Afyon Kocatepe Üniversitesi Fen ve Mühendislik Bilimleri Dergisi
Afyon Kocatepe University – Journal of Science and Engineering
https://dergipark.org.tr/tr/pub/akufemubid

Araştırma Makalesi / Research Article
DOI: https://doi.org/10.35414/akufemubid.1253934
AKÜ FEMÜBİD **24** (2024) 025401 (341-349)
AKU J. Sci. Eng. **24** (2024) 025401 (341-349)

Effect of Storage on the Antioxidant, Color and Sensory Properties of Local Bread

Makale Bilgisi / Article Info
Alındı/Received: 20.02.2023
Kabul/Accepted: 09.03.2024
Yayımlandı/Published: 29.04.2024

Yöresel Ekmeğin Antioksidan, Renk ve Duyusal Özelliklerine Depolamanın Etkisi

Seda YALÇIN*

Afyon Kocatepe University, Afyon Vocational School, Food Processing Department, Afyonkarahisar, Turkey

Abstract

The aim of this study is to evaluate the effect of storage on antioxidant, color and sensory properties of bread, containing sourdough and potato puree, baked in stone oven in Afyonkarahisar which is city of Turkey. Sourdough was used as yeast for the production of bread. Potato puree was added to the formulation at the ratio of 30%. Breads were stored in sealed polyethylene bag at room temperature (20°C) for 1, 5 and 10 days. Bread characterization, color, β-carotene, phenolics, minerals were analyzed and a sensory evaluation was performed. Decrease in bread mass, height, width, crust thickness, total volume and specific volume were observed. β-carotene and phenolic compounds quantity of breads decreased with increasing of storage time. Storage caused a change in the crumb color of breads. Storage statistically didn't affect the crust color values of breads. According to the panelist scores, it can be concluded that all breads stored 1, 5 and 10 days had a desired crust color, crumb texture, porosity, aroma and overall acceptance.

Keywords: *Potato; β-carotene; Bread; Sourdough; Storage*

Öz

Bu çalışmanın amacı, Türkiye'nin Afyonkarahisar ilinde ekşi hamur ve patates püresi içeren taş fırında pişirilen ekmeğin antioksidan, renk ve duyusal özelliklerine depolamanın etkisini değerlendirmektir. Ekşi hamur, ekmek yapımında maya olarak kullanılmıştır. Formülasyona %30 oranında patates püresi eklenmiştir. Ekmekler oda sıcaklığında (20°C) 1, 5 ve 10 gün süreyle polietilen poşet içinde depolanmıştır. Ekmek karakterizasyonu, renk, β-karoten, fenolikler, mineraller analiz edilmiş ve duyusal değerlendirme yapılmıştır. Ekmeğin kütlesi, boyu, genişliği, kabuk kalınlığı, toplam hacmi ve özgül hacminde azalma gözlenmiştir. Ekmeklerin β-karoten ve fenolik bileşenleri miktarı depolama süresinin artmasıyla azalmıştır. Depolama, ekmeklerin iç renginde değişikliğe neden olmuştur. Depolama istatistiksel olarak ekmeklerin kabuk rengi değerlerini etkilememiştir. Panelist puanlarına göre 1, 5 ve 10 gün depolanan tüm ekmeklerin istenilen kabuk rengine, iç dokuya, gözenekliliğe, aromaya ve genel kabule sahip olduğu sonucuna varılabilir.

Anahtar Kelimeler: *Patates; β-karoten; Ekmek; Ekşi hamur; Depolama*

1. Introduction

Afyonkarahisar is a city located in the west of Turkey. Potato sourdough bread is local product in Afyonkarahisar. Afyonkarahisar potato sourdough bread is made by villagers in the countryside or by housewifes in neighborhood bakeries in the city center. Although it is usually made with the same methods, small recipe or process differences have led to the emergence of various flavors and forms. In this sense, Afyonkarahisar's potato sourdough bread is the closest type of bread to the concept of village bread. Homemade breads are made with completely natural sourdough. While preparing bread in Afyonkarahisar, boiled potatoes are added to increase its flavor and nutritional value and to delay staling. It is cooked in stone-based ovens. Its difference from other traditional breads is that its sour flavor and pore structure are richer. The potatoes of the region add a different texture to the bread. It has a non-intense sourness and a confident, modest aroma. It is a type of traditional bread that is very popular with its 10-day shelf life and has a higher nutritional value than normal breads (Gurman, 2018).

Carotenoids are effective antioxidants with health promoting functions like provitamin A activity, reduction of cardiovascular disease, cancer, age related degeneration diseases and prevention of skin disorders (Schieber and Carle, 2005). Sweet potatoes (Ipomoea batatas L.) have high amounts of dietary fibre, minerals, vitamins and antioxidants which are phenolic acids, anthocyanins, tocopherol and β-carotene (Woolife, 1992). These compounds are obtained from yellow sweet potatoes. Sweet potato flour contains high levels of β-carotene, dietary fiber, carbohydrate and protein (Kamal et al., 2013). β-carotene, found as 25-30% of the total carotenoids in plants, is the highest bioconversibility in the human body and prevents development of

