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Araştırma Makalesi/*Research Article*

Creation of Edible Film Formulations with *Stevia Rebaudiana*and Effects on Minimal Processed Apples

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Abstract: In this study, different concentrations of sodium alginate (SA; 1%, 1.25%, 1.5%, 2%) and chitosan (CH; 0.5%, 0.75%, 1%, 1.5%, 2%) films were selected and experienced on sliced apples (Amasya) with various dipping times (0, 15, 20, 30 min). Also, the films were combined with *Stevia rebaudiana* extract (S; 2.5%). For chitosan formulations, a concentration of 0.75% chitosan was more applicable in film formation. Inaddition, the dipping time of the apples was not effective. The best results for SA areobtained at a concentration of 1.5% and a dipping time of 30 minutes. In combinations of stevia-SA (SAS), a concentration of 1.25% is optimal. In the study, the effects of ascorbic acid (AA) and ultrasonic degassing (UD) applications and drying times were also tested. The optimum dryingtimeswere 60 minutesfor CH and 120 minutesfor SA. After the drying of apple slices prepared in the specified formulations, theywerestored in polypropylene (PP) and polyethylene (PE) packages in a modified atmosphere (MAP, +1 °C, 8 days). Better results were obtained from polypropylene packaging material and the shelf life was determined as 3 days.

Keywords: *Stevia rebaudiana*, chitosan, sodium alginate, edible film, apple.

Stevia rebaudiana içeren film formülasyonlarının oluşturulması ve minimal işlenmiş elmalara etkisi

Öz: Bu çalışmada farklı konsantrasyonlarda sodyum aljinat (SA; %1, %1.25, %1.5, %2) ve kitosan (CH; %0.5, %0.75, %1, %1.5, %2) filmleri seçilmiş ve kesilmiş elma (Amasya) üzerinde farklı daldırma süreleri (0, 15, 20, 30 dak) ile denenmiştir. Ayrıca, filmler *Stevia rebaudiana* (S; %2.5) ile kombine edilmiştir. Kitosan formülasyonları için %0.75 konsantrasyonu film oluşumunda daha uygulanabilir olmuştur. Ayrıca elmaların filme daldırılma süresi etkili olmamıştır. SA için en iyi sonuçlar %1.5' lik konsantrasyonda, 30 dakikalık daldırma süresindedir. Stevia-SA(SAS) kombinasyonlarında %1.25 konsantrasyon idealdir. Çalışmada askorbik asit (AA) ve ultrasonik gaz giderme (UD) uygulamalarının etkileri ile kuruma süreleri de test edilmiştir. Kuruma süresi CH için 60 dakika ve SA için 120 dakika olarak bulunmuştur. Belirlenen formülasyonlarda hazırlanan kesilmiş elmalar kurutulduktan sonra modifiye atmosferde (MAP, +1 °C, 8 gün) polipropilen (PP) ve polietilen (PE) ambalajlarda saklanmıştır. Polipropilen ambalaj malzemesinden daha iyi sonuç elde edilmiş ve raf ömrü 3 gün olarak belirlenmiştir.

Anahtar kelimeler: *Stevia rebaudiana,* kitosan, sodyumaljinat, yenilebilir film, elma.

1. Introduction

Edible films can be termed a thin polymer layer which can be a gas and moisture barrier for food, and which can also be used as a carrier for various substances (antioxidants, antimicrobials, etc.) and consumed with foods (Bourtoom 2008). As a coating material for fruit and vegetables, many polymers such as sodium alginate, gellan, carboxymethyl cellulose, chitosan, whey and soy proteins are used (Chiabrando and Giacalone 2016). Attention to coating of fruits with edible coatings are increasingly due to various properties of fruits such as; reducing respiration and sweating rates and increasing shelf life, ability to maintain fruit stiffness, good mechanical properties, non-toxic, environment friendly and low cost (Tezotto-Uliana et al. 2014; Guerreiro et al. 2015). In addition, edible films can be carriers of various active or functional food components such as antimicrobial

compounds, antifungal agents, colorants, aromas, spices, which can extend the shelf life and reduce the risk of developing pathogenic microorganisms on the food surface (Lin and Zhao 2007; Röβle et al. 2011). Antioxidant and antimicrobial properties of stevia leaves are mentioned in litrature. In addition to steviol glycosides, stevia leaves contain high amounts of phenolic compounds with antimicrobial and antioxidant properties, vitamin C, carotenoids and chlorophyll (Muanda et al. 2011; Barba et al. 2015).

