Alginate Based Aloe Vera Gel And/Or Pomegranate Seed Essential Oil Added Edible Coating Film Production Using Casting Method To Extend Strawberries and Cherries Shelf Life

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ABSTRACT

Many types of material used for coating food to extend shelf life and that may be eaten together with the coated food. Today, environmentally friendly technologies, like edible films produced from biodegradable materials, are preferred in food coating. In this study alginate-based (3g) aloe vera gel (1.5g) and/or pomegranate seed essential oil (1%) added plasticized with glycerol (2g) edible films were produced by casting method for use in food coating at 5 different composition. Aloe vera gel and pomegranate seed essential oil (3%) added edible composite films have the lowest (72.56%) water solubility value. Pomegranate seed essential oil added edible films have lower water vapor transmission rate ($0,0897*10^{-3}$), and lower moisture content (19.95%) values. 1% pomegranate seed essential oil added film has the lowest film thickness (0.125 mm). FTIR spectra of the films confirmed the interactions between alginate, aloe vera gel and pomegranate seed essential oil thus proving that the films were prepared successfully. Strawberries and cherries were coated with produced edible coating films and weight loss and color analysis were carried out to observe coating performance. It was seen that alginate based and pomegranate seed essential oil added edible coatings reducing moisture loss, color change and surface deformation of strawberries and cherries. The biggest difference of this study from previous studies is that pomegranate seed essential oil was used for the first time in this study, for edible coating film production and the results were quite successful especially for the cherry’s coating.

KEYWORDS: Edible film, sodium alginate, aloe vera gel, pomegranate seed oil

1. INTRODUCTION

Utilisation of environmentally friendly polymer-based edible films (like polysaccharides, lipids, and proteins) that extend shelf life of foods has been increased day by day. Edible films protect firmness, limit microbial growth, resist the weight loss of the foods and move as a carrier for many active components like antimicrobials and antioxidants to extend the efficiency in the preservation of food. Polysaccharide and lipid based edible films are chemically stable and have good physical, mechanical, and gas barrier properties. Consequently, biopolymer based edible films have appeared as a food coating alternative material [1-3]. Alginates, widely used in medicine and food industries, due to its characteristics such as thickening, stabilizing, suspending, film forming, gel production, emulsion stabilization, non-flammability, biodegradability, and biocompatibility are suitable for use in edible film production.They are produced through the alkali treatment of alginic acid which is extracted from Phaeophyceae plant [4-6]. Numerous edible films originated from alginate can't shield the UV light which has many negative effects on food. Aloe vera gel, extracted from the aloe vera plant, is a promising additive for the improvement of the UV-protecting and antimicrobial properties of edible coatings [7,8]. Essential oils obtained by aromatic plants contain functional bioactive compounds providing strong antioxidant and antimicrobial properties. They are effective natural agents against microorganisms, eco friendly and biodegradable. The addition of essential oils to edible films help in the inhibition of bacterial and fungal growth. Therefore, essential oils can move as natural preservatives for perishable foods as well as fillers to produce functional coating materials [9,10]. Pomegranate (Punica granatum L.) is one of the most widely cultivated and processed fruits. Consumption of pomegranate products has increased recently due to their high antioxidant and health-promoting properties. Pomegranate peel and its extract are a rich source of phenolics and flavonoids, whith antimicrobial and antioxidant properties. Pomegranate seed oil has many applications from food production to preservation. The nutritional value of pomegranate, which is the best natural source of punicic acid and punicalagin, is excellent. Many advantages of food coating materials enriched with pomegranate seed oil, in addition to their antimicrobial activities, reveal their role in food preservation [11-13]. Plasticizers are also incorporated within alginates films to improve their mechanical properties. Among plasticizers, glycerol and sorbitol are the most extensively employed plasticizer in alginate films [14,15].

The aim of this study is to investigate the possibility of producing a new alginate based, aloe vera gel and/or pomegranate seed essential oil added, biodegradable edible coating film with casting method. To determine and compare the aloe vera gel and pomegranate seed essential oil effects, they were added to the coating solution at 5 different ratios. The most important difference of this study from previous studies is the development of aloe vera gel and pomegranate seed oil incorporated alginate-based edible films for the first time, and its application as a coating for the preservation of strawberry and cherrie fruits.

