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Research Article

Characteristics of Pastırma Types Produced from Water Buffalo Meat

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Abstract

Pastırma is a traditional Turkish meat product which produced by using whole meat pieces obtained from water buffalo and beef carcasses. Although there are many studies on the general characteristics of the pastırma produced by using beef meat, the number of the studies on the pastırma produced from water buffalo meat is quite limited. In this study, different types of pastırma (sırt, bohça, kuşgömü, şekerpare and kürek) were made from water buffalo meat; and they were investigated in terms of physco-chemical, microbiological, sensorial and textural properties. There were no differences between pastırma types in terms of pH, redness (a*) value and the amount of non-protein nitrogenous substance (P>0.05). However, the lowest mean a_w value (0.84±0.01) was determined in kuşgömü (P<0.05). Şekerpare showed the highest mean lightness (L*) value (P<0.05). While no significant difference was observed between the types of pastırma in terms of *Micrococcus/Staphylococcus* count (P>0.05), the lowest count of lactic acid bacteria was found in kuşgömü (P<0.05). The highest mean odor score was determined in the sırt type of pastırma (P<0.05). Kuşgömü, which dries more quickly, also showed higher values in terms of firmness and chewiness compared to other types of pastırma (P<0.05). Furthermore, textural differences between the types of pastırma were observed more clearly with the principal component analysis (PCA) applied to textural properties.

Keywords: *Pastırma, Water buffalo meat, Lactic acid bacteria, Texture, Principal component analysis*

Manda Etinden Üretilen Pastırma Çeşitlerinin Özellikleri

Öz

Pastırma geleneksel bir Türk et ürünü olup, manda ve sığır karkaslarından elde edilen büyük parça etler kullanılarak üretilmektedir. Sığır eti kullanılarak üretilen pastırmanın genel karakteristik özellikleri üzerine çok sayıda çalışma bulunmasına karşın manda eti ile üretilen pastırma üzerinde araştırma sayısı oldukça sınırlıdır. Bu araştırmada manda etinden farklı pastırma çeşitleri (sırt, bohça, kuşgömü, şekerpare ve kürek) üretilmiş ve fiziko-kimyasal, mikrobiyolojik, duyusal ve tekstürel özellikler açısından incelenmiştir. Pastırma çeşitleri arasında pH, kırmızılık (a*) değeri ve protein tabiatında olmayan azotlu madde miktarı açısından önemli bir farklılık gözlenmemiştir (P>0.05). Buna karşın en düşük ortalama a_w değeri (0.84±0.01) kuşgömünde belirlenmiştir (P<0.05). Şekerpare en yüksek ortalama parlaklık (L*) değerini göstermiştir(P<0.05). *Micrococcus/Staphylococcus* sayısı açısından pastırma çeşitleri arasında önemli bir farklılık gözlenmezken (P>0.05), en düşük laktik asit bakteri sayısı kuşgömü çeşidinde belirlenmiştir (P<0.05). En yüksek ortalama koku değeri sırt çeşidinde tespit edilmiştir (P<0.05). Daha hızlı bir kurumanın gerçekleştiği kuşgömü çeşidi sertlik ve çiğnenebilirlik açısından da diğer pastırma çeşitlerine göre daha yüksek değerler vermiştir (P<0.05). Ayrıca tekstürel özelliklere uygulanan temel bileşen analizi (PCA) ile pastırma çeşitleri arasındaki tekstürel farklılıklar daha açık bir şekilde gözlemlenmiştir.

