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Effects of cemen paste with lyophilized red cabbage water extract on the quality characteristics of beef pastırma during processing and storage

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Abstract

In this study, the effects of cemen paste with lyophilized red cabbage water extract (LRCWE) on the quality characteristics of pastırma were studied. Cemen paste with LRCWE concentrations of 0.0%, 0.8%, 1.0%, and 1.2% were used for pastırma production. Pastırma was stored at 4°C for 150 days. The a^* values of external and sliced surfaces and sensorial scores were higher in the pastırma added with 1.0% and/or 1.2% LRCWE during processing and storage. LRCWE addition reduced thiobarbituric acid reactive substance (TBARS) ($p < .01$) and pH ($p < .01$) values, while protein oxidation, moisture, and microbiological counts did not change ($p > .05$) in pastırma production. However, TBARS ($p < .01$), pH ($p < .01$), and protein oxidation ($p < .01$) values increased during storage.

Practical applications

Cemening (treatment of dry cured meat with cemen paste) is an important stage in pastırma production as it affects the quality of pastırma. Cemen paste especially affects the color of pastırma. Therefore, synthetic dyes are added to cemen paste to improve the color of pastırma. In addition, the lipid oxidation in pastırma increases during storage. This research could be useful for the food industry and consumers to know that lyophilized red cabbage water extract (LRCWE) is a more suitable natural coloring and antioxidant agent for pastırma cemen paste. In this way, the quality and functional characteristics of pastırma shall be increased during processing and storage.

1 | INTRODUCTION

Pastırma is a dry-cured meat product, and it is traditionally produced from beef and buffalo muscles in Turkey (Cakici et al., 2015; Ceylan & Aksu, 2011). However, it was reported in some research (Benkerroum, 2013; Ren et al., 2015) that goat, pork, camel, horse, and lambs meats can be also used for pastırma production. Sixteen to twenty types of pastırma can be made from water buffalo and beef carcass, and each type of pastırma has different names, shapes, and quality characteristics (Cakici et al., 2015; Ceylan & Aksu, 2011). The raw material and various production stages affect the quality characteristics of the final products. The various stages of pastırma production are dry curing, first drying, first pressing, second drying, second pressing, covering with cemen paste, and again/final drying (Abd-Elghany et al., 2020; Aksu et al., 2016a; Hastaoglu & Vural, 2018), and do not include smoking and heating processes (Cakici et al., 2015). Processing of pastırma takes approximately 3 or 4 weeks. The significant factors affecting the quality of pastırma are covering with cemen paste (cemening or paste seasoning) and substances used in production of cemen paste. In the cemening stage during pastırma processing, the surface of the cured-dried meats is coated with a cemen paste consisting of *Trigonella foenum-graecum* L. seed flour, paprika, red pepper,

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garlic, and water. Cemening process increases color, nutritional values, and typical aromas of pastırma (Aksu et al., 2005a, 2006; Erdemir & Aksu, 2017; Yetim et al., 2017). It also provides protection against pathogen and mold growth, drying, and lipid oxidation during storage. The color of pastırma cemen paste completely depends on the quality of the paprika and/or red pepper used. Paprika and/or red pepper contains various carotenoids such as carotene, zeaxanthin, and luteine. It is impossible to obtain the desired red color in cemen paste prepared with low-quality paprika or red pepper. Kök (1985) pointed out that the addition of synthetic colorant was useful for obtaining the desired color. However, the use of synthetic colorants in the production of cemen paste adversely affects human health (Demirer, 1972; Karasoy, 1961). The use of color additives, such as curcumin (E 100), riboflavin, riboflavin-5-phosphate (E 101), and carmines (Carminic acid, Cochineal, E 120), in pastırma cemen paste are permitted by the Communiqué on Colorants Used in Foods of Turkish Food Codex Regulation Foods (Anonymous, 2013). Carmine (insect *Coccus cacti*) is mostly used in the pastırma production. However, consumers avoid food products made from carmine due to the use of animal-based additive. The use of synthetic colorants has been restricted in the United States and the European Union (Yetim et al., 2017). In addition, Yetim et al. (2017) reported that carmine may cause health problems such as food and IgE-mediated allergy, hypo- and hypertension, and bradycardia.

In recent years, several studies have investigated the potential use of extracts obtained from different vegetables or fruits for improving the antioxidant, antimicrobial, and color properties in meat products (Aksu, Alinezhad, & Erdemir, 2015a; Alp & Aksu, 2010). In this context, red cabbage is a potential vegetable as it contains high amount of anthocyanins. In addition, the antioxidant activity in red cabbage is high due to the presence of phenolic components. Thus, red cabbage extracts are red/purple in color, and have high antioxidant and antimicrobial properties (Aksu et al., 2015b, 2020a; Boo et al., 2011, 2012; McDougall et al., 2007; Wu & Prior, 2005). Several studies have determined various quality features of lyophilized red cabbage water extract (LRCWE), and concluded that it can be used in the production of cemen paste for pastırma in the levels of 1.0% and 1.2%. It has also been suggested that cemen paste with LRCWE affects the quality of pastırma (Aksu et al., 2015b, 2016b, 2020a). Yetim et al. (2017) studied the effects of different juices (e.g., lemon, salgam juices) and additives (e.g., carmine, citric acid) on cemen paste, but the present study is only on cemen paste. Until now, no studies have examined the effects of natural color substances on pastırma. Thus, the aim of this study was to evaluate the effects of cemen paste with the LRCWE (as a new additive) on the color, moisture, pH, lipid and protein oxidation, microbiological counts, and sensory quality of pastırma during processing and storage.

Highlights

- Cemen paste of pastırma was treated with lyophilized red cabbage water extract (LRCWE).
- LRCWE can be used as coloring agent instead of synthetic colorants in pastırma.
- LRCWE strongly increased the color intensity of cemen paste and pastırma.
- LRCWE positively changed the sensory scores of pastırma during storage.
- LRCWE in cemen paste decreased the lipid oxidation of pastırma during storage.

2 | MATERIALS AND METHODS

2.1 | Materials

For the production of pastırma, *M. longissimus lumborum* from the crossbreed Brown Swiss was obtained from commercial slaughterhouse. *M. longissimus lumborum* from carcass were taken after 24 hr from slaughtering. For cemen paste, *T. foenum-graecum* (seed flour), garlic, red pepper powder, paprika, red cabbage (*Brassica oleracea* var. *capitata* f. *rubra*), salt, and sodium nitrite were obtained from Erzurum, Turkey.

