Erzincan Üniversitesi
Fen Bilimleri Enstitüsü Dergisi
2021, 14(3), 979-992
ISSN: 1307-9085, e-ISSN: 2149-4584
Araştırma Makalesi

Erzincan University
Journal of Science and Technology
2021, 14(3), 979-992
DOI: 10.18185/erzifbed.972382
Research Article

Determination of Some Quality Properties of Blueberry Fruit (*Vaccinium Arctostaphylos* L.) Coated with Edible Coating

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Geliş / Received: 16/07/2021, Kabul / Accepted: 25/12/2021

Abstract

In this study, blueberry fruit, which is consumed joyfully, was coated with edible coating material (Semperfresh™) and stored for 15 days at 4 °C. Antioxidant properties and some physical properties were determined after harvest 5 with days intervals (0, 5th, 10th, 15th days). In uncoated fresh fruits, the amount of dry matter soluble in water was determined as 13.22%, pH 3.41, titratable acidity 1.01%, reducing sugar 8.54g/100g, saccharose 0.17g/100g, total sugar 8.72g /100g, vitamin C 20.37mg/100g, L value 27.09, vitamin A value 0.18, vitamin B value 0.60, total phenolic content 2398.65 mg gallic acid/100g dry weight, DPHH radical scavenging activity (IC_{50} value) 0.24 and, ABTS radical scavenging activity (IC_{50} value) 7.61.Coating with Semperfresh™ was statistically significantly effective over the identified parameters in blueberry fruit ($P< 0.01$). When all parameters were examined in the study, it was seen that blueberry fruit lost less weight as a result of 15-day storage at 4°C when coated with Semperfresh™. The amount of ascorbic acid could be determined up until the 10th day.

Keywords: Blueberry, Semperfresh™, Edible Coating, Storage

Yenilebilir Kaplama İle Kaplanan Ayı Üzümü (*Vaccinium Arctostaphylos* L.) Meyvesinin Bazı Kalite Özelliklerinin Belirlenmesi

Öz

Bu çalışmada sevilerek tüketilen ayı üzümü meyvesi, yenilebilir kaplama malzemesi ile (Semperfresh™) kaplanarak 4 °C' de 15 gün depolanmıştır. Hasattan sonra 5 gün aralıklarla (0., 5., 10., 15. gün) antioksidan özellikleri ve bazı fiziksel özellikleri belirlenmiştir. Kaplanmamış taze meyvelerde suda çözünür kuru madde miktarı % 13,22, pH 3.41, titrasyon asitliği %1.01, indirgen şeker 8.54g/100g, sakaroz 0.17 g/100g, toplam şeker 8.72 g/100g, C vitamini 20.37 mg/100g, L değeri 27.09, a değeri 0.18, b değeri 0.60, toplam fenolik madde 2398.65 mg gallik asit/100g kuru ağırlık, DPHH radikal giderme aktivitesi (IC_{50} değeri) 0.24, ABTS radikal giderme aktivitesi (IC_{50} değeri) 7.61 olarak belirlenmiştir. Semperfresh™'le kaplama ayı üzümü meyvesinde belirlenen parametreler üzerine istatistiki olarak önemli derecede etkili olmuştur ($P< 0.01$). Araştırmada bütün parametreler incelendiğinde ayı üzümü meyvesinin 4°C'de 15 günlük depolama sonucunda Semperfresh™'le kaplandığında ağırlık kaybının daha az olduğu görülmüştür. Askorbik asit miktarı ise 10. güne kadar belirlenebilmiştir.

Anahtar Kelimeler: Ayı üzümü, Semperfresh™, Yenilebilir Kaplama, Depolama

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1. Introduction

Today, the rapid increase in the awareness of healthy food consumption pushed humanity to eat healthy products. Due to their many components, fruits and vegetables have been the most consumed products in health and nutrition (Scheerens,2001). One of these products, blueberry fruit (*Vaccinium Arctostaphylos*), shows a spread in the Thracian and Marmara regions of Turkey as well as throughout the Karadeniz region (Altun et al., 2006). This fruit is also rich in terms of the content of anthocyanin, other pigments, and various phytochemicals, and manganese, micronutrients such as vitamin C and K in addition to its antioxidant components (Tiago and Filipa,2017; Dróżdż *et.al*., 2017). When it is fresh, it is considered a source of phenolic components with high antioxidant capacity and low glycemic index (<56) (Lires *et.al*., 2018; Carvalho *et.al*., 2017). Daily intake of *Vaccinium* types protects the body from cancer, urinary, and heart diseases, and prevents aging, memory loss, visual disorders, hypertension, and asthma (Pertuzatti *et al*.,2014; Shi *et. al*., 2008; Dasgupta and Klein,2014).