*Sorumlu Yazar/Corresponding Author: Seda YALÇIN e-posta/e-mail: syalcin@aku.edu.tr

tumorigenesis in skin, lung, liver and colon (de Carvalho et al., 2018). It increases basal dermal defense against UV irradiation and provides longer term protection (Stahl and Sies, 2012). Potato also provides reducing sugar, alternative as natural dye and source of β-carotene in breads. So it can generate economic gains for agribusiness and benefits for human with vitamin A deficiency (Nogueria et al., 2018). Van Jaarsveld et al. (2006) investigated β-carotene of orange-fleshed sweet potato (Resisto) and reported that β-carotene of Resisto ranged between 132-194 mg/g and after boiling of Resisto, 70-80% of β-carotene was retained. Kotíková et al. (2016) investigated the retention of carotenoids in potatoes after thermal processing and reported that boiling and baking caused a decrease in total carotenoids (92% and 88%, respectively). Tian et al. (2016) investigated carotenoid content of purple potatoes after cooking and reported that reduction ranged from 20.15 to 76.16%. Bonsi et al. (2016) investigated β-carotene amount in bread including wheat flour and potato puree (2.5/1) compared to wheat bread and reported that β-carotene amount in bread with potato puree was approximately 6-fold higher. Oluwalana et al. (2012) investigated the quality of breads made with sweet potato flour (Nigeria) and wheat flour in the percentage proportion of 0:100, 5:95, 10:90, 15:85 and 100:0. According to this study, protein, fat and carbohydrate content of breads are 10.15-12.44%, 4.36-4.68% and 80.44-105.97%, respectively. Sodium, calcium and potassium contents of breads are 46.88-73.74 mg/100g, 3.58-4.64 mg/100g and 162.81-358.75 mg/100g, respectively. It was reported that potato flour can be added to formulation up to 15% level. Roudrigez-Sandoval et al. (2012) investigated the effects of potato flour on bread properties. Substitution levels of potato flour were 10% and 20%. It was reported that mass, height and width of bread including 10% potato flour are similar to those of wheat bread. Trejo-González et al. (2014) replaced wheat flour with 5-20% sweet potato flour (Mexican cultivar cv Nylon) in bread formulation and reported that all breads with sweet potato flour were different from control bread in porosity. Iancu (2015) reported that resistant starch content of bread was increased with addition of potato-paste (30%). Wanjuu et al. (2018) investigated the physicochemical properties and shelf life of composite bread with sweet potato puree (30%) and wheat flour (70%) and compared with standard wheat bread (100% wheat flour). Breads were stored at 7, 20, 25 and 30°C. β-carotene content decreased with increasing storage temperature and time. Breads containing sweet potato puree (6 days) had longer shelf life than wheat bread (4 days). Dako et al. (2016) reported that sensory properties such as appearance, aroma, taste, moutfeel and overall acceptability showed that bread including 15% sweet potato flour scored above 6 (like slightly) range and acceptable by panelists. Ma et al. (2022) reported that potato steamed bread including α-amylase (20 mg/kg) and lipase (40 mg/kg) showed the lowest hardness, increasing the specific volume, L* and overall acceptability. Lactic acid bacteria (LAB) especially lactobacillus species is most dominating microorganism in sourdough. Other bacterial species are Leuconostoc, Lactococcus, Enterococcus Weissella, Pediococcus and Streptococcus (Liu et al., 2018). LAB gives flavors to sourdough bread. Fermentation with LAB produces flavors in crumb and crust of bread (Hansen and Schieberle, 2005). Sourdough-based products are healthier than the others which are produced with normal dough. In which, lactobacillus neutralize the phytic acid, thus, making products easier to digest (Hayta and Hendek Ertop, 2017). Degradation of phytates and antinutritional agents enhances the mineral availability (Kariluoto et al., 2004). Sourdough, which has industrial benefits like high shelf life owing to antifungal and antibacterial properties, is a potential tool to increase bread quality without the use of additives and lowers addition of chemicals such as anti-staling and anti-fungal (Sakandar et al., 2019). Barber et al. (1993) investigated the effect of spontaneous sourdough on the characteristics and shelf-life of white bread and reported that spontaneous sourdough gave the bread with the high volume, good crumb grain and the low rate of staling during storage.

Studies examining quality of bread containing potato flour have been investigated (Trejo- González, 2014; Nogueria et al., 2018; Rodrigues-Sandoval et al., 2012). However, no research has been seen in literature about the quality of bread containing both sourdough and potato puree. Therefore, investigation into the effect of storage on quality of local bread with long shelf life (10 days) should be worthwhile. In this present study, the effect of storage (1 day, 5 days, 10 days) on quality of local bread was investigated. Sourdough was used as yeast in local bread production. Potato puree was used for increasing the nutritional value of local bread. The difference from other breads, local bread shows higher shelf life due to containing sourdough.

2. Materials and Methods

2.1. Materials

Hard wheat flour, salt and yellow potatoes were purchased at a local market in Turkey.

2.2. Methods

Yellow potatoes were covered with water and open-pot-boiled for 30 minutes and peeled. Then those were pressed and cooled. Potato puree was obtained. Moisture, ash and protein contents were determined in hard wheat flour and potato puree according to AACC International Approved Methods 44-01.01, 08-01.01 and 46-13.01, respectively (AACC, 2010).