Anahtar sözcükler: *Pastırma, Manda eti, Laktik asit bakterleri, Tekstür, Temel bileşen analizi*

INTRODUCTION

Pastırma, a traditional Turkish dry-cured meat product, is produced by curing, drying and covering with çemen of meat pieces from certain parts of beef or water buffalo carcasses. This product is included in the intermediate moisture food class [1]. This traditional meat product is widely produced and likely consumed in Turkey [2]. Pastırma is quite different from other dry-cured meat products such as dry cured ham, lacon, country style ham, jambon de Savoie and loin in terms of both process time and conditions and raw material. Beef or water buffalo meat is used as the raw material in pastırma production, and the production period is approximately one month. While *Micrococcus/Staphylococcus* and lactic acid bacteria have an important role in the microflora of this product,

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yeasts are also present at different levels in microflora. The pH value of the product is usually above 5.5. Water activity (a_w) is a significant hurdle effect on the microbiological stability of the product. In addition to this, the extreme drying is undesirable in the product in terms of sensorial properties, and a_w is recommended to be between 0.85 and 0.90 [1]. According to the Turkish Food Codex Meat and Meat Products Communique [3], the pH value and moisture content of pastırma must not exceed 6.00 and 50%, respectively. Çemen paste components and chemical and biochemical reaction products occurred in the pastırma processing have a significant effect on the aroma of pastırma [1].

In pastırma production, 16 and even more types of pastırma can be produced from one carcass. The naming of pastırma types is made according to the part where the muscles and/or muscles are located. The pastırma type called as sırt which is obtained from the posterior rib region and loin of the carcass is the most commonly produced type. Furthermore, the types of pastırma called bohça and şekerpare are produced from the round, kürek and kuşgömü are produced from the chuck and tenderloin, respectively. Moreover, different types of pastırma, which are called by different traditional names, can be produced from the other parts of the carcass. According to the classification made in terms of quality, sırt and kuşgömü are the first class types of pastırma while bohça, şekerpare and kürek are included in the second class types of pastırma [4,5]. Although beef is mostly preferred in pastırma production, water buffalo meat is also used in production.

In particular, the fact that the water buffalo meat includes the higher protein, lower fat and cholesterol levels compared to beef has been increased the interest to water buffalo meat and its products in recent years [6-8]. There are many studies in the literature on the use of water buffalo meat in various meat products [9-18]. However, there is only one study on using water buffalo meat in production of pastırma [19], the effects of the use of starter culture on some quality characteristics of pastırma produced with water buffalo meat had been determined in the study. There is no study on the quality characteristics of different types of pastırma which is produced using water buffalo meat. In this study, different pastırma types (sırt, bohça, kuşgömü, şekerpare and kürek) were produced by using water buffalo meat and these types of pastırma were investigated in terms of textural properties as well as physico-chemical, microbiological and sensory properties.

MATERIAL and METHODS

Material

A 2-year-old male water buffalo was provided for pastırma production, and the carcass was conditioned for 24 h after slaughtering. Then, large pieces of meat for pastırma called sırt, şekerpare, bohça, kürek and kuşgömü were obtained from the carcass. The parts obtained from the left half of the carcass were used as the first replication, and the parts obtained from its right half were used as the second replication. Pastırma production was conducted in a meat processing plant (Kadakçıoğlu A.Ş., Erzurum, Turkey) by a traditional method.

Methods

Pastırma Production

At the beginning of production, muscles were trimmed for visible connective tissue and then shaped. Then, several incisions were made to the trimmed and shaped whole meat pieces. After that, the production was subjected according to the following procedure: strips were rubbed and covered with a curing mixture (50 g saccharose + 10 g KNO_3 + 1 kg NaCl, 100 g curing mixture for 1 kg meat), and kept in a room at about 10°C for 2 days. Thereafter, the meat strips were washed under tap water and air-dried for 6 days at 15-20°C (first drying). After drying, the strips were piled up and pressed with heavy weight (15 kg for weight per kg of meat) for 20 h at about 10°C. After this treatment, the meat strips were dried again for 8 days at 15-20°C (second drying) and pressed again (15 kg for weight per kg of meat) for 7 h at room temperature. After final drying (for 3 days at 15-20°C), strips were put in a bowl of seasoning mixture (çemen containing 500 g flour *(Trigolella foenum graecum* flour), 450 g smashed fresh garlic, 300 g red pepper and 1500 mL water) for 2 days and çemen on the surface of the meat strips was removed to a 3-4 mm layer of paste. And then, paste-covered strips were dried again for 8 days at 15°C.

