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ARTICLE

Changes in the Physico-chemical and Microbial Quality during the Production of Pastırma Cured with Different Levels of Sodium Nitrite

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Abstract

Pastırma, a dry-cured meat product, is produced from the whole muscle and/or muscles obtained from certain parts of beef and water buffalo carcasses. The purpose of this study was to determine the effects of different levels of sodium nitrite on changes in the physico-chemical and microbial quality during the production of pastırma. The changes in residual nitrite, salt, pH, moisture, thiobarbutiric acid reactive substances (TBARS), colour (L*, a*, b*), total aerobic mesophilic bacteria (TAMB), lactic acid bacteria (LAB), *Micrococcus/Staphylococcus* (M/S), mould-yeast (M-Y), and *Enterobacteriaceae* counts of pastırma with 0, 50, 100 and 150 ppm sodium nitrite were determined during the production. The nitrite levels and the production stages had significant effects ($p<0.01$) on residual nitrite, TBARS, pH, salt, and colour values. The TBARS values of the pastırma with nitrite were significantly lower ($p<0.05$) than the control. The final TAMB, LAB, M/S, and M-Y counts of pastırma with 150 ppm nitrite were significantly ($p<0.05$) lower than the control. Also, the a* (relative redness) values of control pastırma were significantly lower ($p<0.05$) than the pastırma with nitrite. The production stages had a significant effect ($p<0.01$) on the moisture.

Keywords: pastırma, nitrite, physico-chemical quality, microbial quality, colour

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Introduction

Cured meat products processed in pieces are grouped under two main groups as cooked and raw cured meat products. Unique cured raw meat product processed in pieces in Turkey is known as pastırma. Pastırma is a traditional meat product produced from whole muscle (*Musculus (M.) cutaneus trunci, M. trapezius pars thoracica, M. longissimus dorsi, M. semispinalis, M. spinalis, Semitendinosus, Semimembranosus* etc.) obtained from certain parts of beef carcasses, inspected by veterinarians in stages of antemortem, intramortem and postmortem. Pastırma processing includes salting/curing, drying and pressing stages (Aksu *et al*., 2005a; Aksu *et al*., 2005b; Ceylan and Aksu, 2011; Tekinsen and Dogruer, 2000).

Significant changes of physical, chemical and microbiological properties occur during pastırma processing. Moisture, a_w, pH, TBARS, salt, residual nitrite and nitrate, non-protein nitrogen, myofibrillar fragmentation index, colour, fatty acid composition, volatile compounds, microbial flora and sensory characteristics are affected by production stages (Aksu and Kaya, 2001a; Aksu and Kaya, 2002a; Aksu and Kaya, 2002b; Aksu and Kaya, 2002c; Aksu *et al*., 2005a; Aksu *et al*., 2005b; Dogruer *et al*., 2003)

One of the most important factors affecting the quality of pastırma is the additives used in salting/curing and curing. Salt, nitrate or nitrite or both of them with the addition other chemical substances and various spices depending on the product type are used in the curing of meat products. Curing in meat technology is a process applied to improve the characteristics such as appearance, colour, texture, taste, aroma, and flavour of the product. For this purpose, nitrate or nitrite together with salt is commonly used in pastırma (Tekinsen and Dogruer, 2000). Nitrite is used as a curing agent due to a number of positive effects including: i) a permanent pinkish-red colour formation, ii) antimicrobial effect, iii) specific aroma/flavour formation and iv) an antioxidant effect in meat products (Christensen *et al*., 2000). Desirable colour stability and a pinkish-red colour formation in cured meat products such as pastırma is the most distinct feature of nitrite and this feature is very important in terms of acceptability by the con-

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sumer (Cornforth and Jayasingh, 2004). The main pigment responsible for the specific pinkish-red colour of cured meat is nitrosomyoglobin, which is formed as a result of combining myoglobin with nitric oxide (NOMb. Fe^{+2}). Another important function of nitrite in meat products is its antimicrobial activity. It is reported that nitrite has effect at different concentrations both inhibiting and preventing the growth of some bacteria (especially *C. botulinum*). The benefits/risks of nitrite, particularly the antibacterial effect of nitrite in meat products, are the matter of debate at present (Milkowski *et al*., 2010). Moreover, nitrite contributes to inhibiting the growth of many types of pathogenic bacteria; nitrite has usually been a more effective antibacterial on Gram (+) bacteria. Even low concentrations of nitrite can inhibit a large part of food pathogens (Davidson *et al*., 2004).