Colors of hard wheat flour and potato puree were determined according to the L*, a* and b* parameters, using a spectrophotometer (Konica Minolta, Cr-400/410). β-carotene, phenolics and minerals of hard wheat flour and potato puree were determined according to the methods reported by Akpan et al. (2006); Ulusoy et al. (2009); Caponio et al. (1999) and Gopalani (2007), respectively.

Extensograph properties of hard wheat flour were determined according to the International Association for Cereal Science and Technology with standard method number 114/1 (ICC, 1992) using an extensograph (Brabender, Duisburg, Germany). Dough (150 g) was passed through the balling unit of extensograph. After 45 min resting in the fermentation cabinet, the dough was stretched. The dough was tested again after 45 min. The test was repeated after 45 min. The maximum resistance, the extensibility, the energy (area under the curve) and maximum resistance to extensibility ratio (R/E) were obtained from the extensograph graphic.

2.2.1. Bread production

The production of bread containing sourdough and potato puree was carried out according to Official Geographical Sign and Traditional Product Name Bulletin (Number: 14, Anonymous, September 26, 2017) with some modification. Dough pieces were separated from the previous bread dough and stored in sealed polyethylene bag at room temperature for ten days. During that, the dough was soured. This sourdough was used as yeast in bread production. 10 kg flour, 1 kg sourdough, 3 kg potato puree, 0.15 kg salt and 6 kg water were used. Photographs of breads are shown in Figure 1. The "pre-dough", called yeast, was prepared the night before. Sourdough taken from the previously made bread dough is dissolved with warm water. Flour, salt and melted sourdough were mixed together and the dough was kneaded until it becomes not sticky to the hand by adding enough hot water to withstand the hand. A little flour was sprinkled on the dough, covered with a thick cloth and left at room temperature until the next day (12 hours). In this way, the first fermentation was completed. Since Afyonkarahisar potato sourdough bread does not contain any additives in its composition and is fermented with sourdough, the fermentation process takes many times longer than other types of bread. Then hot water, salt and potato puree were added to dough and mixed for one hour. Dough (1.8kg) was left for one and a half hours to complete the second fermentation. Thereafter, the doughs were brought to a circular shape and left for another hour for the last fermentation. 160°C was applied to the dough in the stone oven for 45 minutes (Ideal, AiM167, Turkey). Breads were left for cooling another 15 minutes. After cooling, breads were stored at room temperature (20°C) in the presence of oxygen and light for 1, 5 and 10 days. Production was made in triplicate.

Figure 1. Photograph of local bread

2.2.2. Analysis of breads

2.2.2.1. Moisture, ash and protein content of breads

Moisture, ash and protein content of breads were determined according to AACC International Approved Methods 44-01.01, 08-01.01 and 46-13.01, respectively (AACC, 2010).

2.2.2.2. Bread technological characterization

Weight of breads was determined by using a balance. Height and width were determined by using ruler. Crust thickness was determined by using caliper.
The baking loss of the breads was determined as below:

$$\text{Baking loss (\%)} = \frac{(\text{dough mass} - \text{bread mass})\text{x}100}{\text{dough mass}} \quad (1)$$

Bread total volume was assessed by rapeseed displacement method 10–05.01 (AACC, 2000). The specific volume of the bread was calculated using the equation: the volume (cm^3)/ mass (g) ratio, after 3 h of cooling. Analysis was made in duplicate.

2.2.2.3. Color values of breads

Colors of bread crumb and crust were determined according to the L*, a* and b* parameters using spectrophotometer (Konica Minolta, Cr-400/410). Analysis was made in duplicate.

2.2.2.4. β-carotene content of breads

β-carotene of breads was extracted according to the method reported by Akpan et al. (2006) and analyzed according to the method reported by Ulusoy et. al. (2009). HPLC (Shimadzu Prominence, Japan), equipped with diode array detector (SPD-M20A) and ODS 2 column (100 x 4.6 mm, 5 µ) were used for determination of β-carotene in breads. Analysis was made in duplicate.

2.2.2.5. Phenolic compounds of breads

Phenolic compounds of breads were analyzed according to the method of Caponio et al. (1999) with some modifications by using HPLC (Shimadzu Prominence, Japan) equipped with diode array detector (SPD-M20A) and Zorbax Eclipse C18 column (250 x 4.6 mm, 5 µ). Analysis was made in duplicate.

2.2.2.6. Mineral content of breads

Potassium, calcium, magnesium, phosphorus and zinc of breads were determined according to the method reported by Gopalani et al. (2007) by using Perkin Elmer ICPOES Optima 8000 (USA). 1 g sample was added to 65% HNO_3 (8 mL) and 30% H_2O_2 (2 mL) and heated to 110°C in 15 min and then waited at these conditions for 15 min at microwave oven (Milestone start D, Italy). The wavelengths of potassium, magnesium, calcium, phosphorus and zinc were 766.49 nm, 279.07 nm, 315.88 nm, 214.91 nm and 213.85 nm, respectively. Analysis was made in duplicate.

