Application of Edible Coatings to Improve Shelf-life of Mexican Guava

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Abstract

One method of extending postharvest shelf-life is the use of edible coatings. Such coatings are made of edible materials that are used to enrobe fresh produce, providing a semipermeable barrier to gases and water vapour. Guavas cultivated at Aguascalientes, Mexico were coated with a solution of one of the following polymers: Potato starch, sodium alginate, carragenan, and pectin. The fruit was covered by immersion in the solution at 50°C, then dried at 50°C during 30 minutes. After coating, the maturation process was compared to uncoated fruit. The evaluation of the functional properties of the edible coatings was done by measurement of the barrier properties of edible films to water vapour (gravimetric method) and to aroma compounds (dynamic method). The results showed an increase of the fruit's shelf-life with at least three days compared to the uncoated fruit, at 25°C and 50-70% R.H. The highest efficiency preserving the fruit was obtained with potato starch and pectin based coatings, increasing the preservation of the sensorial characteristics of the fruit (size, yellow colour and aroma) with 15 days.

INTRODUCTION

The performance of packaging materials depends on their efficiency to reduce transfers between foodstuff and the environment such as the transport of volatile compounds from food to the outer atmosphere or from the surrounding medium to the packaged product (permeation), and the adsorption of volatile compounds at the surface of the packaging (sorption or scalping) (Reineccius, 1991; Benet et al.,1992; Blumenthal, 1997). The technological progress in synthetic packaging materials allows an important and selective reduction of non condensable gas and water vapor exchanges such as that obtained with barrier polymers (Chomon, 1992). Nevertheless, most of plastic packagings have a strong affinity towards hydrophobic volatile compounds, like aroma compounds (Reineccius, 1991; Leufvén and Stöllman, 1992; Miller and Krochta, 1997). Moreover, plastic materials can not be used to protect any kind of foods: for example, to separate two different parts in a heterogeneous product such as a pie or a pizza (Kamper and Fennema, 1985; Kester and Fennema, 1989). Therefore, the combination of edible and plastic materials has been proposed to improve their functional properties.

Many storage techniques have been developed to extend the useful marketing distances and holding periods for fresh horticultural commodities after harvest. Various authorities have estimated that 25 to 80% of harvest fresh fruits are lost due to spoilage. This results in much economic waste in developed countries and more devasting consequences in countries such as Mexico, with economic and agricultural problems in the last 20 years. One method of extending postharvest shelf-life is the use of edible coatings. Such coatings are made of edible materials that are used to enrobe fresh produce, providing a semipermeable barrier to gases and water vapour. To understand the effect of edible coatings on harvested fruits, a background knowledge of postharvest fruit physiology and storage techniques is necessary (Baldwin, 1994).

The objectives of this work were to apply edible coatings based on potato starch, pectin, carragenan or sodium alginate on mexican guava fruit to increase their shelf-life and to better understand the effect of coatings on maturation and respiration of fruits.

MATERIALS AND METHODS

Preparation of Coatings

Guavas cultivated at Aguascalientes, Mexico were coated with a solution of one of the following polymers: Potato starch, sodium alginate, carragenan, and pectin. The polymer content in the solution was between 5 and 10%. Glycerol was used as a plasticizer as commonly signalled in literature (between 10 and 30%). The polymer and plasticizer content in the solution was determined by factorial statistics method. The fruit was covered by immersion in the solution at 50°C, then dried at 50°C during 30 minutes. After coating, the maturation process was compared to uncoated fruit. The evaluation of the functional properties of the edible coatings was done by measurement of the barrier properties of edible films to water vapour (gravimetric method) and to aroma compounds (dynamic method) (Felder, 1978).

Water Vapor Permeability Measurement

The water vapour transfer rates (WVTR) were determined with the gravimetric method described in the ASTM E96-80 standard used for the determination of water vapour transfer rate through sheet packaging materials and modified by Debeaufort *et al*. (1993) Films were fixed between two Teflon® rings on the top of a glass cell containing a saturated salt solution of potassium chloride (Merck, Germany) of which the water activity is 0.84 at 25°C. Test cells were placed onto the balance plate in a ventilated cupboard which temperature and relative humidity were fixed respectively at 25°C and 22% using potassium acetate saturated solution (Merck, Germany). Permeation cells were continuously weighed and recorded by a computer. When the relationship between the weight loss and time was linear, the slope of the plot was used to calculate the water vapor transfer rate (WVTR) and water vapor permeability (WVP). All the films were equilibrated over silica gel at 5-6% RH and 25°C for 15 days before permeability determinations.