Determination of Water Activity

The water activity (a_w) device (Novasina TH-500, Switzerland) was used in determining the water activity of the samples. The device was calibrated at 25°C with six different salt solutions before using. The samples were put in plastic sample containers for analysis, they were placed in the measuring cabinet of the device, and a_w value was determined at 25°C [20].

Determination of pH Value

Ten g sample was weighed for analysis and homogenized with Ultra-Turrax for 1 min by adding 100 mL of distilled water. The pH value was determined by the pH meter which was previously standardized with the appropriate buffer solutions [21].

Instrumental Color

The color intensities of the samples were determined by using a Minolta (CR-200, Minolta Co, Osaka, Japan) colorimeter. L*, a* and b* values were measured to the criteria given by the International Commission on

Illumination CIELAB (Commision Internationele de I'E Clairage) based on three-dimensional color measurement. Accordingly, L*; L*=0 indicates the color intensity of black, L*=100 indicates the color intensity of white (darkness/lightness), a*; +a* = indicates the color intensity of red, -a*= indicates the color intensity of green, and b*; +b*= indicates the color intensity of yellow and -b*= indicates the color intensity of blue [20].

Thiobarbituric Acid Reactive Substances Value

Thiobarbituric acid reactive substances (TBARS) values of samples were determined according to the methods of Lemon [22] and were expressed as µmol malondialdehyde (MDA)/kg.

Non-Protein Nitrogenous Substance Content

Non-protein nitrogenous substance content was determined according to Anonymous [23]; 5 g sample was homogenized with 10 mL of dichloromethane and 50 g of 20% trichloro-acetic acid, allowed to settle at room temperature for 15 min, centrifuged at 3500 x g for 25 min and filtered. After filtration, total nitrogen in the supernatant was determined by Kjeldahl method. The results were expressed as g/100 g of samples.

Microbiological Analysis

Twenty five gram samples were homogenized in 225 mL of sterile physiological saline (0.85% NaCl) for 1 min by using a Stomacher homogenizer (Lab Stomacher Blander 400-BA 7021, Seward Medical). Serial decimal dilutions were prepared in sterile physiological saline. For the enumeration of *Micrococcus/Staphylococcus*, Mannitol Salt agar (MSA, Merck) was used and plates were incubated at 30°C for 48 h. For lactic acid bacteria and *Enterobacteriaceae*, De Man Rogosa Sharpe agar (MRS, Merck) and Violet Red Bile Agar (VRBD, Merck) were used, respectively and incubation was carried out at 30°C for 48 h anaerobically [24].

Texture Profile Analysis

Pastırma samples were subjected to texture profile analysis (TPA) with triplicate using the Texture Analyzer (TA.XT Plus Stable Micro Systems Ltd., Surrey, England) with Texture Exponent Programs. The test was performed with a 35 mm diameter cylinder probe at 1 mm/s speed and 20% strain, on pastırma samples (2 cm with, 1.5 cm height). A time of 5 s was allowed to elapse between the two compression cycles. Force-time deformation curves were obtained with a 30 kg load cell applied and 10 g trigger force. The following parameters were determined: firmness (N) = maximum force required to compress the sample; springiness = degree to which a product returns to its original shape once it has been compressed (Length 2/Length 1); cohesiveness = extent to which sample could be deformed prior to rupture (A_2/A_1, A_1 being the total energy required for first compression and A_2 the total energy required for the second compression); adhesiveness (Ns) = work necessary to pull the compressing plunger away from sample; chewiness (N) = work to masticate the sample for swallowing (firmness x cohesiveness x Springiness) [25].