2.2.2.7. Sensory analysis

Sensory analysis was applied to breads after 1 day, 5 days and 10 days. The sensory panel contained 20 trained people (10 males and 10 females, age range: 18–59 years). The hedonic test with 7 point scale ranged between 1 (extremely dislike) and 7 (extremely like) described by Yuliana et al. (2018). The breads were evaluated for crust color, crumb texture, porosity, aroma and overall acceptance. Score of crust color: 7 (pale brown), 3 (brown), 1 (dark brown). Score of crumb texture: 7 (very soft), 1 (very hard). Score of porosity: 7 (very uniform), 1 (extremely not uniform). Score of aroma: 7 (extremely not acidic), 1 (very acidic). Score of overall acceptance: 7 (extremely like), 1 (extremely disliked).

2.2.2.8. Statistical analysis

Data related to height, width, crust thickness, total volume, specific volume, color values, β-carotene and phenolic compounds of the breads were statistically evaluated in duplicate by one-way analysis of variance procedure. The Duncan test was applied to compare mean values.

3. Results and Discussions

3.1. Characterization of raw materials

Moisture contents of hard wheat flour and potato puree were 13.5% and 79.2%, respectively. Ash content of hard wheat flour was 0.74% dry matter (d.m.) which was higher than ash content (0.58%) of wheat flour reported by Nogueira et al. (2018). Ash content of potato puree was 4.86% (d.m.). Protein content of hard wheat flour was 13.93% (d.m.). Ktenioudaki et al. (2010) reported that protein content of eight wheat varieties from various geographical regions ranged between 8.2% and 13.4% which were lower than protein content of hard wheat flour. Protein content of potato puree was 8.06% (d.m.).
L*, a* and b* color values of hard wheat flour were 88.04, -1.065, and 15.60, respectively. Nogueira et al. (2018) reported that L*, a* and b* color values of wheat flour were 97.00, 0.71 and 10.36, respectively. The color of wheat flour comes from carotenoids, fibers and protein content. L*, a* and b* color values of potato puree were 70.77, -7.56 and 24.53, respectively. The color of potato puree was sustained from carotenoids, anthocyanins and phenolic compounds. L* and a* color values of hard wheat flour were higher than that of potato puree, while b* color value of hard wheat flour was lower than that of potato puree.

β-carotene of hard wheat flour was 275.88 mg/kg (d.m.), while that of potato puree was 510.18 mg/kg (d.m.). β-carotene content of potato puree was higher than β-carotene of potato pulp which was reported by Takahata et al. (1993). Takahata et al. (1993) reported that the carotenoid amount in orange or yellow-white potato pulp ranged between 0.65 and 265 µg/g.

Gallic acid, chlorogenic acid, syringic acid, vanilic acid, p-coumaric acid, ferulic acid and cinamic acid of hard wheat flour were 22.46, 93.26, 37.94, 31.10, 0.01, 12.44 and 0.34 mg/kg (d.m.), while those of potato puree were 1315.95, 896.58, 882.97, 121.77, 0.13, 6.75 and 36.88 mg/kg (d.m.), respectively. The results of potato puree were lower than the results reported by Tian et al (2016). Authors demonstrated that chlorogenic acid, caffeic acid, p-coumaric acid and ferulic acid of raw potatoes were 463.72, 47.31, 22.37 and 24.36 mg/100g (d.m.). After boiling, those were 370.59, 30.84, 21.45 and 15.61 mg/100g (d.m.), respectively. After baking, those were 285.11, 11.10, 18.95 and 10.46 mg/100g (d.m.), respectively. Chlorogenic acid content was notably decreased by all cooking methods (boiling, baking, steaming, microwave, frying). Baking and frying were highly effective on chlorogenic acid. Caffeic acid was significantly affected by cooking methods, especially baking and frying. P-coumaric acid content after baking and steaming decreased a little. Ferulic acid didn't notably altered by boiling. Cooking has a negative impact on phenolic acids. Destruction of caffeic acid was more than that of chlorogenic acid.

Potassium, calcium, magnesium, phosphorus and zinc contents of hard wheat flour and potato puree were 574464, 151254, 155446, 619238 and 1570 mg/kg (d.m.) and 48761.02, 3687.38, 3262.00, 8306.50 and 15.21 mg/kg (d.m.), respectively.

Maximum resistance (670 BU) for hard wheat flour was higher compared to wheat flour samples, reported by Ktenioudaki et al. (2010) which were Cordiale (Ireland), Raffles (Ireland), Hereward (UK), Malacca (UK), Caphorn (France), Tzeneroso (Greece), Tzemele (Greece) and the Canadian blend, while extensibility (127mm) for hard wheat flour was lower.

3.2. Bread properties

3.2.1. Moisture, ash and protein content

Moisture content of local breads stored 1 day, 5 days and 10 days were 33.50, 29.80 and 26.40 %, respectively. Ash content of local breads ranged between 1.79 and 1.92% (d.m.). Protein content of local breads ranged between 9.55 and 10.76% (d.m.), which are similar to protein results reported by Oluwalana et al. (2012). Oluwalana et al. (2012) investigated the quality of breads made with sweet-potato flour (Nigeria) and wheat flour in the percentage proportion of 0:100, 5:95, 10:90, 15:85 and 100:0 and found protein contents in breads between 10.15 and 12.44%.