Vapor Permeability Measurement

A dynamic measurement method of aroma vapor fluxes through films or membranes was used. The apparatus has been described by Debeaufort and Voilley (1994). The permeation cell was composed of two chambers divided by the film to be studied. The film area exposed to transfer was 15.9 cm^2. The two chambers were continuously swept by a 30 $mL.min^{-1}$ helium flow. The aroma concentrations in the vapor phase on the upper side of the cell were obtained by mixing two flows : one containing the volatile compound and the other dry helium. Flows containing vapors were obtained from bubbling dry helium through pure compounds. Organic volatile were analyzed with a flame ionizing detector (FID). Samples were weighed before and after permeation measurements to determine the amount, Q, of volatile sorbed within the films, expressed as micrograms of volatile per milliliter of dry film ($\mu g.mL^{-1}$d.f.). The gravimetric method used to determine Q was compared for some samples to values obtained by the method described further in this paper, and they were considered as enough accurate.

Films were equilibrated at 0% relative humidity at 25°C before permeability determinations. Permeation measurements were carried out at 25°C. Vapor concentration differentials were between 0 and 2.5 µg. mL^{-1} He for 2-nonanone, between 0 and 7.0 µg. mL^{-1} He for 2-octanone and between 0 and 23 µg. mL^{-1} He for 2-heptanone (Quezada Gallo *et al.*, 1998). The highest concentration of aroma in the vapor phase (saturation) was obtained by bubbling a carrier gas through pure aroma at 25°C and atmospheric pressure, which concentration was checked and measured by gas-liquid chromatography (GLC).

RESULTS AND DISCUSSION

The results showed an increase of the fruit's shelf-life with at least three days compared to the uncoated fruit, at 25°C and 50-70% R.H. The highest efficiency preserving the fruit was obtained with potato starch and pectin based coatings, increasing the preservation of the sensorial characteristics of the fruit (size, yellow colour and aroma. Figures 1 and 2) with 15 days.

The kinetics of water loss during preservation indicated that even 28% of the water content in the fruit could be retained after 15 days at 25°C, with a potato starch based coating (Figure 3). Edible coatings based on sodium alginate showed an efficiency against water transfer until 1000 times higher than others (Table 1). Permeability and transfer rate values for sodium alginate are comparable with those for low density polyethylene, which is considered a good barrier (Debeaufort, 1994). Kinetics of water transfer for sodium alginate based film, significant variations of flow were observed between 120 and 170 minutes. It is possible to explain this variations by an structural change in alginate network, because of a plasticization process induced by water. Relaxation phenomena were also reported in literature for methylcellulose films (Debeaufort, 1994; Quezada Gallo et al., 1998). A calorimetric study could verify this hypothesis. Application of this kind of coating will require modifications of polymer or plasticizer concentrations.

To better understand the edible coating function on respiration and maturation process of guava, permeability of edible coatings to 2-pentanone was studied. 2-pentanone was chosen because it is an aroma compound present in several kind of fruits, having physico-chemical properties very similar to ethylene, the chemical agent responsible of maturation. Table 2 shows that potato starch-based coatings have a low retention of 2-pentanone, being similar to methylcellulose-based films. Pectin and sodium alginate-based films are 10 times more efficient to retain the aroma compound than polyethylene. Applied on guava, those films with poor retention of aroma would represent a faster loss of aroma, but a low retention of ethylene. This was the effect of potato starch on guava shelf-life, preserving the fruit 15 days.