Sensory Analysis

Thick slices (1.5 cm) were cut from pastırma samples and used for the sensory analysis. The panellists were selected from the staff of the food engineering department. Ten panellists were asked to evaluate the samples in terms of color, odor, taste, texture and general acceptability parameters at 2 different times and 20 individual results were obtained. The evaluation was performed using a hedonic-type scale (1-9 scales: 1: dislike extremely - 9: like extremely) [21].

Statistical Analyses

The study was established and conducted in accordance with the completely randomized design. The obtained data were subjected to the analysis of variance, and differences between means were evaluated by Duncan's multiple range test using IBM SPSS Statistics 20 package program [26]. A principal components analysis (PCA) [27] was carried out the structure of dependence and correlation among the variables.

RESULTS

The results of the physico-chemical and microbiological properties of different types of pastırma produced from water buffalo meat are presented in *Table 1*. No significant difference was observed between the types of pastırma in terms of pH value (P>0.05), and the pH value varied between 5.68-5.78 in the types of pastırma. In the study, the a_w values varying between 0.84-0.92 were determined for all types of pastırma, and it was determined that these values were significantly affected by the type of pastırma (P<0.01). The L* and b* values of the colour properties were significantly (P<0.05) affected by the type of pastırma factor, whereas there was no difference between the types in terms of the a* value (P>0.05). The amount of non-protein nitrogenous substance, which is an indicator of proteolysis, varied between 3.11-3.83 g/100 g for all types of pastırma, and the type factor was not effective on the amount of non-protein nitrogenous substance (P>0.05). The TBARS value was determined between 25.39 and 41.33 µmol MDA/kg in the types of pastırma. According to the statistical analyses results, TBARS values were significantly affected by type of pastırma (P<0.05).

In the present study, no significant differences were determined between the types of pastırma in terms of *Micrococcus/Staphylococcus* count (P>0.05). In contrast, there were significant differences between kuşgömü type and the other types of pastırma in terms of lactic acid bacteria (P<0.05).

Table 1. *Physicochemical and microbiological properties of different Pastırma types produced from water buffalo meat*[1]

Properties	Pastırma Types					
	Kuşgömü	**Sırt**	**Bohça**	**Kürek**	**Şekerpare**	**Significance**
pH	5.78±0.01^{a}	5.77±0.01^{a}	5.77±0.01^{a}	5.68±0.07^{a}	5.71±0.05^{a}	NS
a_w	0.84±0.01^{c}	0.87±0.01^{b}	0.87±0.01^{b}	0.92±0.00^{a}	0.91±0.03^{a}	**
L*	35.28±1.10^{d}	37.73±0.71^{c}	35.50±0.35^{d}	39.98±0.59^{b}	46.03±1.08^{a}	*
a*	17.12±4.69^{a}	19.08±1.10^{a}	17.08±0.66^{a}	21.55±0.46^{a}	18.66±1.35^{a}	NS
b*	2.85±1.66^{a}	3.54±0.38^{a}	1.43±0.41^{a}	3.60±0.93^{a}	6.96±1.19^{b}	*
Non-protein nitrogenous substance (g/100 g)	3.11±0.10^{a}	3.31±0.30^{a}	3.53±0.17^{a}	3.68±0.19^{a}	3.83±0.00^{a}	NS
TBARS (μmol MDA/kg)	37.11±0.80^{ab}	29.77±5.32^{bc}	41.33±3.53^{a}	25.39±5.79^{c}	27.70±2.33^{bc}	*
Lactic acid bacteria (log CFU/g)	4.74±0.10^{a}	6.55±0.50^{b}	7.15±0.06^{b}	7.09±0.13^{b}	7.30±0.27^{b}	*
Micrococcus/Staphylococcus (log CFU/g)	6.84±0.54^{a}	6.59±0.04^{a}	7.05±0.13^{a}	6.02±0.32^{a}	6.28±0.25^{a}	NS