The determined effects on the quality of the final product of curing agents and methods used in pastırma production and putting these results into practice are important for the quality and standard pastırma production. It is known that nitrite used as curing agent in various meat products affects the quality properties of the product. However, studies about the effects of nitrite on the quality parameters of pastırma are limited (Aksu and Kaya, 2002c; Begendik, 1991). The purpose of this study was to determine the effect of sodium nitrite levels on moisture, residual nitrite, TBARS, pH, salt, colour (L* relative lightness, a* relative redness, b* relative yellowness) values and TAMB, M/S, LAB, M-Y and *Enterobacteriaceae* counts in the pastırma.

Materials and Methods

Pastırma was manufactured according to the process reported by Aksu *et al*. (2005b). The muscles (beef *M. Longissimus dorsi)* obtained from beef carcasses were used as the raw material for pastırma production.

Preparation of the meat for pastırma: The muscles used in the experiment were obtained from two different beef carcasses and the meat of the same animal carcasses was evaluated as a block. For pastırma production, after removing fat and connective tissue from the surfaces of *Longissimus* muscle, the muscle was vertically cut across the centre of the muscle into two pieces. Four pastırma groups (approximately 4 × 2 kg; 30-35 × 10-12 × 5-7 cm) were obtained from a carcass.

Dry curing: The holes with 45-degree angle not exceeding 2/3 of the meat thickness were opened to the surface of prepared meats for pastırma (Şaklama). One of the pieces of meat prepared for pastırma production was evaluated as the control group treated only with salt (50 g/kg). The other three parts were treated with salt (49.95 g/kg) + 50 ppm sodium nitrite (0.05 g/kg), salt (49.9 g/kg) + 100 ppm sodium nitrite (0.10 g/kg) and salt (49.85 g/kg) + 150 ppm sodium nitrite (0.15 g/kg), and were evaluated as the treatment groups. For the curing of meat, 50 g curing mixture was used for each kg of meat and the curing process was treated in different trays for each group. Meats were cured at 6-7°C for 48 h.

First drying: The cured meats were dried at 15°C and 80-85% relative humidity (RH) for 4 d. Meats were dried in a controlled equipment.

First pressing: 25 kg weight for each 1 kg of meat was used for pressing process. The cured, semi-dried meats were pressed at 7-10°C for 17 h.

Second drying: The pressed meats were dried at 20°C and 70% RH for 3-4 d again for second drying.

Second pressing: 25 kg weight for each 1 kg of meat was used. The dried meats were pressed at 25°C for 7 h.

Paste seasoning: After the second pressing step of pastırma production, the dried and pressed meat samples were pasted at 7±0.5°C for 4.5 d with the paste seasoning (çemen) (composition of paste seasoning: 500 g flour of fenugreek (*Trigonella foenum graecum*) seed, 350 g smashed fresh garlic, 75 g paprika, 75 g red pepper, 1200 mL water) and the surface of the meat was covered with the paste seasoning to 2-3 mm thickness.

Final drying (*drying with paste seasoning; çemenleme in Turkish*): The meats with paste seasoning were dried at 15±0.5°C and RH 70% for 2 d, at 18±0.5°C and RH 65% for 2 d and at 20 ± 0.5°C and RH 60% for 4-5 d.

Physico-chemical analysis

Samples for moisture, residual nitrite, TBARS, pH, salt and colour (L*, a* and b*) analyses were obtained from vertically sliced meat and pastırma samples at the end of each pastırma production stage (raw material, end of curing, end of second drying and pastırma). Moisture contents (%) and pH of the samples were determined according to the methods described by Ockerman (1985). Residual nitrite (ppm) and salt (%) values were determined according to Tauchmann (1987). TBARS values were determined by the method of Lemon (1975), and expressed as μmol malonaldehyde/kg tissue. Colour values of the samples during pastırma processing were measured by a tristimulus colorimeter (Illuminant D65, Ø11 mm, Minolta Chroma Meter Measuring Head CR-400, Minolta, Japan), which was used to determine L*, a* and b* values (where

L* measures relative lightness, a* relative redness and b* relative yellowness) by Commission International de l'Eclairage (CIE).

