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New Approaches to Production of Turkish-type Dry-cured Meat Product “Pastirma”: Salt Reduction and Different Drying Techniques

Emre Hastaoglu ^{1,*} and Halil Vural ²

¹Cumhuriyet University, Yildizeli Vocational School, Department of Food Technology, Sivas, Turkey

²Hacettepe University, Faculty of Engineering, Department of Food Engineering, Ankara, Turkey

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*Corresponding author : Emre Hastaoglu
Cumhuriyet University, Yildizeli Vocational School, Department of Food Technology, Sivas, Turkey
Tel: +905053051990
E-mail: ehastaoglu@cumhuriyet.edu.tr

Sodium Chloride (PubChem CID: 5234)
Potassium Chloride (PubChem CID: 4873)
Sodium Nitrite (PubChem CID: 23668193)

Abstract In this study, the possible changes in the quality characteristics of pastirma, Turkish-type dry-cured meat product, produced by using two different salts (NaCl-KCl) in a curing mixture and two different production techniques (natural and controlled condition) were examined. Moisture, pH, salt, sodium, potassium, TBA, fat, water activity, instrumental colour, texture, and sensory analyses were implemented in order to determine the possible effects of these applications. Fat, aw, pH, colour, tiobarbituric acid (TBA), texture, salt, Na and K values may allow these desired modifications in pastirma production to be limited. The substitution of 15% KCl instead of NaCl was acceptable in terms of the sensorial properties of the pastirma. However, the sensory analyses did not allow for using a higher KCl instead of NaCl because both the hardness and chewiness in the texture of the pastirma samples salted with 30% of KCl were not scored positively. Besides this, negative effects, which may occur during the pastirma production under natural conditions, can be eliminated by the production being under controlled conditions.

Keywords pastirma, sodium chloride, salt replacer, meat drying, dry-cured

Introduction

Pastirma is a dry-cured meat product and traditionally processed in Turkey. Its process steps include curing, pressing, drying and coating with spices. The different muscle cuts produce different type of pastirma, and 26 different types of pastirma may be produced from a mature cattle carcass (Kilic, 2009). For traditional production, “Pastirma Summer” is preferred. This is the period covering late September and October-November (Gökalp, 1995). The production time is about 1 month however it can be changed according to the size of muscles used. Its production conditions, especially air temperature and relative humidity, depend on the climate and

weather conditions (Kaban, 2013). Because of the dependence on the weather conditions, it is difficult to produce pastırma all year round. Bacterial contaminations, the variable climate changes, and external factors, are disadvantages when producing pastırma or drying meat under natural conditions such as in air-sun drying (Heinz and Hautzinger, 2007).

Salt, used in many things, is the major additive used in pastırma production. It contributes to the extraction of myofibrillar proteins in meat, so it causes a protein film to form on the surface of the meat. Thus, when the meat product is cooked, the desired taste will be obtained. As the content of the extracted myofibrillar protein increases, the capacity of the water binding of the meat increases (Gillette, 1985). Also, salt prevents the growing of undesirable microorganisms and brings a characteristic flavour to the meat product (Aşkın, 2007). Sodium chloride is essential in all animal feeding. The chlorine ion, which is necessary for the HCl in digestion liquid excreted into the stomach comes from salt (Doyle, 2008).

On the other hand, salt has many adverse effects on people's health. By the aim of reduction the risk of both coronary heart disease and both types of stroke, sodium intake in dietary should be limited wherefore it influences the blood pressure levels in populations (WHO, 2003). Sodium chloride is the main source of sodium. High sodium intake correlated with mortality and risk of coronary heart disease, independent of other cardiovascular risk factors, including blood pressure (Tuomilehto et al., 2001). Many governments are trying to moderate salt intake by establishing or recommending limitations to salt used in processed foods for the improvement of the health of the population health (Toldrá and Reig, 2011). Because of these effects of salt, research on reduction or substitution with salt alternatives in meat products has been accelerated. There are several strategies for sodium reduction (Toldra, 2007; Dötsch et al., 2009) and many patents have been recorded (Toldrá and Barat, 2009). Common approaches, include reducing the amount of salt added during food processing (Corral et al., 2013; Aaslyng et al., 2014; Paulsen et al., 2014), replacement with low-sodium blends (KCl, CaCl₂ or MgCl₂) (Lilic et al., 2008; Zanardi et al., 2010; Armenteros et al., 2012a; Campagnol et al., 2012; Davaatseren et al., 2014; Paulsen et al., 2014; Wu et al., 2014), the use of flavour enhancers such as monosodium glutamate (Campagnol et al., 2011, 2012; Dos Santos et al., 2014), slight salt reduction (Liem et al., 2011), and a change in the form of salt (Kilcast and den Ridder, 2007) have been applied. Alternatively, there are a number of techniques that have or can be implemented in food manufacturing in the various sectors, especially high-pressure processing (Rodrigues et al., 2015). It was suggested that high pressure has changed the interactions between sodium ions and proteins, resulting in the release of Na⁺ and making them more accessible to the taste cells (Clariana et al., 2011). Thus, there is evidence that high pressure can provide a natural increase saltiness, thus being an alternative for salt reduction.

The most important properties of alternative methods are the same as sodium chloride and eliminate the disadvantages of salt. It is known that textural problems occur in meat products which have reduced salt (Stringer and Pin, 2005). This situation has an adverse effect on consumers of dietary products. Thus, to eliminate the quality problems, which may occur in these products, is an important subject area (Aşkın, 2007). The major handicap of salt substitution is the cost, because salt is the cheapest food additive. At the same time, consumer habits make this substitution more difficult. Because of the current tendency to consume low-salt products, the processing conditions for pastırma need to be standardized at a lower amount of salt in order to avoid negative implications on the quality (Uğuz et al., 2011). Locally, consumers want pastırma that tastes good, but they also want pastırma that is healthy (Ahmed et al., 2014). In this study, for the elimination of the negative effects that occur through a high sodium intake, the reduction of sodium and using potassium instead of sodium, and the possibilities of manufacturing at controlled conditions were investigated. The aims of this research are as follows: using potassium chloride instead of sodium chloride and drying under naturally controlled conditions without affecting the taste and flavour in pastırma production, observing the changes in the final product, and setting a scientific and technological

substructure for providing a healthier production of pastirma, which will have a positive effect on the diet of the Turkish people.

