



Changes in the Total Lipid, Neutral Lipid, Phospholipid and Fatty Acid Composition of Phospholipid Fractions during Pastırma Processing, a Dry-Cured Meat Product

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Abstract

Pastırma is a dry-cured meat product, produced from whole beef or water buffalo muscles. This study was carried out to investigate the effect of production stages (raw meat, after curing, after 2nd drying and pastırma) on the total lipid, neutral lipid, phospholipid and fatty acid composition of phospholipid fraction of pastırma produced from beef *M. Longissimus dorsi* muscles. The pH and colour (L^* , a^* and b^*) analyses were also performed in raw meat and pastırma. It was found that pastırma production stages had significant effects ($p < 0.01$) on the total amounts of lipid, neutral lipid and phospholipid, and the highest amounts of lipid, neutral lipid and phospholipid were detected in pastırma. In pastırma, neutral lipid ratio was determined as $79.33 \pm 2.06\%$ and phospholipid ratio as $20.67 \pm 2.06\%$. Phospholipids was proportionately lower in pastırma than raw meat. Pastırma production stages affected pentadecanoic acid (15:1) ($p < 0.01$), linoleic acid (18:2n-6) ($p < 0.05$), γ -linoleic acid (18:3n-6) ($p < 0.05$), erucic acid (22:1n-9) ($p < 0.05$), docosapentaenoic acid (22:5n-6) ($p < 0.05$), total unsaturated fatty acid (Σ USFA) ($p < 0.05$) and total saturated fatty acid (Σ SFA) ($p < 0.05$) ratios of phospholipid fraction and also the moisture content ($p < 0.01$). Pastırma process also affected pH and colour (L^* , a^* and b^*) values ($p < 0.01$), and these values were higher in pastırma than raw meat.

Keywords Pastırma, phospholipid fraction, fatty acid composition, PUFA n-6/n-3, Σ PUFA/ Σ SFA, moisture, pH, colour

Introduction

Pastırma is a traditional meat product produced from beef or water buffalo meat. In pastırma production stages, whole muscles obtained from carcasses are cured/salted, dried, pressed, redried, repressed and redried with cemen paste is added by special methods (Aksu *et al.*, 2005a; Aksu and Erdemir, 2014; Ceylan and Aksu, 2011).

Several factors affect the quality of pastırma. These include the quality of raw meat, curing methods and temperature, drying, pressing, the quality and addition of cemen, and the physical, chemical and microbiological changes in the meat during production. Rich in chemical compound, pastırma also affects the quality with protein, fat and moisture values and the changes in their composition. The highest component in pastırma is protein, other than water, which is followed by fats. Fat content of the pastırma changes between 1.14% and 53.14% (Tekinşen

Received June 20, 2016
Revised October 24, 2016
Accepted November 25, 2016

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and Dođruer, 2000) or between 1.41 and 24.67% (Çakıcı *et al.*, 2015). Amount of intramuscular fat is higher in pastırma with low fat content than that of with high fat content. Therefore, phospholipid amount may be higher in pastırma with low fat.

Phospholipids are dominant lipids in the cell membrane and they constitute 80% of the lipids in sarcoplasmic reticulum. Alcohols and fatty acid compositions bound to R₁ and R₂ positions in phospholipid structure differ. Saturated fatty acids (SFA) are bound to R₁ position, while oleic, linoleic, linolenic and arachidonic fatty acids are bound to R₂ position (Aurand *et al.*, 1987; Muriel *et al.*, 2005). Due to these characteristics, phospholipids have a great importance for meat technology. Muscle type is important in terms of phospholipid content and composition of the meat. Oxidative muscles contain more phospholipids than glycolytic muscles. Moreover, oxidative muscles contain higher ratios of cardiolipin and phosphatidylethanolamine (PE) than glycolytic muscles (Alasnier *et al.*, 1996; Leseigneur-Meynier and Gandemer, 1991). On the other hand, monounsaturated fatty acids are dominant in the phospholipid structure of white muscles and polyunsaturated fatty acids are dominant in the phospholipid structure of dark muscles. Depending on the muscle type, the amount of unsaturated fatty acid is higher in phospholipid fractions of beef (Habeanu *et al.*, 2014). Moreover, the number of double bonds in the structure of unsaturated fatty acid is higher in the phospholipid fraction. While only 0.1% of the triglycerides in beef have four or more double bonds, 19% of the unsaturated fatty acids in the phospholipid structure have four or more double bonds (Hornstein *et al.* 1961). Therefore, phospholipids are more sensitive to oxidation and they oxidise more quickly in both fresh and processed meat (Alasnier and Gandemer, 1997).

Type, amount and fraction of phospholipids in meat are effect from the race, age and sex of the animal (Malau-Aduli *et al.*, 1998). Various technological processes such as fermentation, cooking, drying and salting/curing also affect the phospholipid fraction of processed meat. In fermented products, phospholipid amount decreases as a result of the changes or deformation in the lipid structures depending on the fermentation conditions (such as temperature, moisture and O₂ etc.) (Visessanguan *et al.*, 2006). With cooking, phospholipid amount decreases and neutral lipid amount increases depending on the oxidation of polyunsaturated fatty acids in the phospholipid fraction (Legako *et al.*, 2015). At the maturation stages of the meat

during curing, drying and processing with various products, the amount of free fatty acid increases and phospholipid amount decreases depending on the oxidation of intramuscular fats, lipolytic enzymes and especially lipooxygenase (LOX) enzyme (Jin *et al.*, 2010).