However, these are delicate fruits. Their life after harvest depends on microbial development, ripening, physical processes after harvest, and water loss (Yaman and Bayındırlı, 2002). Different technologies such as cold storage, UV irradiation, ozonation and modified atmosphere packaging are used to preserve the nutritional values of fruits, increase their shelf life and reduce spoilage. Paper, glass, cardboard, aluminum and various plastics can be used as packaging materials to maintain the quality of food and to protect food safety in the time between production and consumption (Hecer, 2012; Öksüztepe and Beyazgül, 2015). Many of these materials cause migration in foods (Öksüztepe and Beyazgül, 2015). As a result of migration, substances that are harmful to human health pass from packaging to food, which makes it necessary for the packaging material used to be safe as food (Altuntas, 2014). Although synthetic packages are usually petrochemical-based and are effective in product protection and preferred in the industry frequently, they are brought to the agenda to be decreased in usage due to pollution and migration problems (Luchese *et.al*., 2017; Ertugay and Sallan, 2011). As an alternative to these packaging materials, edible coatings are also recommended thanks to the fact that they decrease moisture loss, dissolved matter migration, respiratory and perspiration rate, maintaining hardness and latening decay. Edible films and coatings are formed either by the use of protein, lipid, and polysaccharide materials alone or together (Mannozzi *et.al*., 2017). They can be used in different foods such as fruits and vegetables, dried fruits, meat and meat products, cereals, and dairy products (Işık et al., 2013). Edible coatings are applied to foods in liquid form and the product is often dipped in the solution, while edible films are shaped like a solid layer and then applied by wrapping the product (Falguera *et.al*., 2011). Many animals and plant-derived protein, lipid, and polysaccharide materials are used in single or mixed form in edible films and coatings (Robertson, 2013). Semperfresh^{TM}, one of the materials used in the production of edible films and coatings, is a sucrose ester coating used commonly to reduce spoilage in storage without delaying their regular ripening process, weight loss, and protect the green color and fruit pressure for consumers in the fresh fruit and vegetable industry. Semperfresh^{TM} is composed of sucrose ester of fatty acids, sodium carboxymethyl cellulose, and monoglycerides of fatty acid obtained in liquid form (Baldwin *et. al*., 1995; Lin *et. al*., 2003; Gonzalez-Aguilar *et.al*.,

2008; Maftoonazad *et. al*.,2008). By nature, it is hydrophilic and dissolves in cold water, taking the form of a transparent viscous solution or gel. The fatty acid components contained in Semperfresh^{TM} are highly hydrological and significantly increase the moisture barrier property of the coating agent (Fuchs *et.al*., 2008).

This study aims to reveal the physical and chemical properties of blueberry fruit by coating it with Semperfresh^{TM} material to preserve it in the best way.

2. Material and Methods

Blueberry (*Vaccinium Arctostaphylos*) samples were collected from the Maçka district of Trabzon province. Harvested blueberry samples were kept at 15°C and brought to the laboratory. The edible coating solution was procured from the company Semperfresh^{TM} Agricoat Natureseal Ltd. (UK) in liquid form.

Harvested blueberry samples were kept at 15°C and brought to the laboratory. Semperfresh^{TM} materials, which were going to be used as edible coating material, were prepared by pure water heated up to 100 °C and cooled to 40 °C. The temperature of the coating solution prepared at a concentration of 3% (w/v) was kept constant at 40 °C and mixed in a magnetic mixer for 30 minutes without forming foam on its surface. The prepared solution was kept at room temperature for 6 hours in order to remove the air bubbles. Fruits dipped in solution for 4 minutes were taken with a metal strainer and dried for 30 minutes in a fan dryer. Samples were placed in each container with a sterile spatula to be 200 g±5 and stored at 4 ±1 C° for 15 days. As a result of 15 days of storage, microbiological, physical, and chemical analyses were performed on blueberry fruit and the results were evaluated.

The pH, titratable acidity (% expressed as citric acid) of blueberry samples were made according to Dry Matter Soluble in Water (Abbe Refractometer- Bausch & Lomb), Total Dry Matter (DM), Ash, Color Determination (Minolta Chroma meter) (Cemeroğlu,2010), Ascorbic acid determination was made according to Lee and Adel (2000). The sugar determination in the study was made by volumetric Lane-Eynon method (Keleş, 1983; Cemeroğlu,2010), ABTS from other parameters (Garcia- Alonso *et.al*.,2004; Şahin, 2014), DPPH radical scavenging activity (Şahin, 2014), and Total Phenolic Matter Determination was made according to Singleton and Rossi,(1965).

Before coating process, 30 fruit samples were taken for each repeat. Fruit samples that were put in the previously weighted package boxes were weighed in the 0,5,10, and 15th days with 0,0001 g accuracy (Ohaus brand scale), and their weight losses were calculated (Vieira *et.al*., 2016). Their pH values were found via the Hanna brand pH meter. The pH meter was standardized with 4.00 and 7.00 pH buffer solution and then measures were made (Cemeroğlu, 2010).

Electrometric titration method was applied to determine titration acidity and the results were calculated in citric acid (Cemeroğlu, 2010). In the samples, the amount of water-soluble dry matter was determined at room temperature using the ATC portable refractometer (0-32%) device, and the results were determined as the degree of Brix (Cemeroglu, 2010). The color of

fruit samples was determined using colorimeter (Konica Minolta brand) device. (Cemeroğlu, 2010). The volumetric Lane-Eynon method was used in the determination of sugar (total sugar, reduced sugar and sucrose) (Keleş, 1983; Cemeroğlu, 2010). The amount of ascorbic acid was determined by spectrophotometrically measuring the color obtained from the reaction of ascorbic acid with 2.6 dichlorophenol indophenol solution. The amount was calculated using the ascorbic acid standard curve (Regnell, 1976; Lee and Adel, 2000). The Slinkard and Singleton., (1977) method was used in total phenolic matter determination, while gallic acid standard, which is a phenolic compound was used in the preparation of standard graphic (Singleton and Rossi, 1965). The absorbance of the blue color formed after the reaction was read at 760 nm. Total phenolic matter mg GAE (gallic acid equivalent)/100g was given as sample by the help of standard graphic prepared with chemically pure gallic acid.

