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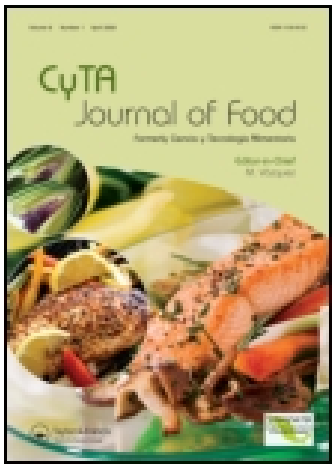

CyTA - Journal of Food
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tcyt20

A survey of the physico-chemical and microbiological quality of different pastırma types: a dry-cured meat product

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Published online: 14 Aug 2014.

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To cite this article: Neslihan Çakıcı, Muhammet İrfan Aksu & Ebru Erdemir (2015) A survey of the physico-chemical and microbiological quality of different pastırma types: a dry-cured meat product, CyTA - Journal of Food, 13:2, 196-203, DOI: 10.1080/19476337.2014.938123

To link to this article: http://dx.doi.org/10.1080/19476337.2014.938123

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CyTA – Journal of Food, 2015
Vol. 13, No. 2, 196–203, http://dx.doi.org/10.1080/19476337.2014.938123

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A survey of the physico-chemical and microbiological quality of different pastırma types: a dry-cured meat product

Revisión de la calidad fisicoquímica y microbiológica de distintas variedades de pastirma: un producto cárnico curado en seco

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(*Received 13 February 2014; final version received 17 June 2014*)

Pastırma, a traditional Turkish dry-cured meat product, is categorized as an intermediate-moisture food. It is produced from whole muscle and/or muscles obtained from certain parts of beef and buffalo carcasses. This is the first study dealing with some physico-chemical (fatty acid composition, moisture, ash, total fat, residual nitrite, pH and colour) and microbiological properties of sırt, şekerpare, bohça and kuşgömü pastırma types. Significant differences were determined among the pastırma types in moisture ($P < 0.01$), ash ($P < 0.01$), salt ($P < 0.01$), total fat ($P < 0.01$), residual nitrite amounts ($P < 0.05$), stearic acid ($P < 0.05$), L^* ($P < 0.01$) and a^* ($P < 0.05$) values, total aerobic mesophylic bacteria ($P < 0.01$), lactic acid bacteria ($P < 0.01$) and *Micrococcus/Staphylococcus* ($P < 0.01$) counts. No difference ($P < 0.05$) was observed in average pH and b^* value and fatty acid composition among the pastırma types except for stearic acid. However, the salt amount in all samples was above the maximum acceptable limit. *Pseudomonas* counts in 48.39% of pastırma samples and *Enterobacteriaceae* counts in 4.84% of pastırma samples were > 2.00 log colony-forming units per gram (CFU g^{-1}).

Keywords: pastırma types; dry-cured meat; microbial quality; chemical composition; fatty acid composition; residual nitrite

Pastirma, producto cárnico curado en seco de tradición turca, se categoriza como un alimento de humedad intermedia y es elaborado a partir del músculo entero y/o de músculos obtenidos de ciertos cortes de vacuno o de búfalo en canal. El presente es el primer estudio centrado en analizar algunas propiedades fisicoquímicas (composición de ácido graso, humedad, ceniza, grasa total, nitrito residual, pH y color) y microbiológicas de las siguientes variedades de pastirma: sırt, şekerpare, bohça y kuşgömü. El análisis realizado reveló que, en los distintos tipos de pastirma se constata la existencia de diferencias significativas en términos de humedad ($P < 0{,}01$), de ceniza ($P < 0{,}01$), de sal ($P < 0{,}01$), de grasa total ($P < 0{,}01$), de nitrito residual ($P < 0{,}05$), de ácido esteárico ($P < 0{,}05$), de L^* ($P < 0{,}01$) y de a^* ($P < 0{,}05$), así como en los niveles de bacteria mesofílica aeróbica ($P < 0{,}01$), de bacteria de ácido láctico ($P < 0{,}01$) y de *Micrococcus/Staphylococcus* ($P < 0{,}01$). Por otra parte, no se observaron diferencias ($P < 0{,}05$) en términos de los valores promedio de pH y de b^*, ni tampoco en la composición de ácido graso, excepción hecha del ácido esteárico. Asimismo, en todas las muestras analizadas la cantidad de sal superó una cota máxima aceptable. Por último, los niveles de *Pseudomonas* en 48,39% y de *Enterobacteriaceae* en 4.84% de las muestras de pastirma fueron de > 2,00 log CFU g^{-1}.

Palabras claves: variedades de pastirma; carne curada en seco; calidad microbiana; composición química; composición de ácido graso; nitrito residual

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Introduction

Pastırma is a meat product produced from whole muscle obtained from certain parts of beef and water buffalo carcasses. It is categorized as an intermediate-moisture food (Aksu, Kaya, & Ockerman, 2005; Gokalp, Kaya, & Zorba, 2010). This product has been produced in Turkey since the twelfth century, and it is still the most popular dry-cured meat product (Gokalp et al., 2010; Tekinsen & Dogruer, 2000). Although pastırma is a traditional Turkish meat product, it is produced in many parts of the world such as the Middle East, Middle Asia and some Mediterranean and European countries.

A great number of dry-cured meat products are produced worldwide, such as pastırma, bacon, Bündnerfleisch and ham with and without heat processes. Although the similarity observed in the types of bacteria growing on and in the cured meat products whose growth are controlled by widely the same main factors effective in production, these products differ greatly in composition and intended eating quality (Roberts & Dainty, 1996). Additionally, dry-cured meat products can be generally produced with processes including curing, drying, heating, smoking and fermentation, although the production of pastırma does not include heating and smoking processes.