[1] Presented values are means ±SD; $^{a-d}$ any two means in the same row having the same letters are not significantly different (P>0.05), P<0.05, ** P<0.01,* ***NS:*** *not significant,* ***SD:*** *standard deviation*

Table 2. *Sensory properties of different Pastırma types produced from water buffalo meat*[1]

Sensory Properties	Pastırma Types					
	Kuşgömü	**Sırt**	**Bohça**	**Kürek**	**Şekerpare**	**Significance**
Color	6.24±0.75^{a}	7.08±0.54^{a}	6.26±0.05^{a}	6.40±0.42^{a}	6.95±0.28^{a}	NS
Odor	6.77±0.03^{b}	7.59±0.15^{a}	6.77±0.04^{b}	6.91±0.30^{b}	7.10±0.01^{b}	*
Texture	6.59±0.84^{a}	7.60±0.28^{a}	6.50±0.15^{a}	6.85±0.50^{a}	7.33±0.37^{a}	NS
Taste	6.70±0.42^{a}	7.61±0.30^{a}	6.79±0.27^{a}	6.85±0.49^{a}	7.16±0.20^{a}	NS
General Acceptability	6.72±0.74^{ab}	7.61±0.02^{a}	6.45±0.21^{b}	6.84±0.20^{ab}	6.80±0.29^{ab}	*

[1] Presented values are means ±SD; $^{a-b}$ any two means in the same row having the same letters are not significantly different (P>0.05), P<0.05, ** P<0.01,* ***NS:*** *not significant,* ***SD:*** *standard deviation*

Table 3. *Textural properties of different Pastırma types produced from water buffalo meat*[1]

Properties	Pastırma Types					
	Kuşgömü	**Sırt**	**Bohça**	**Kürek**	**Şekerpare**	**Significance**
Firmness	63.48±11.72^{c}	38.29±3.95^{b}	31.93±3.31^{ab}	28.35±3.47^{a}	29.18±5.08^{a}	**
Adhesiveness	-0.05±0.01^{b}	-0.04±0.01^{b}	-0.09±0.01^{a}	-0.08±0.04^{a}	-0.04±0.03^{b}	**
Springiness	0.79±0.02^{a}	0.83±0.05^{a}	0.74±0.05^{a}	0.77±0.08^{a}	0.81±0.06^{a}	NS
Cohesiveness	0.68±0.04^{ab}	0.72±0.05^{b}	0.67±0.05^{ab}	0.64±0.02^{a}	0.72±0.05^{b}	**
Chewiness	36.89±6.61^{c}	25.56±2.69^{b}	15.31±1.34^{a}	12.51±2.21^{a}	22.23±5.48^{b}	**

*[1] Presented values are means ±SD; $^{a-c}$ any two means in the same row having the same letters are not significantly different (P>0.05), * P<0.05, ** P<0.01,* ***NS:*** *not significant,* ***SD:*** *standard deviation*

Although no significant differences were determined in terms of color, texture and taste for types of pastırma (P>0.05), different evaluation scores were obtained for odor and general acceptability (P<0.05) *(Table 2)*.

The texture analysis results were given in *Table 3*. The factor of pastırma type had significant effect on firmness, adhesiveness, cohesiveness and chewiness values (P<0.01), while pastırma type did not caused a significant effect on springiness value (P>0.05). However, the highest firmness and chewiness values were found in kuşgömü type of pastırma (P<0.05).