DPPH is an easy and cheap method and gives results in a short time. DPPH* (2,2-diphenyl-1-picrylhydrazyl) is a commercially available free radical, and these radical forms a maximum absorbance in 517 nm wavelength and is dark violet in color (Cuendet *et.al.*, 1997). As a result of the analysis, the concentrations corresponding to the absorbances measured at 517 nm were graphed and IC^{50} values were calculated.

At the end of the reaction made according to ABTS• Garcia-Alonso *et.al.*, 2004, the concentrations of the samples were calculated in $_{IC}{}^{50}$ and determined in accordance with Trolox standard.

The prepared coating solutions were poured into Petri boxes with an inner diameter of 85 mm to be 30 mL. Films were dried by holding for 3 days under ambient conditions. Samples of coatings cut in 4x4 mm sizes were coated with gold in a high vacuum, and surface images of coatings at a voltage of 10 kV were obtained by scanning electron microscopy (Kibar, 2010). In microbiological analyses, the total number of mesophilic aerobic bacteria and the total number of mold-yeast was made according to Yu *et.al*., 2017.

Statistical analyses were performed in the SPSS 20.0 package program according to the 2-factor trial plan depending on the full chance. The data obtained were subjected to variance analysis and the averages were compared with the Duncan multiple comparison test (Yildiz and Bircan, 1994).

3. Results and Discussion

Looking at the percentages of weight loss compared to the coatings applied in blueberry fruits, it was observed that the most weight loss was in uncoated samples and the least loss was in samples coated with Semperfresh™ (Table 1). It was observed that Semperfresh™ coating showed hydrophobic properties thanks to the lipid it contains in its structures, and thus weight loss was reduced. Moisture in food materials can be controlled or limited by edible films. Hydrophobic materials such as lipids are often used to improve barrier properties (Morillon *et.al*., 2002). Applications that extend shelf life have a positive effect on the preservation of the fruit content. In previous studies, it was stated that Semperfresh™ application decreased weight loss effectively in different fruits (Fisk *et.al*.,2008; Yaman and

Bayındırlı,2002; Kaynas and Ozelkok, 1999) and extended shelf life by preventing moisture loss (Nimitkeatkai *et.al*.,2006). In the present study, the Semperfresh^{TM} material, which also had hydrophobic properties, showed good results in terms of water. Therefore, lipid materials should be added to the coating solution in the prevention of weight loss. Looking at weight losses throughout storage, it was observed that weight loss also increased as storage time increased (Table 1). Similar results were obtained in previous studies (Mannozzi *et.al*., 2017; Vieira *et.al*.,2016).

In uncoated samples of plum fruit, the weight loss was 6.74 ± 0.0135(%) after the 14th day, and it was 8.84±0.24 at the end of daily storing, while the samples covered with Semperfresh^{TM} a weight loss of 3.32±0.10 was observed at the end of the 14th day, and 6.74±0.44 at the end of the 35th day (Kumar *et.al*., 2018).

In the coatings applied in blueberry fruit, the highest amount of water-soluble dry matter was obtained from the control application with 14.733, while in the Semperfresh^{TM}-coated sample, this amount was found to be 14.354. As the storage time increased, the amount of water-soluble dry matter in the samples also increased. As the storage time increased, the amount of water-soluble dry matter of both the control and the coated sample also increased (Table 1).

In blueberry fruit coated with alginate, pectin, and alginate-pectin coatings, it was found that there was not a significant difference in terms of water-soluble dry matter at the end of the 14th day. This value changed between 15-18 at the end of the 14th day (Mannozzi *et.al*., 2017).

Ascorbic acid added coatings in aloe vera and different concentrations (1%, 3%, and 5%)were applied to strawberry fruit and stored for 18 days at 1 °C. At the end of storage, aloe vera+ 5% ascorbic acid solution gave the most effective result in maintaining hardness, titratable acidity, pH, water-soluble dry matter, vitamin C properties (Sogvar *et.al*., 2016)

Considering pH value, the pH value of the samples coated with Semperfresh^{TM} was lower than those that were not. An increase in the pH values of samples was observed as the storage time increased, while the lowest pH was observed on the 0th day (Table 1).

Mannozzi *et.al*., (2017) coated blueberry fruit with 3 different coatings (alginate, pectin and alginate-pectin) and stored it at 4 °C for 14 days. As a result, there was no difference between coatings in terms of such parameters as blueberry's weight loss, pH, water-soluble dry matter, and total dry matter, while it was concluded that coatings were more effective in the protection of fruit hardness compared to the control group.