Materials and Methods

In the study, the meats were obtained from a local slaughterhouse and a meat processor (Yıldız Meat Co., Turkey). *Musculus semimembranosus* muscles were obtained at 0-4°C temperature, after 24 hours of the slaughter from six different cattle (Simmental) that were 3 years old, and were examined post mortem. All the cattle had a twin *Musculus semimembranosus* muscle, so we had twelve meat blocks which weighed about 1.5 kg. They were salted with three different salt concentrations, and were dried under two drying types (3×2). For two replications, twelve meat blocks were prepared (3×2×2) and were numbered from 1 to 12 for these six groups. All the species were obtained from a local distributor (Beyza Food Co., Turkey), the sodium chloride was procured from a local salt company (Sivas58 Salt Co., Turkey), the potassium chloride was procured from Dead Sea Works Limited Co. (Israel), and the sodium nitrite was procured from the BASF Chemical Company, Germany.

Pastirma manufacturing and sampling

Different salt concentrations of NaCl and KCl and different production techniques were used in this study. The purpose of using different salt concentrations was to obtain variations that could occur in the pastirmas due to usage of potassium and sodium. At the same time, the samples were produced by using two different techniques; natural (under sunny; about 25-30°C) and controlled drying (in air-conditioned room at 30°C, air flow speed about 30 m/min). This was carried out in order to analyse the differences between the salt concentrations during the drying processes. The first step for all the samples was; deboning, shaving, and drilling the meat blocks. The first samples for the analyses were taken at this step. As seen in Fig. 1, the naturally and controlled drying samples were collected in different days, because the drying rates of different drying types were different. After removing the fat and connective tissue from the surfaces, each block of meat was drilled from six different locations, and filled with the curing mixture, which contained NaCl and/or KCl salt and -nitrite. For the 1st and 4th groups, which were the control groups which were natural (N100NaCl) and controlled (C100NaCl) drying respectively, the curing mixture included 1,000 g NaCl and 12 g sodium nitrite; for the 2nd and 5th groups, which were natural (N85NaCl/15KCl) and controlled (C85NaCl/15KCl) drying respectively, the curing mixture contained 850 g NaCl, 150 g KCl, and 12 g sodium nitrite; and for the 3rd and 6th groups, which were natural (N70NaCl/30KCl) and controlled (C70NaCl/30KCl) drying respectively, the curing mixture contained 700 g NaCl, 300 g KCl, and 12 g sodium nitrite. After 48 hours of brining, the samples were washed with high pressured and water whose temperature is about 15°C in order to clear all the curing agents from the holes in the meat blocks. The second samples for the analyses were taken at this step. For the first drying step in the natural drying technique, the samples were kept for 5 days under sunny (about 25-30°C) and windy weather conditions on the terrace of a factory, which was covered with wire netting. For the controlled drying conditions, the samples were kept in an air-conditioned room at 30°C, and the air flow was set at 30m/min for approximately 2 days. The third samples for the analysis were taken at this step. After the first drying, all the samples were pressed under about 8 bar pressure for 10 hours at room temperature. At the end of the pressing step, the fourth samples for the analysis, from both the naturally dried and controlled drying samples, were taken. For the second drying step of the natural drying process, the samples were kept on the terrace of the factory for 4 days. However, the controlled drying samples were kept in an air-

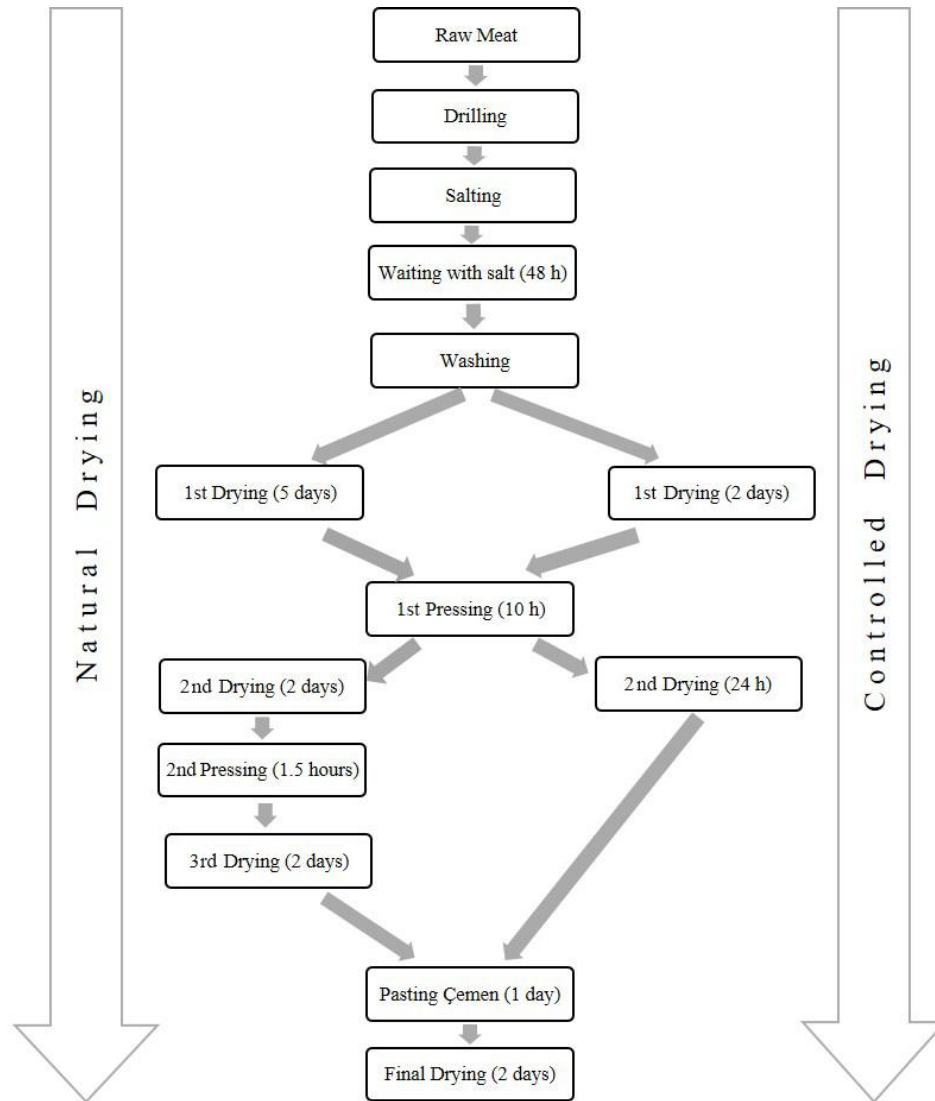


Fig. 1. Production processes of pastırma.

conditioned room at 45°C for 24 hours. The fifth samples were taken at the end of the second drying step. The dried meat blocks were coated with fenugreek, which was composed of water, fenugreek flour, garlic powder, and hot and sweet pepper for 24 hours. During this waiting period, those ingredients were put together with the meats in the paste tub. The following day, all the samples were covered with seasoning paste, which formed a 3-4 mm thickness on the surfaces of all the samples. After the drying of the paste, the final samples for the analysis were collected at this step. In total, six sampling points were defined as follows: before salting, raw material; after salting; after the first drying; after pressing; after the second drying; after the pasting of the fenugreek, and then the final product. The experiment was replicated twice, and two replicates were carried out for all the analysis.