CONCLUSIONS

The results of this work showed that edible coatings from natural origin with low cost could be a good option to increase the shelf-life of guava. The results of permeability to water vapour and to aroma (2-pentanone) showed that the efficiency of edible packaging preserving guava depend on retention of hydrophobic elements more than water vapour. Additional research made after this results put in evidence that the addition of vegetal colour compounds are retained at the surface of coated fruit, improving their sensorial characteristics. A better comprehension of barrier properties of edible packaging used against gas (oxygen and carbon dioxide) transfer is necessary.

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Tables

Table 1. Barrier properties of studied edible coatings against water vapor transfer.

Edible coating	Water Vapour Transfer Rate (10^{-4} g.m^{-1}.s^{-1})	Permeability (10^{-6} g. m^{-1}.s^{-1}. mmHg^{-1})	diffusion Coefficient (10^{-13} m^{2}.s^{-1})
Pectin 10% gly[1] 10%	11.97	14.9	3.6
Pectin 10% gly 20%	11.06	13.8	3.5
Pectin 10% gly 30%	7.17	8.9	2.5
Carragennan 5% gly 10%	15.4	19.3	9.2
Carragennan 5% gly 20%	13.7	17.6	12.7
Carragennan 5% gly 30%	12.1	15.2	8.2
Sodium Alginate 10% gly 10%	0.01	0.013	6.0
Sodium Alginate 10% gly 30%	.021	0.026	0.27
Potato Starch 5% gly 20%	15.9	19.8	8.6

[1] glycerol

Table 2. 2-pentanone transfer rate through edible coatings.

Edible coating	2-pentanone transfer rate (mg.m^{-2}.h)
Potato starch	18.78
Colored potato starch	783.20
pectin	22.10
carragennan	16.95
polyethylene	194.00
methylcellulose	1350

Figures

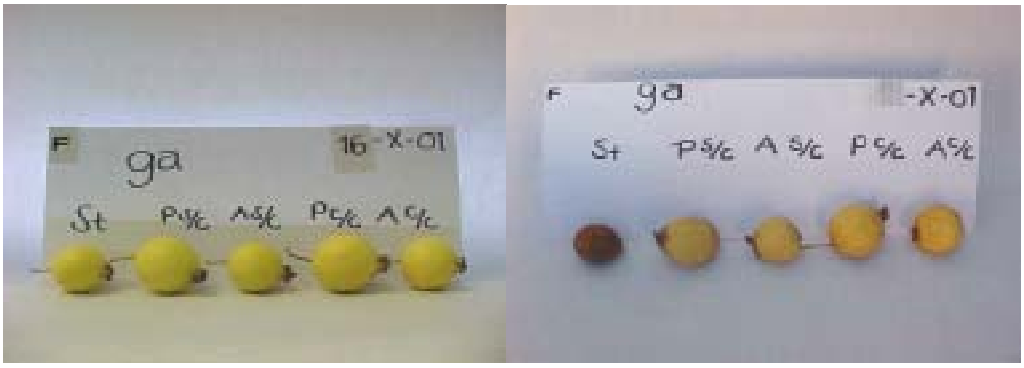

Fig. 1. Guava preservation with edible coatings after 15 days at 25°C and 50% RH. (St = Standard, Ps/c = precipitated potato starch, As/c = filtrated potato starch, Pc/c = precipitated and coloured potato starch, Ac/c = filtrated and coloured potato starch).