During pastırma production, important physical, chemical and microbiological changes occur; production stages and durations affects various quality criteria such as moisture, a_w, pH, salt, nitrite, nitrate, non-protein nitrogen, myofibriller fragmentasyon index, protein amount and structure, free amino acid composition, colour, firmness, fatty acid composition and volatile compounds. Moreover, lipid oxidation is observed at important levels during production and thiobarbutiric acid reactive substances (TBARS) values also increase. As a result of these lipolytic changes, the amount of free fatty acid increases and important changes occur in the fatty acid composition. As known, polyunsaturated fatty acids in the intramuscular fats, which are more prone to oxidation, are generally observed in the structures of phospholipids. Therefore, it is thought that substantial changes may occur in the fatty acid composition of phospholipids during pastırma production. Until today, changes in the fatty acid composition of phospholipids in pastırma or during pastırma production have not been studied. This research aims to determine the amount or ratio of phospholipid fraction during pastırma production and the changes in the fatty acid composition of phospholipids. For this purpose, pastırma was produced from *M. Longissimus dorsi* muscle of beef; moisture, pH, colour (L*, a*, b*) analyses and the neutral lipid amount, phospholipid amount or ratio and the fatty acid composition of phospholipid fraction were determined in the raw meat, after curing, after 2nd drying and in the final product (pastırma).

Material and Method

Material

In this study, beef *M. Longissimus dorsi* muscles was used from a local slaughterhouse, Et ve Süt Kurumu A.Ş., in Erzurum, Turkey.

Production of Pastırma

In this study, pastırma production, in two replicates, was performed in reference to the methods by and Aksu *et al.* (2005b) as following:

Preparation of the meat: The *M. Longissimus dorsi*

muscles obtained from two different beef carcasses were used as the raw material for pastirma production. Right and left *M. Longissimus dorsi* muscles from beef carcass were divided into two pieces, and, in this way, meat for the production of four pastirma was obtained from the same carcass (total n=8). Then, excess fat, tendon and connective tissues on the muscles were removed. The prepared meats for the pastirma process were then cut at a 45-degree angle from one surface to the muscle fibres at a depth of smaller than the 2/3 of the meat thickness.

Curing: During this process, dry curing was applied, and 50 g salt was used per 1 kg meat. Salted meats were stored at 6°C for 30 h with the cuts facing up, then they were turned over with the cuts facing down and they were stored at 6°C for 18 h.

1st Drying: After dry curing, cured meats for pastirma were dried at 15°C for 4 d in an environment of 80-85% relative humidity.

1st Pressing: After the 1st drying process, cured and dried meat was subjected to the 1st pressing process. Pressing was applied at 7-10°C for 17 h.

2nd Drying: After the 1st pressing process, meats were redried for 3-4 d in an environment of 20°C with 70% relative humidity.

2nd Pressing: After the 2nd drying, 2nd pressing was applied. 2nd pressing was performed at 25°C for 7 h.

Addition of Cemen Paste: In the production of cemen paste, 500 g fenugreek seed flour, 350 g freshly crushed garlic, 150 g red pepper (75 g powdered hot red pepper + 75 grams powdered paprika) and 1200 mL tap water mixture were used (Aksu *et al.*, 2006). After drying and pressing processes was completed, meats were waited in cemen paste for 4.5 d (at 7°C), then the excess cemen around the meat was removed leaving behind a thin layer of 2-3 mm and the addition of cemen paste was completed.

Final Drying: After the addition of cemen paste, meats were subjected to the final drying in an environment of 15°C with 70% relative humidity for 2 d, in an environment of 18°C with 65% relative humidity for 2 d and then in an environment of 20°C with 60% relative humidity for 4-5 d.

Analyses

Analyses of moisture and fatty acid composition of phospholipid fraction were performed for raw meat, after curing, after 2nd drying and pastirma. pH and colour (L^* , a^* and b^*) analyses were only performed for raw meat and

pastirma.

pH analysis

For pH analysis, 10 g samples were taken from each pastirma type in parallel, 10 mL distilled water was added to each sample and then they were homogenised in Ultra Turrax for 1 min. Afterwards, pH values of these homogenates were measured with a pH meter. Before measurement, pH meter was calibrated with 4.00 and 7.00 buffer solutions.

Measurement of colour values

Colour intensities (L^* , a^* and b^*) of the samples were determined with a Minolta (CR-400, Minolta Co., Japan) calorimeter. For colour intensities, criteria of the International Commission on Illumination CIELAB (Commission Internationale de l'Éclairage) based on three-dimensional colour measurement was taken as reference.

Moisture analysis

Moisture content of the samples were performed according to the drying method. The 10 g of grounded meat or pastirma samples were put into drying plates in parallel and they were dried in a drying oven at 102°C until a constant weight was provided. Then, dried samples cooled in a desiccator and weighed. Moisture amounts of the samples were determined taking the weight loss into consideration.