Analyses

The analyses performed were moisture, pH, salt content, sodium content, potassium content, and the tiobarbituric acid analyses for all the samples were collected at different stages. The fat content, water activity, colour and texture analyses were performed on raw material and the final product only; the sensory analyses were performed only on the final product. All the

analyses were performed in duplicate.

The pH measurements and tiobarbituric acid (TBA) of the samples were analysed according to (Vural and Öztan, 1996). The moisture and fat content of the pastirma were measured using AOAC (2000) procedures. The samples were analysed in a water activity measurement instrument (Rodel et al., 1975). The Mohr method was used for the analysis of the salt content in the samples. The Inductively Coupled Plasma Atomic Emission Spectroscopy (ICPAES) method was used in order to determine the sodium and potassium in the samples (Krejčova et al., 2001).

The colour analyses of the samples were performed through the colour scale of Hunter, with an appliance called the Minolta Spectrophotometer CM-3600d (Candogan and Kolsarici, 2003). The CM-A106 target mask, and illuminant zone (8.0 mm, Ø 30mm), were placed on the system. The appliance was calibrated by its own standard (The White Calibration Plate-CM-A103). The L*, a* and b* values of each sample were read at three different locations on the surface of the slices, and then averaged for each of the replications.

The sliced samples, with a 10mm thickness, were placed horizontal to the TAplus Texture Analyser (Amatek Lloyd Instruments Ltd., UK) and were compressed with the cylinder stainless steel probe a test speed of 1 mm/s. The parameters of hardness 1 (N, the maximum force needed when sample was initially pressed), hardness 2 (N, the maximum force needed when the sample was pressed a second time), cohesiveness (the positive ratio, and the first press loop to the second one), the gumminess (N, the force needed to cut the sample for chewing), springiness (mm, the ability to become the original of the sample when force removed), and the chewiness (Nmm, the work needed while chewing the sample for swallowing) were read numerically twice, and averaged for each of the replications (Cierach et al., 2009).

The sensory analyses of the pastirma samples were performed with a hedonic type scale. Tekinşen and Doğruer (2000) used for the sensory analyse of pastirma samples. According to this scale, the score table starts from the least preferred 1, to the most preferred 10. Two training sessions were carried out to present the panellists with the samples. The panellists were asked to evaluate the samples for colour, chewiness, smell, and taste of the pastirma, and the samples were scored at the end of production by 20 experienced and educated panellists. Sliced samples 2 mm thick were served to the panellists in artificial light (incandescent) at an ambient temperature in a random order all together. The sensory analyses were performed on the final product, and were applied through consideration of the conditions of panellists such as hunger, relationship with each other, education level and health. The unsliced pastirma was sliced before serving.

The SPSS (ver:15.0) were used for the statistical assessment of the experimental values. The pH, moisture, salt content, sodium content, potassium content, and the TBA values were evaluated using multiple variance analysis and the Bonferroni test; the fat content, water activity, colour (L*, a*, b*), and the texture profile data were evaluated using multiple variance analysis and the Tukey test in order to test the significant effect of drying at a threshold of $p < 0.05$. The model terms included the meat properties (pH, moisture, fat content, water activity, salt content, sodium content, potassium content, TBA, colour, and texture values) were fitted as dependent variables with different drying types (natural/controlled) and different salt mixtures (NaCl/KCl) as the independent fixed effect. For consumer testing, the sensory attributes (colour, chewiness, smell, and taste) were fitted as dependent variables with the panel members as an independent term. The paired Sample *T*-test was applied on the sensory analyses data to evaluate the differences between sample groups ($p < 0.05$).

Results and Discussion

The pH analyses were determined on the raw meat, after salting, after the first drying, after pressing, after the second

drying, and the final product. The mean of the pH values of the raw meat blocks was 5.54. As expected (Table 1), the pH values of the samples increased through salting. The processes (salting, pressing, and drying) affected the pH values of the samples, but were mostly affected in the drying. At the end of the drying process, the pH values of the samples increased through the loss in moisture. In the final product, the pH value was at the highest value. The salt type affected the pH value, the pH values of the samples salted with KCl were in particular, higher than the non-KCl salted samples ($p < 0.05$). Ekmekçi (2012) showed similar influences of the different salt mixtures on the pastırma samples. As Uğuz (2007) and Katsaras et al. (1995) showed, because of the proteolytic changes, the pH value of the pastırma was higher than in the raw meat. According to the Turkish Food Codex Meat and Meat Product Regulations, the pH values of pastırma samples should be 6.0 at most. Thus, in this research, all the samples have pH values under this limit.

Although the mean of the moisture contents in the raw meat was 75.37%, it decreased during the salting process because of the effect of osmotic pressure, as shown in Table 1. Both the drying and pressing processes accelerated that decrease and the lowest moisture content, and after the second drying process, the lowest moisture content was determined (mean 50.34%). The moisture content of the final product slightly increased because the samples were pasted with fenugreek, which is high in moisture content. The drying ratios were calculated by comparing them with the earlier final moisture content. However, the different salt mixtures had no influence on the moisture content of the pastırma samples, but the different drying types did have an effect. In comparison, the drying ratios of the different pastırma production processes, and the drying ratio mean value of the samples dried under natural conditions were higher than the drying ration mean value of the samples dried under controlled conditions. However, Alves et al. (2017) determined that the replacement of NaCl by KCl in low-sodium and low-fat Bologna-type sausages, did not display differences in both water (%) and the fat released. Ceylan and Aksu (2011) showed

Table 1. The changes of pH values and moisture content (%) during the production of pastırma dried by different drying techniques and salted with different concentrations of NaCl and KCl

