THE EFFECT OF CORN ZEIN EDIBLE FILM COATING ON INTERMEDIATE MOISTURE APRICOT *(PRUNUS ARMENICA L.)* QUALITY

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Abstract

Intermediate moisture apricots were produced from sun dried natural apricots which were dipped into a 2.5% citric acid solution at 80 °C for 3 minutes. Intermediate moisture apricots were coated with different formulations of natural corn protein "zein" films by dipping treatment. The potential of antimicrobial and antioxidant agents in edible zein film and the coating effects to maintain the quality of intermediate moisture apricots has been investigated during 10 months storage at 5 and 20 °C. Colour change was reduced remarkably by coating process. The control fruits presented higher values of a^*/b^* (1.0±0.1) than the coated fruits (0.7±0.2). ΔE value of coated samples was found to be 7.9±1.1 at the end of storage period where it was identified as 13.8±0.6 for control samples . Total viable bacteria count of control group was found significantly higher than zein film coated samples ($P<0.05$). Coating with zein film inhibited microbial growth to the extent of around 2 log between control and coated batches. Higher storage temperature caused higher moisture loss from samples , however no significant difference was found between different coating formulations on moisture loss.

Keywords: edible film, corn zein, ascorbic acid, sorbic acid, intermediate moisture apricot

YENİLEBİLİR MISIR ZEİNİ FİLMİ KAPLAMANIN ORTA NEMLİ KAYISI *(PRUNUS ARMENICA L.)* KALİTESİNE ÜZERİNE ETKİSİ

Abstract

Güneşte kurutulmuş naturel kayısıların %2.5 sitrik asit çözeltisine 80 °C de 3 dk daldırılması ile orta nemli kayısı örnekleri üretimi gerçekleştirilmiştir. Orta nemli kayısılar farklı zein film formülasyonları içeren çözeltilere daldırılarak kaplanmıştır. Antimikrobiyal ve antioksidant maddelerin zein film içerisine eklenmesinin etkilerinin araştırılması ve depolama süresince kaplamanın orta nemli kayısı üzerine etkisinin belirlenmesi amacıyla ürünler 10 ay süresince 5 ve 20 °C sıcaklıklarda depolanmıştır. Kayısılarda depolama sırasında oluşan renk değişimi önemli ölçüde kaplama işlemi ile azaltılmıştır. Kontrol örnekleri için a^*/b^* (1.0±0.1) değeri kaplanmış örneklerin a^*/b^* (0.7±0.2) değerinden yüksek bulunmuştur. Depolama süresi sonunda ΔE değerleri ise kaplanmış örneklerde 7.9±1.1 iken kontrol örnekleri için bu değer 13.8±0.6 olarak belirlenmiştir. Kontrol grubu örneklerin toplam canlı sayımı zein film ile kaplanmış örneklere göre istatistiksel anlamda yüksek bulunmuştur ($P<0.05$). Kaplanmış örneklerle kontrol grubu örnekler arasında 2 log düzeyinde farklılık oluştuğu belirlenmiştir. Yüksek depolama sıcaklıklarının nem kaybını arttırdığı ancak farklı kaplama formülasyonları arasında önemli bir farklılık olmadığı bulgulanmıştır.

Anahtar Kelimeler: Yenilebilir film, zein, sorbik asit, askorbik asit, orta nemli kayısı

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INTRODUCTION

Safe food processing technologies used for preventing the microbiological spoilage or preservation of sensory quality characteristics of food materials are very important issues. In order to reduce the amount of chemical compounds used, the current processing applications need to be improved. Edible antimicrobial films and coatings have shown to be an efficient alternative in controlling food contamination. The growth of both deteriorating and pathogenic microorganisms can be prevented by incorporating antimicrobial agents into edible films or coatings (1, 2). The antimicrobial agents most commonly utilized in edible coatings are: sorbic acid, propionic acid, potassium sorbate, benzoic acid, sodium benzoate and citric acid (3). Surface coatings can decrease fruit peel permeance, modify the internal atmosphere, reduce water loss, and depress fruit respiration rate (4-6). Raw materials originating from agricultural sources used in the production of bio-based packaging materials including both edible films and edible coatings have potential for foods preservation (7). Edible films and coatings are thin layers on the food surface or between the heterogenic food components (8). Functional properties of the films are dependent on the polymer structure of the film raw material and film composition (9--12).