In this study; it is aimed to constitute edible film formulations based on chitosan and alginate and development of combinations of the formulations with stevia extracts, applying the obtained formulations to Amasya variety apples to produce ready-to-eat apple slices.

2. Materials and Methods

2.1. Material

Chitosan (>400 mPa.s, 1% in acetic acid, Sigma Aldrich, Germany) and sodium alginate (2.000 cp, 2%, medium viscous, Sigma Aldrich, Germany) were used as film forming. Glycerol (84-88% in purity, Sigma Aldrich, Germany) was added to the coatings as plasticizer. Ascorbic acid (1.65 g/cm^3, Food type, Tito, China) was added to prevent oxidation of the fruit surface. Dried stevia leaves were obtained from a local herbalist (Tokat, Turkey). "Amasya" variety apples were purchased in a local wholesale distributor (Tokat, Turkey) and stored at 1±1 °C until processing. Polypropylene (30 µm) and polyethylene (30 µm) were chosen as packaging material for MAP applications.

Creation of edible film formulations: In the stage of the creation of edible film formulations; chitosan, sodium alginate and combinations of both with stevia were tested. However, all film formulations were prepared in the form of i) ascorbic acid-free, ii) ascorbic acid free-30 min ultrasonic degass, iii) 2% ascorbic acid-30 min ultrasonic degassing.

Chitosan film formulation: The chitosan based edible film production was dissolved 0.5-2% (w/v) chitosan in 1% acetic acid (AC) and added 1.5% glycerol (G) and 2% ascorbic acid. The prepared film was homogenized at 40 °C for one hour and then the film was degassed for 30 minutes with ultrasonic bath (Elmasonic S 100 (H), Elma, Germany). The film solution was spread into the petri plate and allowed to stand at ambient temperature until drying (Meng et al. 2007).

Sodium alginate film formulation: Sodium alginate was dissolved in hot water (45 ˚C) and sodium alginate film was prepared at different concentrations (1-5%;w/v) and glycerol was added at different ratios ranging from 5% to 20% (v/v) (Chiabrando and Giacalone 2016). The film was also subjected to 2% ascorbic acid addition and then the film was degassed for 30 min in an ultrasonic bath (Elmasonic S 100 (H), Apple, Germany). The film solution was dispersed into the petri and waited at ambient temperature up to dry.

Formulations of edible film-stevia combinations: Dried *Steviarebaudiana* leaves were weighed 8.33 g, completed with pure water in boiling temperature to 100 ml (8.33%), and waited for 30 minutes. The heterogeneous mixture was then filtered and stored at -80 °C until use (Carbonell-Capella et al. 2015). Edible film-stevia extract combinations were prepared by slowly adding the 2.5% stevia extract. The final concentration was chosen because it showed the best antimicrobial activity among the tested stevia percentages in previous studies (Savita et al. 2004; Carbonell-Capella et al. 2016). The films were dispersed into the petri and waited at room temperature up to dry.

Application of edible films to apple slices: The apples were washed and dried, cores were pitted and sliced without peeling of pericap before film coating. The application of edible films to apples was done by immersion method. The apples were waited in film solutions for 0, 15, 20 and 30 minutes. The coated apples were kept on perforated plates for 20 minutes, then they were subjected to 30, 45, 60, 90 and 120 min

of drying. Also, the coated apples were subjected to a second dipping treatment after first drying.

Application of MAP to coated apples and determination of storage period: The packaging materials (PE-30µm, PP-30µm) were cut at the appropriate dimensions before packaging, sealed with a thermal sealer and surrounded by an air tight tape despite the possibility of air tightness after heat treatment. Samples in a styrofoam container were placed in PP packages and PE packages and each portion was closed by heat treatment and taped.

In order to determine the shelf life of the samples, control (C) and film coated samples were stored in PP and PE packages at +1 °C for 8 days and weight loss, hardness and O_2/CO_2% ratios were evaluated every two days period.

2.2. Analysis Methods

pH values were measured by using WTW Inolab pH Level1 (Germany) model pH-meter (AOAC 1995).

O_2% and CO_2% concentrations were determined with a gas analyzer (Gaspace 2, England). The injection needle of this tool was immersed in a rubber band pre-glued on the package and the O_2% and CO_2% amounts in the headspace of the package were measured (AOAC 1995).

The weights of the apples at the beginning and at the end of storage are weighed and the weight loss is calculated according to the following formula and expressed as "%" (Eq.1).