Analyse	Type of drying	Sample code	Raw meat	After salting	After first drying	After pressing	After second drying	Final product
pH	Natural conditions	N100NaCl	5.54±0.01 ^{bcA}	5.56±0.01 ^{aB}	5.54±0.01 ^{aA}	5.55±0.01 ^{aA}	5.66±0.01 ^{aC}	5.72±0.01 ^{aD}
		N85NaCl/15KCl	5.56±0.01 ^{cA}	5.66±0.01 ^{cD}	5.61±0.01 ^{dC}	5.60±0.01 ^{bB}	5.75±0.01 ^{bcE}	5.81±0.01 ^{cF}
		N70NaCl/30KCl	5.52±0.01 ^{aA}	5.66±0.01 ^{cBC}	5.68±0.01 ^{eCD}	5.68±0.02 ^{cCD}	5.74±0.01 ^{bCD}	5.83±0.01 ^{dAD}
	Controlled conditions	C100NaCl	5.53±0.01 ^{abA}	5.54±0.01 ^{aB}	5.56±0.01 ^{bC}	5.55±0.01 ^{aB}	5.66±0.01 ^{aD}	5.75±0.01 ^{bE}
		C85NaCl/15KCl	5.56±0.01 ^{cA}	5.60±0.03 ^{bB}	5.59±0.01 ^{cB}	5.56±0.01 ^{aA}	5.75±0.01 ^{bcC}	5.82±0.01 ^{cdD}
		C70NaCl/30KCl	5.53±0.01 ^{abA}	5.66±0.03 ^{cB}	5.70±0.01 ^{fC}	5.69±0.01 ^{cC}	5.76±0.01 ^{cD}	5.84±0.01 ^{dE}
Moisture content (%)	Natural conditions	N100NaCl	76.39±0.95 ^{cA}	67.71±0.04 ^{aB}	61.57±0.26 ^{cC}	60.06±0.28 ^{cD}	52.95±0.28 ^{dE}	53.43±0.44 ^{cE}
		N85NaCl/15KCl	75.55±0.80 ^{bcA}	69.93±0.22 ^{cB}	59.14±0.31 ^{dC}	57.80±0.25 ^{bd}	49.71±0.93 ^{cF}	52.55±0.24 ^{bcE}
		N70NaCl/30KCl	74.06±0.43 ^{aA}	68.70±0.19 ^{bb}	56.58±0.19 ^{bc}	54.66±0.85 ^{ad}	52.11±0.25 ^{cF}	53.30±0.57 ^{cE}
	Controlled conditions	C100NaCl	75.49±0.40 ^{bcA}	67.7±0.02 ^{aB}	59.53±0.66 ^{dC}	57.32±0.89 ^{bd}	49.18±0.34 ^{bF}	51.94±0.68 ^{aE}
		C85NaCl/15KCl	75.01±0.50 ^{ba}	68.98±0.3 ^{bb}	57.91±1.08 ^{cC}	55.04±0.49 ^{ad}	47.13±0.45 ^{aF}	51.14±0.82 ^{aE}
		C70NaCl/30KCl	75.70±0.52 ^{bcA}	67.32±0.55 ^{aB}	55.62±0.25 ^{aC}	54.58±0.43 ^{ad}	50.92±0.43 ^{dF}	52.57±0.51 ^{bcE}

On the table, the same letters in lines and columns express no difference statistically ($p > 0.05$), different letters express a difference statistically ($p < 0.05$). Capital letters were coded for lines, small letters were coded for columns.

that the moisture content of sekerpare, a type of pastirma, was 47.96% in the study on free acid composition of some pastirma types. Beğendik (1991) determined the moisture contents between 47.80 and 53.22 in the study on different cured techniques with different salt mixtures in some pastirma samples.

The fat content (%) of the raw meat and the final product of the pastirma samples, which were dried in natural and controlled conditions and salted with different salt mixtures, are shown in Table 2. It was determined that the fat contents of the raw matter samples were between 1.57-2.11%. After the drying processes, because of the increase in dry matter, the fat contents of the samples consistently increased when compared to the initial fat contents of the dry matter (3.30-6.18%). The different drying techniques did not have any influence on the fat content in the pastirma samples. Gür (1995) found a fat content of 5.53% in the pastirma samples which were produced by salting with 5% salt. Similarly, Aksu (1999) determined a range of 1.92-2.05% in the fat content between the raw meat, in which were added with 5% salt. At end of the 24 day production, it increased to 4.02%. The studies by Gür (1995) and Aksu (1999) showed similar results to this study.

As expected, both the drying process and the salting process affected the water activities of the samples ($p < 0.05$). The mean of the water activities of the raw meat was 0.9955 (Table 2). However, all the initial water activity values of the samples were the same, and after the drying steps, the water activity of the samples, which were salted with salt mixtures of 85% NaCl+15%KCl decreased more in comparison with the samples salted with other salt mixtures. Akköse and Aktaş (2014) showed that a_w values of the pastirma samples decreased from 0.985 to 0.943 at the end of the two-days curing process. In a study which analysed the effects of the salt content to the proteolytic changes on the pastirma, Uğuz (2007) showed that the water activities of the pastirma were 0.87 and 0.91 just as in our study. Also it was stated that the red pepper in fenugreek paste had a lowering effect on the water activity (Kök, 2003). Similarly, Kaban (2009) reported a decrease in the a_w of the pastirma during processing, and attributed this to the intense dehydration.

The salt content (% NaCl) of the pastirma, which was produced with various salt mixtures, was analysed at every stage during the pastirma production (Table 3). After the salting process, the salt content of the samples was between 2.42% and 3.73%, which was thought to be the different diffusion rates of the NaCl and KCl. Because of weight loss, the salt content of the samples increased at every stage until the fenugreek pasting. As other analyses depending on dry matter, fenugreek paste has a high moisture content; therefore, the salt content of fenugreek pasted pastirma samples decreased proportionally. The naturally dried samples, which were salted with only NaCl, had the least salt content (3.57%). Furthermore, the samples

Table 2. Fat content (%), water activity (a_w), and colour values (L^* , a^* , b^*) of raw meat and final product on pastirma samples dried by different drying techniques and salted with different concentrations of NaCl and KCl

Type of drying	Sample code	Fat (%)		Water activity (a_w)		L^*		a^*		b^*	
		Raw meat	Final product	Raw meat	Final product	Raw meat	Final product	Raw meat	Final product	Raw meat	Final product
Natural conditions	N100NaCl	1.57 ^b	4.65 ^c	0.9960 ^b	0.9217 ^{de}	9.78 ^c	11.47 ^a	14.09 ^{ab}	14.79 ^a	43.68 ^{ab}	44.75 ^a
	N85NaCl/15KCl	1.94 ^d	6.05 ^d	0.9960 ^b	0.9062 ^a	8.65 ^{ab}	11.67 ^a	12.32 ^a	13.04 ^a	41.94 ^a	43.71 ^a
	N70NaCl/30KCl	1.4 ^a	3.30 ^a	0.9940 ^a	0.9117 ^{bc}	8.41 ^a	12.79 ^a	13.13 ^b	13.15 ^a	44.90 ^b	45.29 ^a
Controlled conditions	C100NaCl	1.52 ^{ab}	4.71 ^c	0.9955 ^b	0.9167 ^d	8.89 ^{abc}	10.57 ^a	13.51 ^b	12.72 ^a	42.88 ^{ab}	42.94 ^a
	C85NaCl/15KCl	2.11 ^e	6.18 ^d	0.9957 ^b	0.9092 ^{ab}	9.53 ^{bc}	11.43 ^a	13.46 ^b	12.11 ^a	43.81 ^{ab}	42.35 ^a
	C70NaCl/30KCl	1.83 ^c	3.64 ^b	0.9957 ^b	0.9222 ^e	8.74 ^{ab}	11.02 ^a	13.78 ^b	15.45 ^a	44.07 ^{ab}	50.21 ^b

On the table, the same letters in lines and columns express no difference statistically ($p > 0.05$), different letters express a difference statistically ($p < 0.05$). Capital letters were coded for lines, small letters were coded for columns.