In the pastırma process, muscles are cured, two or three times dried, two times pressed and coated with a çemen of garlic, red pepper, paprika, flour ground from seeds of *Trigonella foenum graecum* (Fenugreek) and water. Then, they are subjected to the final drying process until its water content is a maximum of 45% (in pastırma without çemen). Approximately, 20 different types of pastırma can be produced from a carcass, which are named as *şekerpare, sırt, bohça, kuşgömü, antrekot, tütünlük, dilme, arkabaş, etek, omuz, bez, mehle, kenar, kürek, kapak, döş, kavram, potuk* and *meme* (Ceylan & Aksu, 2011; Gokalp et al., 2010; Tekinsen & Dogruer, 2000). Also, each type of pastırma has different shape and quality characteristics. Sırt pastırma (Figure 1a) is one of the longest pastırma types which is rectangular, 60–70 cm long, 15–20 cm wide and 3–4 kg in weight (Ceylan & Aksu, 2011). Sırt pastırma is produced from the loin section containing *Musculus (M.) cutaneus trunci*, *M. trapezius pars thoracica*, *M. lattissimus dorsi* (caudo-dorsal section), *M.*

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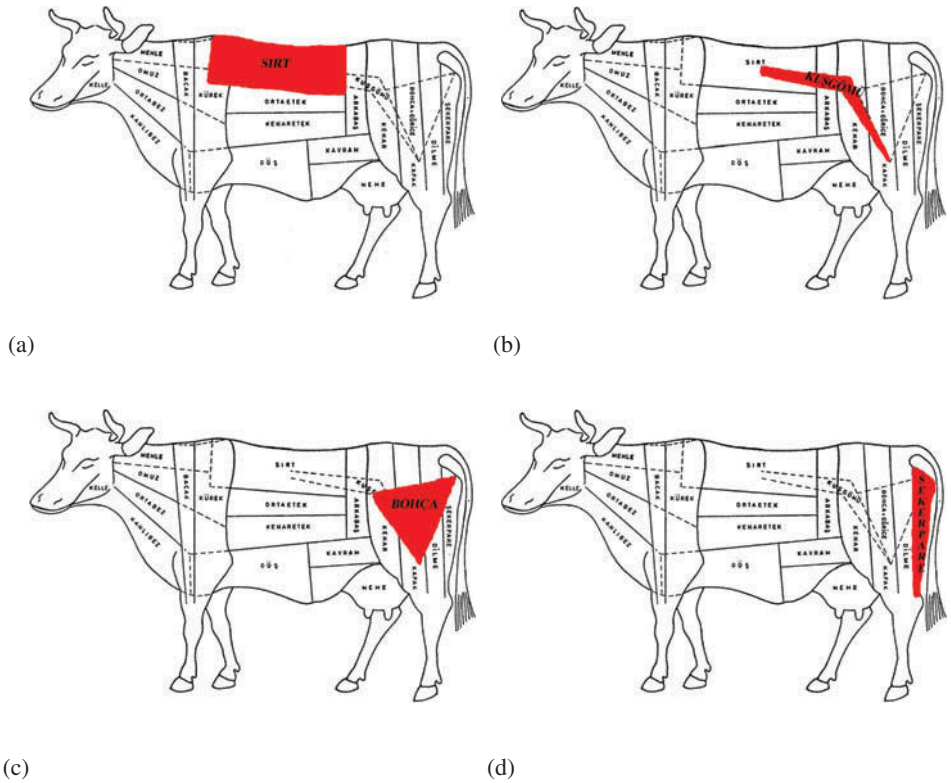

Figure 1. Parts of the carcass for pastırma production: (a) sırt pastırma, (b) kusgömü pastırma, (c) bohça pastırma and d) şekerpare pastırma.

Figura 1. Parte de la carne en canal para la producción de pastirma: (a) pastirma sirt; (b) pastirma kuşgömü; (c) pastirma bohça y (d) pastirma şekerpare.

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serratus dorsalis caudalis, *M. serratus dorsalis cranialis*, *M. longissimus dorsi*, *M. semispinalis*, *M. spinalis*, *M. iliocostalis lumborum*, *M. retractor costae*, *M. multifidus dorsi* (cranial section), *M. rotatores longi* (caudal section), *M. levatores costarum*, *M. intercostalis interni*, *M. İntercostalis externi*, *M. transversus abdominus* (dorsal section), *M. subcostalis* and *M. obliqus abdominus* (dorsal section) muscles (Tekinsen & Dogruer, 2000). Kuşgömü pastırma is triangular-shaped, 60–70 cm long, 8–10 cm wide and 1.0–1.2 kg in weight (Figure 1b). Kuşgömü pastırma is made of *M. psoas major*, *M. psoas minor*, *M. iliacus*, *M. sartorius* and *M. pectineus* muscles (Tekinsen & Dogruer, 2000). Bohça (Egrice, Bohcagömü) pastırma is triangular-shaped, 60–62 cm long, 15–16 cm wide and 1.52.0 kg in weight (Figure 1c). It is produced from muscles obtained from *M. pectineus*, *M. gracilis*, *M. adductor*, *M. vastus medialis* and *M. quadratus lumborum.* Şekerpare pastırma is rectangular-shaped, 50–60 cm long, 10–12 cm wide and 1.2–2.0 kg in weight, and it is produced from muscles of *M. semimembranosus*, *M. semitendinosus*, *M. gastrocnemius* (Figure 1d) (Ceylan & Aksu, 2011; Gokalp et al., 2010; Tekinsen & Dogruer, 2000). On the other hand, quality characteristics of pastırma is affected by a lot of factors such as animal feed levels, animal species, animal sex, cutting age and the carcass section.

In recent years, some studies related to pastırma types have been conducted on determining the free amino acid, moisture and pH values (Ceylan & Aksu, 2011). However, there is no study concerning the fatty acid composition and some physical, chemical and microbiological properties of pastırma types. Thus, the present study was conducted to determine the fatty acid composition, colour (L^*, a^* and b^*), moisture, residual nitrite, salt, fat, pH values and the mesophylic, *Micrococcus/Staphylococcus* (*M/S*), lactic acid bacteria (LAB), mould-yeast, *Pseudomonas* and *Enterobacteriaceae* counts of sırt, kuşgömü, bohça and şekerpare pastırma types.

Materials and methods

Sampling

A total of 62 pastırma samples of 16 sırt, 16 kuşgömü, 16 şekerpare and 14 bohça types were collected from the markets of Erzurum, İstanbul, Bursa and Kayseri cities of Turkey. All pastırma samples taken as whole in this study were vacuum packed in the markets. The samples were transported to the laboratory in iceboxes to prevent microbial growth or changes during transportation, and stored at 4°C until use. Then pastırma samples were aseptically sliced (1–2 mm) and analysed.

