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Improvement of quality properties of cemen paste of pastirma by lyophilized red cabbage water extract

Muhammet Irfan Aksu[1] | Emre Turan[2] | Ihsan Güngör Sat[3] | Ebru Erdemir[4] | Fatih Oz[3] | Mustafa Gürses[3]

[1]Faculty of Agriculture, Department of Food Engineering, Eskişehir Osmangazi University, Eskişehir, Turkey

[2]Faculty of Agriculture, Department of Food Engineering, Ordu University, Ordu, Turkey

[3]Faculty of Agriculture, Department of Food Engineering, Atatürk University, Erzurum, Turkey

[4]Department of Nutrition and Dietetics, Health High School, Ibrahim Çeçen University, Ağrı, Turkey

Correspondence
Muhammet Irfan Aksu, Faculty of Agriculture, Department of Food Engineering, Eskişehir Osmangazi University, Eskişehir 26160, Turkey.
Email: mirfan.aksu@ogu.edu.tr, miaksu@hotmail.com

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Abstract

Red cabbage is an attractive vegetable with its rich anthocyanin content, antioxidant potential, and coloring properties. The aim of this study was to determine the properties of lyophilized red cabbage water extract (LRCWE) obtained from fresh red cabbage and the usability of different ratios (0%, 0.4%, 0.6%, 0.8%, 1.0%, and 1.2%) of this extract in the production of pastirma cemen paste. LRCWE had high total phenolic content, anthocyanin content, and antioxidant activity properties. The results showed that besides the increased total phenolic content, anthocyanin content, and antioxidant potential of pastirma cemen paste, the addition of LRCWE significantly improved the desired redness (a^*) and consumer acceptability compared to control samples. The best results in terms of redness, functional, bioactive, and sensory properties were determined in cemen pastes containing 1.0% and 1.2% LRCWE. In conclusion, the utilization of 1.0% and 1.2% LRCWE can be recommended as an alternative natural additive to synthetic colorants used in the production of pastirma cemen paste and threatening human health.

Practical applications

Pastirma is a meat product produced by the salting/curing, the 1st drying, 1st pressing, 2nd drying, cemening and the final drying processes of the whole muscle or muscles. "Cemening" is defined as keeping the meat in a cemen paste prepared with various materials for a certain period of time and then covering the outer surface of the meat with this paste. Cemening is an important stage affecting the quality features of pastirma. Synthetic dyes that threaten human health are added to the cemen paste to improve the color properties of the pastirma. The results of this research could offer an alternative to the use of colorants produced from natural sources instead of synthetic dyes for pastirma providers and contribute to the nutrition of consumers with healthier and safer meat products. In this way, functional properties of meat products processed as pastirma shall be increased.

1 | INTRODUCTION

Cemen paste is produced by adding water to *Trigonella foenum graecum* seed flour, crushed fresh garlic, hot, and sweet pepper powders (Aksu, Dogan, & Sirkecioglu, 2017; Aksu, Kaya, & Oz, 2006; Erdemir & Aksu, 2017). Cemen paste is not only used in the production of pastirma, a dry-cured meat product, but also consumed as a breakfast food. The application stage of cemen paste to pastirma is named

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as "cemening." This process is one of the most important stages in the formation of the quality of pastirma, and it is a process performed to bring in a unique appearance, color, aroma, and taste to pastirma (Dogruer, Nizamlioglu, & Gurbuz, 1998; Gökalp, Kaya, & Zorba, 2010). Other important features of cemen paste are (i) bactericidal effect due to garlic included in its composition, (ii) preventive effect against excessive drying, getting moldy, and oxidation by avoiding air contact, and (iii) protective effect against external factors and pests (Ceylan & Aksu, 2011; Dogruer et al., 1998). Although it is stated in Pastırma Standard (TS-9268) that the composition of pastirma cemen paste should contain 50% fenugreek flour, 35% garlic and 15% red pepper, there are differences in the usage rates of these ingredients in practical applications (Aksu, Aktas, & Kaya, 2002; Aksu et al., 2017; Aksu & Kaya, 2002, 2005; Aksu, Kaya, & Ockerman, 2005; Erdemir & Aksu, 2017; Tekinsen, Dogruer, Nizamlioglu, & Gurbuz, 1999; Yetim et al., 2017). However, it is stated that the quality of cemen paste dough is primarily affected by ground red pepper and garlic quality. Using low quality or small amount of red pepper in the production of pastirma cemen paste to give color and taste causes color defects in cemen paste. Accordingly, the frequent usage of synthetic dyes that threaten human health in the production of pastirma cemen paste is an important problem in the production of pastirma.