Table 3. The changes of salt content (%) during the production of pastirma dried by different drying techniques and salted with different concentrations of NaCl and KCl

Type of drying	Sample code	After salting	After first drying	After pressing	After second drying	Final product	Salt/dry matter
Natural conditions	N100NaCl	2.42±0.04 ^{aA}	3.95±0.07 ^{aC}	4.20±0.04 ^{aD}	4.75±0.03 ^{aE}	3.57±0.05 ^{aB}	7.66
	N85NaCl/15KCl	2.35±0.07 ^{aA}	4.12±0.08 ^{bB}	5.44±0.03 ^{eD}	5.65±0.02 ^{eE}	4.48±0.05 ^{cC}	9.44
	N70NaCl/30KCl	3.73±0.01 ^{cA}	5.87±0.01 ^{cD}	5.05±0.10 ^{cC}	6.93±0.02 ^{eE}	4.33±0.02 ^{bB}	9.27
Controlled conditions	C100NaCl	2.54±0.05 ^{bA}	3.99±0.08 ^{aC}	4.32±0.06 ^{bD}	4.84±0.02 ^{bE}	3.60±0.13 ^{aB}	7.49
	C85NaCl/15KCl	2.39±0.08 ^{aA}	4.19±0.05 ^{bB}	5.54±0.04 ^{fD}	5.94±0.04 ^{fE}	4.64±0.05 ^{dC}	9.49
	C70NaCl/30KCl	3.73±0.02 ^{cA}	5.92±0.02 ^{cD}	5.20±0.01 ^{dC}	7.02±0.02 ^{fE}	4.41±0.01 ^{bC}	9.29

On the table, the same letters in lines and columns express no difference statistically ($p>0.05$), different letters express a difference statistically ($p<0.05$). Capital letters were coded for lines, small letters were coded for columns.

dried on the controlled conditions and salted with salt mixtures 85%NaCl+15%KCl had the highest salt content (4.64%). The salt contents of the samples showed that both the differences between the drying techniques and the differences between the salting mixtures were statistically significant ($p<0.05$). As in the study by Askar et al. (1993) in which the salt contents of the pastirma samples produced with NaCl were substituted with KCl, was meanly 6.55, similar to our study, the salt content of the samples which were non-pasted with fenugreek, were between 4.75-7.02. Davaatseren et al. (2014) showed that the sensorial properties of pork patties revealed that the addition of Na-replacers (such as KCl), decreased the saltiness intensity significantly ($p<0.05$), and the saltiness was lower with the increasing level of the replacers. Doğruer (1992) determined that the salt content of the pastirma samples salted with 5% salt, had an interval of 5.77–8.04%, Beğendik (1991) determined between 4.2–4.9%, Gür (1995) determined 4.27% and Aksu (1999) 5.88–6.05% of pastirma samples, which were similar in our study. Besides, Aksu (1999) noticed that the effect of the pastirma production time was important in regard to the salt content; and the differences between the salt content in the curing, the first drying, the second drying, the fenugreek pasting, and the final drying were significant. Uğuz (2007) stated that the salt content in pastirma was between 3.6% and 5.8% in a study on pastirma salted with various salt concentrations (3-6-9%).

The mean of the sodium content in the raw meat samples was 262 mg/kg (Table 4). After the drying and pressing steps, the sodium values increased because of moisture loss; moreover, the total sodium content decreased because of pasting it with fenugreek, while the highest sodium content was determined after the second drying step. The variation in the salt content used in the samples affected the sodium content significantly ($p<0.05$) because, as expected, the sodium content in the final product pastirma samples, which were salted with only NaCl, were higher than the samples salted with the NaCl+KCl mixture. Different drying types of pastirma did not have any influence on the sodium content. The differences in the sodium content, which changed according to both the existent sodium in the raw meat and by adding salt mixture including sodium in the samples, were significant ($p<0.05$). Similar to this study, Askar et al. (1993) showed that the sodium content in the pastirma samples salted with only NaCl was 21,900 mg/kg, and the sodium content in the pastirma samples salted with the mixture of NaCl 60%+KCl 40%, was 15,700 mg/kg in some research that studied the effects of the substitution of NaCl, KCl, and K-lactate on pastirma.

The potassium content of the samples was determined at six stages during the pastirma production, and is given in Table 4. The potassium levels contained in the raw meat were nearly and between 4,397 mg/kg and 4,808 mg/kg. After salting with the different salt mixtures, the potassium content of the samples increased at every stage because of the moisture loss, except

Table 4. The changes of potassium contents (mg/kg) and sodium contents (mg/kg) during the production of pastirma dried by different drying techniques and salted with different concentrations of NaCl and KCl

Analyse	Type of drying	Sample code	Raw meat	After salting	After first drying	After pressing	After second drying	Final product
Potassium contents	Natural conditions	N100NaCl	4,808 ^{bb}	3,081 ^{aa}	4,824 ^{ab}	5,130 ^{ac}	5,601 ^{ae}	5,568 ^{ae}
		N85NaCl/15KCl	4,530 ^{aa}	8,386 ^{bb}	11,555 ^{bc}	14,484 ^{bd}	17,298 ^{be}	14,619 ^{bd}
		N70NaCl/30KCl	4,679 ^{abA}	12,498 ^{cB}	19,882 ^{dC}	20,911 ^{dD}	25,807 ^{dE}	20,814 ^{cD}
	Controlled conditions	C100NaCl	4,397 ^{ab}	3,093 ^{aa}	4,857 ^{ac}	5,273 ^{ad}	5,568 ^{ad}	5,443 ^{ad}
		C85NaCl/15KCl	4,490 ^{aa}	8,454 ^{bb}	11,968 ^{cC}	14,918 ^{cD}	17,935 ^{cE}	14,930 ^{bd}
		C70NaCl/30KCl	4,457 ^{aa}	13,753 ^{dB}	19,947 ^{dC}	21,904 ^{eE}	26,505 ^{eF}	21,246 ^{dD}
Sodium contents	Natural conditions	N100NaCl	244.25 ^{aa}	10,950.00 ^{cB}	16,693.50 ^{cC}	18,733.00 ^{aD}	25,308.75 ^{aE}	19,776.25 ^{bD}
		N85NaCl/15KCl	257.35 ^{ba}	6,778.25 ^{aB}	12,112.00 ^{aC}	19,420.25 ^{bD}	25,737.50 ^{cE}	19,150.25 ^{bD}
		N70NaCl/30KCl	271.07 ^{ca}	8,955.50 ^{bb}	18,771.75 ^{eD}	19,450.50 ^{bD}	24,613.75 ^{aE}	17,321.75 ^{aC}
	Controlled conditions	C100NaCl	260.95 ^{ba}	11,518.00 ^{cB}	17,368.25 ^{dC}	18,776.50 ^{aC}	25,522.75 ^{cD}	19,715.25 ^{cC}
		C85NaCl/15KCl	275.72 ^{ca}	6,908.00 ^{aB}	12,772.25 ^{bC}	20,245.00 ^{cE}	26,510.25 ^{dF}	19,772.50 ^{cD}
		C70NaCl/30KCl	264.17 ^{ba}	9,150.25 ^{bb}	18,684.75 ^{eC}	19,777.75 ^{bcC}	25,053.25 ^{bD}	17,220.50 ^{aC}

