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IMPROVEMENT OF SHELF LIFE QUALITY OF GREEN BELL PEPPERS USING EDIBLE COATING FORMULATIONS

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ABSTRACT

In Latin-America, there are countries with high production levels of green bell peppers, which requires of new strategies of conservation for their international trade. Traditional techniques of preservations do not guarantee to prolong the shelf life of these kinds of fruits, for this reason, in the present study, the Influence of different edible coating formulations on shelf-life quality of green bell peppers was studied. Three different biopolymers (pectin, arabic, and xanthan gums) were evaluated in mixtures with candelilla wax as hydrophobic phase, jojoba oil as plasticizer and a crude extract of polyphenols as source of bioactive compounds. Green bell peppers were immersion-treated and then stored at room temperature. Response variables were: weight loss, color, appearance, pH, total soluble solids and firmness changes which were kinetically determined. All peppers treated with edible-coating showed a significant difference (Tukey, $p \leq 0.05$) in weight loss compared to control treatment (without edible coating), while a lower level of deterioration was observed in fruits treated with edible coating formulated with arabic gum, but appearance remained similar among fruits treated with different edible coatings. Use of mixtures of biopolymers, candelilla wax, jojoba oil and polyphenols to develop edible and functionalized coatings significantly extended shelf life of green bell pepper.

Keywords: Candelilla wax, jojoba oil, polyphenols, tarbush, biopolymers

INTRODUCTION

Most of fruits are harvested at physiological maturity requiring specific post-harvest conditions for keeping commercial quality as long as possible, including market and sale periods. Traditionally, post-harvest losses can be minimized by controlling transpiration and respiration rate, reduction of microbial infection and modifying storing atmospheres thus extending fruit shelf life (**Bisen and Pandey, 2008**). But, these techniques should be easily available, economically viable and feasible (**Pandey *et al.*, 2010**).

Senescence process usually leads to yellowing of green vegetables, due to degradation of chlorophyll, this change is critical because influence preference of consumers during purchasing. Intense green color is a trait which gives a fresh look to many vegetables, green color changes to brown, due to formation of pheophytin (**Artés *et al.*, 2003**). Modified atmospheres under refrigeration help to maintain fruit and vegetable quality and extend shelf life of vegetal products, mainly by inhibiting or decreasing the metabolic activity, development of biotic diseases, and enzymatic browning (**Radziejewska-Kubzdela *et al.*, 2007**).

Consumers demand less use of chemicals on minimally processed fruits and vegetables so more attention has been paid to the search of naturally occurring substances able to act as alternative antimicrobials and antioxidants (**Ponce *et al.*, 2008; Ochoa *et al.*, 2011**). By this reason, in recent years, food packaging research has focused more on biodegradable layers, including those made from vegetal sources (**Seydim and Sarikus, 2006**) and natural extracts (**Wijewardane and Guleria, 2011**). Edible coatings can provide a suitable atmosphere (low O_2 and high CO_2) for fruit conservation (**Baldwin, 2005**). The capacity of edible layers to maintain moisture, oxygen, aromas and solute transport may be improved by including chemical or natural additives such as antioxidants, antimicrobials, colorants, flavors, fortifying nutrients, or spices (**Pranoto *et al.*, 2005**). These additives have different active ingredients which diminish losses caused by microbial infections (**Bhowmick and Choudhary, 1992; Wijewardane and Guleria, 2011**).

An edible coating must ensure stability of food and extend its shelf life. Under storage conditions of fruits and vegetables should therefore be considered mechanical and chemical factors that are involved in the coating edible design (**Miranda *et al.*, 2003**). An edible coating is defined as a thin layer of material formed on a food as a coating, or placed (which implies that must be preformed) between food components (**Krochta and De Mulder-Johnston, 1997**). This coating must be from food grade materials mainly biopolymers commonly used in the food industry (**Demirci *et al.*, 2011**) such as xanthan, Arabic, guar, carrageenan and locus bean gum, pectin, etc.