Zein is a natural protein found in corn kernels. Zein coatings have been used to coat nuts and candy for increased gloss, and prevention of oxidation and development of off-odors. Zein coatings offer a reasonable alternative to shellac and carnauba wax (4). Edible films with effective barrier properties can be used to prevent aroma loss in dried foods or antimicrobial added coatings are used in intermediate moisture food for preventing the microbial contamination (13). The coating can serve as a carrier for antimicrobial compounds and/or antioxidants compounds in order to maintain high concentrations of preservatives on the food surfaces (14, 15). Performance of zein films as barrier packaging for popcorn, tomatoes, cooked turkey, and shell eggs has been evaluated. In addition, use of zein-based coatings for reducing oil uptake by deep-fried foods, for obtaining controlled-release of active ingredients in pharmaceutical tablets, and for masking the taste of bitter orally administered drugs has been discussed in recently awarded patents (16).

Turkey is the leading apricot producer followed by Iran. Turkey generates approximately 80-85% of world's total dry apricot sales (17). Due to the large amount of dry apricot production in Turkey, it is essential to find alternative new products such as intermediate moisture apricots to meet the consumers demand. Edible coatings from renewable sources, including lipids, polysaccharides, and proteins can function as barriers to water vapor, gases, and other solutes and also as carriers of many functional ingredients, such as antimicrobial and antioxidant agents, thus enhances the quality and extends the shelf life of fresh and minimally processed fruits and vegetables (18).

The aim of this study is to investigate the effects of corn zein coating on the quality maintenance of intermediate moisture apricots. A film layer was obtained on the surface by dipping the samples into the zein solution. . Effects of different film composition on the quality of intermediate moisture apricots were evaluated by means of physical, chemical and microbiological analyses.

MATERIALS AND METHODS

Materials

Natural dry apricots which were sun dried without any sulfur dioxide addition during drying process ($SO_2 \leq 100$ ppm) were obtained from a local exporter namely "Işık Tarım Ürünleri Sanayi ve Ticaret A.Ş" company in Izmir, Turkey. Samples were stored in Ege University, Food Engineering Department pilot plant at 4 °C in plastic bags. Zein was obtained from Sigma-Aldrich Laborchemikalien (Seelze, Germany) Z 3625. Commercial potassium sorbate (E202), commercial citric acid (E330) and ascorbic acid (Riedel de Haen, Sigma-Aldrich Laborchemikalien (Seelze, Germany) were used. Plate count agar (Oxoid CM0325) and peptone (Oxoid CM009) were used in microbiological analysis.

Preparation of Intermediate Moisture Apricot

Natural dry apricots were washed for 10 seconds under tap water and left for 1 hour to remove the excess water on the surface. After washing, dried apricots were dipped in 2.5% citric acid solution at

80 °C for 3 minutes by stirring up every 15 seconds. The dried fruit/dipping solution ratio was chosen as 1/5. After the dipping treatment, samples were left for 2 hours at the room temperature to remove the excess of surface water. Samples were produced as large batches and used for all tests.

Preparation of Zein Films

Zein film was prepared by mixing 6.75 g zein with 40.6 ml, 95% ethanol and 1.9 ml glycerin was added as plasticizers to overcome film brittleness. The solution was heated for 10-15 minutes until its temperature reached to 70-80 °C while stirring by magnetic stirrer (19). Potassium sorbate (0.1%) and ascorbic acid (1%) was added to the zein film at 50±5 °C for preparation of different formulation of edible films.

Application of Edible Coating to Intermediate Moisture Apricot

Intermediate moisture apricots were dipped into the different film solutions for 30 seconds and dried at room temperature (25 °C) for 30 minutes. Four different treatments, i.e. 1) control (C) (not coated), 2) dipping in zein film suspension containing 0.1% potassium sorbate (ZS), 3) dipping in zein film suspension containing 0.1% potassium sorbate, 1% ascorbic acid (ZSA), 4) dipping in zein film suspension (Z), were applied to intermediate moisture apricots to evaluate the optimized coating formulation and effects of edible film coating on the quality of apricots. After drying the solution on the surface of apricots for 1 hour at room temperature (25±5 °C), samples were packaged in cellophane packages and stored at refrigerator (5±1 °C) and cooled incubator (ES500 Nuve, Turkey) (20±1 °C) for 10 months. All coating applications were done on the same day.