3.2.2. Characterization of breads

The decrease in mass of local breads containing sourdough and potato puree with storage is shown in Figure 2. During storage, the decrease in local bread mass was polinomial so the reaction kinetic followed second order (r^2= 0.9986). The mass loss of local bread during 10 days storage was found as 10.26%. According to Tontul and Babaoğlu (2019), mass loss of white bread during 6 days storage was 14.91%. This indicated that local bread has longer shelf life compared to white bread. Local bread height, width, crust thickness, total volume and specific volume are given in Table 1. The higher baking loss (10.80%) was measured in local bread than that of bread including lentil, dextran and sourdough (7.74%) by Perri et al. (2021). Total volume of local bread was higher (7350cm^3) compared to that of bread including lentil, dextran and sourdough (1533 cm^3). Local bread led to lower specific volume (4.71 cm^3/g) than that of bread including lentil, dextran and sourdough (3.3 cm^3/g). Specific volume of local bread was higher (4.71 cm^3/g) compared to that of bread containing potato flour at the level of 3-9% (3.74-3.47 cm^3/g) reported by Nogueira et al. (2018) and that of orange-fleshed sweet potato bread (3.86-3.99 cm^3/g) reported by Wanjuu et al. (2018). Because local bread contains sourdough. The bread weight, height, width, crust thickness, total volume and specific volume of local breads decreased with increasing of storage time due to staling. Ayo Omogie (2021) reported that specific volume of potato bread including 25% sweet potato flour and 75% wheat flour was 2.08 cm^3/g.

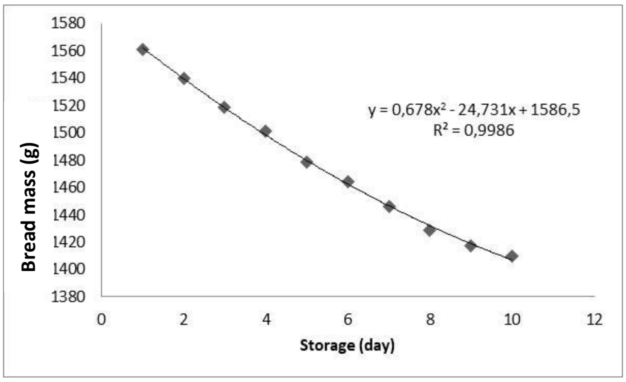

Figure 2. The decrease in local breads weight with storage

3.2.3. Colors of bread crumb and crust

No significant difference among L* crumb color values of local breads containing sourdough and potato puree was observed (Table 2.). Storage time affected a* and b* crumb color of breads, significantly. b* crumb color values increased with increasing of storage time. There is no significant difference between a* crumb color values of breads stored 5 days and 10 days. Storage didn't significantly affect L*, a* and b* crust color values of breads. Yellowness of local bread crumb increased with storage due to β-carotene loss. Because **t**he change in redness (a*) and yellowness (b*) of the bread associate with the carotenoid content. The degradation of carotenoids caused a change in color (Limbo et al., 2007). The present results about crumb color (a* and b*) corroborate with findings of Nogueria et al. (2018) who found that storage caused an increase in a* and b* crumb color values.

3.2.4. β-carotene of breads

Storage negatively affected β-carotene content of local bread containing sourdough and potato puree. β-carotene amount of local bread decreased with increasing of storage time (Table 2). Because β-carotene shows low stability to light, oxygen and temperature (Fonseca et al. 2008). According to Wanjuu et al. (2018), storage of orange-fleshed sweet potato bread at temperatures of 20, 25 and 30°C resulted in loss of β-carotene. Nogueira et al. (2018) reported that β-carotene losses on day 5 was 25%, while on day 10 was 56%, which were higher than β-carotene losses (20%) after 9 day storage of breads.

3.2.5. Phenolic compounds of breads

The effect of storage on phenolic compounds of local breads is shown in Table 3. Storage affected phenolic compounds content of local bread containing sourdough and potato puree. Phenolic compounds (gallic acid, chlorogenic acid, syringic acid, vanillic acid, p-coumaric acid, ferulic acid, cinnamic acid) decreased significantly with the increase of storage time from 1 day to 10 days. Phenolic compounds have effects as antioxidants. So storage at room temperature caused the reduction in phenolic compounds of local breads containing sourdough and potato puree. Stabilities of phenolic compounds to light and oxygen were ranged like this; Ferulic acid > p-coumaric acid > chlorogenic acid > cinnamic acid > gallic acid > syringic acid > vanillic acid.

3.2.6. Minerals of breads

Potassium, calcium, magnesium, phosphorus and zinc amounts of local breads containing sourdough and potato puree were 769617, 165848, 165202, 605945 and 13.87 mg/kg (d.m), respectively. Potassium content of potatoes caused an increase in potassium of local breads. Potassium content in local bread containing sourdough and potato puree was higher compared to that in bread containing potato flour reported by Oluwalana et al. (2012). Oluwalana et al. (2012) reported that sodium, calcium and potassium contents of breads with potato flour were 46.88-73.74 mg/100g, 35.3-4.64 mg/100g and 162.83-38.75 mg/100g, respectively. Helou et al. (2016) reported that potassium, calcium, magnesium, phosphorus and zinc contents of white breads ranged between 189- 207, 25.10-28.70, 33.4-37.8, 146-158 and 1.01-1.25 mg/100 g (d.m.), respectively. Bibiana et al. (2014) reported that β-carotene and calcium increased with increasing levels of sweet potato in bread.