Microbiological analysis

For microbiological analysis, samples (25 g) were aseptically taken from the pastırma with çemen samples and placed into the stomacher bags, and then 225 mL of saline solution containing NaCl 0.85% was added and homogenized for 2 minutes. Then, serial dilutions of the homogenates were prepared and the surface plate method was used for enumeration.

Total aerobic mesophylic bacteria (TAMB) were enumerated on Plate Count Agar (Oxoid CMO325, Hampshire, England)

after incubation at 30°C for 48 hours. MRS (de Man Rogosa Sharpe; Oxoid CMO361, Hampshire, England) agar was used for LAB, and plates were anaerobically incubated at 30°C for 48 hours. For *M/S* bacteria, Mannitol salt phenol-red Agar (Merck, KGaA, Darmstadt, Germany) was used and plates were aerobically incubated at 30°C for 48 hours. *Pseudomonas* was enumerated on *Pseudomonas* Agar Base (Oxoid CMO559, Hampshire, England) with adding Cetrimid-Fusidin-Cephaloridin Selective Agar Supplement (Oxoid SR 0103, Hampshire, England) after incubation at 25°C for 48 hours. Mould-yeast was plated on Potato Dextrose Agar (Oxoid CM0139, Hampshire, England; pH: 3.5) and incubated at 25°C for 5 days. *Enterobacteriacea* counts were enumerated on Violet Red Bile Glucose Agar (Oxoid CMO485, Hampshire, England), with overlay added before incubation, after anaerobically incubation at 30°C for 48 hours. All bacteria counts were expressed as colony-forming units per gram (CFU g^{-1}) of sample.

Determination of residual nitrite and salt

Residual nitrite and salt amount of pastırma with çemen samples were determined according to the methods of Tauchmann (1987). Results of residual nitrite and salt were expressed as $mg \cdot kg^{-1}$ of $NaNO_2$ and percentage, respectively.

Determination of pH

The pH values of pastırma with çemen samples were measured using a pH meter (Orion 3-Star Benchtop pH meter, Thermo SCIENTIFIC, Blk 55, Ayer Rajah Crescent, Singapore). A 10-g pastırma sample was homogenized with 100 mL distilled water using Ultra-Turrax (IKA Werk, Staufen im Breisgau, Germany) and then pH was measured.

Determination of moisture and ash amount

Moisture value was determined as weight loss of 8–10 g ground of pastırma samples after drying at 100 ± 2°C for 18–24 hours. For determination of the ash amount, ground pastırma samples (approximately 5 g) were added in a porcelain crucible, and then placed in an ash furnace for 18–24 hours at 525°C, and then ash amount was determined as weight loss (%).

Determination of colour values

The colour measurements (L^*, a^* and b^*) of pastırma samples were done with a Minolta Chroma Meter CR-400 (Minolta, Osaka, Japan) using pulsed xenon lamp (Illuminant D65) as a source of light. Commision Internationele I'Eclairage (CIE) Lab L^*, a^* and b^* values were determined as indicators of lightness, redness and yellowness, respectively. Before each measurement, the apparatus was standardized against a white tile. For the colour values, four repeated measurements were taken on the internal area of a sliced surface (1–2 mm thickness) of the each pastırma samples.

Determination of total fat

The amount of total fat of the pastırma samples was determined according to the Soxhlet extraction method (Ockerman, 1985).

Determination of fatty acid composition

Folch extraction method was used for extraction of fat from each sample (Folch, Less, & Stanley, 1957). In fatty acid composition analysis, for saponification of fat, 1.5 mL of 2 M NaOH was added to 50 mg of extracted fat from each pastırma sample. After treated with nitrogen, the mixture was placed in a water bath (80°C) for 1 hour and then the mixture was cooled. After adding 2 mL of boron trifluoride-methanol (25%), the mixture was again placed in a water bath (80°C) for 30 minutes and then again cooled. A portion of 1 mL of hexane was added to the mixture and this was vortexed. Then, 1 mL of ultra-distilled water was added to and again vortexed. The hexane phase from the upper layer of the volumetric flask was transferred to flasks with anhydrous sodium sulphate, and again 1 mL hexane was added and vortexed for 30 minutes. After the mixture was centrifuged at 6000 rpm for 10 minutes, the heptane phase from the upper layer of the centrifuge tube was transferred to 2 mL vial and then treated with nitrogen (Metcalfe & Schmitz, 1961). The heptane phase in the vial was used to determine the fatty acids composition. Fatty acid methyl esters were analysed by gas chromatography (Agilent 6980 Gas Chromatograph, Waldbronn, Germany) with a capillary column (DB-23, 60 m × 0.25 mm × 0.25 µm), temperature (increasing from 100°C to 200°C with rate of 5°C min^{-1}), Flame Ionization Detector (FID) detector (H_2 and dry air) at 200°C and hydrogen gas (35 mL min^{-1}) was utilized as carrier gas.

Statistical analysis

Data were analysed with SPSS using the general linear models in the analysis of variance (SPSS for Windows Release 17.00, SPSS Inc., Chicago, IL, USA) for the completely randomized experimental design. The differences among means were tested using Duncan's multiple range test (significance $P < 0.05$). The results of the statistical analysis are shown as mean values and standard deviation in the tables.

Results and discussion

Chemical analysis

The amounts of moisture, pH, ash, salt, residual nitrite and total fat determined in sırt, kuşgömü, şekerpare and bohça pastırma types, and their significance levels and Duncan's test results are shown in Table 1. Pastırma type significantly affected moisture amount ($P < 0.01$). The highest moisture was determined in sırt and şekerpare pastırma types ($P < 0.05$), whereas the lowest moisture was determined in kuşgömü pastırma (Table 1). These differences may result from the various animal species (beef or water buffalo) and anatomic locations of muscles used in pastırma production and processing methods such as drying temperature and processing time. According to the notification of meat and meat products of Turkish Food Codex, the maximum moisture amount of pastırma without çemen should be 45.0% (Anonymous, 2012). The moisture in 9 samples of the 16 sırt pastırma (56.3%), in 4 samples of the 16 kuşgömü pastırma (25.0%), in 13 samples of the 16 şekerpare pastırma (81.3%) and in 6 samples of the 14 bohça pastırma (42.9%) were determined to be higher than the moisture limit (45.0%), as indicated by notification of meat and meat products of Turkish Food Codex. These results showed that the drying process was not applied as required. Ceylan and Aksu (2011) obtained similar results and determined the average moisture amount for sırt, bohça and şekerpare pastırma types as mean values 47.17 ± 5.00% (from

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Table 1. The moisture, pH, ash, salt, residual nitrite, total fat amounts, colour values and microbiological properties of pastırma types.