2. MATERIAL AND METHODS

2.1. Materials

Sodium alginate used in this study was purchased from AFG Bioscience, Glycerol was from Merck (Germany) and D-sorbitol from Carlo Erba (France). Aloe vera leaves, strawberries and cherries were purchased from local markets and PSEO from Arifoğlu in Istanbul, Turkey.

2.2. Aloe vera gel extraction

Aloe vera gel (AVG) was obtained according to the previos studies with some modification. Fresh aloe vera leaves were washed with tap water and then by pure water to eliminate surface impurities. Then, they were peeled with a knife to remove the outer green layer. The obtained AVG was blended and mixed for 20 min with ultrasonic probe, to form a uniform solution. Then, it was filtered to remove impurities arising from cell walls. Finally, AVG was pasteurized at 70 ℃ for 45 min and was cooled to a room temperature (22+0.5 °C). The prepared gel extract was stored at a refrigerator [16,17].

2.3. Alginate/ aloe vera gel/ pomegranate seed essential oil film production.

3 g sodium alginate and 2g glycerol were dissolved in 100 mL distilled water and the obtained solution (C_1) was stirred in a magnetic stirrer at 500 rpm for 60 min., at 60 °C. After that, AVG (0-1.5g) and/or PSEO (1%-3%) were added to the obtained solution at different ratios according to the compositions listed in Table 1

(C_2, C_3, C_4 and C_5), to determine AVG and PSEO effects. The alginate, glycerol, AVG and PSEO ratios were determined by preliminary tests. In order to obtain more homogeneous film solutions, they were first mixed with ultrasonic probe for 10 min. Next, they were placed in an ultrasonic water bath for 10 min., at 50 °C, until the mixtures were completely solubilized. Biodegradable edible films were prepared by using solution-casting method. The film solutions were cast in petri dishes with a diameter of 10 cm followed by drying at 40 ^{0}C in an oven for 24 h. Finally, the films were peeled off and conditioned in a desiccator, at 50% RH and room temperature (22+0.5 °C) until analyzed, after cooling [7, 18].

Table 1 Formulation of alginate/ aloe vera gel/ pomegranate seed essential oil edible films.

Formulation	Alginate (g)	Glycerol (g)	AVG (g)	PSEO (v/W%)
C_1	3	2	-	-
C_2	3	2	1.5	-
C_3	3	2	-	1
C_4	3	2	-	3
C_5	3	2	1.5	1
C_6	3	2	1.5	3

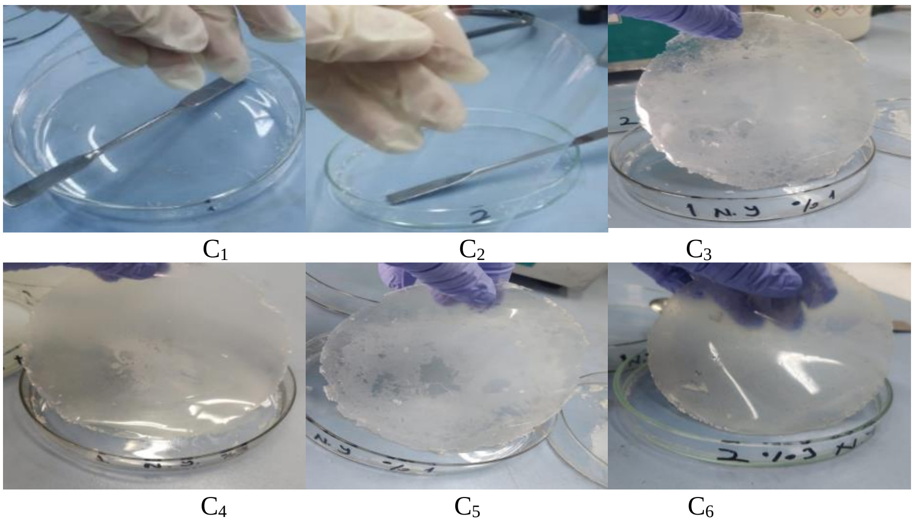

Fig. 1. Alginate/ aloe vera gel/ pomegranate seed essential oil edible films

2.4. Characterization of the films

2.4.1 Fourier transform infrared spectroscopy

The chemical structure of the films was analyzed by FTIR using a PerkinElmer Spectrum One FTIR spectrometer (Waltham, MA, USA) equipped with a universal attenuation total reflectance sampling accessory with a spectral range between 4000 and 400 cm^{-1} with a resolution of 4 cm^{-1}. The films were cut to 10 × 10 mm and placed onto the ATR platform.