Titration acidity value in the sample originally coated was found to be higher than the control. The value decreased on the 5th day in both coated and uncoated samples and increased in the following days. On the fifteenth day, the highest titration acidity was in the covered samples (Table 1). In a study where cherries were coated with Semperfresh^{TM} material, Semperfresh^{TM} was stated to delay the change in titration acidity, Vitamin C, weight loss, color and hardness

values, and did not affect the sugar and water-soluble dry matter at all (Yaman and Bayındırlı,2002).

The difference between reduced sugar, total sugar and sucrose values was significant ($p<0.01$) (Table 1.) The highest amount of reduced sugar, total sugar and sucrose was found in Semperfresh™-coated samples. It was observed that as the storage time increased, their amount also increased, and the highest value was in the products stored on the 15th day (Table 1). It is thought that the values found are caused by the components in the structure of Semperfresh™. In a study on blueberry fruit genotypes (*V. Arctostaphylos* L,) it was determined that the total sugar amount varied between 56 and 104 g/kg (Özkan *et.al.*, 2019).

It is seen that the effect of storage time on ascorbic acid values of blueberry is significant ($p<0.01$) (Table 1). The amount of ascorbic acid in the uncoated fruit was 20.370 g/100g on the first day, while it was not found during the storage period. In fruits covered with Semperfresh™, ascorbic acid was detected until the 10th day, it was not found on the 15th day.

Table 1 Some physical and chemical properties and antioxidant capacities of Semperfresh™ with coated blueberry fruit

	Applications	Storage Time (day)				Mean ($\overline{X} \pm S\overline{x}$)
		0	5	10	15	
Weight Loss (%)	**Control**	0.000	7.67	17.83	20.50	11.50 a
	Semperfresh™	0.000	6.00	13.83	16.00	8.96 b
	Mean ($\overline{X} \pm S\overline{x}$)	0.000d	6.835 c	15.83 b	18.25 a	
Dry Matter Soluble in Water (%)	**Control**	13,217	13.767	15.050	16.900	14.733 a
	Semperfresh™	13,200	13.567	14.633	16.017	14.354b
	Mean ($\overline{X} \pm S\overline{x}$)	13.209 d	13.667 c	14.841 b	16.458 a	
pH	**Control**	3.408	3.477	3.502	3.475	3.465 a
	Semperfresh™	3.330	3.385	3.420	3.437	3.393 b
	Mean ($\overline{X} \pm S\overline{x}$)	3.370 c	3.431 b	3.461 a	3.456 a	
Titration Acidity (%)	**Control**	1.011	0.864	0.955	0.988	0.955 b
	Semperfresh™	1.201	1.023	1.030	1.190	1.112 a
	Mean ($\overline{X} \pm S\overline{x}$)	1.106 a	0.944 d	0.993 c	1.089 b	
Ascorbic acid (g/100g)	**Control**	20.370	0.000	0.000	0,000	5.092c
	Semperfresh™	21.162	10.338	3.197	0,000	8.674 a
	Mean ($\overline{X} \pm S\overline{x}$)	20.766 a	5.169 b	1.598 c	0.000 d	
Total Sugar (g/100g)	**Control**	8.718	8.902	9.073	9.146	8,960b
	Semperfresh™	9.072	9.112	9.275	9.337	9,199a
	Mean ($\overline{X} \pm S\overline{x}$)	8.895d	9.007c	9.174b	9.241a	
Sucrose (g/100g)	**Control**	0.167	0.172	0.182	0.188	0.177**b**
	Semperfresh™	0.202	0.220	0.223	0.228	0.218**a**
	Mean ($\overline{X} \pm S\overline{x}$)	0.184**d**	0.196**c**	0.202**b**	0.208**a**	
Reduced Sugar (g/100g)	**Control**	8.543	8.721	8.881	8.948	8.773 b
	Semperfresh™	8.860	8.881	9.041	9.096	8.969 a
	Mean ($\overline{X} \pm S\overline{x}$)	8.701 d	8.801 c	8.961 b	9.022 a	

There are significant differences between the averages shown in different letters ($p<0.01$).

Ascorbic acid has strong antioxidant properties, is abundant in various vegetables, especially in citrus fruits (Kalt *et.al*.,1999). Ascorbic acid in fruits and vegetables is destroyed by long-term storage and excessive cooking (Nelson and Cox 2000). In a study conducted with Bog bilberry (*Vaccinium uliginosum* L.), the amount of ascorbic acid was found to be 12 ±1 mg/100g in fresh weight (Çolak *et.al*., 2016).

The difference between phenolic substance values according to the applied coating and storage time was significant ($p<0.01$) (Table 2). The highest amount of phenolic substance was observed in control application. It is seen that the impact of storing time on phenolic matter values is significant ($p<0,01$) (Table 2). Considering the storing time, no statistical difference was found in phenolic matter values until the 10th day. The amount of phenolic matter decreased on the 15th day. While there was an increase on the 5th day in the control application, there was a decrease on the 10th day and the following days. In Semperfresh™ application, although the phenolic substance was initially lower than control, a small increase in the amount of phenolic substance was observed until the tenth day, while a decrease occurred on the 15th day occurred. In terms of storage time, the best results were obtained until the 10th day in Semperfresh™ coating and 5th day in the uncoated samples. After the 15th day, the values began to fall in both. However, the highest amount was found in the coated samples on the 15th day (Table 2). In this sense, coating application was found to be effective in increasing and maintaining the total amount of phenolic substances. In a study conducted by Kim *et.al*., (2014), it was stated that adding lemon fat (0.5-4%) to Karnauba-based coating in different concentrations was effective in reducing weight loss and microorganism load at the end of the 28-day period, protection of total phenolic matter and antioxidant activity.