Tabla 1. Niveles de humedad, pH, ceniza, sal, nitrito residual y grasa total. Índices de color y propiedades microbiológicas de variedades de pastirma.

Properties	Pastırma types				
	Sırt	Kuşgömü	Şekerpare	Bohça	Significance
Moisture (%)	47.56 ± 5.29 a (40.81–58.43)	41.91 ± 3.94 c (35.13–49.73)	48.23 ± 4.09 a (38.29–55.05)	45.11 ± 4.95 b (37.74–56.00)	**
pH	5.86 ± 0.18 (5.46–6.21)	5.95 ± 0.20 (5.68–6.39)	5.86 ± 0.16 (5.71–6.47)	5.94 ± 0.19 (5.68–6.34)	ns
Ash (%)	7.08 ± 0.97 b (5.47–8.92)	8.80 ± 1.94 a (5.36–12.98)	8.58 ± 1.56 a (5.42–11.40)	9.23 ± 1.38 a (6.45–11.62)	**
Salt (%)	6.32 ± 1.00 b (4.92–8.67)	8.07 ± 1.63 a (5.20–11.05)	7.92 ± 1.80 a (4.74–12.02)	8.49 ± 1.57 a (5.18–10.78)	**
Residual nitrite ($mg \cdot kg^{-1}$ as $NaNO_2$)	9.45 ± 8.50 b (2.33–34.65)	16.15 ± 15.73 a (2.06–48.89)	14.79 ± 11.44 ab (1.87–38.48)	9.70 ± 6.12 b (1.34–23.21)	*
Total fat (%)	8.80 ± 5.58 a (2.61–22.85)	8.69 ± 5.56 a (2.24–24.67)	5.05 ± 3.02 b (1.41–13.49)	6.42 ± 3.96 ab (1.40–14.47)	**
*L**	40.47 ± 4.58 a (27.50–46.85)	36.15 ± 5.08 b (25.28–43.34)	42.64 ± 7.11 a (28.17–52.96)	36.02 ± 2.72 b (31.91–40.98)	**
*a**	30.22 ± 4.32 ab (21.45–35.40)	30.91 ± 7.43 a (14.01–41.90)	27.45 ± 5.01 b (17.65–34.15)	31.53 ± 4.94 a (21.08–43.59)	*
*b**	16.50 ± 4.09 (7.82–23.54)	15.28 ± 4.96 (4.81–22.39)	17.53 ± 4.83 (7.39–25.01)	15.62 ± 3.27 (10.38–23.81)	ns
Total aerobic mesophylic bacteria (log CFU g^{-1})	7.59 ± 0.71 a (5.90–8.75)	6.90 ± 0.73 b (5.45–8.23)	6.20 ± 0.64 c (5.00–7.59)	6.43 ± 0.87 c (4.95–8.12)	**
Lactic acid bacteria (log CFU g^{-1})	6.81 ± 1.32 a (3.78–8.83)	5.70 ± 1.84 b (2.95–8.17)	5.18 ± 1.61 b (3.00–7.45)	5.24 ± 1.47 b (3.00–8.00)	**
Micrococcus/Staphylococcus (log CFU g^{-1})	7.18 ± 1.03 a (4.70–8.56)	6.17 ± 0.86 b (4.96–7.59)	5.63 ± 0.74 c (4.48–7.37)	6.12 ± 0.89 b (4.85–7.85)	**

Notes: ±: standard deviation; a-c: any two means in the same line having the same letters in the same sections are not significantly different at $P > 0.05$; (): minimum and maximum values; ns: not significant ($P > 0.05$); *significant at the level of $P < 0.05$; **significant at the level of $P < 0.01$.

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35.83% to 55.70%), 46.61 ± 5.42% (from 36.31% to 57.34%) and 47.96 ± 3.21% (from 41.40% to 53.53%), respectively.

pH is a significant quality parameter for pastırma, and it is affected by some factors such as meat quality used in production, salt level, drying level, use of starter culture and fermentation levels. Also, the pH value slightly increases during pastırma processing due to proteolytic changes. According to the notification of meat and meat products of Turkish Food Codex, the maximum pH value of pastırma should be 6.0 (Anonymous, 2012). The results of pH in pastırma types are shown in Table 1. The pH values of sırt, şekerpare, bohça and kuşgömü pastırma types did not show a significant difference ($P > 0.05$). In this study, pH values of 3 sırt, 5 kuşgömü, 1 şekerpare and 4 bohça pastırma samples were higher than 6.0. Uğuz, Soyer, and Dalmış (2011) reported that the pH values of pastırma produced with 3%, 6% and 9% NaCl levels were 5.85, 5.75 and 5.65, respectively. Ceylan and Aksu (2011) determined that the pH values of sırt, bohça and şekerpare pastırma types ranged from 5.60 to 6.06 (mean 5.86), 5.58 to 6.12 (mean 5.79) and 5.67 to 5.98 (mean 5.82), respectively.

The types of pastırma had a significant effect ($P < 0.01$) on ash amount and the lowest average ash amount was obtained in sırt pastırma. However, there were no significant differences in the ash amount among pastırma types ($P > 0.05$) (Table 1). Karasoy (1952) also determined that the ash amount of sırt pastırma samples was lower than kuşgömü, şekerpare and bohça pastırma samples. The ash amount is related to the salt content of pastırma samples, therefore, in this study, higher ash amount was found in pastırma samples containing high salt. Löker et al. (2013) obtained that the ash amount of pastırma was 6.9 g. 100 g^{-1}.