2.4.2 Water solubility

The water solubility of the films was determined as described by Girgin and Tugrul [16] and Oliveira Filho et al. [19] with some modifications. The film samples were dried in a hot air oven at 105 ± 2 ^{0}C for 24 h. Dried films were cut to 2×2 cm and then they were weighed. The samples were then immersed in 10 mL of distilled water and mixed at 100 rpm at room temperature (22+0.5 ^{0}C) for 6 h. The unsolvable part of the film samples was filtered, dried at 105 ± 2 ^{0}C for 24 h. and weighed. All the experiments were carried out in triplicate. Water solubility calculated using equation (1):

$$\text{Water solubility } (\%) = \frac{W1-W2}{W1} \times 100 \tag{1}$$

W_1 = dry weight and W_2 = dry weight of the insoluble fraction of the film.

2.4.3 Water vapor transmission rate (WVTR)

The WVTR (g/sm^2) of the films was determined by the drying method, according to the procedure described by Li et al. [20] and Shafie et al. [21] with some modifications. The film samples were dried in a hot air oven at 105 ± 2 ^{0}C for 24 h until they reach a constant weight. Then the glass test tubes were filled with 5 g of silica gel, the mouth of the tubes (diameter of 13 mm) was closed with the film sample dried in the oven and surrounded with paraffin (for the tube to be completely closed). The prepared samples were weighed every 24 h (at the same time every day) for 5 days. All the experiments were carried out in triplicate. The WVTR was calculated according to the formula below:

$$WVTR = \Delta W / (\Delta t \times A) \quad (2)$$

$\Delta W/\Delta t$ = the amount of water transferred (g) per unit time (s), and A = the exposed area (m^2).

2.4.4 Moisture content

The films moisture content was determined as described by Costa et al. [22] and Mutlu [23] with some modifications. Edible films (2 cm × 2 cm) were cut and weighed, then dried at 105 ± 1 ^{0}C during 24 h until the equilibrium weight was reached. The sample weight loss was determined, and moisture content was calculated as the percentage of water removed from the system using equation (3) .

$$\text{Moisture (\%)} = \frac{(M_0 - M_1)}{M_0} \times 100 \quad (3)$$

M_0 = initial weight, M_1 = dry weight of the films

2.4.5 Film Thickness

The thicknesses values of the films (with 0,01 mm. sensitivity) were measured from five different points using Mitutoyo micrometer (Tokyo, Japan). The measurements were taken from five different point and the average value was recorded [24].

2.4.6 Color

The color values of the samples were assessed using a handheld colorimeter. Hunter scale values for the positive a* values represent redness, the negative ones represent greenness, the positive b* values represent yellowness, and the negative ones represents blueness. All the experiments were carried out in triplicate. Total color changes (ΔE) were calculated from the following equation:

$$\Delta \mathbf{E} = \sqrt{(\mathbf{L_0} - \mathbf{L})^2 + (\mathbf{a_0} - \mathbf{a})^2 + (\mathbf{b_0} - \mathbf{b})^2} \quad (4)$$

where L_0, a_0 and b0 are the color values of the control films and L, a and b are the color values of the produced films.

2.4.7 Application of edible coating films on strawberries and cherries

Strawberries and cherries of homogeneous size and colour were selected, they were washed using a 1% sodium hypochlorite solution for 1 minute and dried at room temperature (22+0.5 °C). All the fruits were dipped to 3 different coating solutions for 1 min: alginate based film solution, alginate and 1% PSEO based film solution, and alginate and 3% PSEO based film solution. Their weight was measured first and eighth days drying. The weight loss rate was calculated based on the ratio of the reduction in the weight of fruit the to the initial weight. Photographs of the coated strawberries and cherries were taken on the first and eighth days to observe the spoilage [25-28].