Microbiological analysis

Sample solutions for microbiological analysis were prepared by the homogenization of 25 g sample with 225 mL physiological saline (0.85% NaCl) in a Stomacher (Laboratory Blender Stomacher 400, Seward, England) for two minutes. Incubation temperature and time for other microbiological analyses were as follows: For counting total aerobic mesophilic bacteria (TAMB), Plate Count Agar (Oxoid) was used. Colonies were counted at the end of incubation for 48 h at 30°C under aerobic conditions. Lactic acid bacteria (LAB) were incubated at 30°C anaerobically for 2 d by using De Man Rogosa Sharpe Agar (Oxoid). *Micrococcus/Staphylococcus* (M/S) were counted using Mannitol Salt Phenol-Red Agar (Oxoid) incubated aerobically at 30°C for 2 d. Mould-yeast (M-Y) were incubated at 25°C aerobically for 5 d by using Potato Dextrose Agar (Oxoid). *Enterobacteriaceae* was incubated on Violet Red Bile Dextrose Agar (Merck) at 30°C anaerobically for 2 d.

Statistical analysis

This experiment was conducted according to a completely randomized block design, using two replications. Analysis of variance by the general linear model (GLM) of the SPSS Package Program (1996) and Duncan's multiple range tests were used to find significant differences ($p<0.05$) between nitrite level and pastırma production stage. The model included the nitrite level (control, 50 ppm, 100 ppm and 150 ppm) and production stage (the raw material, the end dry curing, the end of second drying and pastırma) as main effects, and all their interactions. The results of statistical analysis were shown as mean values ± standard error in tables.

Results and Discussion

Moisture values

Significant effects of the production stage were determined on the moisture content ($p<0.01$), however, no significant effect of the nitrite level was determined ($p>0.05$) (Table 1). On the moisture content, the significant effects of the nitrite level × production stage interaction ($p<0.05$) was also found (Fig. 1a). As seen from the Fig. 1a, the moisture level decreased in parallel in all treatment groups during production, except the pasting seasoning stage. The highest reduction also occurred after the curing stage.

Residual nitrite values

Significant effects of the nitrite level, production stage and nitrite level × production stage interaction ($p<0.01$) were determined for the residual nitrite. The amount of residual nitrite increased with the increasing added nitrite

Table 1. Means and standard errors of moisture, residual nitrite, TBARS, pH, and salt values of pastırma with different nitrite levels during processing

	Moisture (%)	Residual nitrite (ppm)	TBARS (μmol malonaldehyde/kg)	pH	Salt (%)
Nitrite Levels (NL)					
0 ppm (Control)	59.88 ± 3.39	0.86 ± 0.18^{d}	30.26 ± 3.70^{a}	5.74 ± 0.02^{a}	6.71 ± 0.39^{b}
50 ppm	60.12 ± 3.20	3.25 ± 0.51^{c}	23.24 ± 2.58^{b}	5.69 ± 0.03^{b}	6.97 ± 0.47^{b}
100 ppm	59.71 ± 3.26	7.95 ± 1.47^{b}	16.09 ± 2.14^{c}	5.70 ± 0.03^{b}	7.77 ± 0.51^{a}
150 ppm	60.34 ± 3.34	9.34 ± 1.54^{a}	13.57 ± 1.72^{d}	5.71 ± 0.03^{b}	6.71 ± 0.44^{b}
SEM	0.345	0.174	0.421	0.008	0.117
Significance	NS	**	**	**	**
Pastırma Production Stage (PPS)					
Raw material	74.31 ± 0.43^{a}	0.28 ± 0.03^{d}	5.25 ± 0.40^{d}	5.68 ± 0.03^{c}	-
End of curing	69.14 ± 0.50^{b}	12.87 ± 1.78^{a}	12.72 ± 0.70^{c}	5.68 ± 0.03^{c}	5.57 ± 0.28^{c}
End of 2nd drying	54.39 ± 0.45^{c}	3.88 ± 0.58^{c}	28.67 ± 3.40^{b}	5.71 ± 0.02^{b}	8.75 ± 0.23^{a}
Pastırma	42.21 ± 0.64^{d}	4.38 ± 0.09^{b}	36.51 ± 1.14^{a}	5.78 ± 0.01^{a}	6.80 ± 0.15^{b}
SEM	0.345	0.174	0.421	0.008	0.102
Significance	**	**	**	**	**
Interactions					
NL × PPS	*	**	**	**	**

*$p<0.05$, **$p<0.01$

±, Standard error; SEM, Standard error of means; NS, Nonsignificant.