Vegetables such as red cabbage contain color pigments in different amounts and types depending on their maturity. Color pigments contain several anthocyanin, betalain, carotenoid, and chlorophyll compounds of different types and structures (Gandía-Herrero, Escribano, & García-Carmona, 2010; Jensen, López-de-Dicastillo Bergamo, Payet, Liu, & Konczak, 2011). Anthocyanins are the glycosides of the polyhydroxy and poly methoxy derivatives of 2-phenyl benzopirilium. Anthocyanins show differences according to factors such as the number of hydroxyl groups in the molecule, the degree of methylation of hydroxyl groups, the binding position, the number and type of sugars bound to the molecule, and the number and structure of aliphatic and aromatic acids bound to the sugars in the molecule (Mazza & Miniati, 1993). Acylation and copigmentation have important effects on the stability of anthocyanins. Giusti and Wrolstad (2003) stated that specifical aromatic acids and di- or poly-acylated flavylium cations do not discoloration even in environments with pH 5 and above, therefore have higher stability than non-acylated ones. Anthocyanins are the most important natural pigments that can be used commercially. These are the best known food coloring agents that give a shiny red color in a variety of foods. For this reason, Giusti and Wrolstad (2003) and Mizgier et al. (2016) stated that anthocyanins are considered as an important alternative to synthetic colorants. Anthocyanins are also biologically important compounds (Jensen et al., 2011). These compounds also affect human health positively by reducing cancer risk besides its other effects (Lazzè et al., 2004). Anthocyanins display color properties that vary from red to blue according to the pH of the medium (Jensen et al., 2011). However, it is also a known scientific reality that anthocyanins can maintain their color stability in different pH values. Synthetic coloring compounds used in the food industry are known to only improve the color of the food to which they are added. In contrast, coloring compounds from natural sources also improve the quality and safety of food because of their antioxidant and antimicrobial properties.

Red cabbage (*Brassica oleracea var. capitata f. rubra*) belongs to the Cruciferae family and is a colorful cabbage type with thick and plied leaves with red/purple color. Red cabbage is an anthocyanin-rich vegetable, contains 23 anthocyanin structures and the main anthocyanin is cyanidin-3-diglycoside-5-glycoside (McDougall, Fyffe, Dobson, & Stewart, 2007). Several studies have determined that red cabbage is an important antioxidant and antimicrobial (Boo et al., 2012; Demirdöven, Karabıyıklı, Tokatlı, & Öncül, 2015; Mizgier et al., 2016). Red cabbage is a natural source used as a food coloring agent. The coloring properties of red cabbage have been determined in the extracts of different products that are dried under normal or controlled conditions. Studies have been conducted to determine the properties of the lyophilized extract of fresh red cabbage, while no research has been conducted in the literature to identify the quality characteristics of the lyophilized form of the red cabbage water extract.

Compared with other drying methods in terms of maintaining the final product quality, the lyophilization method is recommended as the best choice for drying fruits and vegetables. Because the absence of liquid water, lack of oxygen under vacuum and low temperatures, most of the deterioration reactions slow down or are practically stopped, aroma losses are minimized (Bhatta, Stevanovic Janezic, & Ratti, 2020). In previous studies, it has been reported that the lyophilization technique has significantly benefited in preserving phenolic compounds, color pigments (anthocyanins, carotenoids, etc.), ascorbic acid, aroma components, and textural properties in fruits and vegetables (Bhatta et al., 2020; Gümüşay, Borazan, Ercal, & Demirkol, 2015; Palacios, Guillamón, García-Lafuente, & Villares, 2014; Rajkumar et al., 2017; Rodrigues, Dos Santos, Bergamasco, & Madrona, 2018).

The purpose of this study is to determine the quality characteristics of lyophilized red cabbage water extract (LRCWE), the usability of LRCWE as a natural colorant instead of synthetic food dyes in the production of pastirma cemen paste and its effects on the quality of the cemen paste. In this way, the desired color in cemen paste and pastirma may be provided, while other quality properties of pastirma can be improved due to the stated antioxidant and antimicrobial properties of the red cabbage water extract. For this purpose, primarily LRCWE was obtained from fresh red cabbages and various quality properties were determined. Secondly, these extracts were added to the composition of pastirma cemen paste in different ratios (0%, 0.4%, 0.6%, 0.8%, 1.0%, and 1.2%) and the usability in pastirma cemen paste production was determined. TPC (total phenolic content), FRAP (ferric reducing antioxidant power), DPPH (2,2'-diphenyl-1-picrylhydrazyl) radical scavenging activity, total antioxidant activity, total monomeric anthocyanin content, metal chelating activity, pH, titratable acidity, and color (L^*, a^*, and b^*) values were determined in both LRCWE and cemen pastes produced with different levels of LRCWE. In addition to these analyzes, sensory analysis was also performed on all cemen pastes produced. The current research

is the first research to determine the properties of LRCWE extract and its usability in the cemen paste production.

2 | MATERIALS AND METHODS

2.1 | Materials

The fresh red cabbage (*Brassica oleracea var. capitata f. rubra*), fenugreek seed flour (*Trigonella foenum graecum*), paprika and red pepper powder, and fresh garlic used in the research were purchased from the markets located in Erzurum, Turkey.

