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Research Article

Improvement of Shelf Life and Sensory Quality of Pears Using a Specialized Edible Coating

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An edible coating functionalized with pomegranate polyphenols was designed. Different blends of candelilla wax, gum arabic, jojoba oil, and pomegranate polyphenols were formulated in order to improve the shelf life quality of pears (variety Bartlett), and all formulations were applied by immersion onto the fruit surface. Coated pears with and without polyphenols and uncoated pears (control) were stored under the same conditions. Fruits were analyzed to evaluate changes in their physicochemical, microbiological, and sensorial properties during 30 days of storage at room temperature. Coated pears coded as T13 (candelilla wax 3%, gum arabic 4%, jojoba oil 0.15%, and pomegranate polyphenols 0.015%) extended and improved their shelf life quality due to the minimization of the physic-chemical changes and sensorial properties. Therefore, the results indicated that the formulated edible coating has potential to extend the shelf life and maintain quality of pears. It was probed that coated pears were accepted for consumers as a good product. Edible coating application represents a good alternative to keep pears freshness for longer periods.

1. Introduction

Pears (*Pyrus communis*) are climacteric fruits whose ripening is regulated by ethylene, exhibiting a relatively short shelf life. During ripening of pears, some changes are observed in firmness, color, acidity, sugar content, and development of aroma [1]. The optimum quality for eating pears is characterized by a buttery texture, appropriate color change, characteristic flavor associated with the content of sugars, acids, and volatile compounds [2].

Mexico is the biggest producer of pears in the world; nevertheless, the producers of this country are facing problems in not achieving the integration of horticultural products to national and international markets with quality products. For this reason in the last years, growers and packers are developing orchard management techniques, packing and shipping practices in order to export their fruit and vegetable products [3].

Some recent studies have been reported to prolong the shelf life of pears using edible coatings that are used to improve the mechanical integrity or handling characteristics of the fruits, reporting the ability of this technological strategy to retard changes in moisture, oxygen, aromas, and solute transport [4, 5] and the function of edible coating can be improved by including additives such as antioxidants, antimicrobials, colorants, flavors, fortifying nutrients, and spices in film formulation [6]. Besides, incorporation of antioxidants agents into packaging materials has also become very popular since oxidation is a major problem affecting food quality [7]. The coating applied can serve as a carrier for bioactive compounds and/or antioxidants compounds in order to maintain high concentrations of preservatives on food surfaces [8].

Edible coatings can be obtained from different types of materials, but the most used ones are made of polysaccharides [4, 5]; however, certain limitations or disadvantages have been found due to their hygroscopic nature, particularly those made of starch and pectin.

On the other hand, polyphenols are secondary metabolites produced by higher plants. These compounds play different roles in the plant physiology and have potential healthy properties on human organism like antioxidants and antiallergic, antimicrobial agents among others. The incorporation of the process of the addition of the bioactive molecules like polyphenols to the edible films formulation in edible films is an alternative to bring all of these benefits to human organism through the consumption of natural products as well as help to prolong quality and shelf life thereof [9].

Earlier, we report the high efficiency of candelilla wax-based edible coatings to improve the shelf life of fresh-cut fruits [3], avocado [9], apples [10], strawberries [11], and bell peppers [12]. During their preparation, these lipid edible coatings are emulsified to promote adequate homogenization of the components and additives of the system, ensuring uniformity in size and distribution of the particles at the dispersed phase, improving the barrier functionality against the mass transfer of the film formed [13].

The short shelf life of pears is one of the biggest problems to be solved in Mexico. In the present study, the effort was focused on the elaboration of edible coatings with different concentrations of natural compounds such as candelilla wax (*Euphorbia antisyphilitica* Zucc.), gum arabic, jojoba oil, and polyphenols from pomegranate husk to evaluate the effect on the physicochemical and sensorial quality of pears.