Physical and Chemical Analysis

Water activity (a_w), as Equilibrium Vapour Pressure/100, was measured using Testo A 6 400 model analyzer, acidity (citric acid base) and pH value were measured according to Cemeroglu (20), moisture content was determined according to the Official Methods of Analysis (21), apricots surface colour was evaluated with a Hunter Labscan colorimeter equipped with an optical sensor (ColourFlex). L* (lightness), a* (redness), and b* (yellowness), a^*/b^* were measured and ΔE^* value was calculated according to equation given below.

$$\Delta E^* = \sqrt{[(L^*-L^*_{ref})^2 + (a^*-a^*_{ref})^2 + (b^*-b^*_{ref})^2]}$$

Microbiological Analysis

10 g samples were mixed with 90 ml sterilized peptone water and homogenized for 2 minutes in a sterile plastic bag using a Lab blender. 10^{-1} dilutions of samples were used during experiments. The total viable microbial counts of apricots were determined by standard plate count using the pour plate method as described in (22).

Petri dishes were incubated at 30 °C and total bacteria count was conducted at 24-48 hours intervals following plate count method, results were expressed as colony forming unit per gram of sample (cfu/g sample).

Statistical Analysis

Randomized Block Design was employed to statistically analyze all results ($P<0.05$) by using SPSS 13.0 software.

RESULTS AND DISCUSSION

Natural dried apricots with initial moisture content of 22.5% were dipped into water at 80 °C for 3 minutes to obtain the final moisture content of 28-31%. The water activity (a_w) of the samples was measured as 0.80±0.1 for the given moisture contents. Intermediate moisture foods usually contain around 10 to 50% moisture and have the a_w value of 0.6–0.8 (23).

Moisture Content and a_w Value

The moisture content decreased with the storage time, for all treatments. However, moisture content of the control significantly reduced during the storage period (30% decrease at 20 °C), compared to the coated groups at 20 °C ($P<0.05$). Results are shown in Figure 1. No significant effect was found on moisture contents of samples which were stored at 5 °C storage temperature (data were not shown) and moisture loss was found as 5% approximately for all samples. The film formed on the surface of fruits delayed moisture loss from the fruits into the environment, thus reduced the weight loss during the at high temperature storage periods. Furhermore it was reported that corn zein film delayed loss of weight during storage of tomatoes at 21 °C (24). Similar results were observed for a_w values. For all treatments, changes in a_w value of the samples stored at 5 and 20 °C were affected from the storage period statistically, however treatments and storage temperatures did not have any significant effect on a_w values of the samples ($P<0.05$).

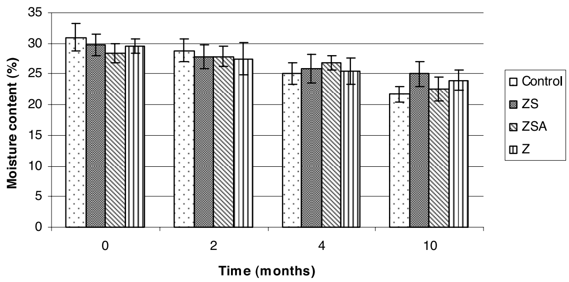

Figure 1. Moisture content (%) of intermediate moisture apricots over 10 month storage for 20 °C as not coated (Control), coated with (0.1%) potassium sorbate added zein film (ZS), coated with (0.1%) potassium sorbate and (1%) ascorbic acid added zein film (ZSA) and coated with zein film (Z).

Acidity and pH Value

Acidity and pH values of samples changed between 0.06-0.07 g/100 g and 5.00-5.40, respectively. Initially, pH value of the ZSA samples was found lowest (4.96) where the acidity was found highest as 0.08 g/100g. This is due to ascorbic acid addition to the zein film suspension. The pH values of the ZSA samples increased at the end of the storage period, nevertheless this phenomenon could be explained by the possible degradation of ascorbic acid during storage period. Coating treatments, storage temperatures and storage period did not have significant effect on the pH and acidity values of the samples ($P<0.05$).