On the table, the same letters in lines and columns express no difference statistically ($p>0.05$), different letters express a difference statistically ($p<0.05$). Capital letters were coded for lines, small letters were coded for columns.

in the samples salted with the non-KCl mixture. The highest potassium content was determined at the end of production; before the fenugreek pasting. The lowest potassium content in the final product (5,568 mg/kg and 5,442 mg/kg) were samples salted with only NaCl, and the highest potassium content of the final product (20,813 mg/kg and 21,246 mg/kg) were with the samples salted with the mixture of 70%NaCl+30%KCl. As seen, different salt mixtures affected the potassium content of the pastirma as added ratios consistently. Askar et al. (1993) conducted some research on the substitution of NaCl with KCl and K-lactate in pastirma, 14 days after curing, the potassium content of the pastirma samples salted with NaCl was 10,500 mg/kg, the potassium content of the pastirma samples salted with the mixture of 60%NaCl+40%KCl was 18,300 mg/kg. The potassium content of the samples salted with the mixture of 70%NaCl+30%KCl in our study was higher than the potassium content of the samples salted with the mixture of 60%NaCl+40%KCl in the study of Askar et al. (1993).

The tiobarbituric acid values at different stages of the pastirma production can be seen in Fig. 2. The differences between the raw meat samples, in terms of tiobarbituric acid values, were not significant statistically ($p>0.05$). However, at the following stages, the tiobarbituric acid values changed towards the samples, and processed between 0.04-0.13 mgMA/kg after salting ($p<0.05$). The TBA values increased in all the dried samples and this continued until pasting with the fenugreek on the samples. In the final product (after pasting and drying of the fenugreek), the increasing of the TBA values was rapid in all the samples, but the TBA values of the controlled dried samples were higher than the TBA values of the naturally dried samples; however, the initial TBA values of all the samples were almost the same. The salt type did not generate any effect on the lipid oxidation as the drying type for the pastirma production because the TBA values of the samples that were dried under controlled conditions increased more than in the samples dried under natural conditions. The TBA values of our pastirma samples were lower than the TBA value results of the Ren et al. (2015) study. They found the TBA values of beef pastirma between 0.33-0.48 mgMA/kg. Zhang et al. (2014) indicated that a high proportion of KCl substitutions may promote the TBA values and lipid oxidation in dry-cured pork. However, Askar et al. (1993) studied the TBA values of dried and

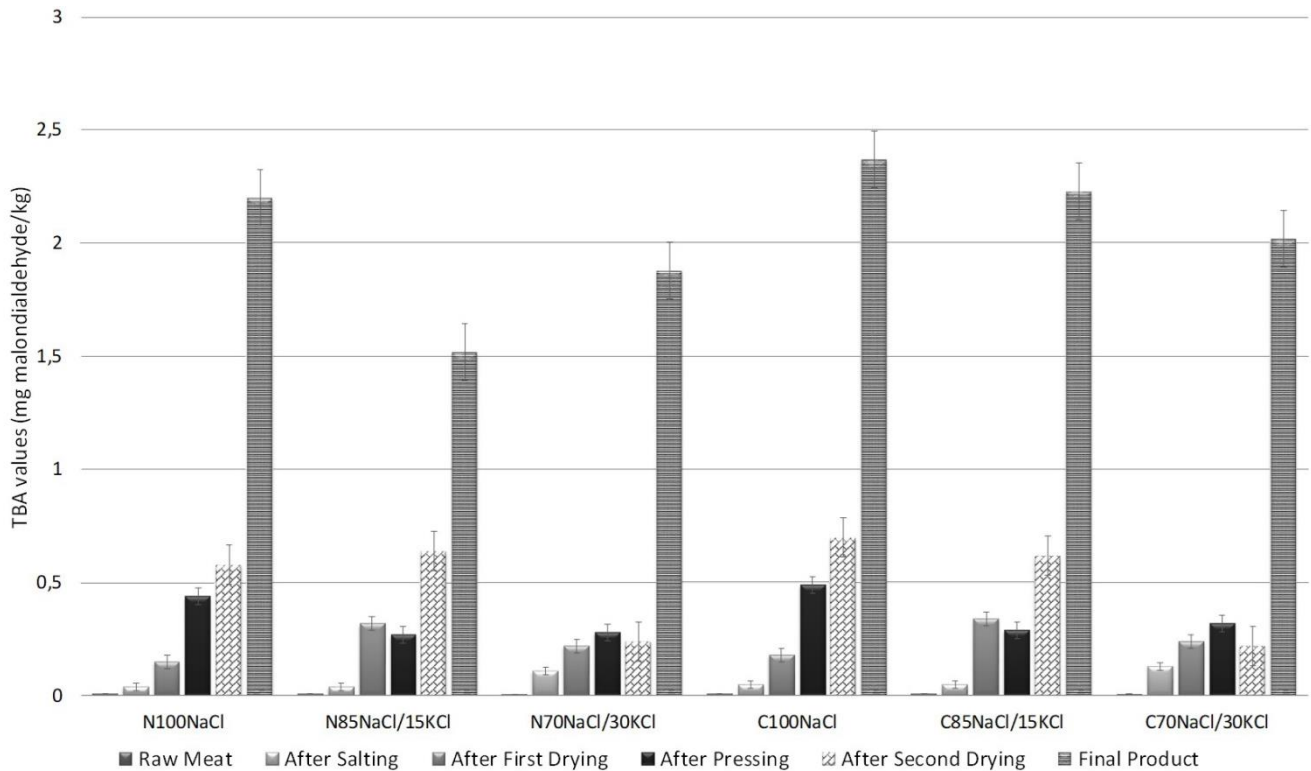


Fig. 2. The changes of tiobarbituric acid values (mg malondialdehyde/kg) during the production of pastırma dried by different drying techniques and salted with different concentrations of NaCl and KCl.