2. Materials and Methods

2.1. Raw Materials. A lot of fruits of "Bartllet" pears (*Pyrus communis* L.) harvested in February of 2010 were obtained from a local market in Saltillo, Mexico, 24 h before treatments application. Fruits selection criteria were homogeneous size, absence of skin damage, visible absence of microorganisms, physiological maturity, and intense green color. Then, pears were taken and sorted in complete random groups, washed with detergent, and disinfected with a solution of sodium hypochlorite (0.2 g L^{-1}) for 5 min; finally, the excess of water was removed at room temperature [14].

2.2. Coating Formulation and Application. For coating formulation (patents RN MX/a/2010/001117 and MX/a/2013/012468), the components were mixed according to the Table 1 by DIA (UAdeC) and jojoba oil was used as plasticizer. The components of edible coating were mixed in water following that reported by Saucedo-Pompa [15] and Ochoa-Reyes et al. [12]. Mixture was heated at 80°C and homogenized at 2500 rpm in an industrial homogenizer (International Mod. LI-17V). 17 different formulations were prepared according to Table 1. Two controls were included, a negative control (fruits without edible coating, SC) and positive control (fruits with edible coating and without polyphenols, BCO). Fruits were coated (2 s) by immersion into coating solutions (Table 2) and then were put under an air flux until the solidification of edible coating (density 0.86 g mL^{-1}). This process was repeated one more time according to that reported by Saucedo-Pompa et al. [3]. After coating, fruits were stored at room temperature for a period of 4 weeks (23°C; 70–75% RH).

Table 1: Treatments and edible coating components (−) negative control, (+) positive control, and (T) treatment.

Treatment	Edible coating components (%)			
	Candelilla wax	Gum arabic	Jojoba oil	Pomegranate polyphenols
T1	2	3	0.3	0.01
T2	1	2	0.15	0.005
T3	3	2	0.15	0.005
T4	1	4	0.15	0.005
T5	3	4	0.15	0.005
T6	1	2	0.45	0.005
T7	3	2	0.45	0.005
T8	1	4	0.45	0.005
T9	3	4	0.45	0.005
T10	1	2	0.15	0.015
T11	3	2	0.15	0.015
T12	1	4	0.15	0.015
T13	3	4	0.15	0.015
T14	1	2	0.45	0.015
T15	3	2	0.45	0.015
T16	1	4	0.45	0.015
T17	3	4	0.45	0.015
T (−)	0	0	0	0
T (+)	2	3	0.3	0

2.3. Shelf Life Assays. During the storage period, 4 parameters were monitored to measure pears shelf life with sampling every 7 days. Pears weight loss was gravimetrically measured with an analytical balance (Ohaus mode E-02130, Pine Brook, NJ). Appearance changes were photographically recorded with a digital camera (SONY Cyber-Shot with 14.1 megapixels with 4x zoom). All photographs were taken at the same angle and distance. Firmness of pears was measured with Humboldt Universal Penetrometer (Model H-1200, Chicago, IL) by measuring penetration (mm). The pH values were obtained using a pH meter (Orion model −420, Boston, MA) using method reported by Saucedo-Pompa et al. [3]. Finally, parameters were weighted (selection index) according to their importance to obtain the best edible coating to preserve pears.

2.4. Sensory Evaluation. At the end of storage (4 weeks), sensorial differences among selected treatments were evaluated using a preference sensory test. 13 untrained judges evaluated

Table 2: Preference results for each treatment of pears.

Attribute	T4	T5	T8	T9	T12	T13	Commercial	Total
Appearance	0.040[b]	0.00	0.00	0.01[b]	0.40[b]	0.40[b]	20.27[a]	21.47[a]
Odor	0.00[b]	0.01[b]	0.70[b]	0.01[b]	0.01[b]	0.00	0.40[b]	1.83[b]
Taste	0.01[b]	0.70[b]	0.40[b]	0.40[b]	0.40[b]	0.01[b]	0.40[b]	4.76[b]
Texture	0.70[b]	0.40[b]	0.40[b]	0.40[b]	0.40[b]	0.70[b]	5.30[b]	7.99[b]

Same small letters are not significantly different from each other ($P > 0.05$).