2.2 | Methods

2.2.1 | Preparation of LRCWE

Briefly, following the removal of one or two outer leaves of red cabbages, the red cabbages were washed, sliced, and crushed thoroughly using a kitchen-type blender. Then, 400 ml of distilled water was added on 20 g of crushed samples (Aksu, Alinezhad, & Erdemir, 2015; Alp & Aksu, 2010). After homogenizing the mixture using an ULTRA-TURRAX, it was stirred on the magnetic stirrer for 15 min at room temperature and filtered with No. 1 Whatman paper. The filtrate was concentrated using a rotary evaporator (at 40°C for 60 min). They were frozen at −38°C prior to lyophilization at −50°C. The obtained lyophilized red cabbage water extracts were kept under refrigerator conditions until used. Lyophilized red cabbage water extract powder is shown in Figure 1.

2.2.2 | Cemen paste production

Cemen paste was prepared by mixing 500 g fenugreek seed flour (*Trigonella foenum graecum*), 350 g fresh garlic, 75 g ground red pepper, 75 g paprika, and 1,200 ml of water (Aksu et al., 2005, 2006). Subsequently, the prepared cemen pastes were divided into six groups and LRCWE was added to each of the first five groups at 0.4%, 0.6%, 0.8%, 1.0%, and 1.2% concentrations, respectively. The sixth group without extract was evaluated as the control (0% LRCWE). The experiment was conducted in triplicate and analyzes were carried out after the samples were kept in airtight glass containers for 24 hr at 4°C. Figure 2 presents cemen pastes produced in three replicates with different concentrations of LRCWE.



FIGURE 1 Lyophilized red cabbage water extract (LRCWE) powder

2.2.3 | pH and titratable acidity

Titratable acidity and pH values of LRCWE and cemen pastes were determined by the methods in Cemeroğlu (2010). The pH measurement was performed using a calibrated pH-meter with buffer solutions (pH 4.0 and pH 7.0). Titratable acidity on the basis of citric acid (%) was determined by titration with 0.1 N NaOH using phenolphthalein as the indicator.

2.2.4 | Color measurement

The color values (L^*, a^*, and b^*) of the extracts and cemen pastes were determined by the Minolta CR-400 (Ø11mm, Minolta Co, Osaka, Japan) colorimeter with D65 illuminant and 2° standard observer after placing the samples in glass Petri dishes on a white surface. CIE Lab (Commision Internationele de l'eClairage) L^* (0 = darkness, 100 = lightness), a^* (+60 = red, −60 = green), and b^* (+60 = yellow, −60 = blue) values are determined as indicators of lightness, redness, and yellowness, respectively (Cakici, Aksu, & Erdemir, 2015). The instrument was calibrated with a standard calibration plate before color measurements.

2.2.5 | Total phenolic content

The total phenolic content (TPC) was determined using the methods described by Singleton, Orthofer, and Lamuela-Raventós (1999). Briefly, 0.5 ml of Folin–Ciocalteu reagent and 0.25 ml of Na_2CO_3 (20%) solution were added into the test tubes containing 1 ml of sample extract and the final volume was adjusted to 10 ml with distilled water. After the mixtures were kept at room temperature for 30 min in the dark, the absorbance was measured against the control at 760 nm with a spectrophotometer. TPC was calculated as mg gallic acid equivalent (GAE)/g weight using a gallic acid standard curve plotted daily.

2.2.6 | FRAP activity

FRAP (ferric reducing antioxidant power) activity of the samples was determined according to Gao, Björk, Trajkovski, and Uggla (2000) with some modifications. Different concentrations of sample extracts were transferred to the test tubes and mixed with the FRAP reagent (contains 0.3 M acetate buffer, pH 3.6, 10 mM TPTZ (2,4,6-tri (2-pyridyl) −1,3,5 triazine) and 20 mM $FeCl_3.6H_2O$ in 10:1: 1 ratio). After the