Surface Colour Changes

L* (lightness), a* (redness), and b* (yellowness), were measured and a^*/b^*, ΔE^* and ΔC^* values were calculated. Values of L* and ΔE^* are shown in Figure 2, 3, 4 and 5 for two storage temperatures. The L^* values of the coated samples were found similar, but the control samples L^* value found the lowest in the 0. day measurements and during storage period for both storage temperatures. The coating process with zein increases the lightness of the apricots because of the yellow colour of zein. After film treatment, lightness of samples were decreased because of maillard and enzymatic reactions and changes in L^* values for all samples stored at both 5 and 20 °C, were affected from process, storage time and temperature significantly ($P<0.05$). The colour changes of the coated and control apricots were evaluated by the chromaticity parameters (a^*/b^*) ratio in function of storage time. The control fruits presented higher values of a^*/b^* (1.0±0.1) than the coated fruits (0.7±0.2). Higher a^*/b^* values represents the increase in redness and that is a parameter for browning of apricots. Thus, evidenced by the decrease in colour changes, demonstrates the effectiveness of this coating process. It was reported previously that coating of tomatoes with cornzein film delayed color change which was probably due to an increase in CO_2 level and a decrease in O_2 level during storage of tomatoes at 21 °C (24). ΔE^* values for coated samples were found 7.9±1.1. The highest ΔE^* value was found for control samples, as 13.28 and 14.22 at the end of the storage period for 5 and 20 °C storage temperatures, respectively. ΔE^* values were significantly affected by treatments, storage temperatures, time and treatment-time interactions ($P<0.05$).

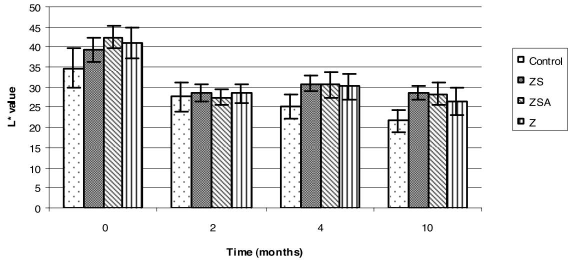

Figure 2. L* (lightness) values of intermediate moisture apricots over 10 month storage for 5 °C as not coated (Control), coated with (0.1%) potassium sorbate added zein film (ZS), coated with (0.1%) potassium sorbate and (1%) ascorbic acid added zein film (ZSA) and coated with zein film (Z).

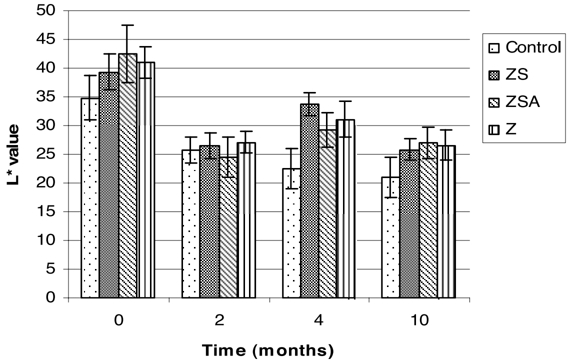

Figure 3. L* (lightness) values of intermediate moisture apricots over 10 month storage for 20 °C as not coated (Control), coated with (0.1%) potassium sorbate added zein film (ZS), coated with (0.1%) potassium sorbate and (1%) ascorbic acid added zein film (ZSA) and coated with zein film (Z).

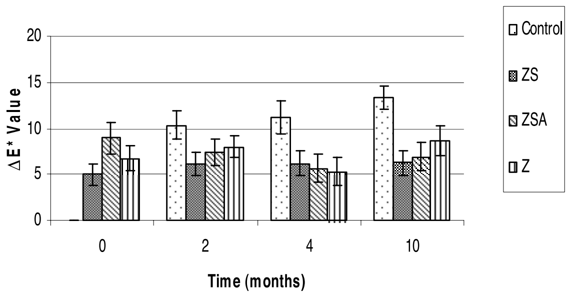

Figure 4. ΔE* values of intermediate moisture apricots over 10 month storage at 5 °C for not coated (Control), coated with (0.1%) potassium sorbate added zein film (ZS), coated with (0.1%) potassium sorbate and (1%) ascorbic acid added zein film (ZSA) and coated with zein film (Z).