2.2 | Methods

2.2.1 | Production of lyophilized red cabbage water extract

The outer leaves of the fresh red cabbages used in the research were discarded, and the rest of the parts were washed and smashed thoroughly in a blender. A quantity of 400 ml water was added to 20 g of the blended sample, and it was homogenized in an Ultra-Turrax (Alp & Aksu, 2010; Aksu et al., 2015a, 2020b). The homogenized mixture was stirred using a magnetic stirrer at 20°C for 15 min and filtered through a Whatman paper No:1. The water was evaporated in a rotary evaporator (at 40°C for 60 min), and the extract was frozen at −38°C and lyophilized at −50°C. The obtained LRCWE was kept at 4°C.

2.2.2 | Preparation of cemen paste with LRCWE

Cemen paste for pastırma was prepared by mixing *T. foenum-graecum* seed flour (500 g), fresh garlic (350 g), paprika (75 g), red pepper powder (75 g), and water (1,200 ml) (Aksu & Kaya, 2005; Erdemir & Aksu, 2017). Cemen paste produced was divided into four groups, and LRCWE was added to three groups in the ratio of 0.8%, 1.0%, and 1.2% of the cemen paste weight. Cemen paste, without extract, was used as the control group. All of the cemen paste groups were produced as three replicates.

2.2.3 | Pastırma production

A total of three carcasses were used for pastırma production in this study, and four pastırma (control, pastırma with 0.8% LRCWE,

pastırma with 1.0% LRCWE, and pastırma with 1.2% LRCWE) were produced from the muscles taken from a carcass. In the study, pastırma were produced as three repeats (in total 12 pastırma). Pastırma was produced according to the methods described by Aksu et al. (2005a) and (2017):

1. **Preparation of the meat:** Connective and fat tissues from the surface of *M. longissimus lumborum* were removed. Then, the muscles were cut vertically into two pieces, and in this way, meat for production of four pieces of pastırma were obtained from a carcass. Each piece of the meat was used for each treatment.
2. **Curing:** Dry curing was applied at 6°C, 48 hr. The curing mixture of 50 g salt and 100 ppm $NaNO_2$ per 1 kg meat was used.
3. **First drying:** Cured meats were dried for 4 days at 15°C and 80%–85% relative humidity (RH).
4. **First pressing:** Cured and dried meats were subjected to the first pressing process at 7°C–10°C for 17 hr.
5. **Second drying:** Pressed meats were dried for 3–4 days at 20°C with 70% RH.
6. **Second pressing:** After the second drying, second pressing was performed at 25°C for 7 hr.
7. **Coating with cemen paste (cemening):** Dried and pressed meats were covered with cemen paste and again dried for 4 days at 7°C. Cemen paste was spread on the outer surface of the meat as a thin layer of 2–3 mm thickness. The addition of cemen paste was completed for control (without LRCWE), pastırma with cemen paste containing 0.8% LRCWE, pastırma with cemen paste containing 1.0% LRCWE, and pastırma with cemen paste containing 1.2% LRCWE.
8. **Final drying:** After cemening, meats were again dried at 15°C for the first 2 days 70% RH, for 2 days at 18°C 65% RH, and at 20°C, 60% RH for further 4–5 days.

2.2.4 | Storage of pastırma

Pastırma produced from each pastırma groups were stored at 4 ± 1°C for 5 months.

2.3 | Analyses

The color of external, surface with cemen paste and sliced pastırma, moisture, pH, and protein and lipid oxidation analyses were performed during the production stages (raw meterial, before addition of cemen paste, after addition of cemen paste, and pastırma) and storage times (0, 30, 60, 90, 120, and 150 days). Microbiological counts (total aerobic mesophilic bacteria, *Micrococcus/Staphylococcus* (M/S), mould-yeast, lactic acid bacteria, and *Enterobacteriaceae*) and sensory analyses (intensity of appearance color, cemen paste quality, palatability, texture and structure, and overall acceptability) were performed at the pastırma stage and storage times. Residual nitrite and salt amount analysis were only performed at the pastırma stage.

2.3.1 | Determination of moisture and pH values

For moisture analysis, about 10 g of ground samples was dried at 100 ± 2°C for 18–24 hr, and results were calculated as weight loss (%). For pH analysis, 10 g of ground samples was homogenized with distilled water (100 ml) using an Ultra-Turrax (IKA Werk, Germany). The pH value of the homogenized mixture was measured using a pH meter (Thermo SCIENTIFIC, Orion 3-Star, Benchtop pH meter, Singapore).

2.3.2 | Determination of color (L^*, a^*, and b^*) values

The color values were determined using a Minolta Chroma Meter CR-400 (Minolta Co, Osaka, Japan) with an 11-mm diameter measuring area on the external surface of meat and pastırma samples and on the internal area of sliced surface (2–3 mm thickness) of each sample. Ten repeated measurements were taken for each sample. The L^* (lightness), a^* (redness), and b^* (yellowness) color values were determined using the illuminant D65 and 2° standard observer conditions according to the Commission Internationale de L'Eclairage (CIE).

2.3.3 | Determination of protein oxidation

The analysis of protein oxidation was performed using the dinitrophenylhydrazine (DNPH) method as reported by Armenteros et al. (2009). Protein oxidation was determined as total carbonyl. One gram of pastırma or meat sample was homogenized with 10 ml of potassium phosphate buffer (10 mM, pH 6.0) and homogenate was divided into two equal parts. In both parts, supernatants were removed by precipitating proteins with 1 ml of 10% TCA solution and centrifuging at 5,000 rpm for 5 min. The first pellet was treated with 1 ml of 2N HCl to determine the protein concentration, while the other pellet was treated with 1 ml of 0.2% (wt/vol) DNPH to determine the carbonyl concentration. Both samples were incubated for 1 hr with shaking every 15 min at room temperature. After the incubation, the samples were precipitated with 1 ml of 10% TCA solution and centrifuged for 5 min after washing with 2 ml of ethanol/ethyl acetate (1:1 vol/vol). The pellets were dissolved in 1.5 ml of 20 mM sodium phosphate buffer (pH 6.5) and centrifuged for 2 min. The amount of carbonyl was measured at 370 nm. BSA was used as a standard for calculation of protein concentration, and results were calculated as nmol carbonyl/mg protein.