3.2.7. Sensory scores of breads

Sensory profile of local breads containing sourdough and potato puree stored for 1 day, 5 days and 10 days is shown in Figure 3. Score of crust color for local bread stored 1 day was similar to that for those stored 5 days and 10 days. Score of crumb texture for those stored 1 day was higher than that for those stored 5 days and 10 days. Score of porosity for those stored 1 day was similar to that for those stored 5 days and 10 days. Score of aroma for bread stored 1 day was higher compared to that for those stored 5 days and 10 days. Overall acceptance score was higher for bread stored 1 day than that for those stored 5 days and 10 days. All scores of those stored 1 day, 5 days and 10 days were found to be higher than 4. Depending on the higher scores (> 4), it can be stated that all local breads stored 1 day, 5 days and 10 days had the desired crust color, crumb texture, porosity, aroma and overall acceptance. According to Lu et al. (2021), potato based bread was chewy when it was fresh and it became floury and crumbly after just one day of storage at room temperature.

Table 1. Characterization of local breads stored for 1 day, 5 days, 10 days

Sample	Height (cm)	Width (cm)	Crust thickness (mm)	Total volume (cm^3)	Spicific volume (cm^3/g)
Bread 1. day	13.9±0.4^a	32±0.7^a	4.5±0.1^a	7350±91^a	4.71±0.1^a
Bread 5. day	13.2±0.2^b	30±0.3^b	4.0±0.1^b	6900±89^b	4.67±0.1^a
Bread 10. day	12.8±0.2^c	28±0.2^c	3.5±0.1^c	6500±75^c	4.61±0.1^a

Mean values in the same column are significantly different ($p<0.05$).
Mean ± Standard deviation

Table 2. L*, a*, b* crust and crumb color values, β-carotene of local breads stored for 1 day, 5 days, 10 days

Sample	L* crust	a* crust	b* crust	L* crumb	a* crumb	b* crumb	β-carotene (IU)
Bread 1. day	42.06±1.74[a]	16.55±0.79[a]	26.60±1.68[a]	71.46±2.40[a]	-3.50±0.18[b]	21.42±0.11[c]	339.96±9.79[a]
Bread 5. day	42.41±1.34[a]	17.36±0.36[a]	27.61±0.40[a]	78.45±0.81[a]	-2.53±0.11[a]	24.61±0.29[b]	253.41±2.09[b]
Bread 10. day	43.65±0.74[a]	17.88±0.19[a]	27.72±0.09[a]	77.85±5.86[a]	-2.53±0.35[a]	26.80±0.45[a]	150.97±3.28[c]

Mean values in the same column are significantly different (p<0.05).
Mean ± Standard deviation.

Table 3. Phenolic compounds of local breads stored for 1 day, 5 days, 10 days

Samples	Gallic acid (mg/kg)	Chlorogenic acid (mg/kg)	Syringic acid (mg/kg)	Vanillic acid (mg/kg)	p-Coumaric acid (mg/kg)	Ferulic acid (mg/kg)	Cinnamic acid (mg/kg)
Bread 1. day	378.60±2.82[a]	37.81±1.06[a]	275.58±3.11[a]	41.35±3.13[a]	0.09±0.02[a]	4.10±0.58[a]	0.98±0.06[a]
Bread 5. day	326.89±3.78[b]	27.63±1.65[b]	251.34±3.45[b]	32.02±6.33[b]	0.07±0.07[b]	1.82±0.18[b]	0.89±0.11[b]
Bread 10. day	224.44±1.88[c]	15.47±1.22[c]	193.50±3.67[c]	29.06±1.96[c]	0.02±0.01[c]	0.059±0.01[c]	0.57±0.02[c]

Mean values in the same column are significantly different (p<0.05).
Mean ± Standard deviation

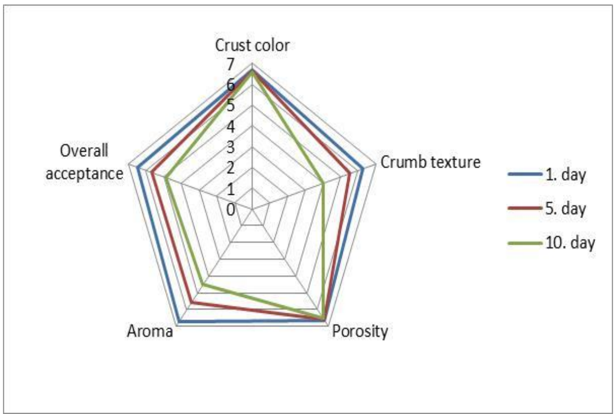

Figure 3. Sensory profile of local breads stored for 1 day, 5 days and 10 days

4. Conclusions

Bread weight, height, width, crust thickness, total volume, specific volume, β-carotene content and phenolic compounds were affected statistically from storage. Local bread is nutritionally beneficial, as it includes high amounts of β-carotene that persisted for 10 days. Local breads had an acceptable sensory properties, because avarage mean score of overall acceptance of local bread stored 10 days is above 4. By visual observation, local bread did not show spoilage until the tenth day. The local bread is hence more shelf stable. From this result, it can be concluded that local bread containing sourdough and potato puree had long shelf life (10 days). Consequently, bread waste can be prevented and this contributes to the World economy because local bread containing sourdough and potato puree lasts longer than other breads. Longer shelf life would also be positive for distribution logistics and therefore also reduce costs.