Weight loss (%): (a-b)/a x 100 (1)

where;

a: beginning weight, g; b: storage end weight, g in equation

The maximum force required to drill apples for 10 mm from the vertical size was used by measuring in Newton for determininghardness value. In the measurement, Zwick Z 0.5 (USA) Tester with 10 mm diameter stainless steel head was used (Anonymous 2002).

Statistical analysis: Statistical evaluations were carried out using the SPSS 16.0 for Widows package program. Differences in practice were assessed according to the "One-Way Anova for Repeated Measures" analysis for the related samples. The mean values were compared with the "Tukey" multiple comparison test at 95% confidence level.

3. Results and Discussion

3.1. FormulationofEdible Films

0.5-2% chitosan range is determined according to the literature.Thus; Tezotto-Ulino et al. (2014) reported that raspberry samples were coated with 0%, 0.5%, 1% and 2% chitosan concentrations before and after harvesting and that chitosan application had a positive effect on shelf life (Tezotto-Uliana et al. 2014).

From the 0.5-2% chitosan (high density) concentration ranges determined for the formation of suitable film formulations of chitosan (CH) and chitosan-stevia combination (CHS); 0.5%, 0.75%, 1%, 1.5% and 2% were tested (Table 1). It was observed that the chitosan films obtained with the ratios of 1.5% and above were intense. Regarding this situation; it has been reported that as the concentration of chitosan increases, as the ambient temperature decreases and as the degree of acetylation increases, the viscosity of the chitosan solution increases (Cahit 2008). However, it was found that 0.5% chitosan content was insufficient in film formation and 1% chitosan coatings dried longer than 0.75% after waiting in room conditions.

As a result of all these data, it was determined that the most suitable concentration of the tested chitosan film formulations was 0.75% chitosan. However, it has been found that the films of the chitosan formulations are more viscous than stevia combinations. In addition, the measured pH values in the 0.75% chitosan concentration range are 4.21 for chitosan film, 3.48 for chitosan-ascorbic acid film and 3.63 for chitosan-stevia-ascorbic acid film.

Although naturally occurring polysaccharides such as cellulose, dextran, alginic acid, agar, agarose, pectin and carrageenan are neutral or acidic, chitosan is a basic polysaccharide (Yıldırım et al. 2016). Accordingly, as the concentration of chitosan in the films increases, it is thought that an increase in the pH values is

observed. It has been found that the films have been poured into petri dishes, dried in 2 to 3 days in room conditions, and that this period has changed according to the film density and the films containing stevia from the drying films are slightly more elastic and darker in color.

Table 1. Tested film formulation ratios to chitosan (CH; chitosan, S; stevia, AC; acetic acid, G; glycerol, AA; ascorbic acid)
***Çizelge* 1.** *Kitosan için test edilmiş film formülasyon oranları (CH; kitosan, S; stevia, AC; asetik asit, G; gliserol, AA; askorbik asit)*

CH ratio (%)	S ratio (%)	AC ratio (%)	G ratio (%)	AA ratio (%)
0.50	-	1	1.00	-
0.75	-	1	1.00	-
1.00	-	1	1.00	-
1.50	-	1	1.00	-
2.00.	-	1	1.00	-
0.50	2.5	1	1.00	-
0.75	2.5	1	1.00	-
1.00	2.5	1	1.00	-
1.50	2.5	1	1.00	-
2.00	2.5	1	1.00	-
0.50	-	1	1.50	2
0.75	-	1	1.50	2
1.00	-	1	1.50	2
1.50	-	1	1.50	2
2.00	-	1	1.50	2
0.50	2.5	1	1.50	2
0.75	2.5	1	1.50	2
1.00	2.5	1	1.50	2
1.50	2.5	1	1.50	2
2.00	2.5	1	1.50	2

From the concentration ranges of 1-5% sodium alginate (medium viscosity) with 20% glycerol determined to form proper film formulations containing sodium alginate and sodium alginate-stevia (SAS); 1%, 1.25%, 1.5%, 2%, 2.5% were tested (Table 2); and it has been observed that the films obtained with the ratios of 2% and above were intensive. The thickness of film on the fruit surface was not excessive. If the coating thickness is too high, the carbon dioxide level will rise to a critical level, while the oxygen concentration in the interior will be lower than the desired level and will cause harmful effects such as anaerobic respiration (Işık et al. 2013). The pH value was determined to be 3.72 for 1.25% sodium alginate-2% ascorbic acid-20% glycerol and 3.85 for 1.25% sodium alginate-stevia-2% ascorbic acid-20% glycerol. In addition, the combination of sodium alginate, stevia and ascorbic acid has reduced the coating's properties and created more gelling. In the literature, it is stated that the viscosity of the alginate solutions increases as the pH value decreases and reaches its maximum value within the range of pH = 3-3.5 (Lee and Money 2012). However, the ratio of 1.25% sodium alginate (20% glycerol) gave better results in stevia film combinations.