2.3.4 | Determination of lipid oxidation

Thiobarbituric acid reactive substance (TBARS) analysis for determination of lipid oxidation was applied as reported by Kilic and Richards (2003) and Aksu (2009). According to the method, 6 ml of trichloroacetic acid (TCA) solution on the 1 gram of meat or pastırma

samples were added. It was homogenized for 15–30 s, and then filtered through a filter paper (Whatman 1). A quantity of 1 ml of 0.02 M thiobarbituric acid (TBA) solution was added to a tube from the filtrate obtained by taking 1 ml. The mixtures were kept in boiling water bath for 40 min. The mixtures were removed from the water bath, cooled under tap water for 5 min, and centrifuged at 2,000*g* for 5 min. The absorbance of the samples was then measured at 532 nm. A quantity of 1 ml of TBA solution was added to 1 ml of TCA solution for blind measurement, and the same steps were applied. 1,1,3,3-Tetraethoxypropane was used as standard. TBARS value was calculated as μmol malonaldehyde/kg tissue.

2.3.5 | Determination of residual nitrite and salt amounts

Residual nitrite (RN, as mg/kg of $NaNO_2$) and salt (%) in the pastırma samples were determined using the method described by Tauchmann (1987). According to the method, 10 ml of the solutions prepared from the pastırma samples were taken and 10 ml of Griess solution was added. Afterward, it was kept at 20°C for 30 min and its absorbance was read at 540 nm. The amount of RN in the pastırma samples was calculated by taking into account the sample weight, absorbance value, dilution factor, and constant coefficient obtained from the standard curve. The amount of salt in the samples was also determined by adding few drops of 10% potassium chromate to the 20 ml of prepared solution for nitrite determination and titrating with 0.1 N $AgNO_3$.

2.3.6 | Microbiological analysis

A quantity of 25 g of samples was homogenized with 225 ml of sterile saline solution (0.85%) in a Stomacher (Laboratory Blender Stomacher 400, Seward Medical, London, UK) for 2 min. Then, serial dilutions were prepared and used for enumeration. Total aerobic mesophilic bacteria (TAMB) colonies of samples were enumerated on plate count agar (Oxoid CMO325) after incubation at 30°C for 48 hr. For lactic acid bacteria (LAB), MRS agar (de Man Rogosa Sharpe, Oxoid CMO361) was used and plates were incubated anaerobically (Anaerocult A, Merck) at 30°C for 48 hr. *Micrococcus/Staphylococcus* (M/S) colonies were enumerated on mannitol salt phenol-red Agar (Merck, KGaA) after incubating aerobically at 30°C for 48 hr. *Enterobacteriaceae* colonies were enumerated on violet red bile glucose agar (Oxoid CMO485) after incubating anaerobically (Anaerocult A, Merck) at 30°C for 48 hr. For mould and yeast counts, potato dextrose agar (Oxoid CM0139, pH: 3.5) was used and plates were aerobically incubated at 25°C for 5 days.

2.3.7 | Sensory analysis

Sensory analysis was performed using a 9-point hedonic scale (1–9 point scale, 9–8 very good, 7–6 good, 5–4 fairly acceptable, and 3–1 not acceptable) by 10 panelists experienced in meat and food science, and the panelists were the same in all sessions. Four pastırma slices (2–3 mm thick) were coded with random numbers, changed each session, and presented to panelists in white plates. The panelists were asked to evaluate the intensity of appearance color, cemen paste quality, palatability, texture and structure, and overall acceptability of the sliced pastırma samples. Bread and water were served to the panelists to neutralize the palates between samples. Sensory analysis was carried out in 18 sessions (six storage times and three replicates).

2.3.8 | Statistical analysis

Statistical analysis was performed using SPSS.20, in generalized linear models, according to completely randomized design procedure. The model included the effects of LRCWE (control, pastırma with 0.8%, 1.0%, and 1.2% LRCWE) on pastırma quality characteristics and their interactions during the production stages (raw material, before addition of cemen, after addition of cemen, surface with cemen, pastırma) and storage times (30, 60, 90, 120, and 150 days). The differences among the means were tested using Duncan's multiple range test (significance was set at $p < .05$). The results are shown as mean value and standard deviation and standard error of means in tables.

3 | RESULTS AND DISCUSSIONS

3.1 | Changes in color values of external surface of pastırma with LRCWE

The addition of LRCWE to cemen paste for pastırma production had significant effect ($p < .01$) on the a^* values of external surface of pastırma, and the a^* values increased significantly ($p < .05$) in all the samples with LRCWE. The L^* and b^* values of all the examples were not affected ($p > .05$) by the addition of LRCWE. The production stages and storage times had a significant effect on the L^* ($p < .01$), a^* ($p < .01$), and b^* ($p < .01$) values of external surface of meat and pastırma with 0.0% (control), 0.8%, 1.0%, and 1.2% LRCWE. The lowest values were observed in the production stage (before addition of cemen paste), and in general, these values did not change after the pastırma production stages or storage times (Table 1). In addition, the interaction of treatment with the production stage and storage time had a significant effect ($p < .05$) on the a^* values of external surface (Table 1, Figure 1a). In the "surface with cemen" stage, the lowest a^* value was determined for the control sample compared to the groups with 0.8%, 1.0%, and 1.2% LRCWE. Similarly, there were significant ($p < .05$) differences between the control sample and LRCWE samples during storage. The color of the external surface of the whole pastırma is a very important quality criterion, and generally discoloration occurs during storage.

Therefore, synthetic colorants are widely used in the production of cemen paste for pastırma, as explained in detail in the introduction, to preserve the color during storage. The results of this study showed that color of the external surface increased with addition of 0.8%, 1.0%, and 1.2% LRCWE (Figure 1a), and was preserved during storage. This was because of the color increasing effect of LRCWE. Red cabbage is an anthocyanin-rich vegetable which contains color pigment, and its extracts are used as natural food coloring agents commercially. Thus, anthocyanins are recognized as an important alternative for synthetic colorants (Bridle & Timberlake, 1997; Giusti & Wrolstad, 2003). In our other studies, the anthocyanin amounts, as malvidin-3-glucoside and cyanidin-3-glucoside, in LRCWE was determined as 5,522.50 ± 86.64 mg/kg and 4,712.70 ± 73.94 mg/kg, respectively (Aksu et al., 2015b; Aksu et al., 2020a).