3. RESULTS AND DISCUSSION

3.1 FTIR spectroscopy

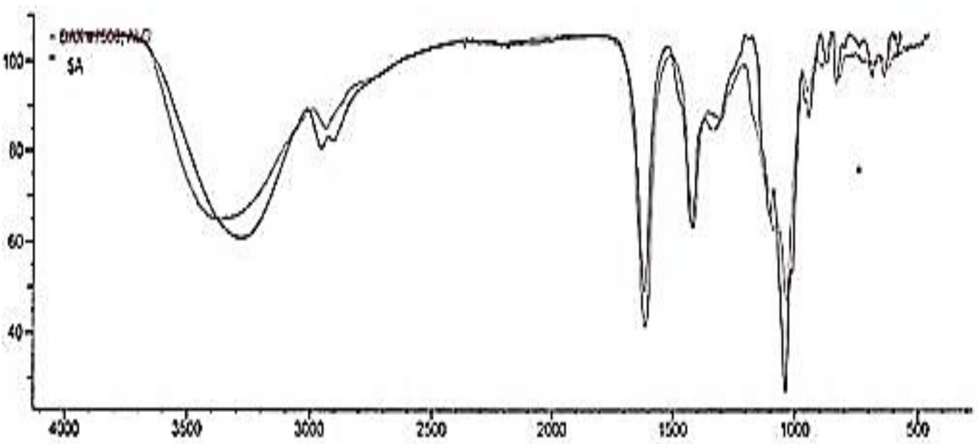

Fig.2. FTIR spectra of alginate based edible films

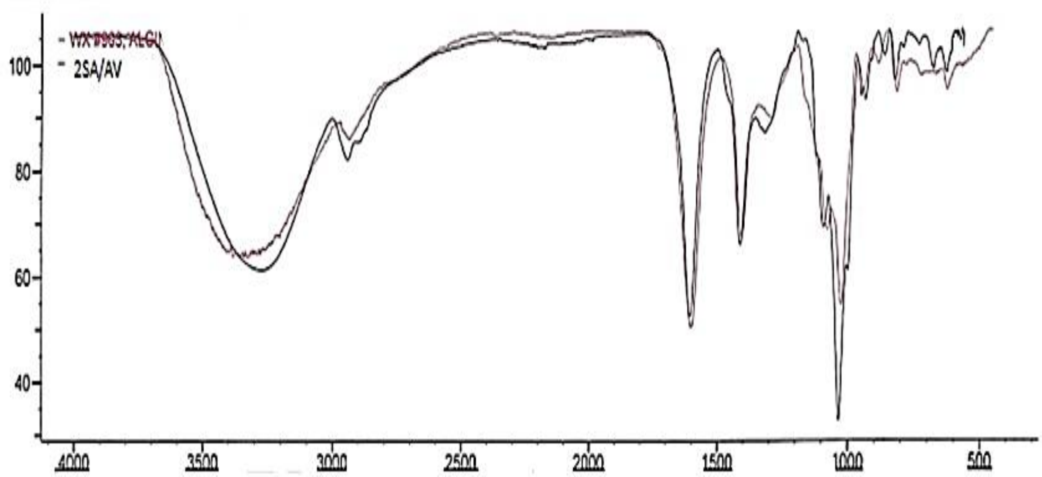

Fig.3. FTIR spectra of alginate/ aloe vera gel edible films

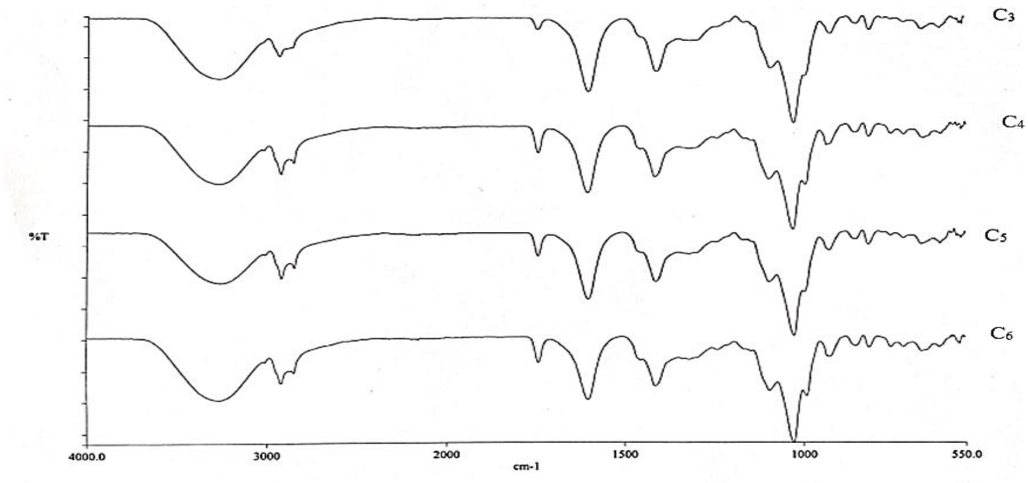

Fig.4. FTIR spectra of alginate/ aloe vera gel/ pomegranate seed essential oil edible films