The plasticizers influence the water binding ability and at the same time increase the film oxygen permeability (McHungh and Krochta 1994a; McHungh and Krochta 1994b; Rojas-Graü et al. 2008). In the study, 5%, 10% and 20% glycerol tests were made for film formulations (Table 2.); the best result was obtained at 20%. However, because of the good results in the 10% concentration, it was more acceptable in terms of reducing the additive. While the 5% glycerol ratio was sufficient in the stevia added formulation, it was insufficient in stevia-free sodium alginate film formation. In order to determine the application of the film formulations, the apples were immersed in the specified formulations and kept at room conditions. During this time, the chitosan and chitosan-stevia were applied to apples that suffered more enzymatic reaction than the control sample, as concentration rises and time progresses; but at the end of the third day there was less moisture loss. Also, stevia applied films showed more browning than untreated films. This is thought to be due to stevia's natural color, variety and the amount of phenolic material it contains. Because, on the 0^{th} day of the film formulations applied, it was observed that the apples covered with stevia combinations were darker and greeny-brown. Similar results on CH and CHS samples were also obtained in the coatings of sodium alginate (SA) and sodium alginate-stevia (SAS) coated samples. In line with these results, it has been determined that edible films are inadequate in the prevention of enzymatic browning in sliced apples alone and stevia does not make a positive contribution in this direction.

The application of ascorbic acid was carried out in two different ways in order to achieve better results in the prevention of enzymatic browning. In the first, apple slices were immersed in 2% ascorbic acid solution and then coated with film. In the second, coatings were made by adding ascorbic acid to the film formulations.

As the result of two tried methods, ascorbic acid prevented enzymatic browning compared to the control sample. However, it has been found that dipping the apples in to the film after waiting in ascorbic acid, has a shorter effect than the addition of ascorbic acid to the film. This is because edible films reduce the diffusion rate of additives (Kandemir 2006). On the other hand; ascorbic acid has been found to be more effective when the edible film concentration is lowered, but the moisture loss is increased by decreasing the edible film concentration. According to Chien et al.'s work on the mangos; the increase in chitosan concentration affected water content (%) positively (Chien et al. 2007).

The color of the samples coated with stevia edible film combinations is greeny-brown; as well as different than the other samples. However, enzymatic browning in apple slices coated with stevia-edible film combination was less common in ascorbic acid supplemented experiments. The antioxidant properties of stevia are enhanced by the addition of ascorbic acid. Thus, the informations about stevia's antioxidant properties are mentioned in the literature. It is also known that ascorbic acid increases their effectiveness when used with other antioxidants (Borenstein 1972). In terms of sensorial, the presence of stevia is clearly felt in the smell and taste of the samples coated with films containing stevia.

Positive results were obtained from ultrasonic application in film production. The apples coated with the film not subjected to ultrasound treatment showed browning in a shorter time than those applied with ultrasound. The reason for this is the dissolution of insoluble particles in film formulations, the removal of air bubbles and occur a more homogeneous structure by ultrasonic degas applications.

Table 2. Tested film formulation ratios to sodium alginate (SA; sodium alginate, S; stevia, G; glycerol, AA; ascorbic acid)
Çizelge 2. *Sodyum aljinat için test edilmiş film formülasyon oranları (SA; sodyum aljinat, S; stevia, G; gliserol, AA; askorbik asit)*

SA ratio (%)	S ratio (%)	G ratio (%)	AA ratio (%)
1.00	-	5	-
1.25	-	5	-
1.50	-	5	-
2.00	-	5	-
2.50	-	5	-
1.00	-	10	-
1.25	-	10	-
1.50	-	10	-
2.00	-	10	-
2.50	-	10	-
1.00	-	20	-
1.25	-	20	-
1.50	-	20	-
2.00	-	20	-
2.50	-	20	-
1.00	-	5	2
1.25	-	5	2
1.50	-	5	2
2.00	-	5	2
2.50	-	5	2
1.00	-	10	2
1.25	-	10	2
1.50	-	10	2
2.00	-	10	2
2.50	-	10	2
1.00	-	20	2
1.25	-	20	2
1.50	-	20	2
2.00	-	20	2
2.50	-	20	2
1.00	2.5	5	2
1.25	2.5	5	2
1.50	2.5	5	2
2.00	2.5	5	2
2.50	2.5	5	2
1.00	2.5	10	2
1.25	2.5	10	2
1.50	2.5	10	2
2.00	2.5	10	2
2.50	2.5	10	2
1.00	2.5	20	2
1.25	2.5	20	2
1.50	2.5	20	2
2.00	2.5	20	2
2.50	2.5	20	2