Declaration of Ethical Standards

The author declares that they comply with all ethical standards.

Declaration of Competing Interest

The author has no conflicts of interest to declare regarding the content of this article.

Data Availability Statement

All data generated or analyzed during this study are included in this published article.

Acknowledgement

I wish to thank Afyon Kocatepe University Scientific Research Projects Coordination Unit for the financial support (Project No: 18.KARİYER.163).

5. References

AACC, 2000. Approved methods of the American association of cereal chemists (11th ed.). MN, USA: St. Paul.

AACC, 2010. International Approved Methods:44-01.01, 08-01.01 and 46-13.01.

Akpan, U. G., Jimoh, A., & Mohammed, A. D., 2006. Extraction, characterization and modification of castor seed oil. *Leonardo Journal of Sciences, **8(1)**,* 43-52.

Anonymous, Official Geographical Sign and Traditional Product Name Bulletin numbered 14 (September 26, 2017) registered by Turkish Patent and Trademark Authority.

Ayo-Omogie, H. N., 2021. Gluten-Reduced sweet Potato-Wheat bread: Influence of fermented sweet potato flour addition on bread quality and dough rheology. *Journal of Culinary Science & Technology*, ***19*****(3),** 187-213.

Bibiana, I., Grace, N., & Julius, A., 2014. Quality evaluation of composite bread produced from wheat, maize and orange fleshed sweet potato flours. *American Journal of Food Science and Technology,* **2(4),** 109-115.

Bonsi, E.A., Zabawa, R., Mortley, D., Bonsi, C., Acheremu, K., Amagloh, F.C., Amagloh, F.K., 2016. Nutrient composition and consumer acceptability of bread made with orange sweet potato puree. *Acta Horticult,* ***1128,*** 7-14.

Caponio, F., Alloggio, V., Gomes, T., 1999. Phenolic compounds of virgin olive oil: influence of paste preperation techniques. *Food Chemistry*, ***64,*** 203-209.

Dako, E., Retta, N., Desse, G., 2016. Comparison of three sweet potato (Ipomoea Batatas (L.) Lam) varieties on nutritional and anti-nutritional factors. Global *Journal of Science Frontier Research: D Agriculture and Veterinary,* ***6(4),*** 62-72.

De Carvalho LMJ, Ortiz G. MD, de Carvalho J.V, de Oliveira ARG, 2018. Carotenoids in Raw Plant Materials. In Progress in Carotenoid Research. IntechOpen (***Chapter 6,*** 107-119).

Fonseca, M. J. D. O., Soares, A. G., Freire Junior, M., de Almeida, D. L., & Ascheri, J. L. R., 2008. Effect of extrusion-cooking in total carotenoids content in cream and orange flesh sweet potato cultivars. *Horticultura Brasileira,* ***26,*** 112-115.

Gopalani, M., Shahare, M., Ramteke, D.S., Wate, S.R., 2007. Heavy metal content of potato chips and biscuits from Nagpur city, India. *B environ contam toxicol,* ***79(4),*** 384-387.

Gurman, Z., 2018. Afyonkarahisar ili ev ekmeği yapımı ve kullanılan gereçler. VIII**.** Uluslararası Afyonkarahisar Araştırmaları Sempozyumu (pp. 271-272).

Hansen, A., & Schieberle, P., 2005. Generation of aroma compounds during sourdough fermentation: Applied and fundamental as- pects. *Trends in Food Science & Technology,* ***16(1),*** 85–94. https://doi.

Hayta, M., & Hendek Ertop, M., 2017. Optimisation of sourdough bread incorporation into wheat bread by response surface methodology: Bioactive and nutritional properties. *International Journal of Food Science & Technology,* ***52(8),*** 1828-1835.

Helou, C., Gadonna-Widehem, P., Robert, N., Branlard, G., Thebault, J., Librere, S., & Tessier, F. J., 2016. The impact of raw materials and baking conditions on Maillard reaction products, thiamine, folate, phytic acid and minerals in white bread. *Food & function,* ***7(6),*** 2498-2507.

Iancu, M. L., 2015. Effect of potato (Solanum tuberosum) addition on dough properties, sensory qualities and resistant starch content of bread. The Annals of the University Dunarea de Jos of Galati. The Annals of the University Dunarea de Jos of Galati. *Fascicle VI-Food Technology,* ***39(1),*** 93-108.

Lu, Z. H., Donner, E., & Liu, Q., 2021. Development and characterisation of gluten-free potato bread. *International Journal of Food Science & Technology*, ***56*****(6),** 3085-3098.

ICC, 1992. International Association for Cereal Science and Technology. Standard method number 114/1.

Kamal, M. S., Islam, M. N., & Aziz, M. G., 2013. Effect of sweet potato flour of two local varieties on quality of breads. *Journal of the Bangladesh Agricultural University,* ***11 (452-2016-35588),*** 301-306.