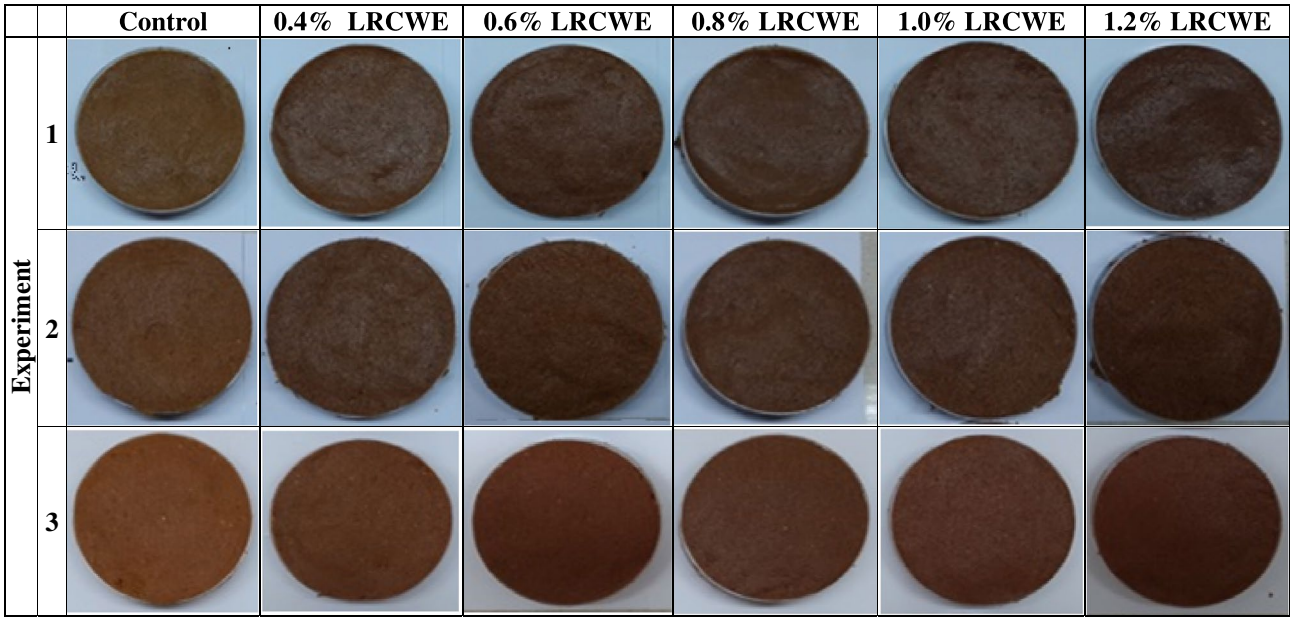


FIGURE 2 Cemen pastes produced with different concentrations of lyophilized red cabbage water extract (LRCWE) in three replications

absorbance was measured at 593 nm. FRAP activities of extracts and cemen samples were calculated as μmol Trolox equivalent (TE)/g.

2.2.7 | DPPH radical scavenging activity

DPPH (2,2'-diphenyl-1-picrylhydrazyl) free radical scavenging activity was determined by the method in Blois (1958). Different concentrations of sample extracts were transferred to test tubes and the final volume adjusted to 3 ml volume with ethanol. After the DPPH solution was added, the mixture was vortexed and kept in the dark for 30 min. Absorbance was measured using a spectrophotometer at 517 nm. DPPH free radical scavenging activity of the samples was calculated as % inhibition.

2.2.8 | Total antioxidant activity

The antioxidant activity of samples was determined according to the thiocyanate method. In a test tube, 0.1 ml of sample solution was mixed with 2.4 ml of phosphate buffer and 2.5 ml of linoleic acid emulsion. After coloring the reaction with Fe^{2+} and thiocyanate (SCN^-) at intervals during the incubation of the mixture at 37°C in the dark, absorbances were determined at 500 nm using a spectrophotometer. Total antioxidant activity was calculated as a percentage inhibition (Yen & Chen, 1995).

2.2.9 | Metal chelating activity

Metal chelating activity was determined by the method in Bursal and Gülçin (2011). Briefly, different concentrations of samples were mixed with 125 μl of $FeSO_4.7H_2O$, 500 μl of Tris–HCl buffer (pH 7.4), and 500 μl of 2,2′-bipyridine solution, and 1,25 ml of ethanol. The total volume was adjusted to 3 ml with distilled water. The mixture was kept at room temperature for 10 min and the absorbance was determined at 522 nm.

2.2.10 | Total monomeric anthocyanin content

Total monomeric anthocyanin contents of lyophilized red cabbage water extract and cemen pastes were determined spectrophotometrically by the pH differential method (Lee et al., 2005). The results were calculated as cyanidin-3-glycoside (cy3-G) and malvidin 3-glycoside (mlv3-G) and expressed in mg/kg.

2.2.11 | Sensory evaluation

Sensory evaluation was performed by taking into account the taste, color, consistency, smell properties, and general acceptability level of cemen pastes produced using different extract levels and a hedonic type scale (1–9) was used in the panel. The expert panelist group of 10–12 people was informed in detail before sensory evaluation.

2.2.12 | Statistical analysis

The research was conducted according to a completely random design with three repeats. The results obtained were subjected to variance analysis and parameters that were found important among treatment groups (cemen paste with 0.0%, 0.4%, 0.6%, 0.8%,

1.0%, and 1.2% LRCWE) were compared with Duncan's Multiple Comparison Test.

3 | RESULTS AND DISCUSSION

3.1 | Properties of lyophilized red cabbage water extract (LRCWE)

Properties of lyophilized red cabbage water extract are presented in Table 1. The total monomeric anthocyanin content of LRCWE was determined as 4,712.70 ± 73.94 mg cy3-G/kg and 5,522.50 ± 86.64 mg mlv3-G/kg, respectively. Bruno, Campañone, and Martino (2012) determined the anthocyanin content of red cabbage extracts obtained with acid solution (1% HCl) as 8.9 mg/ml. Mizgier et al. (2016) reported the total content of anthocyanins present in the extract from red cabbage as 175.0 mg cy3-G/g dry matter. Anthocyanins are natural coloring agents that are widely spread in the food industry as an alternative to synthetic coloring agents (Walkowiak-Tomczak & Czapski, 2007). Espín, Soler-Rivas, Wichers, and García-Viguera (2000) indicated that anthocyanins not only give attractive color properties to food, but also increase the oxidative stability of foods due to their high antiradical capacity. The anthocyanin content found for LRCWE in the current research is quite high and results are remarkable in this regard. These results show that anthocyanins are largely transferred into water and these anthocyanin-rich extracts can be used as natural coloring agents in food industry. Since anthocyanins are structurally sensitive compounds, their quantities decrease depending on the storage conditions. It was determined that the shelf life of red cabbage solution (containing 20 mg/100 ml of anthocyanin) decreased depending on temperature, the increase of pH, and ascorbic acid concentration (Walkowiak-Tomczak & Czapski, 2007). The anthocyanin content of fruits and vegetables depends on genetic and environmental conditions, as well as food processing and storage conditions that have a significant effect (Wiczkowski, Szawara-Nowak, & Topolska, 2015).