The sliced apples were immersed in edible film formulations for 0, 15, 20 and 30 min and the effect of the immersion times was observed. For the formulations containing chitosan and

chitosan-stevia, the duration of immersion was not very effective but the formulations containing sodium alginate and sodium alginate-stevia showed more positive results in 30 min immersion time. In addition, in all film formulations, the apples were immersed again at 30^{th}, 60^{th} and 90^{th} min after the first immersion but no positive results were obtained. This situation increased the enzymatic reaction and extended the drying period.

The drying time of samples coated with edible film was determined to be an important step in preserving the moisture balance and accelerating the enzymatic activity of the apple slices.

The sliced apples remained moist due to the short drying time, so, enzymatic browning accelerated during storage. Because of most enzymes are efficient in water, the amount of water is an important factor in enzyme activity (Saldamlı 2014). And also, with a long hold of drying time, moisture loss has occurred in apple slices, and especially in the nearby parts of the endocarp, browning has consisted. The air circulation and temperature consisted here, has triggered browning. As noted, when all other conditions are standardized, as the temperature of the reaction medium increases, the reaction rate also increases to a certain point (Saldamlı 2014). In addition, the information obtained regarding the factors affecting the drying time is as follows; as the film density increases, the drying time extended. Because of the viscosity of the solution has reduced the heat transmission. The increase in viscosity, generally limits the level of evaporation (Gürses 1986). The re-dipping process applied to the apples increased the drying time. Because, in addition to normal drying of the product, the drying time of the 2^{nd} dipping is added. The size and shape of apple slices is important. Ambient conditions must be appropriate during drying.

In the study, to provide the drying, two ways were tried; drying oven (at 30 °C) and room conditions (drafty). But the drying in drying oven has caused the loss of freshness by increasing the loss of moisture in the apples. The driers used to dry the foods should be in accordance with the characteristics of the product and should provide the characteristics expected from the drying process. But high temperature significantly changes the quality of foodstuff (Demir 2010). In room conditions (25 °C), the times specified for sliced apples are 60 min for chitosan and chitosan-stevia, and 120 min for sodium alginate and sodium alginate-stevia. However, in order to provide moisture balance in the apple slices, the apple slices were turned in every 15 min's during the drying period.

It was also determined that the size and shape of the apple slices were important. Because, it is known that the rate of drying is inversely proportional to the thickness, directly proportional to the surface area of the particles. Therefore; as the smaller dried particles, so the higher surface area, the smaller thickness and thus; the drying rate have positive affect (Er 2011).

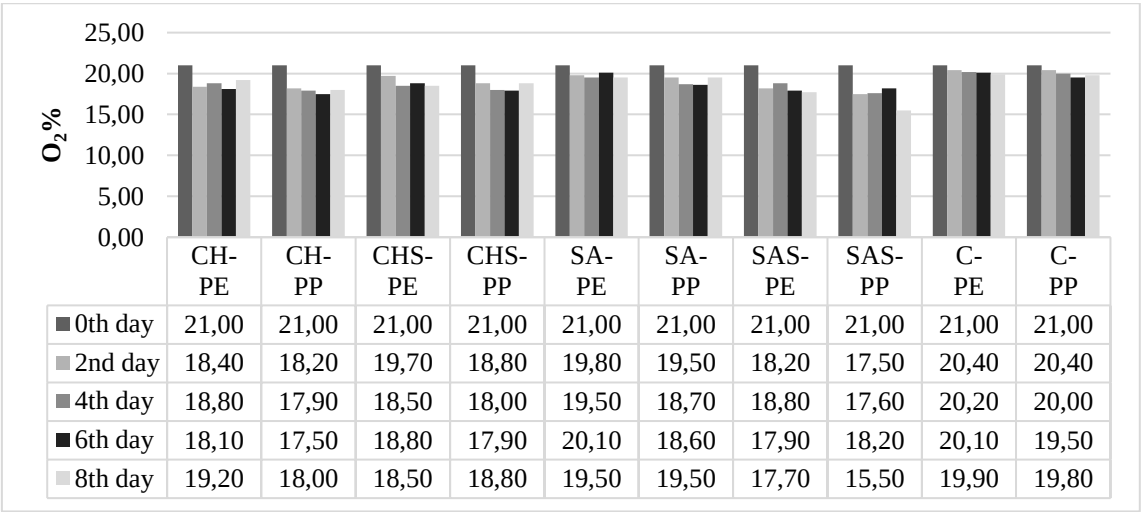
Color browning occurs before drying, during drying and/or during storage. The browning may occur in consequence of enzymatic or non-enzymatic reactions. The browning of color in dried products usually occurs in a non-enzymatic way (Er 2011).