Kariluoto, S., Vahteristo, L., Salovaara, H., Katina, K., Liukkonen, K. H., & Piironen, V., 2004. Effect of baking method and fermentation on folate content of rye and wheat breads. Cereal Chemistry 81(1): 134-139. 81(1), 134–139. https://doi.org/10.1094/CCHEM.2004.81.1.134

Ktenioudaki, A., Butler, F., & Gallagher, E., 2010. Rheological properties and baking quality of wheat varieties from various geographical regions. *Journal of Cereal Science,* ***51(3),*** 402-408.

Kotíková, Z., Šulc, M., Lachman, J., Pivec, V., Orsák, M., & Hamouz, K., 2016. Carotenoid profile and retention in yellow-, purple-and red-fleshed potatoes after thermal processing. *Food chemistry,* ***197,*** 992-1001.

Limbo, S., Torri, L., & Piergiovanni, L., 2007. Light-induced changes in an aqueous β-carotene system stored under halogen and fluorescent lamps, affected by two oxygen partial pressures. Journal of Agricultural and Food Chemistry 55(13): 5238–5245.

Liu, X., Zhou, M., Jiaxin, C., Luo, Y., Ye, F., Jiao, S., ... & Lü, X., 2018. Bacterial diversity in traditional sourdough from different regions in China. *LWT- Food Science and Technology,* ***96,*** 251-259.

Ma, M., Mu, T., Sun, H., & Zhou, L., 2022. Evaluation of texture, retrogradation enthalpy, water mobility, and anti-staling effects of enzymes and hydrocolloids in potato steamed bread. *Food Chemistry,* ***368,*** 130686.

Nogueira, A. C., Sehn, G. A., Rebellato, A. P., Coutinho, J. P., Godoy, H. T., Chang, Y. K., & Clerici, M. T. P., 2018. Yellow sweet potato flour: use in sweet bread processing to increase β-carotene content and improve quality. *Anais da academia brasileira de ciências,* ***90,*** 283-293.

Oluwalana, I. B., Malomo, S. A., & Ogbodogbo, E. O., 2012. Quality assessment of flour and bread from sweet potato wheat composite flour blends. *International Journal of Biological and Chemical Sciences,* ***6(1),*** 65-76.

Perri, G., Coda, R., Rizzello, C. G., Celano, G., Ampollini, M., Gobbetti, M., ... & Calasso, M., 2021. Sourdough fermentation of whole and sprouted lentil flours: In situ formation of dextran and effects on the nutritional, texture and sensory characteristics of white bread. *Food Chemistry*, ***355,*** 129638.

Sakandar, H. A., Hussain, R., Kubow, S., Sadiq, F. A., Huang, W., & Imran, M., 2019. Sourdough bread: A contemporary cereal fermented product. *Journal of Food Processing and Preservation,* ***43(3),*** e13883. https://doi.org/10.1111/jfpp.13883

Schieber, A., & Carle, R., 2005. Occurrence of carotenoid cis-isomers in food: Technological, analytical, and nutritional implications. *Trends in Food Science & Technology,* ***16(9),*** 416-422.

Stahl, W., & Sies, H., 2012. Photoprotection by dietary carotenoids: concept, mechanisms, evidence and future development. Molecular nutrition & food research 56(2): 287-295. https://doi.org/10.1002/mnfr.201100232

Takahata, Y., Noda, T., & Nagata, T., 1993. HPLC determination of β-carotene content of sweet potato cultivars and its relationship with color values. *Japanese Journal of Breeding,* ***43(3),*** 421-427.

Tian, J., Chen, J., Lv, F., Chen, S., Chen, J., Liu, D., & Ye, X., 2016. Domestic cooking methods affect the phytochemical composition and antioxidant activity of purple-fleshed potatoes. *Food Chemistry,* ***197,*** 1264-1270.

Tontul, S. A., & Babaoğlu, H. Ç., 2019. Effect of flour particle size on physical properties and shelf life of bread. *GIDA-Journal of Food*, ***44*****(5),** 898-906.

Trejo-González, A. S., Loyo-González, A. G., & Munguía-Mazariegos, M. R., 2014. Evaluation of bread made from composite wheat-sweet potato flours. *International Food Research Journal,* ***21(4),*** 1683.

Ulusoy, S., Boşgelmez-Tınaz, G., & Seçilmiş-Canbay, H., 2009. Tocopherol, carotene, phenolic contents and antibacterial properties of rose essential oil, hydrosol and absolute. *Current microbiology,* ***59(5),*** 554-558.

Van Jaarsveld, P. J., Marais, D. W., Harmse, E., Nestel, P., & Rodriguez-Amaya, D. B., 2006. Retention of β-carotene in boiled, mashed orange-fleshed sweet potato. *Journal of Food Composition and Analysis,* ***19(4),*** 321-329.

Wanjuu, C., Abong, G., Mbogo, D., Heck, S., Low, J., & Muzhingi, T., 2018. The physiochemical properties and shelf-life of orange-fleshed sweet potato puree composite bread. *Food science & nutrition,* ***6(6),*** 1555-1563.

Yuliana, N., Nurdjanah, S., & Ratna Dewi, Y., 2018. Physicochemical properties of fermented sweet potato flour in wheat composite flour and its use in white bread. *International Food Research Journal,* ***25(3),*** 1051-1059.