[a-d]Means in the same column and same section with the same letters are not significantly different at $p<0.05$

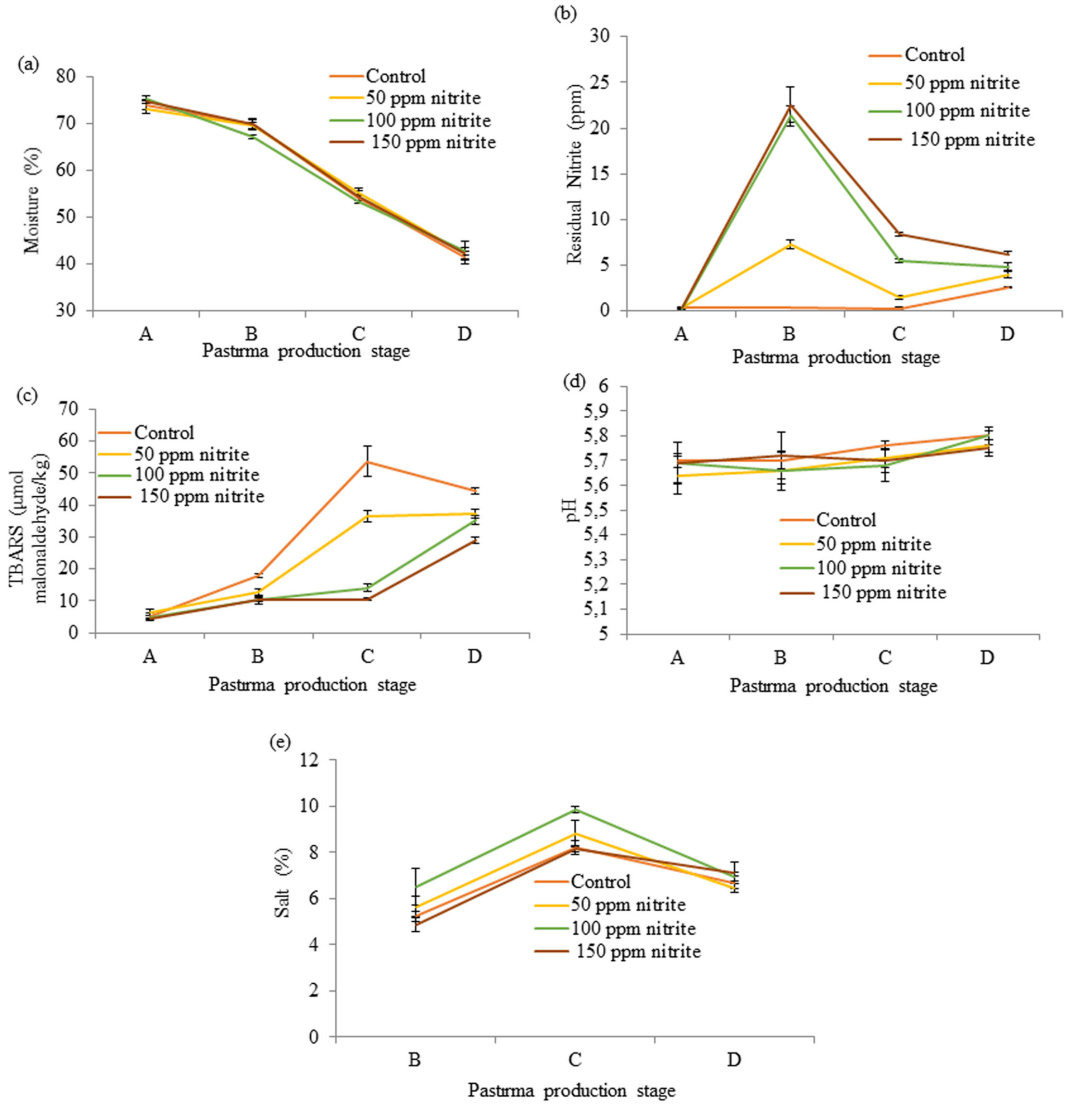

Fig. 1. The effect of the nitrite level × the production stage interaction on moisture (a), residual nitrite (b), TBARS (c), pH (d) and salt (e) values during pastırma processing: A: Raw material, B: End of curing, C: End of second drying, D: Pastırma.

level to the pastırma (p<0.05). More added nitrite increased residue of nitrite (Table 1).