TABLE 1 Some properties of lyophilized red cabbage water extracts (LRCWE)

Properties	Mean ± Std
pH	5.52 ± 0.02
Titratable acidity (% citric acid)	1.96 ± 1.16
Color values	
L^*	22.14 ± 1.26
a^*	21.55 ± 0.82
b^*	−14.22 ± 0.42
Total phenolic content (mg GAE/g)	100.49 ± 4.66
DPPH radical scavenging activity (%)	79.21 ± 1.91
FRAP activity (μmol/g)	131.70 ± 3.67
Metal chelating activity (%)	55.50 ± 0.48
Total antioxidant activity (%)	32.00 ± 5.06
Total anthocyanin content	
as mg cyanidin-3-glucoside/kg	4,712.70 ± 73.94
as mg malvidin-3-glucoside/kg	5,522.50 ± 86.64

Note: ±, Standard deviation.

The total phenolic content of LRCWE was determined as 100.49 ± 4.66 mg GAE/g. FRAP, DPPH radical scavenging, total antioxidant, and metal chelating activities were determined as 131.70 ± 3.67 μmol/g, 79.21 ± 1.91%, 32.00 ± 5.06%, and 55.50 ± 0.48%, respectively (Table 1). These results show that the red cabbage extract has significant properties that eliminate the reactive hydroxyl and superoxide anion radicals with the radical scavenging effect. Due to these properties, red cabbage is evaluated among the plants with high antioxidant capacity (Podsędek, 2007). Mizgier et al. (2016) reported FRAP activity, DPPH, and ABTS (2,2-azinobis (3-ethylbenzothiazoline-6-sulphonic acid) radical scavenging activities of red cabbage extracts as 2.49, 1.50, and 2.53 mmol TE/g, respectively. Upadhyay, Sehwag, and Singh (2016) determined the total phenolic content of red cabbage methanol extracts as 2.26 mg GAE/ g fresh weight. Total phenolic content of LRCWE in the present study is higher than the amount (1.3 mg/100 g) reported by Bruno et al. (2012). Moreover, the same researchers determined the antioxidant activity (DPPH assay) of red cabbage as 67%. These differences are thought to arise from the agricultural conditions in which the plant is grown and the extraction methods.

As shown in Table 1, the pH and titratable acidity values of lyophilized red cabbage water extracts were 5.52 ± 0.02 and 1.96 ± 1.16%, respectively. The L^* value expressing the brightness of the lyophilized red cabbage water extract was determined as 22.14 ± 1.26 and the average a^* value expressing the redness was determined as 21.55 ± 0.82 ranging between 20.28 and 23.54. The b^* value (positive value represents yellow color and negative value represents blue color) was found to be −14.22 ± 0.42 on average. The high amount of anthocyanins in LRCWE increases the redness (a^*) value when a suitable pH range is maintained.

The pH values of fruit and vegetable extracts significantly affects the properties of color pigments. Anthocyanins show color features changing from red to blue according to the pH of the medium (Jensen et al., 2011). However, the color stabilities of anthocyanins at different pH values are also preserved. Giusti and Wrolstad (2003) stated that specifical aromatic acids and di- or poly-acylated flavylium cations do not discoloration even in environments with pH 5 and above, and show higher stability than non-acylated ones. Substances other than anthocyanins in fruit juices and extracts provide this stability are defined as "COPIGMENT". Flavonoids, phenolic acids, alkaloids, amino acids, purines, polysaccharides, and anthocyanins can be shown as copigments (Chen & Stephen Inbaraj, 2019). Theoretically, anthocyanins should not give too much color to fruits and vegetables at their natural pH, but in practice this is just the opposite. Although copigments are colorless substances, they contribute to strengthening anthocyanins and increasing color tone by complexing them (Babaloo & Jamei, 2018). Copigmentation, which is the hydrophobic collaboration of the chromophore of anthocyanin with a planar electronically saturated section of the copigment, leads to a configuration (π-π stacking) of

anthocyanin and copigment molecules due to van der Waals forces and hydrophobic effects in the aqueous medium. Attacks leading to colorless hemiketal and chalcone forms are partially prevented. The red colored flavilium cation is protected against nucleophilic attack of water, peroxide, and sulfur dioxide bleaching, and pH changes (Gordillo, Rodríguez-Pulido, Escudero-Gilete, González-Miret, & Heredia, 2012; Gradinaru, Biliaderis, Kallithraka, Kefalas, & Garcia-Viguera, 2003; Malien-Aubert, Dangles, & Amiot, 2001).Thus, an increase in absorbance (hyperchromic effect) and replacement of the maximum absorbance toward higher wavelengths (bathochromic effect) are observed in the visible region (Gradinaru et al., 2003; Patras, 2019). Babaloo and Jamei (2018) investigated the effects of various concentrations of copigments (tannic, caffeic, benzoic, and coumaric acids) as well as different pH values (1, 2, 3, 4) on anthocyanin-copigment complexes (1:1). Researchers reported that the anthocyanin stability increases due to copigment concentration, caffeic acid provides the best anthocyanin stability compared to other copigments, and the hyperchromic effect and the bathochromic shifts are the strongest at pH 2 and pH 4, respectively.