When DPPH values were examined, it was determined that the difference was significant according to the coating applied ($p<0.01$) (Table 2). The lowest value was obtained from the control application. In the control application, there was a decrease on the 5th day, an increase on the 10th day, and there was again a decrease on the 15th day. In the Semperfresh™ application, there was a constant increase starting from the beginning until the 15th day (Table 2). Coating application was found to be effective in increasing and maintaining the amount of DPPH.

The highest value in terms of ABTS values was obtained from Semperfresh™ application with 7.314 mg/mL. At the end of 15 days of storage, the most effective protection compared to the beginning was obtained from Semperfresh™ application (Table 2). As storage time increased, the values of both control and coated samples decreased. The study by Çolak *et.al.,* (2016) Bog Billberry obtained the highest antioxidant capacity values from FRAP (117 µmol TE/g FW) and then from ORAC (84 µmol TE/g FW).

In terms of color determination, when the values L, a, and b were examined; the highest value was seen in the control application in the parameters L and a, while the value b was seen in the samples covered with Semperfresh™. The L value decreased only on the 5th day in the control application and then increased as the storage day increased. A value decreased gradually both in coated and control samples as storage time increased. In terms of the b

value, the value of samples to which Semperfresh™ was applied was high. There was an increase in terms of b value in the 5th-day storage time and this increase ended up as a decrease on the 10th day and an increase on the 15th day (Table 2).

When examining in terms of mesophilic bacteria, higher mesophilic bacteria was detected in the uncoated samples. As storage time increased, the number of mesophilic bacteria increased in both. Total yeast and mold were found to be higher in coated samples. As storage time increased, the number gradually increased both in the uncoated and coated samples (Table 2).

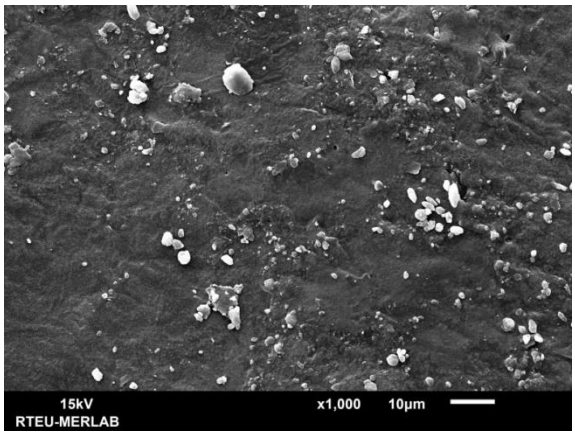
Table 2 Some physical and chemical properties and antioxidant capacities of Semperfresh™ with coated blueberry fruit

		Storage Time (day)				Mean ($\overline{X} \pm S\overline{x}$)
Total Phenolic Substance (mg gallik acid /100 g dry weight)	**Applications**	0	5	10	15	
	Control	2398.647	2522.580	2443.642	2263.727	2407.149 **a**
	Semperfresh™	2360.997	2378.558	2398.585	2301.305	2359.861**b**
	Mean t ($\overline{X} \pm S\overline{x}$)	2379.821 **ab**	2450.569 **a**	2421.113 **a**	2282.515 **c**	
DPPH-IC_{50} (mg/mL)	**Control**	0.241	0.154	0.214	0.212	0.205b
	Semperfresh™	0.218	0.247	0.265	0.285	0.254 a
	Mean ($\overline{X} \pm S\overline{x}$)	0.229 c	0.200 d	0.239 b	0.248 a	
ABTS-IC_{50} (mg/mL)	**Control**	7.613	7.213	6.980	6.579	7.096d
	Semperfresh™	7.823	7.383	7.063	6.986	7.314c
	Mean ($\overline{X} \pm S\overline{x}$)	7.718 a	7.298 b	7.022 c	6.782 d	
L	**Control**	27.088	21.928	27.455	28.462	26.233 ab
	Semperfresh™	23.962	24,378	25.263	24.498	24.525 b
	Mean ($\overline{X} \pm S\overline{x}$)	25.525 b	23.153 c	26.359 a	26.480 a	
a	**Control**	0.183	0.160	0.743	0.662	0.437a
	Semperfresh™	0.047	0.040	0.358	0.293	0.185 b
	Mean ($\overline{X} \pm S\overline{x}$)	0.115 b	0.100 b	0.550 a	0.477 b	
b	**Control**	0.595	0.208	-0.330	0.020	0.123 b
	Semperfresh™	0.932	1.023	0.313	0.515	0.696 a
	Mean ($\overline{X} \pm S\overline{x}$)	0.764 a	0.616 a	-0.008 b	0.268 b	
Mesophilic Bacteria	**Control**	0.000	2.925	4.082	4.672	2.920 a
	Semperfresh™	0.000	2.247	3.838	4.228	2.578 c
	Mean ($\overline{X} \pm S\overline{x}$)	0.000d	2.586 c	3.960 b	4.450 a	
Total Yeast Mod	**Control**	0.000	2.918	3.812	3.495	2.557c
	Semperfresh™	0.000	3.062	3.555	4.213	2.708b
	Mean ($\overline{X} \pm S\overline{x}$)	0.000d	2.990 c	3.683 b	3.854 a	