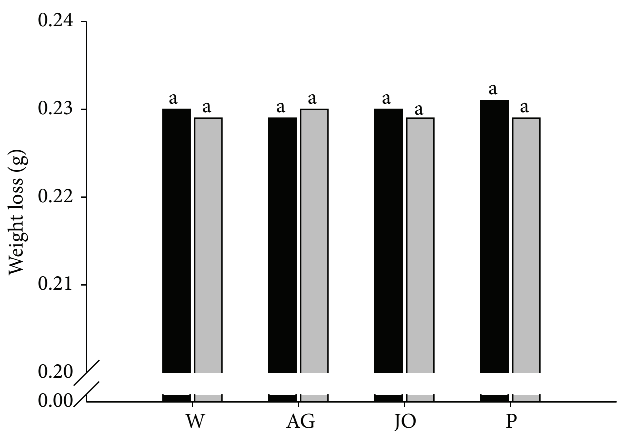

Figure 1: Weight loss: high (black) and low (gray). Same small letters are not significantly different from each other ($P > 0.05$).

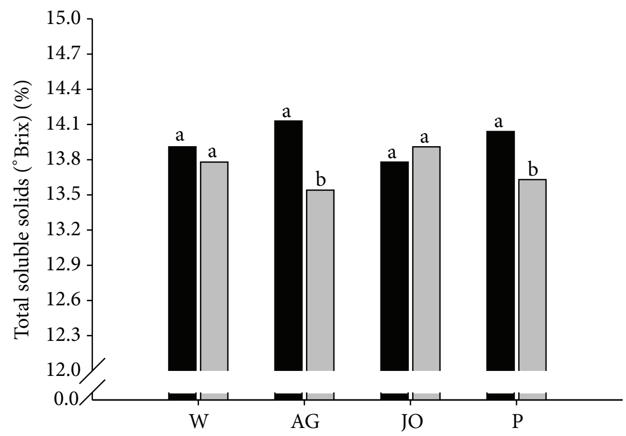

Figure 2: Total soluble solids (°Brix): (W) wax, (AG) gum arabic, (JO) jojoba oil, and (P) polyphenols. High (black) and low (gray). Same small letters are not significantly different from each other ($P > 0.05$).

appearance, odor, flavor, texture, and overall acceptance. For each judge, 7 samples corresponding to the treatments 4, 5, 8, 9, 12, and 13 (selected from the selection index) and control (commercial fruit, fresh and without treatment) were evaluated. Each sample was identified with three digits; the judges were asked to rank the samples according to their preferences, the best appearance, odor, flavor, texture, and overall acceptance of the fruit.

2.5. Statistical Analysis. Data of edible coatings were analyzed using a complete randomized factorial arrangement 3^2 design, with three replications. ANOVA and a Tukey test (HSD), $P < 0.05$ for means comparison, were used to analyze the results using the statistical package SAS 9.0. For the analysis of the sensory test, data were analyzed using χ^2 test. To establish significant difference, a significant level of $P < 0.05$ was applied.

3. Results and Discussion

3.1. Shelf Life

3.1.1. Weight Loss. Weight loss value increases constantly ($P < 0.05$) during the evaluation period in all treatments (Figure 1). However, weight losses present no significant difference when different concentrations of components for all samples were applied. It can also be seen that the pears with the T13 treatment lost lesser weight than those with the control treatment, which showed the highest loss. This is attributed to the reduction of open area of the solids network, which restricted the transport of water vapor from the inside [16]. The use of PPH as an additive into the edible coatings led to decreased moisture loss of fruits. The reduction in weight loss is very important so fruits keep desirable to the consumers and the use of edible coatings is an excellent tool to control the weight reduction [14].

Several authors report that the use of lipid-based coating [17] retards moisture loss in apples [3, 10, 18], avocado [3, 9], papaya [19], strawberries [11], Persian limes [20], and mangoes [21] at room temperature. This is due to the barrier formed around the fruit [22], diminishing the concentration of O_2 and increasing the CO_2 in the fruit, that reduced the number of pores by which the water steam and the other gases are exchanged [23, 24].