A significant effect (p<0.01) of the nitrite level × production stage interaction was determined on the amount of residual nitrite in pastırma, and the figure is presented in Fig. 1b. Depending on the nitrite level added in the curing stage in pastırma, the amount of nitrite increased in groups with 50, 100 and 150 ppm at the end of curing. After this stage, the amount of nitrite gradually decreased in the groups with 100 and 150 ppm. The highest reduction occurred at the drying stages. After the paste seasoning, there was a partial increase in the control and 50 ppm groups. Moreover, differences in the pastırma stage (D) were detected as 2.32, 3.99, 4.74 and 6.16 ppm in the pastırma with 0 (control), 50, 100 and 150 ppm nitrite, respectively (Fig. 1b).

TBARS values

It was detected that the nitrite level, production stages and nitrite level × production stage interaction had significant effects (p<0.01) on the TBARS value (Table 1). While the lowest TBARS value was 13.57±1.72 µmol malonaldehyde/kg in the group with 150 ppm nitrite, the highest TBARS value was 30.26±3.70 µmol malonaldehyde/kg in the group without nitrite. The TBARS value increased during production (p<0.05). The TBARS value determined as the average 5.25±0.40 µmol malonaldehyde/kg in the raw materials used in pastırma production

increased in 36.51±1.14 μmol malonaldehyde/kg in pastırma (Table 1). The highest increase in the TBARS value was determined in drying stage (p<0.05). While the maximum change in TBARS value occurred in the control group during production, the lowest change occurred in groups with 100 and 150 ppm nitrite. While the TBARS value changed slightly in the control group and in the group including 50 ppm nitrite in curing stage, a sharp increase occurred in the second drying stage (Fig. 1c).

pH values

It was found that the nitrite level, production stages, nitrite level × production stage interaction had significant effects (p<0.01) on the pH value. In the pastırma groups, there was no difference among the groups including nitrite, while the highest pH value was determined in the control group (p>0.05) (Table 1). It was identified that the pH value increased after the curing in pastırma production stages.

The nitrite level × production stage interaction determined to have a very significant effect (p<0.01) on pH value is shown in Fig. 1d. The pH value usually increased in both the control and the treated groups during pastırma production stages. The highest increase occurred after the second drying stage. At this stage, the moisture content decreased due to drying, and microorganisms which have proteolytic effect reached the maximum number had important effects in pH increase. The average pH values of pastırma were difference depending on the nitrite levels as shown in Fig. 1d.

Salt values

The nitrite level, production stages and nitrite level × production stage interaction determined to have significant effects on the amount of salt (p<0.01). While the amounts of salt were statistically the same in the control and the groups with 50 and 150 ppm nitrite (p>0.05), the group with 100 ppm nitrite was different despite the same amount of curing component (50 g/kg meat) used in the control group and the groups including 50, 100 and 150 ppm nitrite in the curing stage (p<0.05; Table 1).

The nitrite level × production stage interaction determined to have a significant effect (p<0.01) on the amounts of salt in pastırma is shown in Fig. 1e. The amount of salt at the end of curing and second drying in the groups with 50 and 100 ppm nitrite were found to be higher than other groups. As can be seen in the Fig. 1e, the amounts of salt of pastırma were different. In pastırma stage (D), the average salt amount was found as 6.70%, 6.44%, 6.96% and 7.10% for control, 50, 100 and 150 ppm nitrite, respectively.

Colour values

The values of colour (L*, a* and b*) in pastırma are shown in Table 2. In lightness (L* value), there was no statistical difference (p>0.05) among the control and groups with nitrite. There was a statistical difference in redness (a* value) among all groups. The a* value ranged from to in pastırma. While the control pastırma had the lowest a* value with 32.03±1.85, the pastırma with 150 ppm nitrite had the highest value with 39.16±0.99 (Table 2). These results showed that the a* value expressing the redness of pastırma increased with the 150 ppm nitrite addition. The highest b* value was found in the group with 150 ppm nitrite.

Microbiological changes

Nitrite levels had a significant (p<0.01) effect on TAMB counts. The highest average TAMB count was in the control pastırma, while the lowest counts were in pastırma samples with 150 ppm nitrite (Table 3).

Nitrite levels had a significant effect (p<0.01) on M/S counts. The highest M/S counts were in the control and 100 ppm groups, and the lowest counts were in the pastırma samples with 150 ppm nitrite (Table 3).