substituted NaCl with KCl, and K-lactate of some meat samples, and found the TBA values as 0.536 and 0.660 mgMA/kg in the samples salted with only NaCl and salted with the mixture of 60%NaCl+40%KCl respectively. These values were similar to our study at the stage of the second drying. Aksu et al. (2005) found significant differences in the TBA values of the meat blocks before and after pasting with fenugreek. The TBA values of the samples increased rapidly after pasting with fenugreek. Fenugreek paste, which includes garlic, fenugreek flour, bitter pepper, sweet pepper, and moisture, had an increasing effect on the TBA value according to Arslan (2011). Similar to this study, the TBA values in the final product of the pastırma samples varied between 0.16 mgMA/kg with 2.46 mgMA/kg as Askar et al. (1993), Yağlı and Ertaş (1998), and Aksu (1999). Ripollés et al. (2011), reported that 100% NaCl hams had the lowest TBA values during the initial periods of curing when compared to ham samples cured with a different salt mixture (KCl, CaCl₂, and MgCl₂).

Colour values, as criteria L* relative brightness, a* redness and b* yellowness, were obtained from the raw meat and the final product (Table 2). However, the differences between the brightness values of the raw meat samples were significant ($p < 0.05$), and the final product samples were not significant ($p > 0.05$). Neither the salt type, nor drying type, had any influence on the brightness of the pastırma samples. The highest brightness of the final product samples was 50.21, and this value belonged to the sample dried under controlled conditions and salted with the mixture of 70%NaCl+30%KCl. Turkish consumers prefer pastırma which is bright red in colour because they consider that the darker the colour, the more inferior the pastırma. Over time, pastırma turns browner and darker, and becomes firmer in texture (Ahmed et al., 2013). 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 (Çakıcı et al., 2015). Honikel (1998) found the brightness values on meat samples before salting were a little higher than the general meat brightness value 35-40 (Uğuz, 2007), which is similar to our study. The less fatty meat of the samples, the type of meat and

the type of animal may be the reasons for this difference. In various researches, Aksu and Kaya (2002) and Aksu et al. (2005) reported the brightness values in the pastirma samples to be between 42.30 and 47.38 respectively, which is similar to our study. The differences between the redness values of the raw meat used in pastirma producing were significant ($p < 0.05$); moreover, these values varied between 8.41 and 9.78 as shown in Table 2. Various processes caused the increase in the redness values of the samples. The redness values in the final product samples were similar to each other, and the redness values of the samples which were dried under different conditions and salted with different salt mixture were not affected in different situations. Uğuz (2007), similar to our study, found the redness value to be 12.16 in pastirma, and found that the redness value increased by increasing the salt in the pastirma production. All the yellowness values of the samples changed a little according to the raw meat. It was thought that the dissimilarity was because of the yellowness in the raw meat difference because the differences between the yellowness of the raw meat were significant ($p < 0.05$), and the differences between yellowness of the final product were not significant ($p > 0.05$). The yellowness values were not affected by using NaCl and its replacer KCl and drying under natural and controlled conditions such as brightness and redness values in the pastirma production. In a study that examined the effect of salt content on the proteolysis changes in the pastirma (Uğuz, 2007), the yellowness values of all the pastirma samples salted with different salt concentrations decreased in the production processes and in the storage period. That decrease was caused by the production time, and not caused by salt concentrations. Ekmekçi (2012) determined that salted with salt mixtures which substituted 50%KCl to NaCl did not affect the L^* , a^* and b^* values in the pastirma samples, and was consistent with our study.

The different drying techniques did not affect the texture parameters in the pastirma samples ($p > 0.05$). The differences between the hardness1 and hardness2 values of both the raw meat samples and the final product samples were significant. According to the drying and salting processes, the hardness values of all the values increased. Another significant result was the higher increase in the hardness values of the samples salted with the salt mixture of more substitution of NaCl with KCl (Table 5). Horita et al. (2014) determined that the replacement of NaCl with KCl, resulted in higher hardness1 and hardness2 values than were found in the control formulation, which is similar to our study. The cohesiveness values of the raw meat samples varied between 0.37 and 0.42. After all the processes, the cohesiveness values of the samples changed differently, the mean cohesiveness values of the samples salted with only decreased, but other samples increased. The changes in the gumminess values were similar to the changes in the hardness values. The difference between the gumminess values of the final product samples were statistically significant ($p < 0.05$), and the increase in the gumminess values of the samples salted with only NaCl were higher than the increase in the gumminess values in other samples. The springiness values of the samples changed independently with the different salt types and different drying types; so some of them decreased, some of them increased. The chewiness values of the unprocessed meat samples increased dependently to the NaCl/KCl ratios of the salt mixtures, and independently to the different drying techniques because the chewiness values of the pastirma samples salted with 70%NaCl+30%KCl and the samples salted with 85%NaCl+15%KCl were higher than the samples salted only with NaCl. However, the initial chewiness values of the samples were similar. In a study on NaCl substitution with KCl in the pastirma, Ekmekçi (2012), determined that the pastirma samples cured with only NaCl had the highest chewiness value in comparison with other samples salted with salt mixtures which included NaCl, KCl, and $CaCl_2$.

The pastirma samples were evaluated in terms of the criteria colour, the chewiness, smell, and taste, and were scored out of 10. The differences between the colour values of the samples were significant ($p < 0.05$), and the most desirable were the samples dried at controlled conditions and salted with the mixture of 85%NaCl+15%KCl (Fig. 3.). On the other hand, the smell scores of the samples were statistically similar to each other ($p > 0.05$). Because all the samples were covered with the

Table 5. Hardness 1 (Newton-N), hardness 2 (Newton-N), cohesiveness, gumminess (Newton-N), springiness (mm) and chewiness (Nmm) values of raw meat and final product on pastirma samples dried by different drying techniques and salted with different concentrations of NaCl and KCl