Extraction of fat from the samples and separation of phospholipid fraction

For the extraction of fats from the samples, Folch extraction method shown in Fig. 1 was used (Folch *et al.*, 1957). Fats taken by this method were subjected to various pre-treatments and they were separated into neutral lipid and phospholipid fractions.

Determination of the fatty acid composition of the phospholipid fraction

Tubes containing phospholipid fraction were waited under nitrogen until a constant weight was provided. 200 microliters of the standard solution (methynonadecanone 8 mg for 1 mL) was added to the samples at a constant weight again, they were waited under nitrogen for the second time. 2 mL BF_3 -methanol (25% of Borontrifluoride methanol) was added to the samples and they were waited in the drying chamber at 80°C for 30 min. Then, tubes were cooled down to room temperature. 1 mL hex-

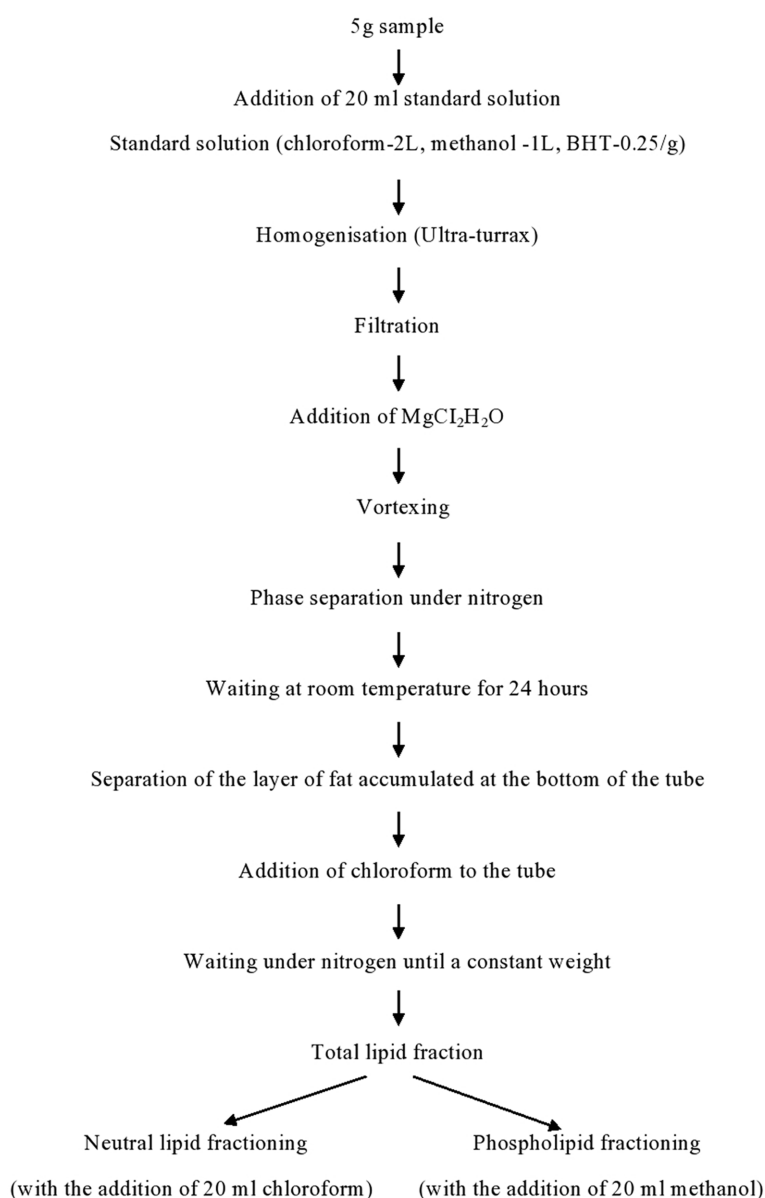


Fig. 1. Fat extraction stages.

ane was added to the tubes and then they were vortexed. 1 mL ultra-distilled water was added to the tubes and then they were vortexed again. Afterwards, these tubes were centrifuged at 3,000 rpm for 5 min. After centrifuge, the top phase was taken, put into another tube containing sodium sulphate and 1 mL hexane was added. Then, it was vortexed and the top phase was removed to another vial. Fatty acid compositions of these samples were determined by gas chromatography (Name of the device: Agilent 6980 Gas Chromatography (GC), Detector used in the Gas Chromatography: FID, Colon: DB-23 (60 m × 0.25 mm × 0.25 μm), Detector Temperature: 200°C, Col-

umn Temperature: waited at 165°C for 15 min. Then reach to 200°C by 5°C increases per min., Flow Rate: 1/50 (nitrogen/dry air), Air Pressure: 350 mL/min).

Statistical analyses

The study was conducted according to completely randomised experimental design in two replicates. Data were analysed with SPSS in variance analysis (SPSS, 22.0), means of the main significant variance sources were compared with Duncan's Multiple Range Test. The results of the statistical analysis are presented with the standard deviations.