Nitrite levels had a significant effect (p<0.01) on LAB

Table 2. Means and standard errors of L*, a* and b* values in the final pastırma product with different nitrite levels

Nitrite levels	L* value	a* value	b* value
0 ppm (Control)	42.02 ± 1.65	32.03 ± 1.85^{c}	19.88 ± 0.92^{b}
50 ppm	43.07 ± 0.72	34.66 ± 1.15^{b}	21.35 ± 0.70^{b}
100 ppm	41.30 ± 0.06	35.50 ± 1.04^{b}	20.75 ± 0.47^{b}
150 ppm	41.24 ± 1.40	39.16 ± 0.99^{a}	23.51 ± 0.24^{a}
SEM	1.062	1.302	0.605
Significance	NS	**	**

**p<0.01

±, Standard error; SEM Standard error of means, NS, Nonsignificant.

[a-d]Means in the same column and same section with the same letters are not significantly different at p<0.05.

Table 3. Means and standard errors of total aerobic mesophilic bacteria (TAMB), lactic acid bacteria (LAB), *Micrococcus/Staphylococcus* (M/S), mould and yeast, and *Enterobacteriaceae* counts in pastırma (final product) with different nitrite levels (Log CFU/g)

Nitrite levels	TAMB	M/S	LAB	M-Y	*Enterobacteriaceae*
0 ppm (Control)	7.36 ± 0.24[a]	7.48 ± 0.25[a]	4.82 ± 0.23[a]	5.63 ± 0.14[a]	< 2.00
50 ppm	6.84 ± 0.19[bc]	6.94 ± 0.24[b]	4.14 ± 0.49[c]	4.46 ± 0.11[b]	< 2.00
100 ppm	7.02 ± 0.47[b]	7.25 ± 0.40[a]	4.85 ± 0.33[a]	4.87 ± 0.93[b]	< 2.00
150 ppm	6.73 ± 0.24[c]	6.62 ± 0.26[c]	4.27 ± 0.29[b]	3.08 ± 0.22[c]	< 2.00
SEM	0.081	0.083	0.036	0.084	
Significance	**	**	**	**	

**$p<0.01$; ±, Standard error; SEM, Standard error of means
[a-d]Means in the same column and same section with the same letters are not significantly different at $p<0.05$.

counts. The highest LAB counts were in the control and 100 ppm groups, and the lowest counts were in the pastırma samples with 50 ppm nitrite (Table 3).

The used of nitrite in pastırma production was determined to have a significant effects on the number of M-Y, the highest value was identified as 5.63±0.14 log CFU/g in the control pastırma. The lowest number of M-Y determined in pastırma with 150 ppm had the maximum nitrite addition, only yeast development was observed in the flora, mould development was not found (Table 3).

As shown in Table 3, the number of *Enterobacteriaceae* were found below the number which can be detected (< 2.00 CFU/g) in all pastırma groups. During pastırma production, water activity of the final product decreased due to the salting/curing, drying, paste seasoning and redrying applications, and the microorganisms of *Enterobacteriaceae* inactivated.

Discussion

The moisture content in the all of pastırma samples decreased during the production process (Table 1). During the production process of pastırma, except the pasting seasoning stage, the moisture content decreased, because between pastırma and the paste seasoning consists occurs salt-water balance in the pasting seasoning stage. It was seen that the present research findings were similar to various previous findings (Aksu and Kaya, 2002b; Aksu and Kaya, 2002c; Dogruer *et al*., 2003; Hastaoglu, 2011; Uguz *et al*., 2011). It is indicated that the moisture content in pastırma has to be maximum 45% in the Turkish Food Codex Meat and Meat Products Communique (2012), but Çakıcı *et al.* (2015) reported that the moisture amount of ready-to-eat pastırma should be maximum 40.0% for the microbiological safety.