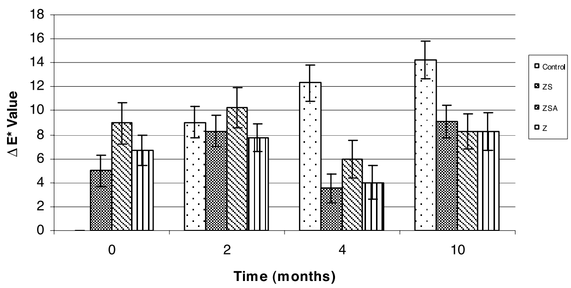

Figure 5. ΔE* values of intermediate moisture apricots over 10 month storage at 20 °C for not coated (Control), coated with (0.1%) potassium sorbate added zein film (ZS), coated with (0.1%) potassium sorbate and (1%) ascorbic acid added zein film (ZSA) and coated with zein film (Z).

Microbiological Analysis

The effect of coating process on the total viable bacteria count of apricots

Total bacteria counts of samples stored at 5 and 20 °C are given in Figure 6 and 7, respectively. An initial reduction in total bacterial counts was observed in all coated samples. After coating treatment, microbial load of samples increased after 4 months of storage at 5 and 20 °C. Coating with zein film inhibited microbial growth to the extent of around 2 log between control and coated batches initially and during storage period at 5 and 20 °C. Additional antioxidant and antimicrobial agents decreased the microbial count slightly compared to the plain zein film coating. However, no significant effect was found between different film solutions ($P<0.05$). The initial microbial load of the control group was found higher than the coated samples. Because of dipping zein film solution temperature (50±5 °C), initial microbial load of samples were decreased initially.

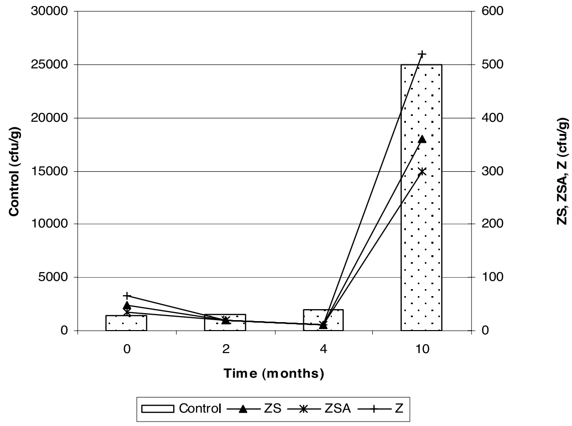

Figure 6. Changes of total bacteria count of intermediate moisture apricots over 10 month storage at 5 °C for not coated (Control), coated with (0.1%) potassium sorbate added zein film (ZS), coated with (0.1%) potassium sorbate and (1%) ascorbic acid added zein film (ZSA) and coated with zein film (Z).

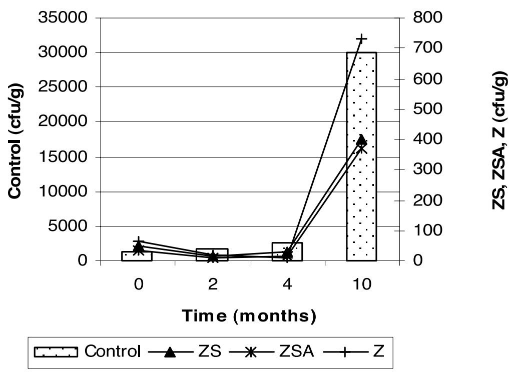

Figure 7. Changes of total bacteria count of intermediate moisture apricots over 10 month storage at 20 °C for not coated (Control), coated with (0.1%) potassium sorbate added zein film (ZS), coated with (0.1%) potassium sorbate and (1%) ascorbic acid added zein film (ZSA) and coated with zein film (Z).

CONCLUSION

The corn-zein film coating on the surface of intermediate moisture apricot delayed microbial growth and colour changes. L^*, a^*/b^* and ΔE^* values of the control samples showed higher variation compared to coated samples values during storage period at both storage temperatures (5 and 20 ºC). Moisture content of control samples were affected by the coating treatment at high storage temperature but no significant moisture loss effect was found between samples at low temperature. Corn-zein film coating provided barrier effect and beneficial internal O_2 composition for inhibiting microbial growth. It is valuable to conduct advanced researches on coating of intermediate moisture fruits with different coating materials or different combinations of edible films. Usage of different additives or antimicrobial agents, determination of film thickness, could be alternative research areas for improving film coating effect on intermediate moisture fruits.

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