As known, salt is an important quality parameter for the sensory quality of pastırma which affects the acceptability of pastırma by consumers. In this study, the salt amounts of all pastırma samples were higher than the maximum acceptable limit (7.0% as percentage of dry mass) as stated in notification of meat and meat products of Turkish Food Codex (Anonymous, 2012). The amount of salt was significantly affected ($P < 0.01$) by the types of pastırma. The highest average amount of salt was determined in bohça pastırma (8.49 ± 1.57%) followed by kuşgömü pastırma (8.07 ± 1.63%) with şekerpare pastırma (7.92 ± 1.80%) and the lowest (6.32 ± 1.00%) was in sırt pastırma (Table 1). In Turkey, pastırma is mainly produced with the traditional dry-curing method. In this method, the surface of the meat is completely coated with salt (10% of the meat weight) for 2–3 days, and then the remaining salt on the surface is removed with tap water or by plunging into 2–3% of saline water. Therefore, the salt amount of pastırma is high, and it has been a significant problem for customer in recent years. However, there is some research on reducing the amount of salt used for dry curing of pastırma, and it was recommended that 50–60 g of curing mixture containing NaCl for 1 kg of meat in used pastırma production should be used for dry-curing (Aksu & Kaya, 2002a, 2002b, 2002c, 2002d, 2005; Aksu, Aktas, & Kaya, 2002). On the other hand, to decrease the amount of salt in the final product, the brine curing (15%, 2/1 meat/brine) can be used in the curing process (Aksu & Kaya, 2002b) or dry- and/or brine-curing methods can be combined (Yetim & Cankaya, 2001).

In the present study, the residual nitrite amount was significantly ($P < 0.05$) affected by the types of pastırma. The highest residual nitrite amount was determined in kuşgömü pastırma types ($P < 0.05$), whereas the lowest amount was determined in sırt and bohça pastırma types (Table 1). In addition, there was a significant variation among the samples of the same pastırma types. For example, the residual nitrite amounts of sırt, kuşgömü,

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şekerpare and bohça pastırma samples were determined to be 2.33–34.65, 2.06–48.89, 1.87–38.48 and 1.34–23.21 mg·kg^{-1}, respectively (Table 1). These differences may be explained by the curing mixture, with and/or without nitrite and nitrate of curing mixtures and curing methods. It also was dependent on the use of starter culture, pastırma production procedure, stored temperature, time, the properties of the raw material used in pastırma production and manufacturers (Aksu & Kaya, 2001a). In addition, nitrate and nitrite is used as a curing agent and preservative in meat products, and nitrite is considered to be a very reactive compound. There has been some research on the amount of residual nitrite in ready-to-eat pastırma. Tyrpenou, Gouta, Tsigouri, and Vlasiotis (2000) found that the amount of residual nitrite in Greek pastırma was 0.85–190 mg·kg^{-1} as sodium nitrite. Aksu and Kaya (2001b) reported that the amount of residual nitrite of pastırma marketed in Erzurum of Turkey ranged from 0.93 to 11.6 mg kg^{-1}. Zahran and Kassem (2011) reported that the amount of residual nitrite during production of Egyptian pastırma was 51.99–251.60 mg kg^{-1}. El-Khateib, Schmidt, and Leistner (1987) reported that the amount of residual nitrite in Turkish pastırma was 12 mg kg^{-1} as average. Sanlı and Kaya (1988) reported that the amounts of residual nitrite in pastırma samples obtained from the market place in Ankara, Turkey were between 4.3–48.2 mg kg^{-1}. Sancak, Ekici, and İşleyici (2008) also reported that the amount of residual nitrite in pastırma ranged from 0.93 to 49.87 mg kg^{-1}. Soyutemiz and Ozenir (1996) reported that the amount of residual nitrite in pastırma samples obtained from the market place in Bursa, Turkey were between 0–41.06 mg kg^{-1} and average 15.95 mg kg^{-1}.

There were significant differences in total fat among pastırma types ($P < 0.01$). The highest average total fat was determined in sırt and kuşgömü pastırma, the lowest amount was determined in şekerpare pastırma ($P < 0.05$). There was also a significant variation among samples of the same pastırma types for total fat (Table 1). The total fat of pastırma samples was dependent on the chemical composition or fat levels of the raw material used for pastırma production. As a rule, the fat of muscles of the loin section of carcasses is high. Therefore, the fat of sırt pastırma was higher than other pastırma types due to it is produced from muscles of the loin section of carcasses. However, the total fat of pastırma types is affected by a lot of factors such as animal feed levels, animal species, animal sex, cutting age, the carcass section and so on. Pastırma types are categorized according to their fat levels as low, medium and high. Tekinsen and Dogruer (2000) reported that kuşgömü, bohça and şekerpare pastırma types include fat at low level, while sırt includes at medium level. In the present study, in contrast, the average fat amount of the kusgömü pastırma type is statistically the same as the sırt pastırma type (Table 1). These differences were caused by using different carcass in pastirma production. Similarly, Karasoy (1952) reported that the total fat amount of the kuşgömü and sırt pastırma types are similar, and the total fat of kuşgömü, sırt, bohça and şekerpare pastırma types is 26.42%, 27.76%, 15.93% and 16.69%, respectively.

Colour values

The colour of pastırma and/or pastırma types is one of the most important quality attributes, and the acceptability of sliced pastırma is a common concern attribute both by producers and consumers. As shown in Table 1, the pastırma type had a significant effect on L^* ($P < 0.01$) and a^* ($P < 0.05$) values of the samples. The sırt and şekerpare pastırma types had higher L^* values than kuşgömü and bohça ($P < 0.05$), while bohça and kuşgömü pastırma types had higher a^* values than sırt and şekerpare pastırma types ($P < 0.05$). Pastırma types had no effect ($P > 0.05$) on b^* values. The colour of first class pastırma changes from pink to red, from red to dark red for class 2, and dark red for class 3 pastırma. However, the colour values of pastırma types are affected by a lot of factors such as the properties of the raw material (myoglobin and fat levels of muscle etc.), curing methods and time, curing compounds, storage time and temperature, microbiological counts of pastırma and packaging type (Aksu & Kaya, 2002b; Gök, Obuz, & Akkaya, 2008).