The nitrite in the pastırma production is an active substance in the colour and aroma formation, preventing rancidity and extending the shelf life. However, the amount of residual nitrite is required to be very low in the final product (the average 4.38±0.09 ppm, Table 1). The amount of residual nitrite decreases due to reaching a certain number of *Micrococcaceae* in pastırma production. Moreover, Geisen *et al*. (1992) indicated that nitrite can be degraded by the addition of *Micrococcus* and *Staphylococcus* in meat products and decrease the amount of residual nitrite in products. Aksu and Kaya (2002c) investigated the effects on the quality characteristics of the final product of different starter cultures using 250 ppm sodium nitrite as a curing agent in pastırma production. Researchers identified that the amounts of residual nitrite (9.89-26.80 ppm) in the final product added starter cultures were less than in the control samples (28.621-45.22 ppm). Dogruer and Guner (2005) determined that the amounts of residual nitrite found 22.13-51.06 ppm in pastırma decreased to 3.20-9.51 ppm with storage for 60 d. Furthermore, Aksu *et al.* (2005b) found that the initial amounts of residual nitrite (11.60 and 22.40 ppm) in pastırma produced from fresh and frozen/dissolved meats at the beginning of the storage decreased to 2.57 and 5.27 ppm at the end of 150 d storage. El-Khateib *et al.* (1987) found that the amount of residual nitrite was the average 12 ppm in pastırma, Çakıcı *et al.* (2015) determined that the residual nitrite amounts of sırt, kuşgömü, şekerpare and bohça pastırma samples were 2.33-4.65 mg/kg, 2.06-48.89 mg/kg, 1.87-38.48 mg/kg and 1.34-23.21 mg/kg, respectively. The change in the amounts of residual nitrite in research carried out by Aksu and Kaya (2002c) was also similar to our findings. Researchers defined that the amounts of nitrite that were 75.23 ppm at the end of the curing decreased to the average 22.71 ppm in the final product.

TBARS results showed that nitrite had an antioxidant effect in pastırma production. One of the most remarkable features of nitrite is delay of oxidative rancidity. This effect occurs even in the presence of salt, a strong oxida-

tion promoter. Nitrite in meat and meat products is oxidised to nitrate by free oxygen. Thus, nitrite shows its antioxidant effect. In addition, nitric oxide oxidizes nitrite by an oxygen molecule which can contribute to the prevention of oxidation (Sebranek, 2009). Begendik (1991) found that oxidation decreased with the increasing amount of nitrite added in pastırma. Investigators found that lipid oxidation continued during pastırma production, and TBA and/or TBARS values increased as a measure of the lipid oxidation (Aksu and Kaya, 2002c; Begendik, 1991; Kaban, 2009). This change could be explained by the loss of volatile organic compounds such as hexanal (Gok *et al*., 2008). Kaban (2009) determined the amount of hexanal in different stages of pastırma production, and the amount of hexanal as 35.39±2.45 at the end of the second drying decreased to 15.82±5.08 in pastırma. Furthermore, Gok *et al*. (2008) identified that the amount of hexanal in pastırma was as about 15 mg/kg.

There was no statistically significant difference in terms of pH value in the raw materials and at the end of curing (p>0.05) (Table 1). Ockerman (1985) stated that there was no change in the pH value of the cattle muscles with 3-5% salt stored at 4°C. The pH value was found averagely as 5.68 ± 0.03 in the raw material and increased to 5.78 ± 0.01 in the final product pastırma (Table 1). The change in pH in various studies carried out on pastırma was parallel to the present research findings and pH was increasing during production (Aksu and Kaya, 2002b; Hastaoglu, 2011). Ingham *et al.* (2006) found that the pH value was between 5.6 and 6.0 in pastırma. pH values of pastırma samples purchased from ten different small-scale firms, butchers and local markets in Tokat/Turkey were found as 5.69-5.92 (Karabıyıklı *et al*., 2015). Ceylan and Aksu (2010) have reported that in "sırt pastırma" type, pH value is between 5.60 and 6.06. The pH values determined in the final product is below the upper limit (6.0) identified in the Turkish Food Codex Meat and Meat Products Communique (Anonymous, 2012).

The pasting process applied after the second drying process is an important stage of pastırma production, at this stage, between cured-dried meat and fenugreek paste provided the moisture-salt balance. This event is effective in reducing the amount of salt rising after the second drying (Aksu and Kaya, 2002b; Dogruer *et al*., 2003; Hastaoglu, 2011). Aksu and Kaya (2002c) found that the amounts of salt in the curing, 1st drying and 2nd drying processes, pasting and pastırma stages of pastırma produced by added 5% curing component were 4.17%, 4.40%, 5.11%, 4.32%, 5.21%, respectively. Uguz *et al*. (2011) also determined results similar with the present research findings in pastırma produced with 6% salt addition, and the amounts of salt were found as 5.96%. Yetim and Cankaya (1998) determined that the amount of salt in pastırma was 5.12-5.65%.