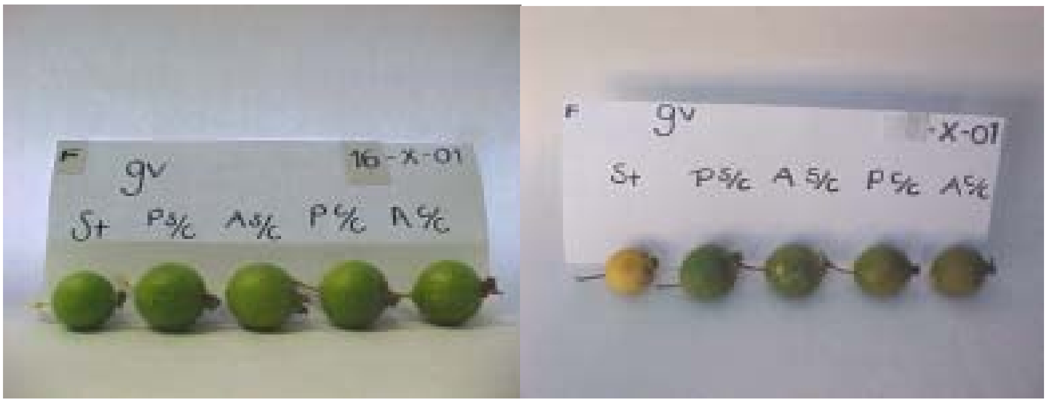

Fig. 2. Green guava preservation with edible coatings after 15 days at 25°C and 50% RH. (St = Standard, Ps/c = precipitated potato starch, As/c = filtrated potato starch, Pc/c = precipitated and coloured potato starch, Ac/c = filtrated and coloured potato starch).

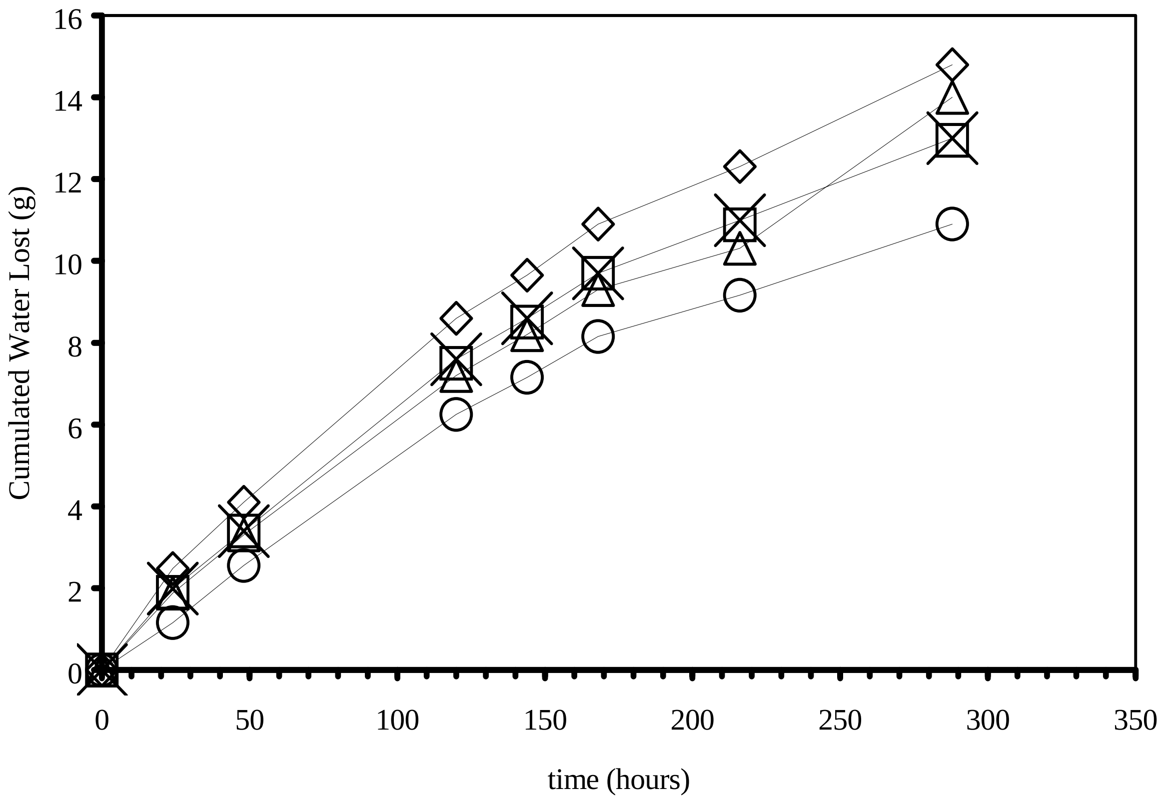

Fig. 3. guava weight lost kinetic applying potato starch-based edible coatings. ◇guava without coating. □ guava with potato starch based coating (precipitaded starch). △ guava with potato starch based coating (filtred starch). ✕ guava with colored potato starch coating (precipitaded starch). O guava with colored potato starch coating (filtred starch)