Enzymatic browning was more common in the edge regions of apples that sliced wedge type. This has been attributed to the excess of cell destruction in that region resulting from the cutting. Phenolic substances in the cell extract, which break down in sliced fruits, cause enzymatic browning reactions catalyzed by polyphenol oxidase (PPO) enzymes (Erbay and Demir 2006). However, this situation has not been observed in apple slices that have been transformed into cubes.

It is also important to remove the nucleus house and their surrounding areas during the formation of the apple slices. As a matter of fact, enzymatic browning is more common in the nucleus house and its surrounding areas. Regarding this, PPO activity has been determined by scientists in different tissues of plants showing changes depending on their developmental process. Vamos-Vigyazo et al. reported that PPO activity was found on all sides of apple and pear fruit, but showed higher activity in seed and crust regions (Vamosi-Vigyazo et al. 1985).

3.2. Selection of packaging film and determination of storage time

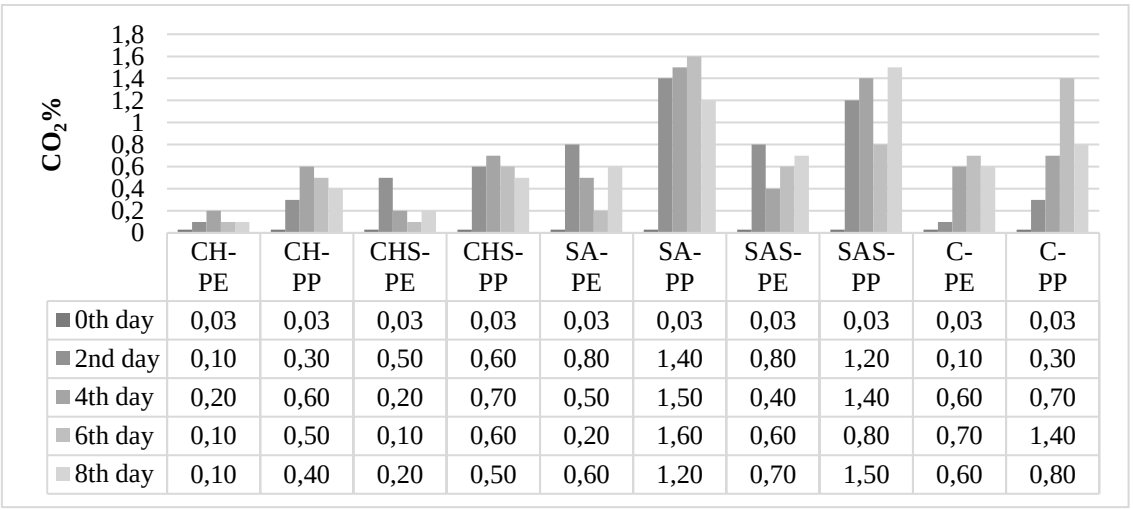
At this stage, the edible films in the specified formulations were applied to sliced apples and stored in prepared PE (30 µm) and PP (30 µm) packages. During this time, the optimum packing material and storage time were determined by considering the weight and texture value variations of the samples and the O_2% and CO_2% ratios of the packages. Sample analyzes were performed by sampling every 2 days in an 8 day storage period. As the results of analysis, it was determined that the gas atmosphere of the apples packed with PP was more modified than the apples packed with PE, and accordingly the apples lost more weight (Figure1, 2, 3).