3.2 | Changes in color values of sliced surface of pastırma with LRCWE

According to the result of variance analysis, LRCWE addition, production stages, and storage times had no significant effect ($p > .05$) on L^* values of sliced pastırma. However, LRCWE treatment, production stages and storage times had significant effect on the a^* values ($p < .01$) (Table 1). The addition of LRCWE increased the a* values of the sliced surfaces of pastırma and the highest values were determined in samples containing LRCWE compared to the control group. In addition, the interaction of treatment x the production stage and storage time had a significant effect ($p < .05$) on the a^* values of sliced pastırma (Figure 1b). LRCWE tended to increase the a^* value during processing. After cemening stage, the highest average a^* values were determined in pastırma with the addition of 1.2% LRCWE. Thanks to

TABLE 1 Mean values of L^*, a^*, and b^* pastırma produced with the different levels of LRCWE-ADDED cemen pastes, and Duncan's multiple comparison test results ($p < .05$)

Extract level in cemen	Color values of external surface			Color values of sliced meat and pastırma		
	L^* value	a^* value	b^* value	L^* value	a^* value	b^* value
Treatment (T)						
0.0% (Control)	32.21 ± 5.02	7.09 ± 4.42^{c}	9.46 ± 4.89	39.50 ± 2.97	34.03 ± 5.18^{b}	17.91 ± 4.60^{b}
0.8%	33.08 ± 4.34	8.08 ± 4.18^{b}	10.26 ± 4.41	39.93 ± 2.10	35.86 ± 5.72^{a}	19.23 ± 4.65^{a}
1.0%	33.52 ± 4.12	8.38 ± 4.69^{a}	10.60 ± 3.97	38.57 ± 2.15	35.71 ± 5.96^{a}	18.57 ± 4.67^{ab}
1.2%	33.08 ± 3.88	8.31 ± 4.57^{a}	10.12 ± 3.91	38.99 ± 2.16	36.39 ± 5.78^{a}	18.87 ± 4.39^{ab}
SEM	0.442	0.157	0.348	0.471	0,321	0.398
p	NS	**	NS	NS	**	**
Production stages and storage times (PST)						
Production stage						
Raw material	39.82 ± 1.52^{a}	19.68 ± 1.43^{a}	9.87 ± 1.23^{d}	40.14 ± 2.12	20.90 ± 2.41^{d}	7.69 ± 1.54^{d}
Before addition of cemen	27.95 ± 1.00^{c}	2.83 ± 0.45^{e}	2.50 ± 0.45^{f}	37.24 ± 1.68	34.17 ± 2.90^{c}	16.85 ± 2.11^{c}
After addition of cemen	28.28 ± 1.73^{c}	5.60 ± 1.24^{d}	5.70 ± 1.94^{e}	39.46 ± 2.35	35.67 ± 1.99^{b}	19.49 ± 1.48^{b}
Surface with cemen	39.25 ± 1.97^{a}	10.95 ± 1.45^{b}	17.78 ± 2.75^{a}	–	–	–
Pastırma	31.74 ± 1.06^{b}	7.14 ± 0.79^{c}	9.90 ± 1.32^{d}	40.28 ± 2.11	38.43 ± 1.56^{a}	21.74 ± 1.90^{a}
Storage (days)						
30	33.39 ± 3.26^{b}	6.78 ± 0.56^{c}	12.08 ± 2.61^{b}	38.96 ± 2.31	37.72 ± 1.72^{a}	19.32 ± 2.24^{b}
60	33.16 ± 2.67^{b}	6.72 ± 0.67^{c}	11.64 ± 2.34^{bc}	40.33 ± 2.82	38.20 ± 0.91^{a}	21.69 ± 1.76^{a}
90	32.39 ± 2.61^{b}	6.44 ± 0.77^{c}	10.88 ± 2.20^{bcd}	38.96 ± 2.36	37.94 ± 1.11^{a}	20.10 ± 1.94^{ab}
120	32.14 ± 3.07^{b}	6.51 ± 0.92^{c}	10.31 ± 2.49^{cd}	39.20 ± 2.80	37.87 ± 0.97^{a}	20.75 ± 2.47^{ab}
150	31.59 ± 2.83^{b}	7.01 ± 0.83^{c}	10.41 ± 1.93^{bcd}	38.67 ± 1.44	38.60 ± 1.94^{a}	20.18 ± 2.03^{ab}
SEM	0.699	0.248	0.551	0.707	0.0.482	0.596
p	**	**	**	NS	**	**
Interactions						
T × PST	NS	*	NS	NS	*	NS

Note: a–f: Any means in the same section and column with the same letters are not significantly different at $p < .05$. **$p < .01$. ±: Standard deviation
NS, not significant ($p > .05$).

Abbreviation: *SEM*: standard error of the mean.