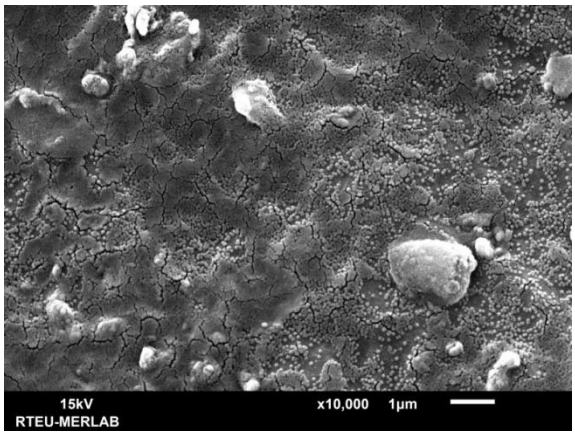
There are significant differences between the averages shown in different letters ($p<0.01$).

Information about the surface homogeneity of films can be obtained with scanning electron microscopy. A homogeneous surface is perceived as a sign of structural integrity, and coatings with such a surface are also expected to have good mechanical properties. Additionally, surface homogeneity also affects the opacity value of coatings. It is possible to relate the mechanical properties of the prepared coatings to the obtained micrograph results. It is expected that the tensile strength of coatings with homogeneous surfaces is high, and the elongation values of coatings with rough surfaces, i.e., their flexibility, are lower. It is thought

that the water vapor permeability of coatings will be negatively affected by porous structures (Kibar, 2010). Surface micrographs obtained by scanning electron microscopy of coating samples are given in the following figure.



Surface micrograph of the coating prepared with Semperfresh™ (1000x)



Surface micrograph of the coating prepared with Semperfresh™ (10000x)

Figure 1. Surface micrographs of coatings

The surface roughness of the coating prepared with Semperfresh™ is high. It has a spongy structure and pores. This loss in structural integrity shows that phase decoupling occurs between the components that make up Semperfresh™.

4. Conclusion

In this study, blueberry fruit was coated with Semperfresh™, and stored for 15 days. The impacts of the coating were tried to be determined by comparing coated samples with uncoated fruits and making analyses of weight loss, pH, titration acidity, water-soluble dry matter, total sugar, reduced sugar, sucrose, phenolic substance, antioxidant activity, total mesophilic bacteria, yeast, and mold.

As a result of the analysis, weight loss was the most in uncoated samples, while the loss of coated samples was less. Samples coated with Semperfresh™ were found to have a high value of ascorbic acid, reduced sugar, total sugar, sucrose, total yeast and mold. The total amount of phenolic and antioxidant activity of the uncoated samples was high.

As a result, the use of coating materials in fruits and vegetables both increases their shelf life and protects them. For this purpose, the use of edible coatings, which are harmless both in terms of environment and health, should be increased. However, further studies should be conducted on them. It is believed that their effects will be increased, especially by using them together with more than one material, rather than alone.

Acknowledgements

This study was supported by the project number 17.F5115.02.01/2902 of Gumushane University Scientific Research Project Coordinator. We would like to thank Gumushane University for supporting the project.

References

Altay, A.,2018. Antıoxıdant And Cytotoxıc Properties of *Salvıa Frutıcosa M*. And Its Effects on Gene Expressıons of Some Cyp450 And Antıoxıdant Enzymes In Ht-29 Cell Lıne, Mıddle East Technıcal Unıversıty, The Graduate School of Natural and Applıed Scıences, Phd, Department of Biochemistry 131s.

Altun, L., Usta, A., Günlü, A., Kulaç, Ş., Güney, D., Güvendi, E.,2006. Some Ecological Characteristics of Naturally Growing Blueberry (V. arctostaphylos L.) in Çaykara Region, 1st International Symposium on Non-Wood Forest Products, KTU Forestry Faculty, 1- 4 November 2006, Trabzon.

Altuntaş, Ü., 2014. Measurement of migration from packaging materials into some foods launched in Turkey. Master Thesis, Istanbul Technical University, Institute of Science and Technology, Isparta, 78s.

Baldwin, E. A., M. O. Nisperos-Carriedo, R. A., Baker, 1995. Use of edible coatings to preserve quality of lightly (and slightly) processed products. Critical Reviews in Food Science and Nutrition, 35: 509–524.

Blois, M.S. 1958. Antioxidant determinations by the use of a stable free radical. Nature. 181:1199–1200.

Carvalho, J. M., Gouveia, S. C., Vieira, C. A., Pereira, C. A., Carvalho, A. Miguel, Marques, C. J., 2017. Nutrtional and Phytochemical Composition of *Vaccinium padifolium* Sm Wild Berries and Radical Scavenging Activity. Journal of Food Science. Vol.82, Nr:11.2554-2561.

Cemeroğlu, B.S., 2010. Food Analysis, 4th Edition, Istanbul, 480p.