	CH-PE	CH-PP	CHS-PE	CHS-PP	SA-PE	SA-PP	SAS-PE	SAS-PP	C-PE	C-PP
0th day	21,00	21,00	21,00	21,00	21,00	21,00	21,00	21,00	21,00	21,00
2nd day	18,40	18,20	19,70	18,80	19,80	19,50	18,20	17,50	20,40	20,40
4th day	18,80	17,90	18,50	18,00	19,50	18,70	18,80	17,60	20,20	20,00
6th day	18,10	17,50	18,80	17,90	20,10	18,60	17,90	18,20	20,10	19,50
8th day	19,20	18,00	18,50	18,80	19,50	19,50	17,70	15,50	19,90	19,80

Figure 1. The average O_2% ratios of the CH (Chitosan), CHS (Chitosan-Stevia), SA (Sodium Alginate), SAS (Sodium Alginate-Stevia), C (Control) samples in different packages (PE; polyethylene, PP; polypropylene)

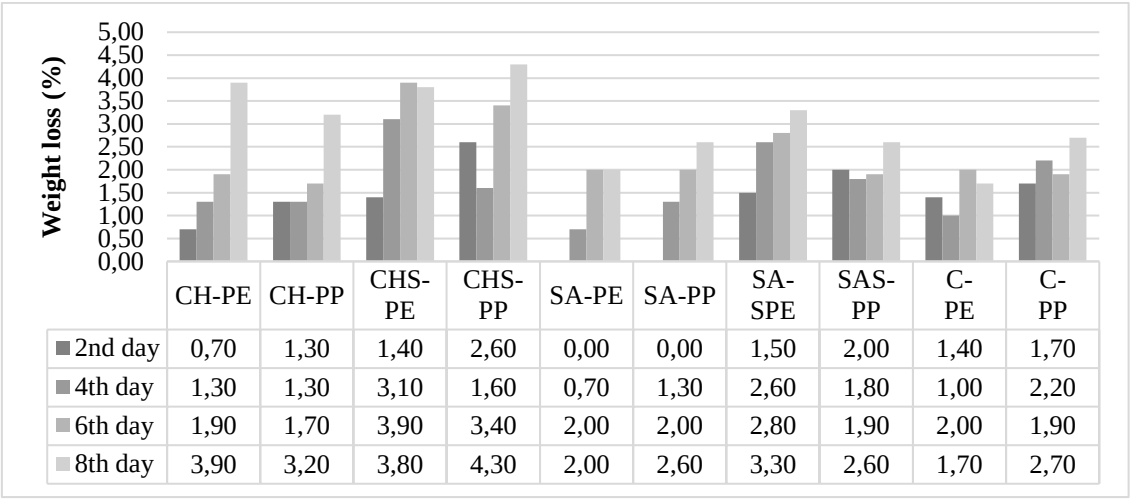
Şekil 1. *Farklı ambalajlarda bulunan CH (Chitosan), CHS (Chitosan-Stevia), SA (Sodyum Aljinat), SAS (Sodyum Aljinat-Stevia), C (Kontrol) elma dilimlerinin ortalama% O_2 oranları (PE; polietilen, PP; polipropilen)*



	CH-PE	CH-PP	CHS-PE	CHS-PP	SA-PE	SA-PP	SAS-PE	SAS-PP	C-PE	C-PP
0th day	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03
2nd day	0,10	0,30	0,50	0,60	0,80	1,40	0,80	1,20	0,10	0,30
4th day	0,20	0,60	0,20	0,70	0,50	1,50	0,40	1,40	0,60	0,70
6th day	0,10	0,50	0,10	0,60	0,20	1,60	0,60	0,80	0,70	1,40
8th day	0,10	0,40	0,20	0,50	0,60	1,20	0,70	1,50	0,60	0,80

Figure 2. The average CO_2% ratios of the CH (Chitosan), CHS (Chitosan-Stevia), SA (Sodium Alginate), SAS (Sodium Alginate-Stevia), C (Control) samples in different packages (PE; polyethylene, PP; polypropylene)

Şekil 2. *Farklı ambalajlardaki CH (Chitosan), CHS (Chitosan-Stevia), SA (Sodyum Aljinat), SAS (Sodyum Aljinat-Stevia), C (Kontrol) örneklerinin ortalama% CO_2 oranları. (PE; polietilen, PP; polipropilen)*



	CH-PE	CH-PP	CHS-PE	CHS-PP	SA-PE	SA-PP	SA-SPE	SAS-PP	C-PE	C-PP
2nd day	0,70	1,30	1,40	2,60	0,00	0,00	1,50	2,00	1,40	1,70
4th day	1,30	1,30	3,10	1,60	0,70	1,30	2,60	1,80	1,00	2,20
6th day	1,90	1,70	3,90	3,40	2,00	2,00	2,80	1,90	2,00	1,90
8th day	3,90	3,20	3,80	4,30	2,00	2,60	3,30	2,60	1,70	2,70