Results and Discussion

Moisture content

Moisture content of the raw meat, after curing, after 2nd drying and final product (pastırma), and means of the pH and colour (L*, a* and b*) values for raw meat and pastırma and the results of the Duncan's Multiple Range Test are presented in Table 1. Moisture content of pastırma production stages was determined between 74.54-75.23%, 65.38-68.83%, 44.25-48.46% and 35.79-41.48% respectively. It was found that production stages significant ($p<0.01$) affected the moisture content (Table 1). Moisture content decreased during production ($p<0.05$). Moisture content was determined as $74.38\pm 0.52\%$ in the raw meat used for pastırma production, and it decreased to $38.88\pm 1.78\%$ in pastırma. In their research, Aksu and Kaya (2002a) determined the decreasing moisture content as 75.13% in raw meat, as 55.82% after 2nd drying and as 45.02% in pastırma. Yilmaz and Gecgel (2009) determined that moisture content of pastırma was between 37.71% and 45.56%. Similarly, Aksu and Kaya (2002b) found that the moisture content decreased during pastırma production. According to Turkish Food Codex Meat and Meat Products Notification (Anonymous, 2012), moisture content should be maximum 45% in pastırma without cemen paste.

pH values

pH value was determined between 5.47-5.58 in raw meats used in pastırma production and between 5.65-5.76 in pastırma. Production stages were determined to significant effects ($p<0.01$) on the pH value. The pH value was determined as 5.53 ± 0.05 in raw meat and it increased to 5.71 ± 0.05 in pastırma. Proteolytic changes during pastırma production process (Erdemir and Aksu, 2016), drying, fermentation and the quality of the raw meat affected pH value. The mean value determined in the final product pastırma was below the upper limit of 6.0 determined by

Turkish Food Codex Meat and Meat Products Notification (Anonymous, 2012). In various studies, changes in the pH values are in parallel with our findings and they all increase during production process (Aksu and Kaya, 2001a; Aksu and Kaya, 2002a; Aksu and Kaya, 2002c; Aksu *et al.*, 2016).

Colour values

Significant effects of the production stages were found on the L* value ($p<0.01$). L* value was determined as 35.77 ± 2.59 in raw meat and it increased to 38.86 ± 2.04 in pastırma (Table 1). Aksu and Kaya (2001b) found the L* value in their control group pastırma as 41.22 in average. Aksu and Kaya (2005) determined that the L* value is 38.08 ± 0.07 in raw meat and it increased to 47.38 ± 1.59 in pastırma. Aksu *et al.* (2016) also found the L* value as 38.40 ± 5.44 in raw meat, it increased during production process and determined as 41.91 ± 3.64 in the final product.

Colour is a significant quality criterion for pastırma. The a* value is especially important in terms of consumer choices. The a* value was determined between 20.94-32.50 in the raw meat used in the pastırma production, and between 38.57-40.06 in pastırma. It was found that production stages affected significant ($p<0.01$) on the a* value. The mean a* value determined as 26.05 ± 4.69 in raw meat increased to 39.14 ± 0.43 in pastırma (Table 1). Aksu and Kaya (2005) specified a* value in pastırma as 36.38 ± 1.15 . The quality of raw meat, production conditions and duration, production methods, packaging, storage time and conditions may affect the colour properties of pastırma, especially a* value (Aksu and Kaya, 2002a; Aksu and Kaya, 2005). Therefore, in the market researches, important variations have been determined in a* values of sliced pastırma. In this context, Aksu and Kaya (2001a) found that the a* value between 13.66-36.63 in pastırma samples, Çakıcı *et al.* (2015) found it changing between 21.45-30.22 in the pastırma.

While b* value changed between 5.96-13.86 in raw

Table 1. The results of Duncan's multiple range test for the mean values of moisture, pH and colour values in the raw meat, after curing, after 2nd drying and in the final product ($p<0.05$)

Properties	Production Stage				p
	Raw Material	End of curing	End of second drying	Pastırma	
Moisture (%)	74.38 ± 0.52^a	66.88 ± 1.11^b	45.26 ± 1.62^c	38.88 ± 1.78^d	**
pH	5.53 ± 0.05 b	-	-	5.71 ± 0.05 a	**
L* values	35.77 ± 2.59 b	-	-	38.86 ± 2.04 a	**
a* values	26.05 ± 4.69 b	-	-	39.14 ± 0.43 a	**
b* values	9.26 ± 2.67 b	-	-	20.62 ± 1.80 a	**

^{a-d} Any means in the same column with the same letters are not significantly different at $p<0.05$, \pm : Standard deviation, ** $p<0.01$.

meat used for pastirma, it was determined between 17.50-23.71 in pastirma. Significant effects of the production stages were determined on the b^* value ($p < 0.01$), and the b^* value was as 9.26 ± 2.67 in the raw meat and it increased to 20.62 ± 1.80 in pastirma. In various researches, b^* value was determined as 16.67-19.54 (Aksu and Kaya, 2001a), 19.23 ± 0.75 (Aksu and Kaya, 2005) and 21.75 ± 3.5 (Aksu *et al.*, 2005a) in the sliced pastirma samples produced from *L. dorsi* muscle. Same researchers stated that b^* value increased during pastirma production.