Cuendet, M., Hostettmann, K., Potterat, O., Dyatmiko, W., 1997. Iridoid Glucosides with Free Radical Scavenging Properties from *Fagraea blumei*, Helvetica Chimi Acta, 80, 1144-1152.

Çolak, N., Torun, H., Gruz, J., Strnad, M., Hermosin-Gutierrez, I.,Hayırlıoğlu-Ayaz, S., Ayaz, A.F., 2016. Bog bilberry phenolics, antioxidant capacity and nutrient profile. Food Chemistry, 201, 339-349.

Dasgupta A, Klein K. 2014. Chapter 12 - Fruits, vegetables, and nuts: good sources of antioxidants. In: Klein AD, editor. Antioxidants in food, vitamins and supplements. San Diego: Elsevier. p 209–35

Dróżdż, P., Šėžienė, V. ve Pyrzynska, K., 2017. Phytochemical Properties and Antioxidant Activities of Extracts from Wild Blueberries and Lingonberries, Plant Foods for Human Nutrition, 72,4, 360-364.

Ertugay, M.F.,Sallan S, 2011. Wax Applications in Fruits and Vegetables, Food, 36, 3, 153-160.

Falguera, V., Quintero, J.P., Jiménez, A., Muñoz, J.A., Ibarz, A., 2011. Edible Films and Coatings; Structures, Active Functions and Trends in Their Use, Trends in Food Science&Technology, 22, 292-303.

Fisk, L.C., Silver, M.A., Strik, B.C., Zhao, Y., 2008. Postharvest quality of hardy kiwifruit (Actinidia arguata 'Ananasnaya') associated with packaging and stored conditions. Postharvest Biology Technology 47: 338-345.

Fuchs, S.J., Mattinson, D.S., Fellman, J.K., 2008. Effect of Edible Coatings on Postharvest Quality of Fresh Green Asparagus, Journal of Food Processing and Preservation, 32, 951-971.

Garcia-Alonso, M., Pascual-Teresa, S., Santos-Buelga, C., Rivas-Gonzalo, J.C., 2004.

Evaluation of the Antioxidant Properties of Fruits, Food Chemistry, 84, 13-18.

Gonzalez-Aguilar, G. A., Celis, J., Sotelo-Mundo, R. R., 2008. Physiological and biochemical changes of different fresh cut mango cultivars stored at 5°C. International Journal of Food Science and Technology, 43: 91–101.

Hecer, C., 2012. Packaging Methods in Meat Technology, Uludag Universitiy Journal of the Faculty of Veterinary Medicine, 31,1, 57-61.

Işık, H., Dağhan, Ş. ve Gökmen, S., 2013. A Research on Edible Coatings Used in the Food Industry, Electronic Journal of Food Technologies, 8, 1, 26-35.

Kalt, W., Forney, C.H., Martin, A., Prior, R.L., 1999. Antioxidant capacity, vitamin C, phenolics, and anthocyanins after fresh storage of small fruits. J. Agric. Food Chem. 47, 4638–4644.

Kaynas, K., Ozelkok, I.S., 1999. Effect of SemperfreshTM on Postharvest Behavior of Cucumber (Cucumis sativus l.) and Summer Squash (Cucurbita Pepo L.) Fruits. Acta Horticulturae, 492, 213-220.

Keleş, F., 1983. Fruit and Vegetable Processing Technology Laboratory Notes, Atatürk University Faculty of Agriculture, Erzurum.

Kibar, A.A.E., 2010. Production of methylcellulose-corn starch and carboxymethylcellulose-corn starch based biodegradable films and determination of permeability, mechanical and structural characteristics. PhD Thesis, Hacettepe University Institute of Science, Ankara, 174p.

Kim, I.-H., Oh, Y.A., Lee, H., Song, K.B.,Min S.C., 2014. Grape Berry Coatings of Lemongrass Oil-Incorporating Nanoemulsion, LWT- Food Science and Technology, 58, 1-10.

Kumar, P., Sethi, S., Sharma, R.R., Srivastav, Singh, D., Varghese, E., 2018. Edible coatings influence the cold-storage life and quality of 'Santa Rosa' plum (*Prunus salicina* Lindell). J. Food Sci. Technol.55(6):2344-2350.

Lee, Seung K., Adel, A. K., 2000, Preharvest and Postharvest Factors İnfluencing Vitamin C Content Of Horticultural Crops.", Postharvest Biology And Technology, 20.3:207-220.

Lin, H. T., Y. F. Xi and S. J. Chen, 2003. Postharvest softening physiological mechanism of Huanghua pear fruit. Scientia Agricultura Sinica, 36: 349–352

Lires, C.M.L. Docters, A., Horak, C.I., 2018. Evaluation of the quality and shelf life of gamma irradiated blueberries by quarantine purposes. Radiation Physics and Chemistry, 143 (15) pp. 79-84

Luchese, C.L., Sperotto, N., Spada, J.C.,Tessaro, I.C., 2017. Effect of Blueberry Agro-Industrial Waste Addition to Corn Starch-based Films for the Production of a pH-indicator Film, International Journal of Biological Macromolecules, 104, 11-18.