The values of colour (L*, a* and b*) in pastırma are shown in Table 2. Aksu and Kaya (2001a) reported that L* value in the control group pastırma was averagely 41.22. The same researchers, in a different study (Aksu and Kaya, 2005), determined that the L* value was 47.38 ± 1.59 in pastırma. Hastaoglu (2011) stated that the L* value was between 50.21 and 42.35 in pastırma produced by adding different amounts of NaCl and KCl. Çakıcı *et al*. (2015) also determined that the L* value was averagely 40.47 (27.37-50.08) in sırt pastırma. One of the most relevant roles of nitrite is the formation and stability of the desirable pinkish-red colour in curing meat products, and this feature is very important in terms of acceptability of the consumer (Cornforth and Jayasingh, 2004). The nitrosomyoglobin (NOMb.Fe^{+2}) occurred as a result of the combination of myoglobin and nitrite oxide (NO) that forms the pinkish red colour in the cured product. It was identified in the study carried out by DuBose *et al*. (1981) that there was no difference among the colour properties of the hams produced by adding 25, 75 and 125 ppm nitrite, although the colour properties of these hams were better than those without nitrite. The a* value determined as 36.38 ± 1.15 in pastırma by Aksu and Kaya (2005) was similar to the value in the present study. Aksu and Kaya (2001b) found that a* values of pastırma sliced 1-2 mm thick in the Erzurum market were between 13.66 and 36.63.

The using of nitrite at different rates in pastırma production was affected the microbiological properties of pastırma. Means and standard deviations of TAMB, M/S, LAB, M-Y and *Enterobacteriaceae* counts (Log CFU/g) in pastırma with different nitrite levels are shown in Table 3. These were similar to the results of many studies showing TAMB counts of pastırma generally between 10^5 and 10^8 CFU/g (Aksu and Kaya, 2001a; Aksu and Kaya, 2002c; El-Khateib *et al*., 1987; Karabıyıklı *et al*., 2015). *Micrococcus* and *Staphylococcus* were dominated in pastırma microflora because of its resistant to high salt concentration (Aksu and Kaya, 2002b; Kaban, 2009). The M/S number was explained between 10^3 and 10^7 CFU/g in the studies (Aksu and Kaya, 2001b; Aksu and Kaya, 2002a, Aksu and Kaya, 2002b; Aksu *et al*., 2008; DuBose *et al*., 1981; Elmali *et al*., 2007). *Micrococcus* and *Staphylcoccus* that can develop in aerobic or very low-oxygen envi-

ronments are the dominant bacteria group in the pastırma and are very important bacteria in the formation of the desired quality of pastırma. These bacteria can be effective in the reduction of nitrate to nitrite and in the formation of the desired colour and flavour (Katsaras *et al*., 1996). The change in LAB counts in various studies carried out on pastırma was parallel to the present research findings (3-5 Log CFU/g) (Aksu and Kaya, 2002c; Aksu *et al*., 2008; Christensen *et al*., 2000; DuBose *et al*., 1981; Gurbuz *et al*., 1995). In the researches carried out, M-Y count in pastırma was indicated as $< 10^2$ to 10^6 CFU/g (Aksu and Kaya, 2002c; Dogruer *et al*., 2003; Elmali *et al*., 2007; Gurbuz *et al*., 1995). Also, M-Y counts of the pastırma samples purchased from ten different small-scale firms, butchers and local markets in Tokat/Turkey were found ranged between < 1.00-4.83 Log CFU/g (Karabıyıklı *et al*., 2015). In the studies carried out, the number of *Enterobacteriaceae,* indicator of the general microbiological quality, in pastırma was indicated between $< 10^2$ and 10^4 CFU/g (Aksu and Kaya, 2001a; DuBose *et al*., 1981).

The results of this study show that the addition of nitrite in pastırma production significantly affects the quality attributes of pastırma. The addition of nitrite in the pastırma production prevented lipid oxidation. The a* value being an important quality properties for ready-to-eat pastırma increased with the addition of nitrite. In addition, the usage of nitrite in pastırma production was affected from the microbial flora. LAB and M/S counts were found at the highest level in the control (0 ppm nitrite) pastırma and pastırma with 100 ppm nitrite. Moreover, the use of nitrite in pastırma production caused a reduction in the amount of M-Y.

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