Total fat, neutral lipid and phospholipid ratio or amounts

Total fat, neutral lipid and phospholipid ratios or amounts of the phospholipid fraction in raw meat, after curing, after 2nd drying and in the final product, and their percentages, are presented in Table 2. Total lipid amount was determined as 1.16-1.57 g/100 g, in raw meat, as 0.77-1.40 g/100 g after curing and as 1.19-1.97 g/100 g after 2nd drying. It reached the maximum level in pastirma due to reduction of water during processing and it was determined between 2.14-2.96 g/100 g. During production, neutral lipid was specified between 0.77-1.18 g/100 g in raw meat, between 0.58-1.00 g/100 g after curing, between 0.80-1.57 g/100 g after 2nd drying and between 1.75-2.37 g/100 g in pastirma. The ratio of neutral lipid was 66.38-75.16% in raw meat, 71.42-78.79, 2% after curing, 66.39-79.29% after 2nd drying and 76.98-81.78% in pastirma. Phospholipid amount was found between 0.39-0.40 g/100 g in raw meat and between 0.39-0.60 g/100 g in pastirma. Phospholipid ratio was 24.84-33.61% in raw meat and 18.22-23.02% in pastirma.

Significant effects of the pastirma production stages were determined on the lipid amount ($p < 0.01$), and the highest total lipid amount was determined as 2.60 ± 0.36 g/100 g in pastirma (Table 2). During production, there was not any statistical difference ($p > 0.05$) among the values in raw meat, after curing and 2nd drying in terms of lipid

amount. Pastirma production stages also significant ($p < 0.01$) affected the total neutral lipid amount and its percentage, and in total lipid amount, neutral lipids were determined to be dominant with $79.33 \pm 2.06\%$. It was determined that pastirma production stages affected ($p < 0.01$) the phospholipid amount and percentage in total lipid amount, the lowest amounts were detected after curing and the highest were detected in pastirma (Table 2). In various researches, parallel to our findings, neutral lipid amount was determined to be higher than the phospholipid amount in intramuscular fats. Yang *et al.* (2005) researched the changes in intramuscular lipid fractions during the production of traditional Xuanwei jambon, and they found that the neutral lipid ratio was $73.2 \pm 2.33\%$ in raw meat and it increased to $80.2 \pm 3.02\%$ in final dried product, while the phospholipid ratio decreased from $25.3 \pm 1.31\%$ to $5.8 \pm 0.41\%$. Similarly, He *et al.* (2012) reported that the neutral lipid amount was $76.72 \pm 0.99\%$ and the phospholipid amount was 20.54 ± 1.06 in the intramuscular lipid content of beef *M. Longissimus* muscle. Jin *et al.* (2010) found the neutral lipid amount as $67.8 \pm 2.6\%$ in raw meat, as $71.1 \pm 2.5\%$ after curing, as $73.0 \pm 1.2\%$ in the final product, while determined the phospholipid as $22.4 \pm 0.7\%$ in raw meat, as $16.1 \pm 0.3\%$ after curing and as $10.3 \pm 0.3\%$ in the final product. Additionally, several researches pointed out that phospholipid amount decreased during the processing of various meat types from different animals (Huang *et al.*, 2014; Muriel *et al.*, 2005).

Saturated fatty acid composition of phospholipid fraction

Palmitic (16:0) and stearic (18:0) acids were determined to be the dominant saturated fatty acid in phospholipid fractions during all production stages. However, production stages did not affect these fatty acids ($p > 0.05$; Table 3). Similarly, pastirma production stages did not have any effects on the amounts of myristic ($p > 0.05$), pentadecanoic ($p > 0.05$), margaric ($p > 0.05$) and arachidonic acid

Table 2. The results of Duncan's multiple range test for the mean values of total fat, neutral lipid and phospholipid amounts in the phospholipid fraction in raw meat, after curing, after 2nd drying and in the pastirma, and their percentages ($p < 0.05$)

Fat or fractions	Amounts or ratio (%)	Production Stage				P
		Raw Material	End of curing	End of second drying	Pastirma	
Total Lipids	g/100g	1.37 ± 0.23^b	1.10 ± 0.27^b	1.48 ± 0.34^{ab}	2.60 ± 0.36^a	**
Neutral Lipid	g/100g	0.98 ± 0.23^b	0.81 ± 0.18^b	1.08 ± 0.34^b	2.06 ± 0.27^a	**
	%	70.77 ± 5.07^b	75.03 ± 3.03^{ab}	72.11 ± 5.33^b	79.33 ± 2.06^a	**
Phospholipid	g/100g	0.39 ± 0.01^b	0.27 ± 0.10^c	0.40 ± 0.00^b	0.54 ± 0.10^a	**
	%	29.23 ± 5.07^a	25.22 ± 3.03^{ab}	27.89 ± 5.33^a	20.67 ± 2.06^b	**

^{a-c} Any means in the same column with the same letters are not significantly different at $p < 0.05$, \pm : Standard deviation, ** $p < 0.01$.

