.05	0.164^{a}±0.01	0.186^{a}±0.03	0.136^{a}±0.02	0.140^{a}±0.03
C18:3n-6	0.282^{b,c}±0.007	0.164^{d}±0.006	0.219^{c,d}±0.07	0.352^{a,b}±0.06	0.398^{a}±0.05
C20:1	0.320^{a}±0.01	0.244^{a}±0.04	0.311^{a}±0.14	0.356^{a}±0.02	0.331^{a}±0.06
C18:3n-3	0.119^{a}±0.03	0.132^{a}±0.06	0.114^{a}±0.02	0.186^{a}±0.005	0.170^{a}±0.06
C22:0	0.173^{a}±0.01	0.125^{a}±0.01	0.173^{a}±0.04	0.187^{a}±0.04	0.223^{a}±0.13
C20:3n-3	0.148^{a}±0.01	0.153^{a}±0.03	0.249^{a}±0.19	0.259^{a}±0.11	0.380^{a}±0.030
C24:0	0.132^{b,c}±0.01	0.097^{c}±0.03	0.189^{a,b}±0.06	0.196^{a,b}±0.008	0.261^{a}±0.05
C22:5n-3	0.242^{a,b}±0.01	0.122^{b}±0.04	0.192^{a,b}±0.05	0.233^{a,b}±0.01	0.293^{a}±0.16
C22:6n-3	0.201^{a}±0.03	0.103^{a}±0.04	0.203^{a}±0.16	0.247^{a}±0.07	0.128^{a}±0.05
∑SFA	54.631^{a}	53.124^{c}	54.193^{b}	51.699^{e}	52.402^{d}
∑MUFA	41.302^{b}	41.972^{a}	40.614^{e}	41.181^{d}	41.252^{c}
∑PUFA	4.055^{e}	4.555^{d}	5.235^{c}	7.166^{a}	6.327^{b}
PUFA/ SFA	0.074^{e}	0.085^{d}	0.096^{c}	0.138^{a}	0.120^{b}
n-6 / n-3	4.71^{e}	7.93^{a}	5.90^{c}	7.31^{b}	5.15^{d}
∑Trans FA.	1.419^{c}	1.293^{e}	1.66^{b}	1.859^{a}	1.319^{d}
AI	0,976	0,829	0,87	0,87	0,87
TI	2,18	2,10	2,12	1,85	1,89

a, b, c, d, e ; different superscript letters in the same row indicate significant statistical differences (P <0.05)

The mean values of fatty acid composition are presented in Table 2. In decreasing order of percentage, the major FAs of both raw and cooked meat were oleic (18:1c9, 34-36 %), palmitic (16:0, 28-30 %), stearic (18:0, 17-21 %) and linoleic (18:2c6, 2-5 %) acids. As a SFA, only 16:0 was significantly higher in raw meat control. All of the cooking methods had exhibited a significant decrease in the SFA level. The MUFA level had also decreased significantly, except for in boiling, in the cooked beef compared to raw meat. Previous studies also reported reduction of MUFA in cooked samples which was explained by the oxidative degradation of unsaturated fatty acids during heat treatment (Selani et al., 2016). Cooked beef had higher concentrations of PUFA

