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The effect of edible coatings on water and vitamin C loss of apricots (*Armeniaca vulgaris* Lam.) and green peppers (*Capsicum annuum* L.)

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Abstract

Edible coatings of varying composition were applied on fresh apricots and green peppers. The water and vitamin C losses of these coated fresh foods were followed and compared with those of uncoated ones. The main components of the coating were methyl cellulose (MC) and polyethylene glycol (PEG). Stearic acid (SA) and ascorbic acid (AA) or citric acid (CA) were added to the coating formulation to control the barrier properties toward water and oxygen. It was found that coatings of any composition studied lower the water loss rate of fresh apricots and green peppers. Coating formulation of MC–PEG–SA was the most effective in reducing the water loss. Inclusion of AA or CA in the coating formulation as antioxidants lowered the vitamin C loss.

Keywords: Edible coatings; Oxygen permeability; Vitamin C; Water loss

1. Introduction

Edible coatings applied on fresh foods to reduce the moisture transfer, the oxidation and the respiration are important to prolong the shelf-life of such foods. The measurements of permeabilities of stand-alone films of various compositions to water vapour, oxygen and carbon dioxide help the selection of coating formulation to be applied on foods. The water vapour permeability (WVP) of edible films is the most extensively studied property of edible films (Ayranci, Buyuktas, & Cetin, 1997; Ayranci & Cetin, 1995; Gontard, Marchesseau, Cuq, & Guilbert, 1995; Kamper & Fennema, 1984; McHugh, Aujard, & Krochta, 1994), mainly due to the importance of the role of water in deteriorative reactions and probably partly due to the ease of the measurement. The correlation between moisture sorption isotherm and WVP of cellulose-based edible films was also sought (Ayranci, 1996). Lipid, either as the main component or as an additive in the film formulation, usually helps to reduce water vapour transfer due to its hydrophobic character. Oxygen is also involved in many degradation reactions in foods, such as fat and oil rancidity, micro-organism growth, enzymatic browning and vitamin loss. Thus many packaging strategies seek to exclude oxygen to protect the food product (Gontard, Thibault, Cuq, & Guilbert, 1996). On the other hand, the permeability to oxygen and carbon dioxide is essential for living tissues, such as fresh fruits and vegetables, for respiration. So, moderate barrier coatings are more appropriate. If a coating with the appropriate permeability is chosen, a controlled respiratory exchange can be established and thus the preservation of fresh fruits and vegetables can be prolonged. It is expected that oxygen permeability (OP) of edible films can be controlled by using some antioxidants as additives in the film composition. Ascorbic acid (AA) or citric acid (CA) can be used for this purpose. OP of various films has been reported in the literature (Gennadios & Weller, 1993; Greener & Fennema, 1989; Kester & Fennema, 1989a, 1989b, 1989c; Park, Weller, Wergano, & Testin, 1993; Rico-Pena & Torres, 1990).

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In recent works from our laboratory, simple methods were proposed for the measurement of CO_2 permeability (Ayranci, Tunc, & Etci, 1999) and oxygen permeability (Ayranci & Tunc, 2003) of edible films, and applied successfully to various cellulose-based edible films (Ayranci & Tunc, 2001). Although data on permeability properties of edible films are being accumulated in the literature, the number of studies on application of such films on foods is limited. For example, Lerdthanangkul and Krochta (1996) coated bell pepper fruit with several types of edible coatings and investigated their effects on respiration rate, internal gases, texture, colour and weight loss. The excellent moisture barrier property of the mineral-oil-based coating resulted in reduced moisture loss and maintained fruit firmness and freshness. In an other study by Sumnu and Bayindirli (1995), Amasya apples were coated with different coatings. All of the coatings were effective in reducing the rate of weight loss, AA loss, colour loss and firmness change, and in increasing post-storage life of Amasya apples. Ayranci and Tunc (1997) applied cellulose-based edible coatings with fatty acids, such as SA, palmitic and lauric acids on fresh beans and strawberries to decrease the water losses of these fresh foods. They observed that, as the fatty acid content increased in the film composition, the water loss of fresh foods decreased. They also found that SA was the most effective, among the fatty acids studied, for decreasing the water loss of fresh beans and strawberries.

The purpose of the present study was to examine the effects of cellulose-based edible coatings on water and vitamin C losses of some fresh foods. Fresh apricots and green peppers were selected as the fresh foods for this study. SA, AA and CA were used as additives in the coating formulation to improve the water and oxygen barrier properties of the coatings.