Table 3. The results of Duncan's multiple range test for the mean values of saturated fatty acid compositions in raw meat, after curing, after 2nd drying and in the pastırma ($p < 0.05$) (%)

Fatty Acids	Raw Material	End of curing	End of second drying	Pastırma	<i>p</i>
Myristic (14:0)	0.93±0.20	1.51±0.88	1.44±0.55	1.01±0.61	NS
Pentadecanoic (15:0)	0.62±0.05	0.61±0.03	0.54±0.05	0.57±0.09	NS
Palmitic (16:0)	20.16±0.50	20.67±0.39	20.62±1.09	20.27±0.21	NS
Margaric (17:0)	0.96±0.08	1.05±0.08	1.00±0.05	0.97±0.02	NS
Stearic (18:0)	11.54±0.17	12.17±0.82	12.12±0.48	11.65±0.36	NS
Arachidonic (20:0)	0.08±0.03	0.08±0.01	0.07±0.00	0.09±0.03	NS
ΣSFA	34.27±0.47 ^c	36.09±0.41 ^a	35.82±1.15 ^{ab}	34.56±0.44 ^{bc}	*

^{a-c} Any means in the same column with the same letters are not significantly different at $p < 0.05$, ±: Standard deviation, * $p < 0.05$. NS: Not significant ($p > 0.05$).

($p > 0.05$). On the other hand, pastırma production stages significant ($p < 0.05$) affected the total saturated fatty acid of phospholipid fraction (Table 3). The lowest amount of saturated fatty acid was determined as 34.27±0.47% in raw meat and the highest as 36.09±0.41% after curing. In the produced pastırma, saturated fatty acid amount of phospholipid fraction was determined as 34.56±0.44%, which was very close to the value determined in raw meat. Indurain *et al.* (2006) determined the highest amount of palmitic acid (C_{16:0}) as 26.49±3.19% and stearic acid (C_{18:0}) as 19.98±5.42% among the saturated fatty acids in the intramuscular fatty acid composition of male beef. Huang *et al.* (2014), in the fatty acid composition of phospholipid fraction during the production of Chinese traditional smoke-cured bacon, found that the amounts of palmitic (19.52±0.51%) and stearic (12.68±0.28%) acids were higher than other fatty acids among saturated fatty acids.

Unsaturated fatty acid composition of phospholipid fraction

The values of unsaturated fatty acid composition in phospholipid fractions of the samples at the stages of raw meat, after curing, after 2nd drying and pastırma are presented in Table 4. In the unsaturated fatty acid compositions of the phospholipid fraction, the dominant fatty acids were oleic (18:1n-9) and linoleic (18:2n-6) acids, followed by arachidonic (20:4n-6), palmitoleic (16:1n-7), α-linolenic (18:3n-3), eicosapentaenoic (20:5n-3) and vaccenic (18:1n-7) acids.

It was determined that total unsaturated fatty acids detected in the phospholipid fractions during production stages were mostly in the structure of polyunsaturated fatty acid, and the total amounts of unsaturated fatty acid (ΣUSFA) were detected as 65.13-66.26%, 63.31-64.23%, 62.79-65.49% and 65.10-66.07%, total amounts of mono-

unsaturated fatty acid (ΣMUFA) as 26.01-28.15%, 25.36-27.17%, 26.17-27.39% and 26.25-27.08%, total amounts of polyunsaturated fatty acid (ΣPUFA) as 36.98-41.82%, 36.14-38.87%, 36.24-39.32% and 38.00-39.82%, respectively in raw meat, after curing, after 2nd drying and in pastırma (Table 4). Corazzin *et al.* (2012) determined that the total amount of monounsaturated fatty acid (ΣMUFA) as 20.68%, 19.94%, and the total amount of polyunsaturated fatty acid (ΣPUFA) as 36.27%, 41.55% in the fatty acid composition in the phospholipid fraction of *M. Longissimus thoracis* muscle of Holstein and Simmental cattle. Yang *et al.* (2005) determined the total amount of monounsaturated fatty acid (ΣMUFA) as 21.05% and the total amount of polyunsaturated fatty acid (ΣPUFA) as 42.14% in the phospholipid fraction of the pork hams.

It was found that production stages had significant ($p < 0.01$) effect on the amount of pentadecanoic acid (15:1) (Table 4), and the highest value was determined after curing and 2nd drying. This value is quite low in pastırma. Significant effects of the pastırma production stages were found on the dominant unsaturated fatty acid, linoleic acid, in phospholipid fraction ($p < 0.01$) (Table 4). The amount of linoleic acid (18:2n-6) determined as 18.91±0.62% in raw meat decreased after curing and 2nd drying, and was detected as 18.53±0.20% in pastırma. The decrease in the linoleic acid during pastırma production and its increase in pastırma once again were attributed to the amount of fat in the cemen paste. In the pastırma produced with different commercial cultures, Aksu and Kaya (2002a) determined the ratio of unsaturated fatty acid as 30.77-44.71% before the addition of cemen, and this value increased to 51.07-55.48% after the addition of cemen. Küçük and Gürbüz (1999) determined that the fat ratio in cemen paste between 4.01% and 5.89%, and found the mean value as 4.92±0.64%.