Figure 3.The average weight loss (%) of the CH (Chitosan), CHS (Chitosan-Stevia), SA (Sodium Alginate), SAS (Sodium Alginate-Stevia), C (Control) samples in different packages (PE; polyethylene, PP; polypropylene)
Şekil 3. *Farklı ambalajlardaki CH (Kitosan), CHS (Kitosan-Stevia), SA (Sodyum Aljinat), SAS (Sodyum Aljinat-Stevia), C (Kontrol) örneklerinin ortalama ağırlık kaybı (%) (PE; polietilen, PP; polipropilen)*

Table 3. The average fruit hardness values of the CH (Chitosan), CHS (Chitosan-Stevia), SA (Sodium Alginate), SAS (Sodium Alginate-Stevia), C (Control) samples in different packages (PE; polyethylene, PP; polypropylene)
Çizelge 3. *Farklı ambalajlardaki CH (Chitosan), CHS (Chitosan-Stevia), SA (Sodyum Aljinat), SAS (Sodyum Aljinat-Stevia), C (Kontrol) numunelerinin ortalama meyve sertlik değerleri (PE; polietilen, PP; polipropilen)*

Group	Hardness of fruit (N)				
	Storage period (day)				
	0	2	4	6	8
CH-PE	1.982 ± 0.0^{cA}	1.311 ± 0.2^{bA}	1.025 ± 0.2^{abA}	0.904 ± 0.1^{abA}	0.680 ± 0.2^{aA}
CH-PP	1.982 ± 0.0^{cA}	1.487 ± 0.4^{bcA}	1.007 ± 0.2^{abA}	0.921 ± 0.0^{abA}	0.760 ± 0.1^{aA}
CHS-PE	1.920 ± 0.2^{bA}	0.792 ± 0.2^{aA}	1.049 ± 0.5^{abA}	1.482 ± 0.1^{abA}	0.780 ± 0.1^{aA}
CHS-PP	1.920 ± 0.2^{bA}	0.850 ± 0.0^{aA}	1.127 ± 0.0^{aA}	1.010 ± 0.3^{aA}	0.770 ± 0.0^{aA}
SA-PE	1.196 ± 0.2^{bA}	0.404 ± 0.2^{aA}	0.262 ± 0.5^{aA}	0.228 ± 0.1^{aA}	0.221 ± 0.1^{aA}
SA-PP	1.190 ± 0.2^{bA}	0.355 ± 0.0^{aA}	0.276 ± 0.0^{aA}	0.272 ± 0.3^{aA}	0.226 ± 0.0^{aA}
SAS-PE	1.357 ± 0.1^{bA}	0.214 ± 0.1^{aA}	0.238 ± 0.0^{aA}	0.250 ± 0.0^{aA}	0.281 ± 0.0^{aA}
SAS-PP	1.357 ± 0.1^{cA}	0.101 ± 0.1^{aA}	0.231 ± 0.2^{bA}	0.200 ± 0.2^{abA}	0.206 ± 0.2^{abA}
C-PE	2.008 ± 0.0^{aA}	1.925 ± 0.2^{aA}	1.750 ± 0.0^{aA}	2.070 ± 0.3^{aA}	1.950 ± 0.1^{aA}
C-PP	2.000 ± 0.0^{aA}	1.923 ± 0.1^{aA}	1.815 ± 0.1^{aA}	1.960 ± 0.2^{aA}	1.750 ± 0.0^{aA}

n = 3, (± standard deviation), $^{a, b \cdots} \leq 0.05$ represent the differences in the same line, $^{A, B, C} \leq 0.05$, respectively, on the same column

To specify the shelf life of the coated samples in the packaging material determined, the changes in color and texture which caused the lose of fresh apple appearance were regarded and the shelf life was determined to be 3 days in the 8 day storage period

4. Conclusions

In the CH and CHS film formulation studies, 0.75% CH-1% AC-2% AA-1.5% G was chosen as the best formulation, also 2.5% stevia extract for CHS and 30 min dipping time and 60 min drying time were selected. The best formulations for SA and SAS film formulations were 1.25% SA-2% AA-10% G, also 2.5% stevia extract additives for SAS, 30 min dipping time and 120 min drying time. PP was selected as the proper packaging material and its shelf life was determined as 3 days.

It is thought that this study will give new ideas about the application of SA and CH films to the fruits, which have the potential to be applied not only in the production of apple slices but also in the production of ready-to-eat fruit, and will contribute to the literature. These films can also be improved by combining antioxidants and antimicrobial agents against the problems seen in fruits (for example, $CaCl_2$ may be added for elimination of softening in the SA sample in this study). It is also suggested to take into account the problems caused using stevia extracts and to find solutions to these problems.

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