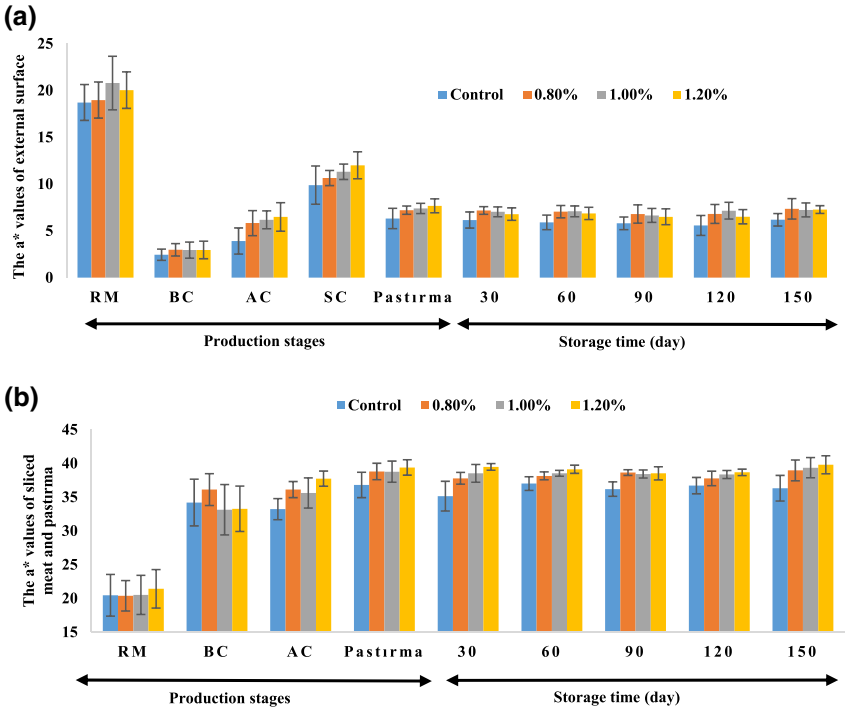


FIGURE 1 The effects of lyophilized red cabbage water extract during production stages and storage time (a)on the exterior surface a^* values, and (b) on the a^* values of sliced meat and pastirma (AC, after adding cemen; BC, before adding cemen; RM, raw material; SC, surface with cemen)

the addition of 1.0% and 1.2% LRCWE, the amount of anthocyanins of cemen paste is approximately doubled (Aksu et al., 2020a). In this way, the increase of LRCWE in cemen paste increased the a^* value of the pastırma. The a^* values did not change in pastırma samples containing LRCWE throughout storage period. This is because of the increasing color formation and decreasing discoloration effects of LRCWE due to anthocyanins and the other compounds. These results showed that LRCWE levels in cemen paste promotes color quality and stability of pastırma both during the processing and storage period. However, the lowest a^* values during the storage period were observed in the sliced pastırma samples coated with control cemen paste without LRCWE. In the sliced pastırma samples coated with cemen paste, similar findings were observed in the study by Aksu et al. (2020a), and they stated that the a^* values of cemen paste with 0.0%, 1.0%, and 1.2% LRCWE were 15.65 ± 0.94, 19.76 ± 3.01, and 19.56 ± 2.10, respectively. The color properties of sliced pastırma, especially a^* values, are a very important in terms of producer choice, and it is affects many factors such as quality of raw material (meat), production conditions and methods, curing methods and duration, curing compounds (salt, nitrite, nitrate, sugars, and starter cultures), cemen paste quality, cemening duration and temperature, storage period, storage conditions (packaging method, temperature, etc.), and microbiologic properties (Aksu & Kaya, 2005; Gok et al., 2008). However, the increase in the a^* value of pastırma in this research is due to the use of extracts obtained by lyophilization technique. In the lyophilization method, phytochemicals, phenolic compounds, and color pigments such as anthocyanins are protected and the loss of these substances is minimized (Sablani et al., 2011). There were some significant variations in terms of a^* values among pastırma samples. Aksu and Kaya (2001) determined that the a^* values changed between 13.66 and 36.63. Similar changes (14.01–43.59) were also found by Cakici et al. (2015). After 30 days of storage, a slight decrease in redness values in parallel with moisture loss was observed similar to the results by Lorenzo (2014), who reported that moisture loss increased pigment (myoglobin) concentrations and caused a decrease in L^* and a^* values. Results showed that using LRCWE had an effect ($p < .01$) on the b^* value of pastırma. Pastırma with added 0.8% LRCWE had higher b^* values than control pastırma (Table 1). The high b^* value in cemen paste with 0.8% LRCWE is due to the presence of lower levels of anthocyanins than in cemen paste with 1.0% and 1.2% LRCWE (Aksu et al., 2020a). In addition, the high b^* value in cemen paste with 0.8% LRCWE led to high b^* value in the pastırma. However, the control pastırma samples had a low b^* value than the other samples. The production stages and storage times had significant ($p < .01$) effect on b^* value of the sliced pastırma color. The b^* value significantly ($p < .05$) increased during the production stages, while this values had no changed after 60 days of storage time (Table 1). In parallel with the decrease in the external surface of the pastırma, the internal surface b^* values also decreased during storage. In Yetim et al. (2010), they found that b^* value decreased during the 21-day storage of cemen paste with red cabbage extract. The obtained results for control samples of pastırma were parallel with Aksu et al. (2005a). Similarly, Aksu et al. (2017) stated that the production stages significantly affect the L^*, a^*, and b^* values of the pastırma, and the redness and yellowness values were between 38.57 - 40.06 and 17.50 - 23.71, respectively.

3.3 | Amounts of salt and residual nitrite in pastırma with LRCWE

In this study, no significant differences ($p > .05$) in salt and residual nitrite amounts were observed between control and pastırma with

added LRCWE. The residual nitrite amounts in pastırma with added 0.0%, 0.8%, 1.0%, and 1.2% LRCWE were 1.27 ± 1.33, 1.19 ± 0.75, 1.06 ± 0.60, and 1.12 ± 0.62 ppm, respectively. In same pastırma samples, the amounts of salt were 5.41 ± 0.30, 5.02 ± 0.18, 5.14 ± 0.30, and 5.21 ± 0.38, respectively. The salt amount in pastırma was higher than the other traditional Turkish meat products such as kavurma (cooked meat, maximum 3.0%) (Anonymous, 2019). Similar results were reported by several researchers (Aksu & Kaya, 2001; Cakici et al., 2015; Erdemir & Aksu, 2017).

3.4 | Changes in moisture values in pastırma with LRCWE

It was observed that LRCWE addition had no effect ($p > .05$) on the moisture, while the production stages and storages time had a significant effect ($p < .01$) (Table 2). The storage time led to decrease ($p < .05$) in the mean moisture values from 44.01 ± 1.35% to 40.86 ± 2.25%. The moisture values determined in the pastırma samples are within the acceptable limits (<50.0% in pastırma without cemen) according to Turkish Food Codex (Anonymous, 2019). Similarly, it was reported that the moisture amounts of sliced pastırma decreased from 43.65 ± 0.18 to 40.41 ± 0.55% during the storage at 4°C for 150 days (Aksu & Kaya, 2005).