Table 2 Physical properties of starch-based control films.

Formulation	Solubility (%)	WVTR (g / (s.m^2)	Moisture (%)	Thickness (mm)
C_1	41.31	$0,8793*10^{-3}$	27.93	0.090
C_2	87.57	$0,4914*10^{-3}$	22.56	0.130
C_3	86.22	$0,1091*10^{-3}$	28.05	0.080
C_4	83.36	$0,0897*10^{-3}$	19.95	0.140
C_5	84.95	$0,1267*10^{-3}$	29.40	0.125
C_6	72.56	$0,1207*10^{-3}$	22.90	0.178

As exhibited in Fig. 2, Fig. 3 and Fig. 4, strong peak observed at around 3300 cm^{-1} showed the typical bands of alginate; -OH stretching vibrations which confirms the presence polysaccharides, phenols and carboxylic acids present in AV and polyphenols in the PSEO. The band observed at around 1700 cm^{-1} represented the stretching of C=O and N-H groups of PSEO. The presence of carbonyl C = C group was confirmed through the presence of a strong band at about 1600 cm$^{-1.}$ The peak at about 1400 cm^{-1} was related to CH_3 bending vibration, indicating the presence of COOH groups. The relevant vibration peaks around 1000 cm $^{-1}$ were due to the presence of O-C-O group in polysaccharides, and the presence of C-C, C-O and C-

N bounds in complex polysaccharides. FTIR results explain the changes in physical properties of the PSEO added films [2, 7, 29, 30]

3.2 Water solubility

When the water solubility values of the alginate based edible films given at Table 2 were examined, it was seen that the solubility increases with the addition of AVG from 41.31% to 87.57%. The solubility value was increased from 41.31% to 86.22% when 1% PSEO was added and it was increased from 41.31% to 83.36% when 3% PSEO was added. Water solubility decreased when the PSEO concentration increased. This may be caused by the hydrophobic nature of the PSEO and high water solubility of the AVG components (sugars, organic acids, amino acids) which could be solubilized from the edible films increasing water solubility. Similar results have been obtained by Nazir and Wani [31] and Pinzon et al. [32]. Edible films having low solubility does not degrade quickly and can be used as a food coating film. Alginate based, AVG and PSEO added composite edible films water solubility is lower than only AVG and only PSEO added alginate based films (84.95% when1% PSEO was added and 72.56% when 3% PSEO was added). It was seen that alginate based edible composite films water solubility are suitable than the others films produced.

3.3 Water vapor transmission rate (WVTR)

Water vapor transmission rate of the alginate based edible films was given at Table 2. Edible films used in food coating must have low WVTR values to reduce the transfer rate of water from food to its environment. The addition of AVG to alginate based edible film reduced the WVTR value from 0,8793*10^{-3} (g/(s.m^2) to 0,4914*$10^{-3.}$ (g/(s.m^2). This reduction, is due to the interactions between alginate and AVG, which decrease the availability of the hydrophilic groups of alginate and prevent the interaction with water. Similar results have been obtained by Pinzon et al. [32] and Salama and Aziz [33]. WVTR of the alginate based edible films was decreased also after PSEO addition from 0,8793*10^{-3} (g/(s.m^2) to 0,1091*10^{-3} (g/(s.m^2) (1% PSEO) and to 0,0897*10^{-3} (3% PSEO). This is because essential oils moved as the hydrophobic dispersed phase. The increase of the PSEO concentration increased the distance travelled by water molecules diffusing through the film matrix. So, the transfer rate of water molecules and the WVTR of edible film were reduced. Similar results have been obtained by Zhang et al. [34]. Edible composite films WVTR values were 0,1267*10^{-3} with 1% PSEO addition and to 0,1207*10^{-3} with 3% PSEO addition respectively. PSEO added alginate based edible films have lower WVTR values. So they are suitable for using at food coating.