3.2 | Results of cemen pastes produced with lyophilized red cabbage water extract

3.2.1 | Physicochemical properties

The pH, titratable acidity, and color (L^*, a^*, and b^*) values determined in cemen pastes produced with different levels (0.0%, 0.4%, 0.6%, 0.8%, 1.0%, and 1.2%) of LRCWE are given in Table 2. The addition of lyophilized red cabbage water extract had a significant effect on pH ($p < .01$) and titratable acidity ($p < .05$) values in cemen paste. Depending on the increased extract level, the pH value of cemen pastes decreased and titratable acidity increased (Table 2). This decrease in pH can be attributed to the acidity of LRCWE. The pH values determined in the control cemen paste are compatible with Aksu et al. (2006) but higher than the values determined by Yetim et al. (2017). The color values of cemen paste were significantly affected by the addition of lyophilized red cabbage water extract ($p < .01$). The redness value (a^*) of cemen pastes generally increased depending on the amount of extract added, and the highest values were observed in groups with 1.0% and 1.2% LRCWE, increasing by about 4 units. The addition of extract reduced the L^* and b^* values of cemen pastes. In a previous study, it was found that some acidic additives increased the redness value of cemen pastes and this redness value was preserved to a great extent during 30 days of storage at 4°C (Yetim et al., 2017). Similarly, Yetim, Ekici, Simsek, and Sagdic (2010) determined that anthocyanin-based extracts of red cabbage and black carrot can be used as color stabilizers in cemen paste for at least 7 days of storage. The color values in the current study are quite important since the redness can be improved by the addition of LRCWE to pastirma cemen paste, and these extracts can be used instead of synthetic coloring agents. Depending on the level of extract added to cemen paste, it can be stated that the increase in acidity value and the decrease in pH value are effective in increasing the redness (a^*) value. Chigurupati, Saiki, Gayser, and Dash (2002) emphasized that solutions produced from dried red cabbage change color according to pH and red color pigments are more stable at low pH values.

3.2.2 | Total phenolic content and antioxidant activity

The addition of LRCWE significantly affected the total phenolic content of cemen paste ($p < .05$) and the amount of phenolic substance increased in parallel with the increase in LRCWE level ($p < .05$) (Table 3). The highest increase was determined in 1.0% and 1.2% LRCWE-added groups compared to control samples. FRAP activities of cemen pastes were significantly affected by the addition of LRCWE ($p < .01$). The lowest and highest values were determined in the control sample and 1.2% extract-added cemen pastes as 237.06 ± 11.17 and 316.98 ± 27.16 μmol/g, respectively (Table 3).

Metal chelating activity, DPPH free radical scavenging, and total antioxidant activities of cemen pastes treated with lyophilized red cabbage water extract are presented in Table 3. The addition of lyophilized red cabbage water extract improved the metal chelating activity

TABLE 2 The pH, titratable acidity, and color (L^*, a^*, and b^*) values of cemen pastes containing different levels of LRCWE

Extract levels	pH	Acidity (%)	L^*	a^*	b^*
Control	5.99 ± 0.12 a	0.74 ± 0.11 b	48.36 ± 1.48 a	15.65 ± 0.94 b	32.98 ± 3.34 a
0.4%	5.88 ± 0.76 b	0.77 ± 0.10 ab	41.72 ± 4.12 b	17.13 ± 0.55 ab	28.91 ± 2.23 ab
0.6%	5.84 ± 0.04 c	0.83 ± 0.07 ab	38.77 ± 3.92 b	17.58 ± 0.21 ab	28.22 ± 3.57 b
0.8%	5.75 ± 0.02 d	0.89 ± 0.08 ab	40.27 ± 2.86 b	17.67 ± 0.99 ab	26.19 ± 2.53 b
1.0%	5.75 ± 0.01 d	0.91 ± 0.08 a	37.76 ± 1.39 b	19.76 ± 3.01 a	24.82 ± 1.34 b
1.2%	5.71 ± 0.05 e	0.94 ± 0.11 a	37.86 ± 2.55 b	19.56 ± 2.10 a	25.27 ± 1.03 b
SEM	0.037	0.05	1.685	0.934	1.455
p	**	*	**	*	**

Note: a–e: Any means in the same column with the same letters are not significantly different at $p < .05$.
LRCWE, lyophilized red cabbage water extract; ±, Standard deviation; SEM, Standard Error of Means.
**$p < .01$; *$p < .05$.