With a selection index (Figure 6), it was possible to determine which treatment showed the best parameters values to preserve the fruits (better appearance, less weight loss, loss of firmness, and pH changing), resulting in the treatment T13, containing higher concentrations of the components, and resulting in the best formulation to improve the quality and prolong shelf life of pears.

3.1.2. Total Soluble Solids. Figure 2 shows changes in total soluble solids (TSS). The results ($P < 0.05$) indicate that using higher concentrations of candelilla wax (*Euphorbia antisyphilitica* Zucc.), gum arabic, and polyphenols from pomegranate husk and lower concentration of jojoba oil

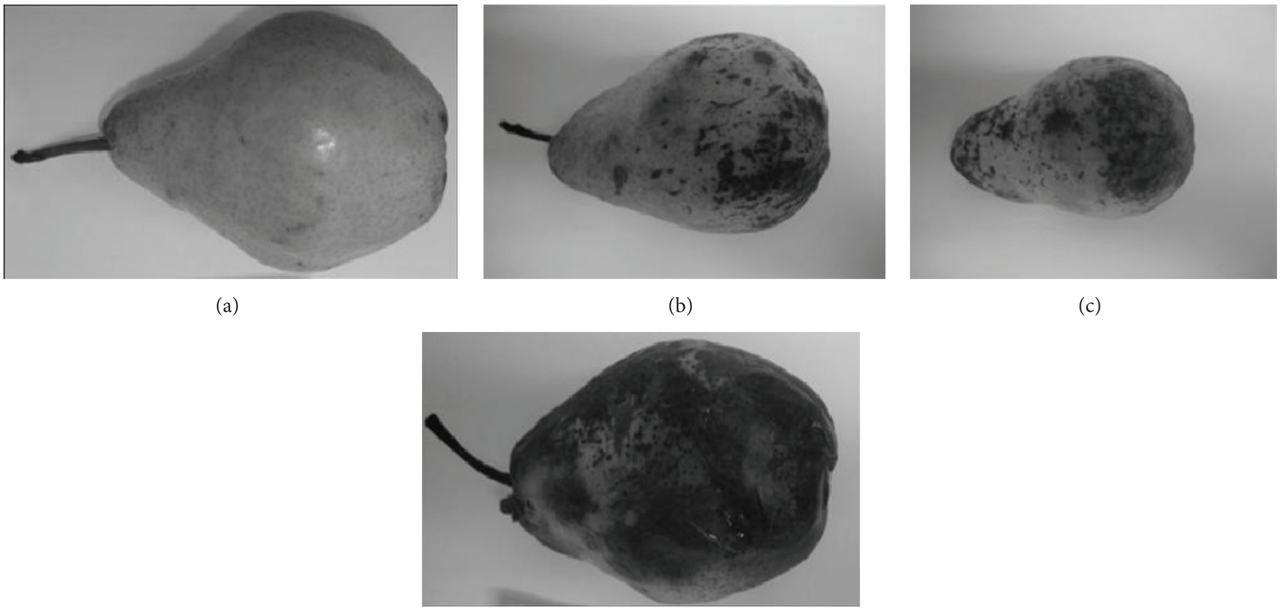

Figure 3: Visual appearance of pears with different treatments. T13 (a), T1 (positive control) (b), white (c), and negative control (d). Same small letters are not significantly different from each other ($P > 0.05$).

kept high TSS content, compared to treatments with lower concentrations of those compounds which is related to the acceleration of ripening of control fruits. This phenomenon can be explained due to the soluble solids and organic acids of fruit are substrates that are consumed by respiration during storage [25, 26].