compared to raw meat, mainly due to the significant increase of some n-6 fatty acids, of which linoleic acid is the major fatty acid. In this study, the percentages of individual trans fatty acids almost remained unaffected by the cooking treatments, whereas in the group of all trans fatty acids significant differences had arisen among the treatments. Trans fatty acids were decreased by boiling and grilling, and they were increased by frying and roasting. Trans-9 octadecenoic acid, also known as elaidic acid, was the most abundant trans fatty acid, and is known as the primary industrial trans fatty acid, whereas its presence in this study is probably due to the rumen biohydrogenation of C18 PUFA according to Bessa et al. (2000). The dietary ratio of n-6 / n-3 fatty acids is more important than the dietary intake of these PUFAs alone. It is essential to provide a balance between n-6 and n-3 fatty acids to maintain homeostasis, normal development, and mental health over the course of healthy life cycle (Simopoulos, 2011). n-3 fatty acids were less affected by cooking than n-6 fatty acids. This result endorses the hypothesis by Kouba et al. (2008) which claims that n-3 fatty acids are less susceptible to changes by cooking as a result of being structural lipids. Similar results were found by Campo et al. (2013) for lamb. From a nutritional perspective, some nutritional authorities suggest that the PUFA/ SFA ratio in human diets should be 0,40 or higher and the n-6 / n-3 ratio should not exceed 4,0 (BHD, 1994). The latter ratio was also considered as a risk factor in different cancers and coronory heart disease (Enser, 2001) . Neither PUFA/ SFA nor n-6/ n-3 ratios are in agreement with the recommended ratios. These results can mainly be attributed to the higher content of SFA. Both of these ratios are in agreement with some findings previously reported by other researchers also for lamb and beef (Campo et al.,2013; Badiani et al., 2002). Alongside the composition of fatty acids, the related health lipid indices, atherogenic index and thrombogenic index, are also noteworthy. The atherogenic index is defined as the ratio between the fatty acids which favour the adhesion of lipids to cells of the immunological and circulatory system and the fatty acids which inhibit the aggregation of plaque and lower the levels of esterified fatty acid, cholesterol and phospholipids, thereby preventing the appearance of micro- and macro-coronary diseases. Thrombogenic index shows the tendency to form clots in the blood vessels and is determined with the ratio between pro-thrombogenic (saturated) and the anti-thrombogenic fatty acids (MUFAs, PUFAs – n6 and PUFAs –n3) (Garaffo et al., 2011). It was specified that these cardiovascular indexes should be low in a healthy diet (Attia et al., 2015). It was stated that higher saturated fatty acids concentrations may cause more atherogenic and thrombogenic effects on health (Hu, 2001; Henderson et al. 2008; Attia et al., 2017). No significant differences observed between cooking methods with regards to atherogenic indexes, our results are rather higher than the results that McDaniel et al. (2013) reported and both atherogenic and thrombogenic indexes are higher in comparison with Badiani et al. (2002). These differences might be related to the higher saturated fatty acid content of our cuts. About these indixes, currently available literature data provides little information about beef. Many studies about other species were previously reported, for lamb and sheep (Yakan & Unal, 2010; Sinanoglou et al., 2013; Flakemore et al., 2017), for pork (Li et al., 2016; Fiedorowicz et al., 2016) and for fish and seafood (Garaffo et al., 2011; Chakraborty et al., 2017). Rather than steaks or fresh cuts, atherogenicity and thrombogenicity studies about beef and pork burgers and patties (Selani et al., 2016; Rodriguez-Carpena et al., 2012; Romero et al., 2013; Afshari et al., 2017, Mancini et al., 2017) are available for products with new and healthier formulations. Present study is the first report on the effects of different cooking methods on the health lipid indices, atherogenic and thrombogenic indexes of beef steak.

CONCLUSION

We analyzed the effects of four cooking methods on certain characteristics of *longissimus dorsi* muscles of beef. The present study demonstrates that boiling process is not suitable for longissimus dorsi because of highest losses in cooking yield. Favorable effects, nutritional and quality characteristics, of boiling are less than those

yielded by other cooking methods. Frying and oven-roasting did not constitute remarkable consequences. Phenomenally, grilled samples showed the lowest cooking losses and minimum TBARS which seems to be related to the fire brick barbecue. This kind of barbecue is differentiated from other barbecues with its better insulation capacity due to stone wool coating. Stone wool provides absorption of the excess heat, preserving meat from severe heating. Eventually, grilling in fire brick barbecue has been shown as preferable culinary process for cooking beef *longissimus dorsi* with slightly better changes in nutritional composition, relatively higher PUFA and lower SFA and trans fatty acids. Present study is one of the rare reports on the effects of cooking methods on nutritional composition and also fatty acids of beef *longissimus dorsi*. Further research is required in order to investigate the effects of different cooking methods on different types of muscles.

ACKNOWLEDGMENT

The authors wish to thank Dr. Senem Güner for her editorial comments.

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