In the research, PCA was applied to assess the relationships between pastırma type and textural parameters. Two principal components were able to explain the 100% (99% PC1 and 1% PC2) of the total variance observed. All of pastırma types as well as chewiness and firmness

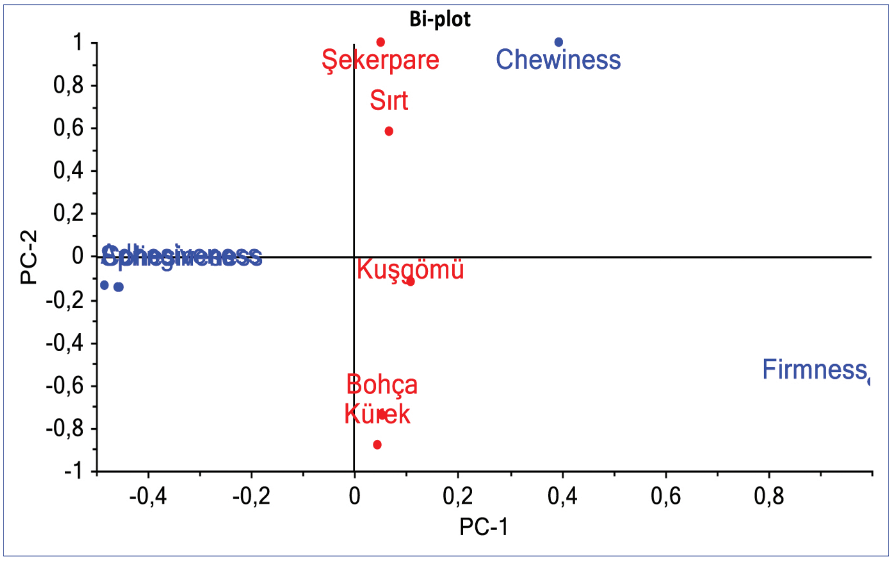

Fig 1. Principal component analysis biplot of the relationships between pastırma types and textural parameters

properties placed to positive side of PC1, while other textural properties located negative side of PC1. On the other hand, scores biplot in *Fig. 1* showed also that textural parameters except chewiness located at negative side on PC2.

DISCUSSION

According to the Turkish Food Codex Meat and Meat Products Communique [3], the pH value in pastırma must be 6.0 at the most. The pH values determined in this study were found to be lower than this limit value specified for all types of pastırma. However, it was determined that the pH value did not fall below 5.5 in the studies on pastırma produced using beef [1,28-31] and water buffalo meat [19] as well as in this study, too. Unlike fermented sausages, no low pH values are observed in pastırma since there is no true lactic acid fermentation [1].

The a_w value is an important parameter which has an effect on various chemical and biochemical reactions and microbiological events. As a result of the production process of pastırma, the a_w value of the product decreases, and because of that this traditional dry-cured meat product could be accepted as shelf stable product. However, Leistner [32] reported that the a_w value should be between 0.85-0.90 for pastırma. In the study, the lowest a_w value was determined in the kuşgömü type of pastırma ($P<0.05$). The a_w value was found to be above 0.90 in the types of şekerpare and kürek which were removed from the round and chuck parts of carcasses, respectively. It is thought that the differences in a_w values were due to the salt diffusion and the drying rate factors affected by the size of the muscles and the fiber structure.

The color is one of the most important quality characteristics for the consumer in accepting food. In the study, the L* value, which is the measure of lightness, was found to be higher in şekerpare, which is a type of pastırma obtained from the round part, compared to other types of pastırma *(Table 1)*. Similarly, Çakıcı *et al.*[33] reported that L* value of şekerpare was significantly higher than the values of sırt and bohça types. On the other hand, there was no difference between the types of pastırma in terms of a* value. According to this result, the desired reddish color formed in all of pastırma types. It is thought that the differences between the L* and b* values determined in the types of pastırma were due to the raw material properties. Indeed, many researchers have reported that the curing mixture and curing process as well as the raw material are effective on the color of pastırma [29,34]. The color pigment formed in pastırma is very sensitive to external factors [4]. Therefore, the product is subjected to a partial heat treatment before çemen-application for color stability, even if just a bit, in industrial production, and a stable color formation is ensured.