3.1.3. Appearance Changes. All fruits presented changes in their external appearance, but the pears with T13 suffered a minor change compared with the other treatments (Figure 3). Also, positive controls suffered less damage than negative controls. The use of edible coatings considerably reduces apparent changes in fruits like papaya [14], apples [3, 10, 27], strawberries [11], and pears [28–31]. These changes can be due to the modified atmosphere created in the domestic fruit, with high levels of CO_2 and low levels of O_2, retarding the maturation processes [14, 20]. Also, the benefits of using polyphenols like ellagic acid with candelilla wax as edible film have been clearly evidenced by Saucedo-Pompa et al. [3] that they demonstrated that these coatings improve the color and texture of fruits.

3.1.4. Firmness. Losses in the texture and consequent drop in consumer acceptability are the most noticeable changes occurring in pears during the prolonged storage in controlled atmosphere [32]. Our results obtained can be observed in Figure 4, in which it is possible to see that high concentrations of the components keep at the minimum this parameter. Also, the coated pears ($P < 0.05$) maintained initial firmness values. However, negative controls were severely affected compared to those coated with antioxidants adding. These results are similar to other authors to preserve pears from different varieties like "Flor de Invierno" [28], "Huanghua" [29, 30],

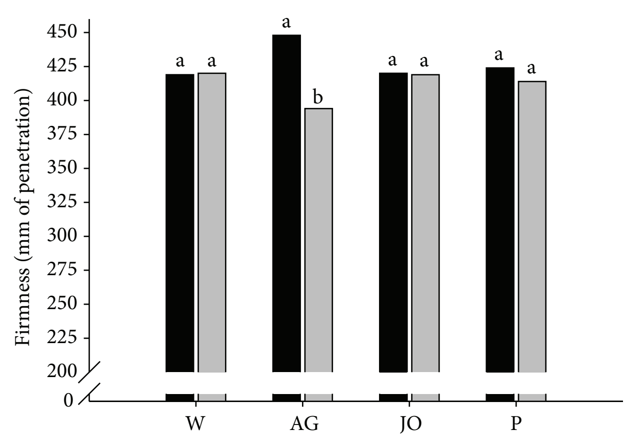

Figure 4: Loss of firmness: high (black) and low (gray). Same small letters are not significantly different from each other ($P > 0.05$).

"d'Anjou" [31], and other fruits and vegetables as tomatoes [33], apples [3, 11], and Japanese loquat [19].

This phenomenon can be explained by previous research that indicated the consequence of disassembly of primary cell wall and middle lamella structures of fruit flesh could contribute to changes in fruit texture during storage [34]. Firmness during ripening in climacteric fruit, such as pears, is generally attributed to degradation of the cell wall and loss of turgor pressure in the cells reduced by water loss [35–37]. The data, mainly T13, indicated that coating treatments maintain firmness. This phenomenon may be due to the inhibition of water loss and the activities of pectin-degrading enzymes closely related to fruit softening by reducing the rate of metabolic processes during senescence [38, 39].

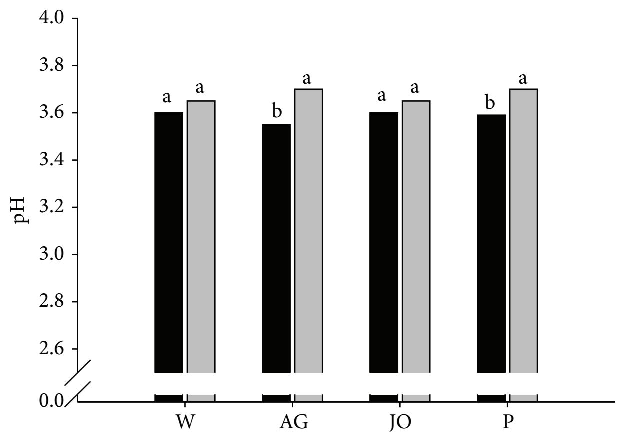

Figure 5: pH effect: high (black) and low (gray). Same small letters are not significantly different from each other ($P > 0.05$).