Microbial quality

Pastırma types had significant effects on TAMB ($P < 0.01$), and the highest average TAMB count was determined in sırt pastırma as 7.59 ± 0.71 log CFU g^{-1} and the lowest average values were found in the şekerpare and bohça pastırma types as 6.20 ± 0.64 and 6.43 ± 0.87 log CFU g^{-1} (Table 1). Aksu and Kaya (2001b) observed that the counts of TAMB in pastırma from the markets of Erzurum, Turkey were 5.00–8.39 log CFU g^{-1}. Dogruer, Gurbuz, and Nizamlioglu (1995) also found that the counts of TAMB in pastırma from markets of Konya, Turkey were 1.2×10^7 CFU g^{-1}. There were significant differences in *M/S* (Gram-positive, catalase-positive cocci) counts ($P < 0.01$) among pastırma types, and the lowest count was found in the şekerpare pastırma type. The highest count was determined in the sırt pastırma type as average 7.18 ± 1.03 log CFU g^{-1} and the others were between 4.70 and 8.56 log CFU g^{-1}. There were no significant differences in *M/S* counts for kuşgömü and bohça pastırma types ($P > 0.05$). As shown in Table 1, pastırma types affected the LAB count ($P < 0.01$), and the highest count was found in the sırt pastırma groups ($P < 0.05$). LAB can reach high counts in pH 5.5–5.8. In this study, it was observed that the pH values of sırt pastırma were generally in these ranges. Therefore, the LAB count was higher in sırt pastırma type than others. This is first study about microbiological properties of pastırma types such as sırt, bohça, şekerpare and kuşgömü. However, there have been some researches dealing with the count of *M/S* in ready-to-eat pastırma in Turkey. In this sense, Aksu and Kaya (2001b) found that the count of *M/S* in pastırma ranged from 4.00 to 7.45 log CFU g^{-1}, 10^4–10^7 CFU g^{-1} by Ozdemir, Sireli, Sarimehmetoglu, and Inat (1999) and 7.8×10^5 CFU g^{-1} was found by Dogruer et al. (1995). Both *M/S* and LAB are dominant bacteria in the pastırma (Aksu & Kaya, 2001b, 2002a, 2002b), although the LAB counts were never reach as high as *M/S* counts. The manufacturing process of pastırma (curing, drying, pressing, coating with a çemen and again drying) greatly favour the development of *M/S* and LAB, and they have proteolytic and lipolytic properties. Micrococcaceae is also resistant to high salt levels. In addition to, in pastırma production, nitrate used in the curing of meat is mostly reduced by members of Micrococcaceae. Therefore, some researchers proposed that both *M/S* and LAB can used as starter cultures in pastırma production (Aksu & Kaya, 2002a, 2002b; Katsaras, Launtenschllager, & Bosckova, 1996).

Mould and yeast counts in 10 of the 16 sırt pastırma samples (2.00–6.67 log CFU g^{-1}), in 7 of the 16 kuşgömü pastırma samples (2.48–6.54 log CFU g^{-1}), in 6 of the 16 şekerpare pastırma samples (2.48–7.24 log CFU g^{-1}) and in 7 of the 14 bohça pastırma samples (2.00–5.22 log CFU g^{-1}) were determined to be above the detection level (>2.00 log CFU g^{-1}). The

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counts of mould and yeast in the other pastırma samples were found to be under <2.00 log CFU g^{-1}. These differences may arise from raw material and çemen quality or garlic levels in çemen. In this sense, Dogruer, Nizamlioglu, Gurbuz, and Kayaardi (1998) reported that the counts of mould and yeast in pastırma were changed according to garlic levels in pastırma çemen (flour from the *Trigonella foenum graecum* seed, smashed fresh garlic, paprika, red pepper and water). Similarly, Aksu and Kaya (2001b) reported that the mould and yeast counts of pastırma were <2.00–5.76 log CFU g^{-1}, while they were 1.2×10^5 CFU g^{-1} according to Dogruer et al. (1995) and 3.00 log CFU g^{-1} by Askar, El Samahy, Sheta, and Tawfik (1993).

In this study, *Pseudomonas* bacteria counts were observed under the detection level (<2.00 log CFU g^{-1}) in 32 of 62 pastırma samples. *Pseudomonas* counts in 8 of the 16 sırt pastırma samples (2.70–4.81 log CFU g^{-1}), in 8 of the 16 kuşgömü pastırma samples (2.48–5.69 log CFU g^{-1}), in 6 of the 16 şekerpare pastırma samples (2.60–3.95 log CFU g^{-1}) and in 8 of the 14 bohça pastırma samples (2.30–4.45 log CFU g^{-1}) were determined to be above the detection level (>2.00 log CFU g^{-1}). High levels of *Pseudomonas* counts in some pastırma samples may be caused by several reasons: (1) High moisture content of pastırma samples could favour their growth and/or (2) *Pseudomonas* counts in raw material (meat) used in pastırma production could be higher. *Pseudomonas* is sensitive bacteria against moisture and water activity. Therefore, its growth in pastırma is unsuitable. Ozdemir et al. (1999), El-Khateib et al. (1987) and Elmali, Yaman, Ulukanli, and Tekinsen (2007) reported that *Pseudomonas* counts were under of 2.0 log CFU g^{-1}. In contrast, Gök et al. (2008) found that *Pseudomonas* counts in pastırma were 4.38 log CFU g^{-1}.

Enterobacteriacea counts in all şekerpare pastırma samples were <2.00 log CFU g^{-1}, while *Enterobacteriacea* counts in one sample of each sırt, kuşgömü and bohça pastırma type were 3.94, 5.01 and 3.56 log CFU g^{-1}, respectively. Çemen paste containing garlic and loss of water in the drying process has an inhibitory effect on pathogen bacteria (Aksu, Kaya, & Oz, 2008; Yetim, Sagdic, Dogan, & Ockerman, 2006); therefore, *Enterobacteriacea* counts of pastırma samples is generally <2.00 log CFU g^{-1}. Aksu and Kaya (2001b) and El-Khateib et al. (1987) reported similar findings for *Enterobacteriacea* counts in ready-to-eat pastırma. Elmali et al. (2007) also found that *Enterobacteriacea* counts in pastırma sold in Turkey were <10^2–10^3 CFU g^{-1}.