Earlier our group reported that a edible coating of wax candelilla functionalized with ellagic acid extends and improves shelf life of Golden Delicious apples during 8 weeks of storage (**Ochoa *et al.*, 2011**), without altering sensory quality of fruits. Similar results were obtained when edible coatings of candelilla wax were functionalized with a tar bush extract improving the physicochemical quality of apples (**De León-Zapata, 2012**).

In this study, the objective was to extend and improve the shelf life quality of green bell pepper using an edible coating of candelilla wax.

MATERIAL AND METHODS

Raw materials

Green bell peppers were purchased at a local market, 24 h before treatments application. Fruit selection criteria were: size, absence of skin damage, visible absence of microorganisms, physiological maturity and intense green color. Then, green bell peppers were taken and sorted in complete random groups, washed with detergent and disinfected with a chlorine solution (500 ppm) for five minutes, finally, the excess of water was removed at room temperature (**Gonzalez-Aguilar *et al.*, 2005**).

Grouping and classification of vegetables

Green bell peppers were selected and assigned to a batch completely at random, Each group was analyzed in triplicates. Then each group was already ordered; each pepper was numbered in order to have a strict control for observations and monitoring data during the course of the experiment.

Application of edible coating

Three different edible coating systems were formulated; arabic gum - candelilla wax - tar bush extract (ACT), pectin gum – candelilla wax - tar bush extract (PCT) and xanthan gum - candelilla wax - tar bush extract (XCT) at different concentrations (Table 1). A control fruit treatment was considered; untreated fruit (WOC). All additives were food grade. Green bell peppers were carefully submerged in the respective formulated emulsion for a period of 2 s and then were dried under an air flux until solidification of the edible coating; this process was repeated twice. Then, peppers were stored at room temperature (25 ± 2°C) and monitored during ten days, having a strict control of treatments and replicates respectively.

Evaluation of shelf life quality

During the storage period, six parameters were monitored to measure green bell peppers shelf life with sampling every 48 h. Green pepper *weight loss* was gravimetrically measured with a semi-analytical balance (Explorer, OHAUS). *Appearance changes* were evaluated using a photographic camera (13.6 Mpix Ciber Shot, Sony). *Total soluble solids* (TTS) content was determined by the method 932.12 of the A.O.A.C. (**AOAC, 1980**) using a refractometer (PCE-Oe) with a capacity range up to 45% °Brix. *Color* of green bell peppers was recorded using the CIE-L* a* b* system in a portable colorimeter (ColorTec-PCM, Clifton, NJ). where L* indicates lightness, a* chromaticity on an axis from green (-) to red (+) and b* chromaticity in a shaft from blue (-) to yellow (+), v*Firmness* of green bell peppers was measured with a Humboldt universal penetrometer (model H-1200, Chicago, IL) by measuring penetration (mm), where samples were placed in a such way for a equatorial penetration. The *pH* values were obtained using a pH meter (Orion model -420, Boston, MA) using the method reported by **Saucedo-Pompa *et al.* (2007**).

Statistical analysis

Data were analyzed using a complete randomized block design with a factorial arrangement 4 x 5, with two replications. Results were analyzed using an ANOVA test, when it was needed, standard deviations were calculated for each sampling time, means comparison was performed using the Tukey´s multiple range test. Data analysis was performed using SAS statistical analysis software package (**SAS, 2002**)

RESULTS AND DISCUSSION

Weight loss

Weight loss value increased during the evaluation period in all treatments (Figure 1a). It can also be seen that peppers with the ACT, PCT, XCT treatments lost lesser weight (22% in average) than those with the control treatment (28% in average), which showed the highest weight loss.

Samples with any wax coating recorded the lowest percentage of weight loss; this can be attributed to reduction of open area of the emulsified solid network, which restricts water vapor transport from pepper inside (**Báez *et al.*, 2001**), (see Table 2). **Hoa *et al.* (2008**) reported that use of a lipid-based coating reduced weight loss of "cat Hoa loc' mangoes after 1 week at room temperature, while **Ochoa *et al.* (2011**) mentioned that a coating of candelilla wax with ellagic acid extends and improves shelf life quality of Golden Delicious apples during 8 weeks of storage without altering fruits sensorial quality. **Saucedo-Pompa *et al.* (2009**) reported that weight loss in avocados was lower in those fruits with the wax coating in comparison with those with the control treatment (without coating).