3.4 Moisture content

The moisture content of an edible film is determined by the total amount of water molecules present in the microstructure networks of the film.The moisture content of the films indicated the film hydrophilicity and affect water permeability of the films. The results given at Table 2 indicated that AVG addition decreased edible films moisture content from 27.93% to 22.56%. This can be caused by the formation of interaction between the free hydroxyl groups of alginate chains and

AVG, which leads to the decrease of free hydroxyl groups and the reduction of the moisture content of the film. The increase of PSEO concentration from 1% to 3% decreased the moisture content of the edible films from 28.05% to 19.95%, because, the essential oil components may interact with the hydroxyl groups of the film matrix to reduce the film's affinity for water. Edible composite films moisture content values were 29.40% for 1% PSEO added films and 22.90% for 3% PSEO added composite film [34-37]. Lower moisture content value was obtained from the PSEO added alginate based edible films.

3.5 Film Thickness

The thickness of the alginate based edible films is related to the total dry mass in the film-forming solution. It is preferred that the film thickness is less than 0.3 mm. When the thickness values of the films given at Table 2 were examined, it was seen that the film thickness increased with the addition of AVG, from 0.090 mm to 0.130 mm. Similar results have been obtained by Gutiérrez and Álvarez [38]. When the PSEO concentration increased from 1% to 3%, the film thickness increased from 0.080 mm to 0.140 mm. Similar results have been obtained by Roshandel-hesari et al [9]. It is preferred that the film thickness is less than 0.3 mm so that the packaged food can be eaten together with the edible film. Produced edible composite films thickness values was 0.125 mm for 1% PSEO added films and 0.178 mm for 3% PSEO added composite film.

3.6 Application of edible coating films on strawberries and cherries

Weight loss is an important characteristics of fruits during storage. Strawberrie and cherrie fruits display weight losses at long storage times. Water loss caused by respiration and water evaporation leads to fruit shrinking [39-40]. The weight loss (%) of coated and uncoated strawberries and cherries during 8 days storage at 4^0C, were given in Table 3. The results showed that maximum weight loss values were seen at uncoated strawberries and cherries, 15.83% and 15.02% respectively. Alginate coated strawberries weight loss was 12.25% lower than the uncoated strawberries. Alginate and 1% PSEO coated strawberries weight loss was 23.06% lower than the uncoated strawberries. And alginate and 3% PSEO coated strawberries weight loss was 28.99% lower than the uncoated strawberries. Alginate coated cherries weight loss was 52.20% lower than the uncoated cherries. Alginate and 1% PSEO coated cherries weight loss was 70.37% lower than the uncoated cherries. And alginate and 3% PSEO coated cherries weight loss was 77.90% lower than the uncoated cherries. As a result, it was seen that edible coating film reduced the weight loss of the fruits, moving as a water barrier between the fruits and the environment. Incresing PSEO % in coating solution decreases weight loss %, and the lowest weight loss was observed for fruits coated with alginate and 3% PSEO. The color change is one of the fruit quality parameter taken care of by consumers. The color change of coated fruits were confirmed using L*, a*, b*, and ΔE values (Table 4). The L^* (lightness) values of strawberries and cherries reduced after 8 days storage at 4^0C. This decrease may be caused by water loss of the fruits. At day 8 maximum L^* value was obtained by alginate and 3% PSEO coated fruits. a* (redness), b* (yellowness) and ΔE values were decreased also similar to lightness [41-43]. Maximum a* value was obtained by alginate and 1% PSEO coated fruits, maximum b* value was obtained by alginate coated fruits and maximum ΔE value was obtained by alginate and 1% PSEO coated fruits. The results indicated that alginate based and PSEO added edible coatings reducing moisture loss, color change and surface deformation of fruits. Images of uncoated and coated strawberries and cherries were given at Fig.5.