Pearson's correlation coefficients amongst quality properties of pastırma samples are shown in Table 2. There was a significant correlation among the ash and salt amount ($P < 0.01$) and residual nitrite ($P < 0.05$). There was also a positive correlation among the L^*, a^* and b^* values, and a similar correlation was also observed between pH and a^* and b^* values of the samples (Table 2). Similarly, variations were observed in samples of the same pastırma type in terms of colour values. The variations for colour pastırma samples agree with the study by Aksu and Kaya (2001b). In this sense, Aksu and Kaya (2001b) determined that the colour values of sliced pastırma samples ranged from 32.05 to 50 for the L^* value, from 13.66 to 36.63 for the a^* value and from 6.67 to 20.54 for the b^* value. In addition, *M/S* count was significantly and positively correlated ($P < 0.01$) with the TAMB and LAB counts of pastırma types, and negatively correlated ($P < 0.01$) with pH, ash and salt amount. The LAB count was also significantly and positively correlated ($P < 0.01$) with TAMB, and negatively correlated ($P < 0.01$) with pH of pastırma samples (Table 2).

Fatty acid composition

The fatty acid composition determined in sırt, kuşgömü, şekerpare and bohça pastırma types, and their significance levels and Duncan's test results are shown in Table 3. As shown in Table 3, pastırma types had a statistically significant difference ($P < 0.05$) in terms of stearic acid (C18:0). The highest stearic acid values were determined in kuşgömü pastırma and averaged 19.25 ± 5.76%, and the lowest values were determined in şekerpare as an average of 11.21 ± 5.10%. The oleic (C18:1n9), palmitic (C16:0), stearic (C18:0) and linoleic (C18:2n6) acids were dominant in fatty acid composition of sırt, kuşgömü, şekerpare and bohça pastırma. Similarly, some researchers indicated that dominant fatty acids of pastırma were stearic, palmitic, oleic and linoleic (Aksu & Kaya, 2002c; Askar et al., 1993; Yılmaz & Gecgel, 2009). However, the results showed that the gadoloic (C20:1n11), eicosenoic (C20:1n9) and eicosatrienoic (C20:3n3) fatty acids were found at the notable concentration in pastırma types (Table 3). On the other hand, there was a significant variation among samples of the same pastırma types in terms of total saturated fatty acid (SFA), total monounsaturated fatty acids (MUFA), total polyunsaturated fatty acid (PUFA) and total unsaturated fatty acid (USFA). USFA amount of sırt, kuşgömü, şekerpare and bohça pastırma samples was determined as 46.87–64.56%, 42.78–56.21%, 44.74–63.80% and 41.41–64.08%, respectively (Table 3). These differences may be explained by the meat quality, çemen mixture and

Table 2. Determined Pearson's correlation coefficient between quality properties of pastırma samples.

Tabla 2. Determinación del coeficiente de correlación de Pearson entre propiedades cualitativas de muestras de pastirma.

Quality properties	pH	Ash	Salt	Total fat	Residual nitrite	L^* value	a^* value	b^* value	TAMB	LAB	*M/S*
Moisture	0.049	−0.499**	−0.475**	−0.276**	−0.020	0.154	0.093	0.052	−0.032	0.053	0.030
pH		−0.018	−0.103	−0.049	0.099	0.045	0.188*	0.189*	−0.272**	−0.436**	−0.152
Ash			0.927**	−0.147	0.186*	0.048	0.061	0.113	−0.396**	−0.428**	−0.345**
Salt				−0.170	0.096	−0.013	−0.039	0.025	−0.425**	−0.419**	−0.320**
Total fat					0.405**	−0.053	0.025	−0.034	0.422**	0.466**	0.400**
Residual nitrite						0.109	−0.126	0.044	0.080	0.092	0.040
L^* value							0.203*	0.761**	−0.101	−0.053	−0.060
a^* value								0.595**	0.124	−0.004	0.156
b^* value									−0.064	−0.048	−0.019
TAMB										0.779**	0.850**
LAB											0.641**

Notes: TAMB: total aerobic mesophylic bacteria; LAB: lactic acid bacteria; *M/S: Micrococcus/Staphylococcus;* *significant at the level of $P < 0.05$; **significant at the level of $P < 0.01$.

Table 3. Fatty acid composition of pastırma types.

Tabla 3. Composición de ácido graso de variedades de pastirma.