TABLE 3 Amounts or rations (%) of total phenolic content, FRAP activity, DPPH radical scavenging activity, total antioxidant, and metal cheating activities of cemen pastes containing different levels of LRCWE

Extract levels	Total phenolic content (mg/g)	FRAP activity (μmol/g)	DPPH radical scavenging activity (% inhibition)	Total antioxidant activity (%)	Metal chelating activity (%)
Control	3.73 ± 0.04 b	237.06 ± 11.17 d	40.40 ± 6.09	31.78 ± 2.77 c	11.86 ± 0.70 e
0.4%	4.08 ± 0.06 ab	257.917 ± 9.82 c	45.86 ± 6.34	40.44 ± 5.82 bc	15.08 ± 0.29 d
0.6%	4.00 ± 0.14 ab	269.64 ± 14.05 bc	44.90 ± 6.28	38.22 ± 10.20 c	15.66 ± 0.63 cd
0.8%	4.14 ± 0.28 ab	274.94 ± 14.84 b	46.96 ± 8.79	54.22 ± 3.35 ab	17.01 ± 1.02 bc
1.0%	4.16 ± 0.19 ab	283.31 ± 21.41 b	50.57 ± 6.29	54.67 ± 9.34 a	17.96 ± 0.87 b
1.2%	4.44 ± 0.41 a	316.98 ± 27.16 a	54.09 ± 7.44	53.78 ± 9.20 ab	19.96 ± 1.47 a
SEM	0.131	10.097	4.007	4.274	0.523
p	*	**	NS	**	**

Note: a–e: Any means in the same column with the same letters are not significantly different at $p < .05$.
LRCWE, Lyophilized red cabbage water extract; NS, Non-significant; ±, Standard deviation; SEM, Standard Error of Means.
$^{**}p < .01$; $^{*}p < .05$.

TABLE 4 Amounts of monomeric anthocyanin of cemen pastes containing different levels of LRCWE

	Monomeric anthocyanin content (mg/kg)	
Extract levels	Cyanidin3-glucoside	Malvidin-3-glucoside
Control	149.31 ± 9.64 d	157.59 ± 10.17 d
0.4%	163.06 ± 8.07 d	172.10 ± 8.52 d
0.6%	168.12 ± 12.46 d	177.44 ± 13.15 d
0.8%	243.14 ± 12.08 c	256.62 ± 12.76 c
1.0%	290.65 ± 24.06 b	306.77 ± 25.39 b
1.2%	326.11 ± 33.08 a	344.20 ± 34.91 a
SEM	10.884	11.487
p	**	**

Note: a–d: Any means in the same column with the same letters are not significantly different at $p < .05$.
LRCWE, lyophilized red cabbage water extract; ±, Standard deviation; SEM: Standard Error of Means.
$^{**}p < .01$.

($p < .01$) and total antioxidant activities ($p < .01$) of cemen pastes, but had no significant effect on DPPH radical scavenging activity values ($p > .05$). The highest value of metal chelating activities was determined in cemen paste containing the highest extract level and an increase of approximately 8% ($p < .05$) was observed in these samples compared to the control. Total antioxidant activity properties of cemen pastes were also improved by adding red cabbage lyophilized water extract to pastirma cemen paste ($p < .01$) and the highest values were found in samples with 0.8%, 1.0%, and 1.2% extract ($p < .05$) (Table 3). Total antioxidant activities of LRCWE added cemen pastes increased by about 9%–13% compared to the control group. Although DPPH radical scavenging activities of cemen pastes treated with LRCWE increased by about 5%–14% compared to the control group, there was no significant difference between treatments ($p > .05$). Considering all antioxidant activity values, the highest antioxidant activities were determined in cemen pastes containing 1.2% and 1.0% extracts.

Cemen paste has important effects in creating the quality and extending the storage period of pastirma. Pastirma, a traditional product produced by dry salting, is exposed to lipid oxidation hence quality features decrease during production and storage. In other words, lipid oxidation is an important problem in pastirma. Therefore, improving antioxidant activities of cemen paste by adding LRCWE shall also increase the pastirma quality.

3.2.3 | Total monomeric anthocyanin content

Total monomeric anthocyanin contents as cyanidin−3-glucoside and malvidin-3-glucoside of cemen pastes produced by adding different ratios of lyophilized red cabbage water extract are presented in Table 4. The anthocyanin content of cemen pastes was significantly affected by the addition of LRCWE containing high amounts of anthocyanins ($p < .01$). Total anthocyanin content as cyanidin-3-glucoside determined as 149.31 ± 9.64 mg/kg in control group, increased in samples added 0.8%, 1.0%, and 1.2% extract and the highest value was determined as 326.11 ± 33.08 mg/kg in cemen pastes containing 1.2% extract. Similar changes were also observed with regard to the amount of malvidin-3-glucoside and the highest increase compared to control (157.59 ± 10.17) was found in 1.2% extract-added cemen pastes (344.20 ± 34.91 mg/kg) (Table 4). The high amount of anthocyanins in LRCWE increased the anthocyanin content of cemen pastes. Apart from rich acylated anthocyanin structure with strong antioxidant activity and many nutritional benefits, red cabbage is valued by consumers due to its intense red color that increases the aesthetic value of foods (Wiczkowski, Szawara-Nowak, & Topolska, 2013). In control samples, the amount of anthocyanin detected at the level of about 150 mg/kg is related to ground hot and sweet pepper in the cemen paste formulation. The main anthocyanin found in pepper species is delphinidin-3-trans-coumaroyl rutinoside-5-glucoside (nasunin). It has been reported that the total anthocyanin content of some pepper species as equivalents cyanidin-3-glucoside and delfinidin-3-glucoside range between