γ-linolenic acid (18:3n-6), erucic acid (20:1n-9) and

Table 4. The results of Duncan's multiple range test for the mean values of unsaturated fatty acid compositions in the phospholipid fraction in raw meat, after curing, after 2nd drying and in the pastırma ($p < 0.05$) (%)

Fatty acids	Raw material	End of curing	End of second drying	Pastırma	<i>p</i>
Myristioleic (14:1)	0.38±0.05	0.52±0.28	0.47±0.16	0.44±0.20	NS
Pentadecanoic (15:1)	0.92±0.21 ^b	1.53±0.26 ^a	1.54±0.25 ^a	0.99±0.13 ^b	**
Palmitoleic (16:1n-7)	1.89±0.19	1.77±0.03	1.81±0.04	1.85±0.11	NS
Heptadecanoic (17:1)	1.02±0.11	1.07±0.08	1.05±0.04	1.03±0.04	NS
Vaccenic (18:1n-7)	1.13±0.07	1.28±0.10	1.22±0.05	1.24±0.09	NS
Oleic (18:1n-9)	20.34±1.69	19.60±1.24	20.28±0.57	20.40±0.21	NS
Linoleic (18:2n-6)	18.91±0.62 ^a	17.66±0.49 ^b	17.73±0.69 ^b	18.53±0.20 ^{ab}	*
α -linolenic (18:3n-3)	2.26±0.17	2.13±0.10	2.09±0.03	2.19±0.06	NS
γ -linolenic (18:3n-6)	0.15±0.02 ^{ab}	0.17±0.05 ^a	0.13±0.01 ^b	0.13±0.02 ^b	*
Stearidenoic (18:4n-3)	0.14±0.01	0.15±0.00	0.13±0.04	0.14±0.02	NS
Eicosenoic (20:1n-9)	0.05±0.02	0.06±0.03	0.04±0.00	0.04±0.01	NS
Gadoleic (20:1n-11)	0.10±0.02	0.10±0.01	0.10±0.01	0.10±0.01	NS
Eicosadienoic (20:2n-6)	0.47±0.04	0.47±0.02	0.48±0.01	0.51±0.01	NS
Eicosatrienoic (20:3n-3)	0.30±0.02	0.30±0.03	0.30±0.01	0.30±0.01	NS
Dihomo γ -linolenic (20:3n-6)	1.60±0.19	1.54±0.10	1.52±0.05	1.62±0.06	NS
Eicosatetraenoic (20:4n-3)	0.08±0.02	0.10±0.04	0.10±0.02	0.10±0.08	NS
Arachidonic (20:4n-6)	9.89±1.58	9.50±0.84	9.40±0.53	9.80±0.43	NS
Eicosapentaenoic (20:5n-3)	1.27±0.21	1.23±0.15	1.24±0.10	1.26±0.08	NS
Erucic (22:1n-9)	0.18±0.10 ^a	0.19±0.11 ^a	0.04±0.00 ^b	0.05±0.02 ^b	*
Ketoleic (22:1n-11)	0.05±0.01	0.07±0.05	0.07±0.04	0.06±0.04	NS
Docosadienoic (22:2n-6)	0.99±0.05	0.95±0.01	0.96±0.02	1.01±0.04	NS
Docosatetraenoic (22:4n-6)	0.16±0.02	0.17±0.03	0.16±0.02	0.17±0.01	NS
Docosapentaenoic (22:5n-3)	0.11±0.01 ^b	0.19±0.07 ^a	0.19±0.03 ^a	0.19±0.05 ^a	*
Docosahexaenoic (22:6n-3)	3.08±0.41	2.92±0.26	2.93±0.15	3.04±0.15	NS
Nervonic (24:1n-9)	0.28±0.05	0.25±0.04	0.25±0.02	0.26±0.03	NS
Σ USFA	65.73±0.46 ^a	63.92±0.41 ^b	64.18±1.15 ^b	65.44±0.43 ^a	*
Σ MUFA	26.32±1.79	26.55±0.81	26.86±0.59	26.48±0.40	NS
Σ PUFA	39.36±1.98	37.36±1.13	37.32±1.39	38.98±0.76	NS

^{ab}Any means in the same column with the same letters are not significantly different at $p < 0.05$, \pm : Standard deviation, * $p < 0.05$, ** $p < 0.01$. NS: Not significant ($p > 0.05$).

docosapentaenoic acid (22:5n-3) are other unsaturated fatty acids that are significant ($p < 0.01$) affected by the production stages. While the amounts of γ -linolenic (18:3n-6) and erucic (20:1n-9) acid decreased during pastırma production ($p < 0.05$), the lowest value was determined in pastırma. The amount of docosapentaenoic acid (22:5n-3) increased during pastırma production.

It was determined that pastırma production stages had significant ($p < 0.01$) effect on the total amount of unsaturated fatty acid. The total amount of unsaturated fatty acid of phospholipid fraction, determined as 65.73±0.46% in raw meat, decreased after curing (63.92±0.41) and 1st drying (64.18±1.15), and increased in pastırma again (Table 4). K and G (1999) found that the fatty acids in cemen content as unsaturated such as linoleic acid (18:2n-6), linolenic (18:3n-6), oleic acid (18:1n-9), and saturated such as myristic acid (14:0). They also stated that

the mean values of the fatty acids in cemen line as linoleic acid 44.64%, linolenic acid 23.12%, oleic acid 19.34% and myristic acid 10.24%. On the other hand, despite being statistically no significant ($p > 0.05$), the amount of polyunsaturated fatty acid decreased after curing and 2nd drying compared to raw material, and then increased again after these stages. Since the change in the total amounts of unsaturated fatty acid and polyunsaturated fatty acid is parallel to each other, the increase in the total amount of unsaturated fatty acid is attributed to the increment of polyunsaturated fatty acid.