Table 3 Weight loss % of strawberries and cherries after 8 days storage at 4^0C

Fruit Type	Coating Solution	Weight Loss (%)
Strawberries	Uncoated	15.83
	Alginate	13.89
	Alginate and 1% PSEO	12.18
	Alginate and 3% PSEO	11.24
Cherries	Uncoated	15.02
	Alginate	7.18
	Alginate and 1% PSEO	4.45
	Alginate and 3% PSEO	3.32

Table 4 Color parameters of strawberries and cherries after 8 days storage at 4^0C

Time	Fruit Type	Coating Solution	L^*	a^*	b^*	ΔE
Day1	Strawberries	Uncoated	31.42	21.27	17.89	40.63
		Alginate	35.49	25.56	20.90	46.50
		Alginate and 1% PSEO	43.99	19.28	16.66	48.65
		Alginate and 3% PSEO	39.91	17.74	8.51	44.37
	Cherries	Uncoated	34.36	25.17	15.26	43.82
		Alginate	35.71	28.57	14.27	47.91
		Alginate and 1% PSEO	34.78	23.02	12.52	43.54
		Alginate and 3% PSEO	35.93	21.31	7.89	42.51
Day8	Strawberries	Uncoated	30.09	14.48	14.53	32.72
		Alginate	27.83	15.91	15.80	38.27
		Alginate and 1% PSEO	27.77	17.64	7.73	44.88
		Alginate and 3% PSEO	31.27	15.81	7.77	42.51
	Cherries	Uncoated	29.39	20.65	10.36	37.57
		Alginate	28.71	18.05	10.99	35.46
		Alginate and 1% PSEO	30.01	20.05	9.80	42.15
		Alginate and 3% PSEO	30.54	14.74	4.86	41.25

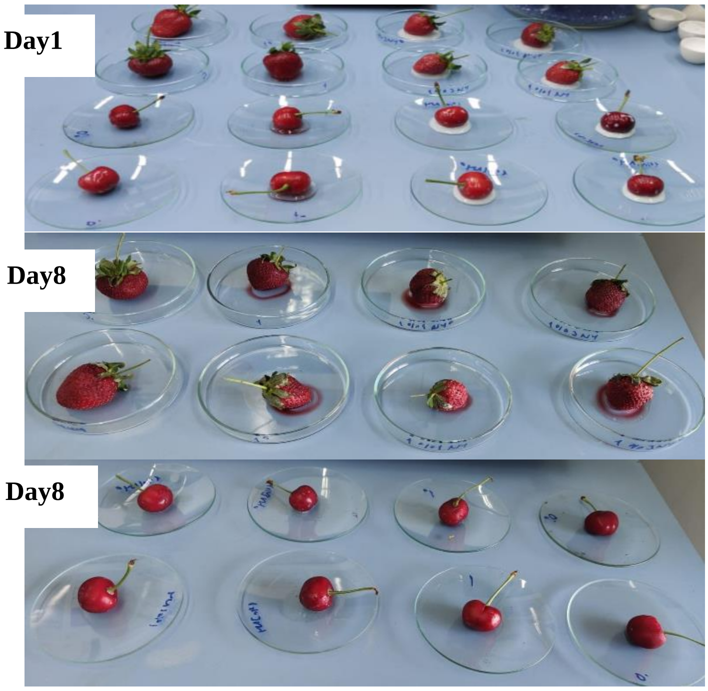

Fig.5. Images of uncoated and coated strawberries and cherries

4. CONCLUSIONS

In this study, the possibility of producing a new environmentally friendly, alginate-based, AVG and/or PSEO-added, biodegradable, edible coating film by casting method was investigated. To determine AVG and PSEO effects, they were added to the coating solution at 5 different ratios. Alginate based, AVG and PSEO added composite edible films water solubility is lower than only AVG and only PSEO added films. PSEO added alginate based edible films have lower WVTR and lower moisture content value, and films thickness were 0.125 mm for 1% PSEO added films and 0.178 mm for 3% PSEO added composite film. Strawberries and cherries were coated with produced edible coating films and weight loss and color analysis were carried out to observe coating performance. Alginate and 3% PSEO coated strawberries weight loss was 28.99% lower than the uncoated strawberries, and alginate and 3% PSEO coated cherries weight loss was 77.90% lower than the uncoated cherries. It was concluded that alginate based and PSEO added edible coatings reducing moisture loss, color change and surface deformation of strawberries and cherries. The biggest difference of this study from previous studies is that, PSEO was used for the first time in this study, for edible coating film production and the results were quite succesful especially for the cherrys coating.

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