TABLE 5 Scores of sensory analysis of cemen pastes containing different levels of LRCWE

Extract levels	Color	Consistency	Smell	Taste	Overall acceptability
Control	4.67 ± 0.14 c	6.69 ± 0.15	6.71 ± 0.04	5.98 ± 0.06	5.96 ± 0.11 c
0.4%	5.61 ± 0.41 b	7.07 ± 0.16	6.81 ± 0.16	5.89 ± 0.29	6.18 ± 0.18 c
0.6%	6.08 ± 0.22 ab	6.87 ± 0.26	6.78 ± 0.21	6.18 ± 0.31	6.27 ± 0.47 bc
0.8%	6.38 ± 0.34 ab	6.97 ± 0.25	6.59 ± 0.30	6.29 ± 0.55	6.53 ± 0.26 abc
1.0%	6.63 ± 0.64 a	7.04 ± 0.21	6.65 ± 0.35	6.70 ± 0.62	6.85 ± 0.51 ab
1.2%	6.86 ± 0.81 a	7.18 ± 0.20	6.60 ± 0.13	6.79 ± 0.51	6.99 ± 0.44 a
SEM	0.280	0.122	0.128	0.251	0.208
p	**	NS	NS	NS	**

Note: a–e: Any means in the same column with the same letters are not significantly different at $p < .05$.
LRCWE, lyophilized red cabbage water extract; NS, Non-significant; ±, Standard deviation; SEM, Standard error of means.
**$p < .01$.

0.80–49.2 mg/kg fresh weight and 90–321.5 mg/kg fresh weight, respectively (Arnnok, Ruangviriyachai, Mahachai, Techawongstien, & Chanthai, 2012; Lightbourn et al., 2008). To our best knowledge, there have been no studies conducted to determine the anthocyanin content of pastirma cemen paste. The results in the present study are very important in this respect. It is understood from the current results that the anthocyanins in the traditional cemen paste combination are insufficient to provide the desired color. By improving the color properties of the cemen paste combination, pastirma color quality shall also be improved. Therefore, the supplement of natural additives containing anthocyanins is very important in the combination of cemen paste.

3.2.4 | Sensory analysis

Sensory analysis results determined in cemen pastes produced by adding different rates of (0.0%, 0.4%, 0.6%, 0.8%, 1.0%, and 1.2%) red cabbage lyophilized water extract are given in Table 5. The addition of different levels of red cabbage lyophilized water extract to pastirma cemen paste had important effects on color and overall acceptability ($p < .01$) (Table 5). The color scores of cemen pastes increased with increasing extract concentration, and the color score which determined as 4.67 ± 0.14 in the control, increased by approximately 2 points in cemen pastes containing 1% and 1.2% extract. The addition of LRCWE had no significant effect on the consistency, smell, and flavor properties of cemen pastes ($p > .05$). Although the taste scores of cemen pastes treated with LRCWE increased compared to the control samples, no significant difference was observed between treatments ($p > .05$). LRCWE contributed significantly to the overall acceptability levels of cemen pastes ($p < .01$) and the groups with the highest overall acceptability were cemen pastes containing 1% and 1.2% LRCWE in parallel to color scores ($p < .05$) (Table 5). Considering these findings, it is concluded that 1.0% and 1.2% LRCWE provides the desired color and improves the sensory quality of pastirma cemen paste without negatively affecting the taste and consistency.

4 | CONCLUSION

In this research for the first time, the properties of LRCWE and its effects on the quality properties of pastırma cemen paste were determined. The LRCWE had substantially anthocyanin and phenolic content and showed high antioxidant activity. In this way, the red color formation of cemen paste increased as well as its antioxidant and sensory properties were improved.In this study, it is revealed that LRCWE is a suitable additive that can be used instead of synthetic dyes in cemen paste production with its high anthocyanin content and color properties. As a result, utilization of 1.0% and 1.2% lyophilized red cabbage water extracts can be suggested to reduce the use of synthetic dyes in cemen paste production and to maintain the functional food properties of pastirma. In addition, this extract can be used in meat products other than pastirma and in the production of foodstuffs with red food coloring added.

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CONFLICT OF INTEREST

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

ORCID

Muhammet Irfan Aksu https://orcid.org/0000-0001-9391-6955
Emre Turan https://orcid.org/0000-0002-4289-0107
Ihsan Güngör Sat https://orcid.org/0000-0001-9868-0208
Ebru Erdemir https://orcid.org/0000-0001-5001-8151
Fatih Oz https://orcid.org/0000-0002-5300-7519
Mustafa Gürses https://orcid.org/0000-0001-6859-4085

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