The results of Duncan's Multiple Range Test for the mean values of $\Sigma n6$ PUFA, $\Sigma n3$ PUFA, $\Sigma n6/\Sigma n3$ and $\Sigma n3/\Sigma n6$ ratios determined in raw meat, after curing, after 2nd drying and in the pastırma are presented in Table 5. Pastırma production stages did not affect ($p > 0.05$) the amounts of $\Sigma n6$ PUFA ($p > 0.05$), $\Sigma n3$ PUFA ($p > 0.05$), $\Sigma n6/$

Table 5. Mean values of $\Sigma n6$ PUFA, $\Sigma n3$ PUFA, $\Sigma n6/\Sigma n3$ and $\Sigma n3/\Sigma n6$ determined in the phospholipid fraction in raw meat, after curing, after 2nd drying and in the pastirma (%)

Total n3 or n6 fatty acids	Raw Material	End of curing	End of second drying	Pastirma	<i>p</i>
$\Sigma n6$ PUFA	32.17±1.59	30.26±0.92	30.36±1.14	31.76±0.54	NS
$\Sigma n3$ PUFA	7.24±0.47	7.05±0.47	7.02±0.45	7.22±0.25	NS
$\Sigma n6/\Sigma n3$	4.45±0.17	4.31±0.28	4.33±0.20	4.40±0.10	NS
$\Sigma n3/\Sigma n6$	0.22±0.01	0.23±0.02	0.23±0.01	0.23±0.01	NS

±: Standard deviation, NS: Not significant ($p>0.05$).

$\Sigma n3$ ($p>0.05$) and $\Sigma n3/\Sigma n6$ ($p>0.05$).

The dominant fatty acid in the structure of $\Sigma n6$ PUFA fatty acid in pastirma was linoleic acid (18:2n-6), and in the structure of $\Sigma n3$ PUFA fatty acid was α -linolenic (18:3n-3) acid. Williams (2000) stated that n-3 PUFA fatty acids were formed of α -linolenic acid (18:3) and n-6 PUFA fatty acids were formed of linoleic acid (18:2), and the amount of n-6 PUFA was higher than n-3 PUFA. Cordain *et al.* (2002) also reported that the amount of n-6 PUFA was higher than n-3 PUFA in beef muscle tissues.

Σ PUFA/ Σ SFA and PUFA n-6/n-3 are among the specific parameters in defining the nutrition qualities of the lipid fractions of foods. It is deemed acceptable when Σ PUFA/ Σ SFA ratios is >0.4 , and PUFA n-6/n-3 ratio is <4 . For phospholipid fraction of pastirma, these ratios are determined as 1.13 for Σ PUFA/ Σ SFA and 4.40 ± 0.10 for PUFA n-6/n-3. The PUFA n-6/n-3 ratios have been associated with cancer, coronary heart diseases and especially embolus formation, and it has been recommended that this ratio should remain below 4 (Wood *et al.*, 2003). Similar arguments have found support from various authorities and low PUFA n-6/n-3 ratio is stated to help preventing several chronic diseases (EFSA, 2005). Moreover, Wood *et al.* (2003) also stated that PUFA n-6/n-3 ratio in red muscle tissues should remain below 4 for health reasons. Habeanu *et al.* (2014) determined that the n-6/n-3 ratios in phospholipid fatty acid compositions in *Longissimus thoracis* and *Semitendinosus* muscles as 4.31 and 3.99, respectively.

Conclusion

Total lipid amount increased during pastirma production and the highest value was determined in pastirma. Decreasing moisture content from raw meat to pastirma caused this increase. During pastirma production, both neutral lipid and phospholipid ratios statistically significant changed ($p<0.01$); while neutral lipid ratio increased ($p<0.01$), phospholipid ratio decreased ($p<0.01$). While

the available total lipid fraction in raw meat was proportionately formed of neutral lipids by $70.77\pm 5.07\%$ and phospholipids by $29.23\pm 5.07\%$, the lipid fraction in pastirma was formed of neutral lipids by $79.33\pm 2.06\%$ and phospholipids by $20.67\pm 2.06\%$.

Palmitic and stearic acids were determined as the dominant saturated fatty acids in phospholipid fraction during pastirma production, while oleic and linoleic acids were determined as dominant fatty acids in unsaturated fatty acid compositions. On the other hand, production stages significant ($p<0.01$) effect on the total saturated and unsaturated fatty acid in phospholipid fractions. Polyunsaturated fatty acids have an important place among unsaturated fatty acids, and during pastirma production, Σ MUFA ratio was found quite lower than Σ PUFA ratio. Although Σ PUFA ratio decreased and Σ MUFA ratio slightly increased during pastirma production, these differences are statistically not significant ($p>0.05$). Based on these results, we can conclude that fatty acid composition in phospholipid fraction during pastirma production is substantially preserved. On the other hand, the mean value of $\Sigma n6/\Sigma n3$ ratio of phospholipid fraction in pastirma was determined as 4.40, which was very close to the recommended value (4.0) for meat and meat products. Σ PUFA/ Σ SFA ratio of this fraction was 1.13.

Acknowledgements

Authors would like to thank the Atatürk University Research Center for financial support (BAP: 2013/390) in making this study possible.

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