Protein degradation products are reported to be highly effective in the development of texture and aroma in meat products [35,36]. The raw material and processing conditions on the level of non-protein nitrogenous substance may be also effective [1]. The levels of non-protein nitrogenous substance obtained in this study are similar to the values determined by Kaban [1] for the pastırma produced from beef meat.

The TBARS value, one of the most important indicators of oxidation in meat products, varied between 25.39-41.33 µmol MDA/kg in the types of pastırma *(Table 1)*. Similar results were also determined in the pastırma samples produced from beef meat by Kaban [1]. The highest TBARS value was determined in bohça type, while the kürek type pastırma showed the lowest TBARS value *(Table 1)*. The raw material properties as well as production and storage conditions are highly effective on TBARS value. It is thought that the properties of raw material were effective on the TBARS value obtained in this study.

It is stated that *Micrococcus/Staphylococcus* and lactic acid bacteria constitute the dominant microflora in pastırma [1,28,37]. While the number of lactic acid bacteria was found to be 4.74 log CFU/g in kuşgömü type of pastırma, high values were obtained in other types of pastırma. Although similar average results were obtained in a study in which the microbiological properties of the types of pastırma produced from beef meat were determined, the highest counts of *Micrococcus/Staphylococcus* and lactic acid bacteria were determined in sırt type of pastırma [33]. Kaban [1] reported that the numbers of *Micrococcus/Staphylococcus* and lactic acid bacteria increased during pastırma production stages and that the number of lactic acid bacteria was less than 5 log CFU/g and the number of *Micrococcus/Staphylococcus* was higher than 6 log CFU/g in the final product. The number of *Enterobacteriaceae* in pastırma was generally low. In the present study, the number of *Enterobacteriaceae* was also found below the detectable limit (<2 log CFU/g) in all pastırma types.

According to the sensory evaluation, the highest odor and general acceptability scores were determined in the sırt type of pastırma. Tekinşen and Doğruer [5] have reported that the sırt type of pastırma is included in the first-quality pastırma class. While no significant difference was found between the other types of pastırma in terms of odor scores, the lowest evaluation scores were obtained for the bohça type of pastırma in terms of general acceptability.

Texture is one of the factors affecting the quality of meat products and the consumer preferences [38,39]. The product composition and processes applied in production are among the important factors affecting the textural properties of meat products. There are curing, pressing and drying processes in the production of pastırma. These processes can have significant effects both on the composition and the components constituting the composition of the product. As a result of these processes, a significant reduction occurs especially in the water content of the meat and significant changes are also observed in meat proteins [40]. In this study, the highest average firmness and chewiness values were determined in the kuşgömü type of pastırma samples. Because of faster drying, a lower a_w value in this type was observed compared to other types of pastırma. According to these results, a_w was correlated to firmness and chewiness so that decreasing a_w increased firmness and chewiness values of the product. These findings are in agreement with those reported by Lorenzo [41] for dry cured ham. On the other hand, the highest average values in terms of adhesiveness and cohesiveness were found in sırt and şekerpare types, and kuşgömü type followed these types.

According to the PCA results, pastırma types, kürek, bohça, kuşgömü, sırt and şekerpare, were clearly distinguished through PCA in terms of textural properties. Şekerpare and sırt were positively high correlated with chewiness in PC1. Moreover, kuşgömü, bohça and kürek were especially positive correlated with firmness in PC1 *(Fig 1)*.

As a result, there are some differences between the types of pastırma produced from different parts of the water buffalo carcass due to the properties and dimensions of the raw material used. Sırt type gives better results in terms of some textural and sensory properties while şekerpare type shows a better result for L* value, which is an important criterion, when compared to the other pastırma types. Another important finding of the research is that *Micrococcus/Staphylococcus*, which are technologically important, constitute the dominant flora in all types as this is the case for pastırma produced from beef. Moreover, as in pastırma produced by beef, pH of pastırma produced from water buffalo meat is over 5.5.

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