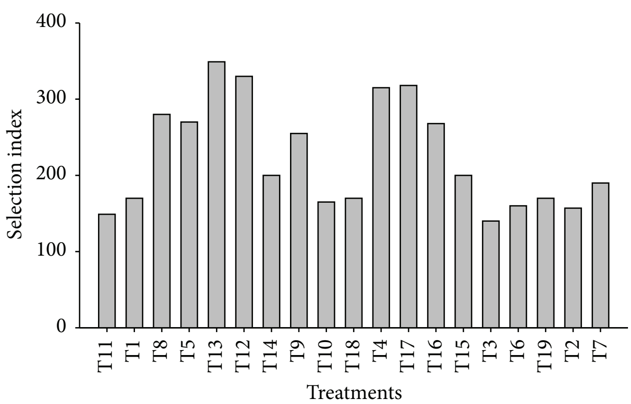

Figure 6: Selection index.

3.1.5. pH Values. The pH values (Figure 5) show no significant difference when using higher or lower concentration of candelilla wax and jojoba oil; nevertheless, when higher concentration of gum arabic and PPH is used, pH values increased. This change in pH was significantly low in comparison with the negative control samples, while the best results were obtained with T13 ($P < 0.05$). These results are consistent with those obtained by Gonzales-Aguilar et al. [14] that found a decrease in the increase of pH values of papaya treated with covers. On the other hand, Cantwell and Portela [40] observed an increase in the pH of melon stored at 5°C and Saucedo-Pompa et al. [9] found a decrease in pH increasing in avocado treated with edible coatings with ellagic acid.

3.2. Sensory Evaluation. Changes in sensory attributes including odor, flavor, and texture of coated and uncoated fruits were taste at the end of shelf life assay. Sensory evaluation was performed only to those treatments with values above 270 in the selection index. The results indicate no significant difference ($P < 0.05$) among sensory attributes of the 7 treatments, and it is remarkable that the presence of the coating does not change these sensory attributes. Nevertheless, significant difference ($P < 0.05$) was found in the attribute of appearance of commercial treatment with respect to the other ones (4, 5, 8, 9, 12, and 13). There is no significant difference between treatments ($P = 0.01$) on sensory attributes of appearance and taste.

Bárcenas et al. [41] indicate that, at the time of evaluating the preference of a product, consumers do not have the same concepts of quality, which makes an extensive margin of preference; this means that each consumer can get a sense of what is the smell, taste, texture, and appearance as considered ideal. Organoleptic preferences for many foods are influenced by regional culture [42] and it is necessary to determine, for each product, the standards that meet the target market [43]. Similar results were obtained by Zhou et al. [29] and Oms-Oliu et al. [28] where the use of edible coating on pears variety "Huanghua" and variety "Flor de Invierno," respectively, has no significant differences between the treatments. Also, our results of sensory evaluation are consistent with those reported by De-Leon-Zapata [44] testing taste and appearance in golden delicious apples, applying the same patented formula of edible coating based on candelilla wax and Ochoa et al. [10] carried out a triangular sensory test in golden delicious apples, applying the same patented formulation showing similar results. It means that edible coating did not modify the sensorial parameters measured.

4. Conclusions

The use of coating increased substantially the coating water vapor resistance that provided an attractive alternative to the fruits. In addition, the incorporation of PPH not only helped browning but also retarded the deterioration of pears. However, T13 also reduced changes in pH, firmness, and weight loss in the fruit but the different levels of all components influenced the integrity of cell wall constituents, which affected the changes of pears. In addition, edible coatings (mainly T13) were effective in keeping sensory quality for 4 weeks.

Practical Applications

Today the main problems to be faced in the production of fruits and vegetables are their quality changes during preservation in postharvest state. Often, these products are not consumed directly from the field and take time to get to supermarkets and also to the table of consumers; besides that, in many cases these fruits and vegetables are stored and transported for long periods of time. The edible coatings are an emerging strategy to meet these demands by providing additional protection to the food acting as a selective barrier to gases and thus prolonging its shelf life. It is noteworthy that there is no universal edible coating and each formulation is specific to the food according to their characteristics.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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