3.5 | Changes in pH values of pastırma with LRCWE

In Turkish Food Codex had been reported that the pH value of pastırma should be < 6.0 (Anonymous, 2019). In the present study, it was determined that the pH values of all pastırma groups was under <6.0 (Table 2). However, treatment had a significant effect ($p < .01$) on pH values. The addition of LRCWE to cemen paste led to decrease ($p < .05$) in pH values of pastırma due to lyophilized red cabbage water extracts have highly acidity properties (Aksu et al., 2016b). In pastırma, the low pH value provides advantages in terms of effectiveness of anthocyanins in the extract. There was a relation between low pH and preservation and stabilization of the a^*

TABLE 2 Mean values of moisture, pH, TBARS, and protein oxidation of pastırma produced with the different levels of LRCWE-added cemen pastes, and Duncan's multiple comparison test results ($p < .05$)

Extract level in cemen	Moisture (%)	pH	TBARS[1]	Protein oxidation[2]
Treatment (T)				
Control (%0)	47.60 ± 11.29	5.62 ± 0.09^{a}	23.65 ± 12.64^{a}	3.02 ± 0.94
0.8%	48.10 ± 11.01	5.59 ± 0.09^{a}	17.77 ± 9.54^{b}	3.11 ± 1.03
1.0%	47.70 ± 11.27	5.55 ± 0.07^{b}	16.58 ± 8.30^{b}	3.08 ± 1.16
1.2%	47.56 ± 11.11	5.56 ± 0.09^{b}	14.77 ± 7.49^{b}	3.17 ± 0.88
SEM	0.345	0.018	1.252	0.119
p	NS	**	**	NS
Production stages and storage times (PST)				
Production stage				
Raw material	75.64 ± 0.76^{a}	5.46 ± 0.10^{e}	2.21 ± 0.69^{d}	1.93 ± 0.33^{d}
Before addition of cemen	45.96 ± 2.37^{c}	5.62 ± 0.06^{b}	7.60 ± 3.18^{c}	1.96 ± 0.64^{d}
After addition of cemen	56.19 ± 1.21^{b}	5.55 ± 0.06^{cd}	16.67 ± 3.15^{b}	2.37 ± 0.35^{cd}
Pastırma	44.01 ± 1.35^{d}	5.53 ± 0.09^{d}	22.64 ± 5.40^{a}	2.74 ± 0.51^{c}
Storage (day)				
30	42.65 ± 1.53^{de}	5.60 ± 0.05^{bc}	23.20 ± 9.06^{ab}	3.33 ± 0.35^{b}
60	42.45 ± 1.48^{e}	5.56 ± 0.05^{cd}	22.91 ± 6.98^{a}	4.01 ± 0.58^{a}
90	40.97 ± 1.28^{f}	5.59 ± 0.06^{bc}	24.10 ± 8.15^{a}	4.02 ± 0.84^{a}
120	40.85 ± 1.44^{f}	5.63 ± 0.06^{b}	21.06 ± 9.16^{ab}	3.88 ± 0.86^{a}
150	40.86 ± 2.25^{f}	5.68 ± 0.05^{a}	23.31 ± 10.65^{a}	3.61 ± 0.58^{ab}
SEM	0.518	0.037	1.878	0.179
p	**	**	**	**
Interactions				
T × PTS	NS	NS	*	NS

Note: a–h: Any means in the same section and column with the same letters are not significantly different at $p < .05$. **$p < .01$. ±: Standard deviation. NS, not significant ($p > .05$).

SEM, standard error of the mean.

[1]μmol malonaldehyde/kg.

[2]nm carbonyl/mg protein.

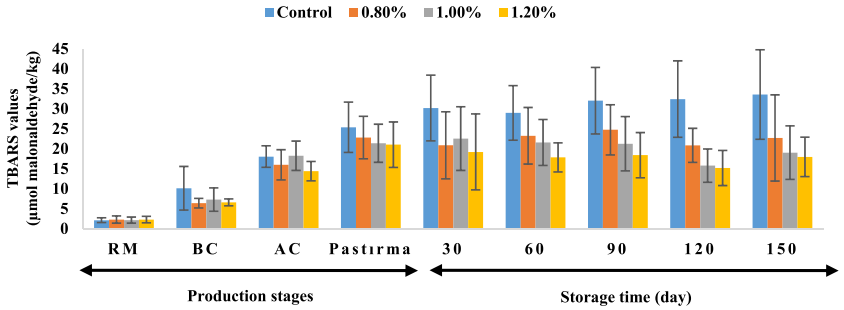


FIGURE 2 The effects of treatment and the production stages and storage time on the TBARS values of sliced meat and pastırma (AC, after adding cemen; BC, before adding cemen; RM, raw material)

values of pastırma during the production and storage; therefore, the use of LRCWE increased the quality of produced pastırma. In addition, the production stages and storage times had a significant effect ($p < .01$) on the pH value. The lowest pH values were found during the production stage (after addition of cemen) due to the presence of LRCWE in cemen paste (Table 2). Also, when the storage times were compared, it was observed that there was a significant increase in pH values ($p < .05$) and the highest pH values were on the 150 day of the storage period. In general, the pH values of pastırma increases during the processing stages and storage times due to proteolytic changes (Cakici et al., 2015). According to the results of the present study, pastırma with 1.0% and 1.2% LRCWE had the lowest pH values. These results showed that proteolytic changes at pastırma during storage had retarded with low pH with addition of LRCWE in cemen paste for pastırma.

3.6 | Changes in the lipid oxidation (TBARS) of pastırma with LRCWE

In the production stages and storage times of pastırma, lipid oxidation is slightly increased due to lipolytic changes (Aksu & Kaya, 2005; Gok et al., 2008; Ren et al., 2015). In this study, changes in the cemen paste with LRCWE were reflected in the changes TBARS values of pastırma (Table 2). Lipid oxidation decreased with increasing concentration of LRCWE in cemen paste of pastırma ($p < .01$, Table 2), and control pastırma without LRCWE had higher TBARS value than pastırma samples with LRCWE ($p < .05$). In other words, lipid oxidation reduced ($p < .01$) depending on the extract level in cemen paste of pastırma; consequently, LRCWE had more efficient inhibitor effect on primary oxidation. Pastırma including the extracts had the lowest values during storage ($p < .05$, Figure 2). This is because of the increasing antioxidant activity in the cemen paste with LRCWE (Aksu et al., 2020a). In addition, they reported that the total phenolic, FRAP reducing and metal chelating of cemen paste with 0.8%, 1.0%, and 1.2% LRCWE were higher than control cemen paste, and values of total antioxidant activity for 0.0%, 1.0%, and 1.2% were 31.78 ± 2.77%, 54.67 ± 9.34% and 53.78 ± 9.20%, respectively. However, antioxidant capacity of fresh red cabbage had stronger than treated red cabbage (stored, fermented stewed) (Wiczkowski et al., 2015). On the contrary, present study also showed that there was a relation between lipid oxidation and a^* values, because the increasing in the lipid oxidation had decreased redness (Tables 1 and 2).