Type of drying	Sample code	Hardness 1 (N)		Hardness 2 (N)		Cohesiveness		Gumminess (N)		Springiness (mm)		Chewiness (Nmm)	
		Raw meat	Final product	Raw meat	Final product	Raw meat	Final product	Raw meat	Final product	Raw meat	Final product	Raw meat	Final product
Natural conditions	N100NaCl	0.58 ^{ab}	1.40 ^a	0.40 ^{ab}	0.27 ^a	0.21 ^a	0.37 ^a	0.26 ^a	1.02 ^a	3.41 ^c	1.23 ^a	0.75 ^d	1.64 ^c
	N85NaCl/15KCl	0.46 ^a	3.68 ^b	0.42 ^a	0.43 ^c	0.31 ^b	1.51 ^b	0.33 ^{ab}	3.11 ^b	2.73 ^a	3.55 ^d	0.73 ^d	4.49 ^b
	N70NaCl/30KCl	0.58 ^{ab}	3.83 ^b	0.36 ^a	0.38 ^a	0.32 ^b	1.43 ^b	0.41 ^b	3.22 ^b	3.06 ^b	3.21 ^{cd}	0.46 ^a	4.43 ^b
Controlled conditions	C100NaCl	0.68 ^b	1.72 ^a	0.37 ^{ab}	0.25 ^a	0.19 ^a	0.23 ^a	0.24 ^a	1.23 ^a	3.44 ^c	2.52 ^b	0.73 ^d	1.06 ^c
	C85NaCl/15KCl	0.72 ^b	3.62 ^b	0.41 ^{ab}	0.36 ^a	0.32 ^b	1.34 ^b	0.43 ^b	3.79 ^b	2.85 ^a	3.03 ^c	0.65 ^c	4.25 ^b
	C70NaCl/30KCl	0.50 ^a	3.70 ^b	0.39 ^{ab}	0.38 ^a	0.37 ^b	1.39 ^b	0.34 ^{ab}	3.03 ^b	3.82 ^d	3.37 ^{cd}	0.56 ^b	3.95 ^b

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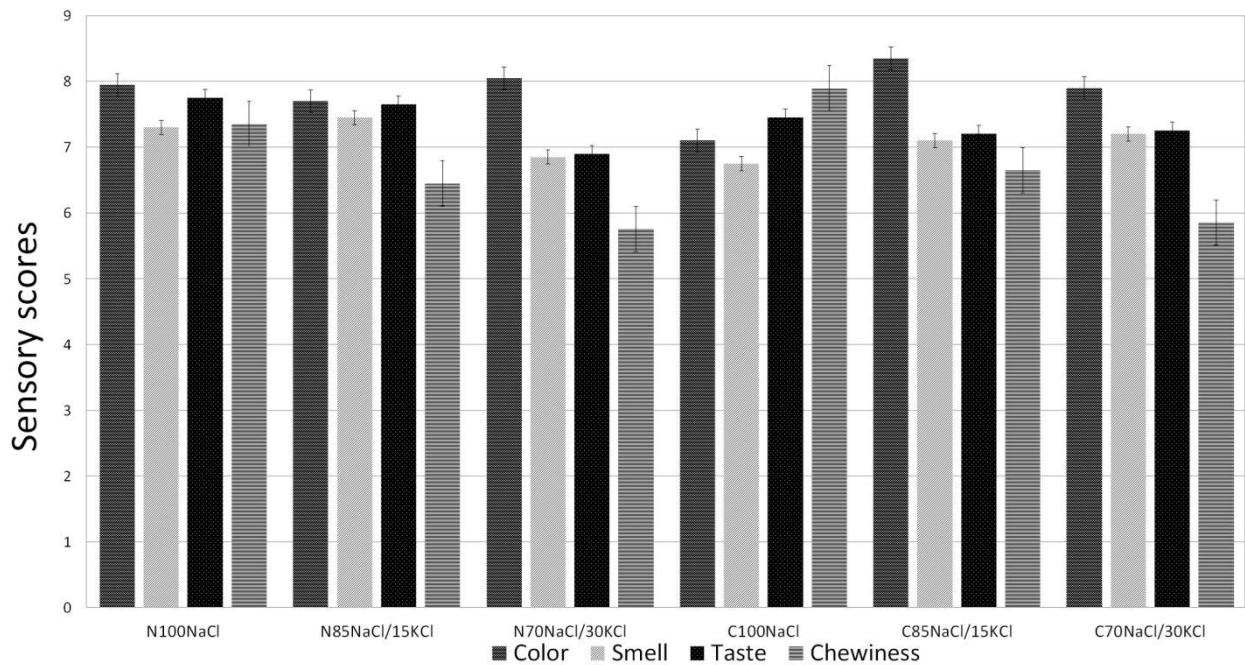


Fig. 3. Sensory values of pastirma samples salted with different concentrations of NaCl and KCl.

same fenugreek paste, this could affect the smell as already predicted. The differences between the taste scores in the pastirma samples were statistically significant ($p<0.05$). The chewiness values, which were determined by using sensory analyses, decreased by increasing the KCl. As a result however, the use of KCl may promote the development of the bitter tastes in the final product (Armenteros et al., 2012a), and it was determined that using 15%KCl instead of NaCl in the curing of pastirma was acceptable in terms of sensory analyses. And also, in the pastirma production, the negative effects of drying under natural

conditions (such as variable climate conditions, microbial contamination, and external factors) were eliminated by drying under controlled conditions.

During the pastirma production, at all steps, the pH values increased. At the same time, the levels of the potassium content affected the pH value. The more use of potassium chloride as a substitution for sodium chloride, the higher the pH value. The moisture contents in all the samples decreased during the production. The moisture content of the pastirma samples dried at controlled conditions was lower than the samples dried in natural conditions. The fat, salt, sodium, and potassium content of the samples increased, and the water activity in the samples decreased during the pastirma production because of moisture loss. The salt content in the controlled dried samples was higher than in the naturally dried ones as a result of the drying ratios. The tiobarbituric acid levels of all the samples increased at all steps, but after the fenugreek pasting, this parameter increased significantly. Besides this, the tiobarbituric acid levels of the naturally dried samples were lower than the controlled dried. Using potassium chloride in the pastirma production increased the hardness in terms of the analysed textural properties and the reason of this may be derived from the crystal structure of KCl. The sensory values were similar samples, which were potassium chloride as a substitution for the sodium chloride, except for the chewiness values because, the chewiness of the samples brined with potassium chloride were high when compared to other samples.

Conclusion

While evaluating the analyse parameters of pastirma production, either to obtain and to consume all year round (controlled conditions) or to substitute KCl instead of NaCl in the pastirma product, were possible. The moisture, a_w , pH, fat, colour, TBA, texture, salt, Na, and K values, may allow these desired alterations in pastirma production up to a limit. Using potassium chloride in a proportion of 15% as a substitution for sodium chloride was acceptable in terms of the sensorial properties in the pastirma. However, the sensory analyses did not allow for the use of higher potassium chloride instead of sodium chloride because both the hardness and taste of pastirma samples salted with 30% of potassium chloride were not scored positively. On the other hand, the consumption of pastirma in every season could be possible because the negative effects of traditional production of pastirma, which occur under natural conditions, can be eliminated by production under controlled conditions.

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