2. Materials and methods

2.1. Materials

Methyl cellulose, with an average molecular weight of 41,000, polyethylene glycol (PEG), with an average molecular weight of 400, stearic acid (SA) and AA were purchased from Sigma. Citric acid (CA), $CuSO_4 \cdot 5H_2O$ and $H_2C_2O_4$ were obtained from Merck. Ethanol was reagent grade and water was distilled. Apricots and green peppers were obtained from a local bazaar.

2.2. Preparation of coating solutions

Three grammes of MC were dissolved in a solvent mixture of 66 ml ethanol and 33 ml water. After the addition of 1 ml PEG, the solution was homogenized with an Ultra-turrax T25 homogenizer (Staufen im Breisgau, Germany) at 24,000 rpm for 5 min. It was rehomogenized after the addition of fatty acid and other additives. The final solution was kept in a Nüve EV 018 vacuum oven (Ankara, Turkey) at 80 °C for about 5 h in order to remove air bubbles or dissolved air.

Table 1
Compositions of the coating solutions applied to apricots and peppers

Coating No	SA (g)	Antioxidant (g)
1	No	No
2	0.6	No
3	0.6	0.5 AA
4	0.6	0.5 CA

Each solution contains 66 ml ethanol, 33 ml water, 3 g MC and 1 ml PEG.

The compositions of various coating formulations studied are given in Table 1. The relative amounts of additives, such as SA, CA and AA, to be used in the coating formulation were decided according to the results of our previous works (Ayranci & Tunc, 2001; Ayranci & Tunc, 1997) to optimize both the water and the vitamin C loss. It is to be noted that a greater amount of SA than 0.6/3 g MC, which is being added mainly to lower the water loss, may cause an undesirable taste problem. On the other hand, greater amounts of CA or AA than 0.5/3 g MC, which are being added mainly to lower OP and thus to lower the vitamin C loss, may cause an increase in WVP and thus in water loss because these two additives are considered as hydrophilic compounds. So, intermediate amounts of SA, CA and AA were used in coating formulations as given in Table 1.

2.3. Coating procedure

Apricots and green peppers were selected as model systems for the application of coating formulations for several reasons. They contain a sufficient amount of vitamin C, so the loss can easily be followed. They are produced in large amounts in Turkey. Finally the coatings can easily be applied on these foods. Whole apricots and green peppers were used for coating. Fresh foods were dipped completely into the coating solutions (whose compositions are given in Table 1) for about 5 s at room temperature and then taken out. This dipping procedure was repeated twice. Then the coating was dried with a fan.

Coated and uncoated foods were kept in a Sanyo MIR 152 incubator (Japan) at 25 °C and 84% relative humidity before the analysis for water loss and vitamin C as a function of time.

2.4. Measurement of water loss

The coated and uncoated fresh apricots and green peppers were weighed to the nearest 0.1 mg and kept in an incubator at 25 °C and 84% relative humidity. They were reweighed every 24 h in order to follow the moisture loss as a function of time over a period of 10 days.

In order to check if there is any contribution to the weight change of coated fresh foods from the coating itself, a solution of coating 1 (Table 1) was applied on a glass marble exactly in the same way that it was applied on fresh foods. Then the weight change of coated marble was followed over a period of 5 days at 25 °C and 84% relative humidity. It was found that it remained constant within 0.9% of the initial weight.

2.5. Vitamin C determination

The concentration of vitamin C in foods was determined by a spectrophotometric method (Sawyer, Heineman, & Beebe, 1984). 10 g of food were homogenized by a homogenizer in about 25 ml of 4% $H_2C_2O_4$ solution. The mixture was filtered through a blue band filter paper and diluted to 100 ml with 4% $H_2C_2O_4$. One millilitre of 50 μg ml^{-1} $CuSO_4 \cdot 5H_2O$ solution (pH 6) was added to an aliquot of this sample solution and diluted to a certain volume again with 4% $H_2C_2O_4$. The optical absorbance of this final solution was measured at 249 nm with Shimadzu 160A UV–Vis Spectrophotometer (Shimadzu Corporation, Kyoto, Japan).

For the calibration process, the standard solutions were prepared in the same manner from 100 μg ml^{-1} AA solution in 4% $H_2C_2O_4$. Then, calibration lines of absorbance vs. concentration of AA were derived.

Measurements of both water loss and vitamin C were carried out on duplicate samples and average of the two were taken for evaluation purposes.