3.7 | Changes in protein oxidation values of pastırma with LRCWE

Protein carbonyls are important components of protein oxidation in meat and meat products, and it commonly used as indicator. Results of this study showed that using LRCWE in cemen paste had no effect ($p > .05$) on protein oxidation of pastırma. However, the production stages and storage times had a significant effect ($p < .01$) on protein oxidation values. The highest increase in protein oxidation values was noted during the production stages and storage periods between 0 and 60 days. The carbonyl content, which reached its maximum level on day 90, decreased in the following storage periods (Table 2). Similarly, Li et al. (2019) reported that the carbonyl content of sarcoplasmic and myofibrillar proteins in sausages decreased after reaching the maximum on the 35th day during 90 days of ripening. Researchers attributed this reduction to the oxidation of carbonyls to carboxylic acids or the further reaction into Schiff-base adducts. Covalent modification of proteins with directly reactive oxygen species or with the seconder products of oxidative stress is named as protein oxidation. Lorido et al. (2016) expressed that the cross-links formation by the carbonylation pathway had an effect on the quality of the dried-cured loins produced from frozen meat and it might be a key oxidative damage. Estévez et al. (2011) and Utrera et al. (2014) also reported that meat proteins oxidized during storage. Researchers found that the oxidation of meat proteins leaded to a wide variety of chemical reactions such as formation of Schiff base structures, deperdition of thiols and tryptophan, formation of protein carbonyls. The various microbiologic and enzymatic changes occur in production stages (curing, drying, and cemening) and storage times of pastırma. The levels of fragmentation of protein as a result of this significant changes increase. In this way, water-soluble nitrogen, free amino acid and non-protein nitrogen amounts increase regularly depending on the processing stages and storage times (Ahhmed et al., 2014; Aksu et al., 2002, 2005a, 2005b; Aktas et al., 2005).

3.8 | Changes in microbiological counts of pastırma with LRCWE

The mean values of microbiological counts of pastırma produced with LRCWE-added cemen pastes and Duncan multiple comparison test results ($p < .05$) were showed in Table 3. The results clearly showed that LRCWE-added cemen pastes had no significant effect ($p > .05$)

on microbiological counts of pastırma. M/S counts were consistent with studies reporting that the dominant flora in dry-cured meat and pastırma were these microorganisms (Aksu et al., 2016a), and it was also determined that the addition of the extract had no effect on this bacterial group (Table 3). Our data for microbiological counts of pastırma was supported by Cakici et al. (2015) and Aksu and Kaya (2001, 2005)'s previous observations. *Enterobacteriaceae* counts were <2.00 log cfu/g in all pastırma samples. The storage time had significant effect on only mould-yeast count, and the highest reduction of this parameter occurred at 120 and 150 days of storage (Table 3). The mould-yeast count of pastırma during storage decreased consequently decreasing the moisture (Dogruer et al., 1998). According to our findings, the dominant microorganisms in the mold-yeast were yeast. Similarly, in the research carried out by Aksu and Kaya (2005), it was emphasized that the counts of mold-yeast decreased during the storage period in the sliced pastırma, which was stored for 150 days at 4°C and 10°C by vacuum and modified atmosphere packaged (50% N_2 + 50% CO_2), and the yeast dominated the flora within this microorganism group. This is also in agreement with results of other research (Aksu & Kaya, 2002a, 2002b; El-Khateib et al., 1987). Bruno et al. (2012) determined that pigments extract from red cabbage had a natural antimicrobial effect on *Staphylococcus aureus*, while no antimicrobial effect was reported on *Aspergillus niger*. Demirdöven et al. (2015) found that red cabbage extracts, in vitro, had a natural antimicrobial for *E. coli*, *B. cereus*, *L. monocytogenes*, *Salmonella* Typhimurium, and *S. aureus*.

3.9 | Changes in the sensory quality of pastırma with LRCWE

The quality of cured meat products such as pastırma depends on the extent and changes in sensory properties during processing and storage. In this study, five properties (intensity of appearance color, cemen paste quality, palatability, texture and structure, and overall acceptability) to determine the effect of LRCWE on the sensory quality of pastırma during the storage time were used. The intensity of appearance color increased significantly ($p < .01$) in the sliced pastırma with LRCWE, and the highest points were determined in pastırma groups with 1.0% and 1.2% lyophilized red cabbage water extract (Table 4). However, the storage time had no effect on the intensity of appearance color. Changes in the obtained results for the a^* values of sliced pastırma samples were paralleled with appearance color (Table 1). This results showed that LRCWE levels in cemen paste promote appearance quality and stability of pastırma color during the storage period. Similar changes were also found for "cemen paste quality" properties of pastırma, and there was a significant increase in the samples with 1.0% and 1.2%

TABLE 3 Mean values of microbiological counts of pastırma produced with the different levels of LRCWE-added cemen pastes, and Duncan's multiple comparison test results ($p < .05$)