Fatty acid	Pastırma types				Significance
	Sırt	Kuşgömü	Şekerpare	Bohça	
$C_{14:0}$	1.16 ± 1.08 (0.00–2.96)	1.19 ± 0.90 (0.00–2.70)	1.49 ± 0.74 (0.73–2.65)	0.85 ± 0.61 (0.37–2.30)	ns
$C_{15:0}$	0.64 ± 0.76 (0.00–1.98)	0.81 ± 1.66 (0.00–5.44)	1.21 ± 2.05 (0.00–5.99)	0.18 ± 0.29 (0.00–0.75)	ns
$C_{16:0}$	25.18 ± 3.78 (22.24–34.09)	25.70 ± 2.87 (20.76–30.43)	26.13 ± 4.53 (19.78–31.97)	26.41 ± 2.76 (22.28–30.34)	ns
$C_{17:0}$	1.34 ± 1.04 (0.38–2.75)	0.77 ± 0.32 (0.44–1.51)	1.90 ± 1.43 (0.37–4.02)	1.77 ± 1.18 (0.61–3.43)	ns
$C_{18:0}$	13.03 ± 7.18 ab (5.68–26.35)	19.25 ± 5.76 a (11.80–31.62)	11.21 ± 5.10 b (7.30–21.06)	14.57 ± 6.94 ab (7.19–28.52)	*
$C_{20:0}$	2.95 ± 3.15 (0.20–7.48)	1.25 ± 1.61 (0.31–5.46)	2.46 ± 2.02 (0.44–5.43)	2.45 ± 2.25 (0.47–6.09)	ns
∑SFA	44.30 ± 6.62 (35.44–53.14)	48.96 ± 4.01 (43.78–57.21)	44.39 ± 6.12 (36.21–55.28)	46.25 ± 6.53 (35.93–58.558)	ns
$C_{14:1}$	0.41 ± 0.47 (0.00–1.28)	0.44 ± 0.36 (0.07–1.21)	0.76 ± 0.84 (0.00–2.62)	0.47 ± 0.31 (0.00–0.97)	ns
$C_{15:1}$	2.43 ± 2.16 (0.19–5.65)	1.36 ± 2.13 (0.00–6.55)	3.44 ± 3.43 (0.00–8.10)	2.11 ± 2.24 (0.22–7.20)	ns
$C_{16:1n7}$	2.49 ± 0.93 (1.46–3.82)	1.79 ± 0.73 (0.81–3.58)	2.59 ± 0.96 (1.15–4.07)	2.22 ± 0.93 (1.00–4.01)	ns
$C_{17:1}$	2.51 ± 2.78 (0.16–7.38)	0.94 ± 1.23 (0.11–3.62)	2.38 ± 1.83 (0.15–4.87)	2.02 ± 2.40 (0.10–6.51)	ns
$C_{18:1n9}$	30.85 ± 16.56 (10.62–47.21)	33.70 ± 7.05 (19.26–39.29)	26.15 ± 13.30 (6.97–43.18)	27.96 ± 12.81 (14.17–44.11)	ns
$C_{18:2n6}$	5.65 ± 1.77 (3.33–8.01)	7.71 ± 3.00 (4.38–15.06)	5.65 ± 1.37 (3.93–7.63)	7.06 ± 3.80 (4.03–13.42)	ns
$C_{18:3n3}$	1.51 ± 1.68 (0.21–4.51)	0.91 ± 1.01 (0.15–3.68)	1.85 ± 1.60 (0.17–4.58)	1.71 ± 1.76 (0.17–5.62)	ns
$C_{20:1n11}$	2.31 ± 2.53 (0.27–6.59)	1.38 ± 1.45 (0.22–4.51)	3.50 ± 2.82 (0.16–7.61)	2.37 ± 2.32 (0.09–6.48)	ns
$C_{20:1n9}$	4.96 ± 4.79 (0.59–11.56)	2.29 ± 1.81 (0.00–6.13)	6.79 ± 5.25 (0.32–16.69)	5.37 ± 4.57 (0.54–13.57)	ns
$C_{20:3n3}$	2.59 ± 3.21 (0.17–8.60)	0.51 ± 0.47 (0.00–1.71)	2.52 ± 2.54 (0.16–6.72)	2.46 ± 3.49 (0.00–10.48)	ns
∑MUFA	43.05 ± 11.96 (18.48–57.37)	41.91 ± 3.58 (38.73–45.35)	45.60 ± 6.05 (36.03–56.39)	42.52 ± 5.36 (36.35–51.33)	ns
∑PUFA	12.65 ± 12.30 (4.54–41.75)	9.12 ± 3.40 (4.75–16.08)	10.02 ± 4.95 (4.26–18.11)	11.23 ± 6.93 (5.06–21.19)	ns
∑USFA	55.70 ± 6.62 (46.87–64.56)	51.03 ± 4.02 (42.78–56.21)	55.62 ± 6.11 (44.74–63.80)	53.75 ± 6.54 (41.41–64.08)	ns

Notes: ±: standard deviation; a-b: any two means in the same line having the same letters in the same sections are not significantly different at $P > 0.05$; (): minimum and maximum values; ns: not significant ($P > 0.05$); ∑SFA: total saturated fatty acids; ∑MUFA: total monounsaturated fatty acids; ∑PUFA: total polyunsaturated fatty acids; ∑USFA: total unsaturated fatty acids; *significant at the level of $P < 0.05$.

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the use of oil in çemen production or not. In the research, the amounts of oleic, linoleic and linoleic acids in flour of *Trigonella foenum graecum* seed used for çemen preparation were determined as 19.34%, 44.64% and 23.12%, respectively (Kucuk & Gurbuz, 1999). The pastırma types had no effect on total SFA and USFA amounts. In terms of mean values, USFAs were the dominant fatty acids in all pastırma types. In addition, the SFAs amounts in 2 of the 16 sırt pastırma samples (51.59%), in 5 of the 16 kuşgömü pastırma samples (50.89%, 51.50%, 51.67%, 52.15% and 57.21%), in 1 of the 16 şekerpare pastırma samples (55.28%) and in 2 of the 14 bohça pastırma samples (51.94% and 58.58%) were higher than the USFA amounts. Depending on breed, age and type of production (feed), USFA can easily be greater than SFA. Also, the USFA amount of pastırma can increase due to the çemen mixture and from the use of oil in çemen production or not, and it is in agreement with results reported by Aksu and Kaya (2002c). Yılmaz and Gecgel (2009) reported that the amount of SFA was higher than the USFA amounts in three pastırma samples.

Conclusions

Based on the results of this study, it was determined that the quality properties of sırt, şekerpare, bohça and kuşgömü pastırma types were generally significantly different, and there was a significant variation among the samples of the same pastırma types. The salt amount in all samples was above the maximum acceptable limit (7.0% in dry matter). Moisture amount in 32 pastırma samples (51.6%) and pH values in 13 pastırma samples (21.0%) were also determined to be above the acceptable legal level (<45% and 6.0). Moreover, *Pseudomonas* counts in 30 pastırma samples and *Enterobacteriaceae* counts in 3 pastırma samples were >2.00 log CFU g^{-1}.

The results of the study indicate that quality properties of ready-to-eat pastırma are generally unsuitable for acceptable legal limits. Therefore, (1) the salt level should be reduced by use of different of curing methods and using low level salt (<10%) during dry curing; (2) the moisture amount of pastırma should be maximum 40.0% for the microbiological safety

(especially for *Pseudomonas* and *Enterobacteriaceae* counts) of pastırma during storage and sale; (3) the pH value should be decreased using suitable raw material and manufacturing process; and (4) pastırma manufacturing plants, markets and retail outlets should be permanently controlled by the authorities.

Acknowledgements

Authors would like to thank the Atatürk University Research Center for financial support (BAP Project No: 2011/159) in making this study possible. We would also like to thank Assoc. Prof. Dr. Nejdet SIRKECIOGLU for fatty acid composition analysis.

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