3. Results and discussion

3.1. The effects of coating on water loss of fresh foods

% Weight losses due to water loss at the end of 10th day, for apricots and green peppers both uncoated and coated with different coating formulations, are given in Table 2. Apricots with coatings of any composition examined have lower water losses than uncoated ones. The effect of lowering the water loss is greatest with the coating containing only SA (coating 2) as an additive. This is an expected result due to the hydrophobicity provided to the coating by SA (Ayranci & Tunc, 1997). The coating without SA and antioxidant AA or CA (coating 1) is the least efficient in reducing water loss of apricots among the other coatings. The inclusion of AA and CA, in addition to SA, in the coating formulation (coatings 3 and coating 4) lowers, to a certain extent, the hydrophobicity provided to the coating by SA. Thus, apricots with these coatings have slightly larger water losses than those with the coating containing only SA (coating 2).

The water loss trends for green peppers are very similar to those for apricots; for e.g., water loss is highest for uncoated green pepper and lowest for green pepper with the coating containing only SA (coating 2). The water loss rates of green peppers with coatings containing additives (coating 2 with SA, coating 3 with SA + AA and coating 4 with SA + CA) are found to be very close to each other.

Water loss values of apricots are seen to be higher than those of green peppers. This may result from several factors. The initial water content of apricot is expected to be higher than that of pepper. It is very likely that the original skin of green pepper has a greater water barrier property than that of apricot. Finally, the water in green pepper is probably in a more strongly bound state than that in apricot.

3.2. The effects of coating on vitamin C loss of fresh foods

The resistance provided by the coatings for the vitamin C loss of apricots and green peppers was followed by measuring the vitamin C contents of these foods without coating and with coatings of varying compositions. The percent vitamin C losses were followed as a

Table 2
Water and vitamin C analysis of uncoated and coated apricots and green peppers

Fresh food	Coating	% Weight loss (due to water loss) at the end of 10th day	Initial vitamin C content	% Vitamin C loss at the end of 12th day
Apricots	No coating	19.8 ± 0.2	9.0 ± 0.1	78.3 ± 0.2
	Coating 1	12.8 ± 0.2	9.0 ± 0.1	73.9 ± 0.2
	Coating 2	7.82 ± 0.05	9.0 ± 0.1	60.1 ± 0.2
	Coating 3	8.61 ± 0.05	9.0 ± 0.1	36.7 ± 0.2
	Coating 4	9.25 ± 0.05	9.0 ± 0.1	41.5 ± 0.2
Green peppers	No coating	5.02 ± 0.05	68.7 ± 2.9	71.9 ± 0.2
	Coating 1	3.47 ± 0.05	68.7 ± 2.9	70.2 ± 0.2
	Coating 2	2.87 ± 0.05	68.7 ± 2.9	63.2 ± 0.2
	Coating 3	2.95 ± 0.05	68.7 ± 2.9	50.9 ± 0.2
	Coating 4	2.99 ± 0.05	68.7 ± 2.9	55.3 ± 0.2

function of time. The initial vitamin C contents and the % vitamin C losses at the end of the 12th day for apricots and green peppers, uncoated and coated with varying coating formulations, are given in Table 2.

It was found that coating 1, which does not contain any additive, has a very small effect in reducing the vitamin C loss rate of both foods. SA, as an additive in coating, has slightly greater effect in reducing vitamin C loss of apricot than of green pepper. However, the major effect in reducing the vitamin C loss rate comes from the inclusion of an antioxidant, CA or AA, as an additive in the coating formulation (coatings 3 and 4). Furthermore, it should also be noted that vitamin C losses of both foods coated with coatings containing AA (coating 3) are slightly lower than those with coatings containing CA (coating 4). This can be explained by possible diffusion of some AA from coating to the food coated with coatings containing AA, the effect being more pronounced in the case of apricot.

The lowering of vitamin C loss of foods with coatings containing antioxidants (AA or CA) can be attributed to the low OP of these coatings (Ayranci & Tunc, 2003). Keeping oxygen away from the food delays the deteriorative oxidation reaction of vitamin C.

It should be noted that the oxidation of AA to dehydroascorbic acid does not represent the loss of vitamin C, as both forms have the vitamin C property. The loss of vitamin C, here, represents the conversion of dehydroascorbic acid to diketogulonic acid by further oxidation (Rai & Saxena, 1988). In the analysis, the samples were pretreated with Cu^{2+} ions to convert AA to dehydroascorbic acid and then the total vitamin C was determined.

In conclusion, it can be stated that MC-based edible coatings, having SA as an additive, are effective in reducing the water loss of fresh apricots and green peppers. Furthermore, inclusion of CA or AA as an additive in coating formulation reduces the vitamin C loss of these fresh foods.

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