Extract level in cemen	Total aerobic mesophilic bacteria count (log cfu/g)	*Micrococcus/Staphylococcus* count (log cfu/g)	Lactic acid bacteria count (log cfu/g)	Mould–Yeast count (log cfu/g)	*Enterobacteriaceae* count (log cfu/g)
Treatment (T)					
Control (%0)	6.20 ± 0.58	5.84 ± 0.65	3.75 ± 1.12	3.88 ± 1.24	<2.00
0.8%	6.41 ± 0.71	5.80 ± 0.67	4.03 ± 1.31	3.59 ± 0.96	<2.00
1.0%	6.36 ± 0.50	5.90 ± 0.55	3.86 ± 1.35	3.70 ± 0.97	<2.00
1.2%	6.18 ± 0.68	5.69 ± 0.56	3.52 ± 1.21	3.61 ± 0.70	<2.00
SEM	0.165	0.160	0.329	0.238	
p	NS	NS	NS	NS	
Storage time (ST)					
Pastırma	6.31 ± 0.66	5.73 ± 0.60	3.47 ± 0.98	3.56 ± 1.05^{ab}	<2.00
30	6.39 ± 0.75	5.96 ± 0.83	3.60 ± 0.77	4.30 ± 0.92^{a}	<2.00
60	6.22 ± 0.56	5.88 ± 0.59	3.68 ± 1.01	4.20 ± 1.19^{ab}	<2.00
90	6.43 ± 0.70	5.94 ± 0.65	3.87 ± 1.28	3.45 ± 0.94^{ab}	<2.00
120	6.21 ± 0.56	5.79 ± 0.52	4.05 ± 1.62	3.32 ± 0.63^{b}	<2.00
150	6.14 ± 0.53	5.56 ± 0.33	4.06 ± 1.64	3.34 ± 0.61^{b}	<2.00
SEM	0.202	0.196	0.403	0.291	
p	NS	NS	NS	*	
Interactions					
T × ST	NS	NS	NS	NS	

Note: a–c: Any means in the same section and column with the same letters are not significantly different at $p < .05$. ±: Standard deviation. *$p < .05$. **$p < .01$. *SEM*, standard error of the mean. NS, not significant ($p > .05$)

TABLE 4 Mean values of sensory analysis results determined in pastırma produced with the different levels of LRCWE-added cemen pastes, and Duncan's multiple comparison test results ($p < .05$)

Extract level in cemen	Intensity of appearance color	Cemen paste quality	Palatability	Texture and structure	Overall acceptability
Treatment (T)					
Control (%0)	6.56 ± 0.60^{b}	6.75 ± 0.41^{c}	6.67 ± 0.44^{c}	6.80 ± 0.41^{c}	6.71 ± 0.43^{c}
0.8%	6.76 ± 0.48^{b}	7.02 ± 0.31^{b}	6.96 ± 0.26^{b}	6.99 ± 0.39^{bc}	7.02 ± 0.36^{b}
1.0%	7.41 ± 0.39^{a}	7.21 ± 0.31^{ab}	7.17 ± 0.39^{b}	7.17 ± 0.41^{ab}	7.18 ± 0.36^{b}
1.2%	7.46 ± 0.43^{a}	7.39 ± 0.34^{a}	7.40 ± 0.43^{a}	7.39 ± 0.46^{a}	7.48 ± 0.35^{a}
SEM	0.109	0.081	0.076	0.086	0.079
p	**	**	**	**	**
Storage time (ST)					
Storage (day)					
0	7.09 ± 0.56	7.31 ± 0.40	7.42 ± 0.43^{a}	7.50 ± 0.28^{a}	7.46 ± 0.31^{a}
30	7.08 ± 0.61	7.02 ± 0.40	7.03 ± 0.48^{bc}	7.07 ± 0.38^{bc}	7.05 ± 0.43^{bc}
60	6.75 ± 0.79	7.01 ± 0.57	6.84 ± 0.44^{c}	7.05 ± 0.44^{bc}	6.96 ± 0.51^{c}
90	7.30 ± 0.52	6.97 ± 0.34	6.96 ± 0.47^{c}	6.81 ± 0.40^{c}	7.00 ± 0.41^{c}
120	6.89 ± 0.60	7.03 ± 0.39	6.79 ± 0.37^{c}	6.79 ± 0.55^{c}	6.83 ± 0.52^{c}
150	7.35 ± 0.53	7.22 ± 0.27	7.26 ± 0.32^{ab}	7.31 ± 0.31^{ab}	7.31 ± 0.30^{ab}
SEM	0.133	0.099	0.094	0.106	0.097
p	NS	NS	**	**	**
Interactions					
T × ST	NS	NS	NS	NS	NS

Note: a–c: Any means in the same section and column with the same letters are not significantly different at $p < .05$. *$p < .05$. **$p < .01$. ±: Standard deviation. *SEM*, Standard error of the mean. NS, not significant ($p > .05$).

LRCWE (Table 4). On the contrary, "palatability" and "texture and structure" properties of sliced pastırma were affected significantly by treatment ($p < .01$), and the lowest scores were found in the control samples while the highest scores were found in the group with 1.2% LRCWE. The storage time had also effects on palatability scores ($p < .01$), the average scores determined at the beginning of storage were higher than the values in the other days of storage (Table 4). Processing technologies (e.g., curing compounds, drying and fermentation/ripening conditions, contents of cemen paste and cemening time and temperature, storage conditions) as well as raw material (e.g., beef or water buffalo meat, muscle type) contribute to the variation of pastırma sensory and quality characteristics. In this study, the addition of LRCWE in cemen paste for pastırma led to increase in "overall acceptability" scores. It was also observed that all pastırma samples had acceptable properties in terms of "overall acceptability" scores for up to 6-point (Table 4). A little research had been devoted to determine the relationship between the sensory characteristics of pastırma or cemen paste during storage and its acceptability (Aksu et al., 2020c; Cetin et al., 1996; Dogruer et al., 1998; Kök, 1985; Nizamlioglu et al., 1998).

4 | CONCLUSIONS

The results indicated that the a^* color values of the surface of whole pastırma and the sliced pastırma increased compared to the control group depending on the level of LRCWE added to cemen paste for pastırma and this difference is maintained during storage. Similarly, the lipid oxidation reduced depending on the LRCWE levels. Pastırma produced with LRCWE-added cemen paste was more appreciated by sensorial compared to the control group pastırma. The addition of extracts to cemen paste of pastırma did not cause any changes on the moisture, protein oxidation, and microbiological properties of pastırma. Consequently, it was determined that cemen paste produced by using 1.0% or 1.2% LRCWE, as a natural colorant and antioxidant, could improve the quality of pastırma. The incorporation of LRCWE in cemen paste is a viable natural alternative instead of synthetic colorant agents to increase the quality characteristics of pastırma.

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CONFLICT OF INTEREST

The authors have declared no conflicts of interest for this article.

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