Maftoonazad, N., Ramaswamy, H. S., Marcotte, M., 2008. Shelf life extension of peaches through sodium alginate and methyl cellulose edible coatings. International Journal of Food Science and Technology, 43: 951–957

Mannozzi, C.,Cecchini, J.P., Tylewicz, U., Siroli, L., Patrignani, F., Lanciotti, R., Rocculi, P., Dalla Rosa, M.,Romani, S., 2017. Study on the Efficacy of Edible Coatings on Quality of Blueberry Fruits During Shelf-Life, LWT- Food Science and Technology, 85, 440-444. DOI: 10.1016/j.lwt.2016.12.056.

Morillon, V., Debeaufort, F., Blond, G., Capelle, M.,Voilley, A., 2002. Factors Affecting the Moisture Permeability of Lipid-Based Edible Films: A Review, Critical Reviews in Food Science and Nutrition, 42, 1, 67-89.

Nelson, D.L., Cox, M.M., 2000. *Lehninger Principles of Biochemistry.*4th Ed., pp. 130-131, W.H. Freeman and Company, New York.

Nimitkeatkai, H., Srilaong, V., Kanlayanarak, S., 2006. Effect of edible coating on pineapple fruit quality during cold storage. Acta Horticulture 712: 643-647

Öksüztepe, G., Beyazgül, P., 2015. Intelligent Packaging Systems and Food Safety, Fırat University Health Sciences Veterinary Journal, 29,1, 67-74.

Özkan, G., Ercişli, S., Zeb, A., Ağar, G., Sağbaş, H.İ., İlhan, G., Gündoğdu, M.,2019. Some Morphological and Biochemical Characteristics of Wild Grown Caucasian Whortleberry (*Vaccinium arctostaphylos* L.) Genotypes from Northeastern Turkey. Not Bot Horti Agrobo, 47(2):378-383

Pertuzatti, P. B., Barcia, M. T., Rodrigues, D., Cruz, P. N., Hermosín- Gutiérrez, I., Smith, R., & Godoy, H. T.,2014. Antioxidant activity of hydrophilic and lipophilic extracts of Brazilian blueberries. *Food Chemistry*, 164, 81-88. PMid:24996309. http://dx.doi.org/10.1016/j. foodchem.2014.04.114.

Pokorny J., Yanishieva N., Gordon M.H. 2001. Antioxidants. In: Food: Practical Applications. Woodhead Publishing Limited, Cambridge: 16–18.

Regnell, C., 1976. Analytical Methods for Quality Control of Processed Vegetables and Fruits, Bursa Food Control Teach., 2.

Robertson, G.L., 2013, Food Packaging: Principle and Practice, Third Edition, CRC Press, Boca Raton, 703p.

Scheerens, J.C., 2001. Phytochemicals and The Consumers: Factors Affecting Fruit and Vegetable Consumption and The Potential For Increasing Small Fruit In The Diet. Horttech 11:547-556.

Shi, J., Pan, Z., McHugh, T. H., Wood, D., Hirschberg, E., & Olson, D. 2008. Drying and quality characteristics of fresh and sugar-infused blueberries dried with infrared radiation heating. *LWT - Food Science and Technology (Campinas.)*, 41(10), 1962-1972. http:// dx.doi.org/10.1016/ j.lwt.2008.01.003.

Slinkard, K., Singleton, V.L., 1977. Total Phenol Analyses: Automation and Comparison With Manual Methods. Am. J. Enol. Vitic, 28, 49-55.

Singleton, V.L., Rossi, J.A., 1965. Colorimetry Of Total Phenolics With Phosphomolybdic-Phosphotungstic Acid Reagents, Amer J Enol Viticult., 16, 144- 158.

Sogvar, O.B., Saba, M.K., Emamifar, A., 2016. Aloe vera and Ascorbic Acid Coatings Maintain Postharvest Quality and Reduce Microbial Load of Strawberry Fruit, Postharvest Biology and Technology, 114, 29-35.

Şahin, H., 2014. Analysis of Grayanotoxin-III (GTX-III) Isoform in Rhododendron Honey and Plant by LC-MS/MS, PhD Thesis, Karadeniz Technical University Institute of Science, Trabzon, 87p

Tiago, B., S., Filipa, V.M., S., 2017. High Pressure Processing and Storage of Blueberries: Effect on Fruit Hardness, High Pressure Research, 1-10.DOI: 10.1080/08957959.2017.1402895.

Vieira, J. M., Flores-López, M. L., Rodríguez, D. J., Sousa, M. C., Vicente, A. A., Martins, J.T., 2016. Effect of Chitosan-*Aloe vera* Coating on Postharvest Quality of Blueberry (*Vaccinium corymbosum*) Fruit, Postharvest Biology and Technology, 116, 88-97.

Yaman, Ö., Bayındırlı, L., 2002. Effects of an Edible Coating and Cold Storage on Shelf-Life and Quality of Cherries, LWT- Food Science and Technology, 35, 2, 146-150.

Yıldız, N., Bircan, H., 1994. Research and Trial Methods, Atatürk University No: 697, Faculty of Agriculture No: 305, Textbook No: 57, Erzurum, 277p.

Yu, Y., Jin, T.Z., Fan, W., Xu, Y., 2017. Osmotic Dehydration of Blueberries Pretreated with Pulsed Electric Fiels: Effects on Dehydration Kinetics and Microbiological and Nutritional Qualities, Drying Technology, 35, 1543-1551.