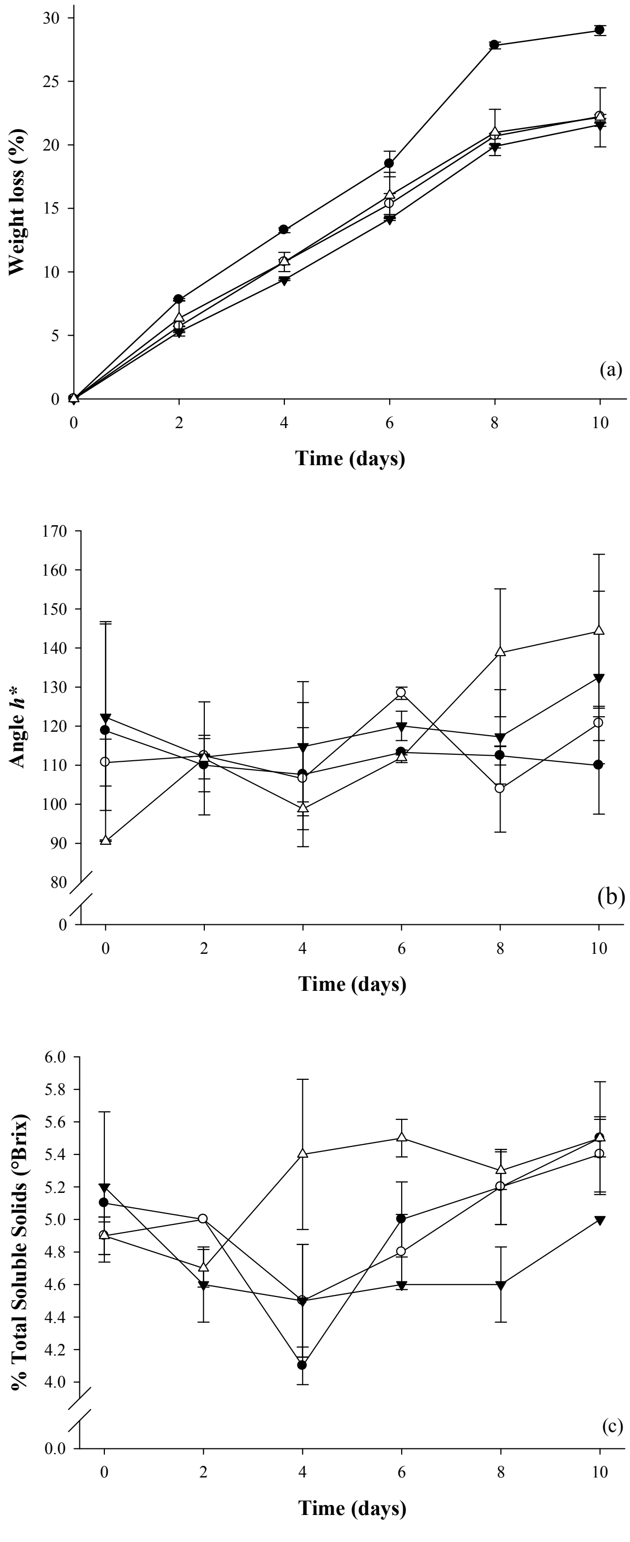
All of these results are similar to the ones reported by **Kester and Fennema (1986**), whom reported that use of lipids as coating decreases loss of humidity. **Beaulieu *et al.* (2009**) reported a decrement of weight loss in green bell peppers utilizing oilseed lipid films. Similar findings were noted by **Bisen *et al.* (2012**) in lime fruits coated with coconut oil; it may be explained by closure of opening of the stomata, reducing transpiration and respiration rate and also reducing microbial activity (**1996**).

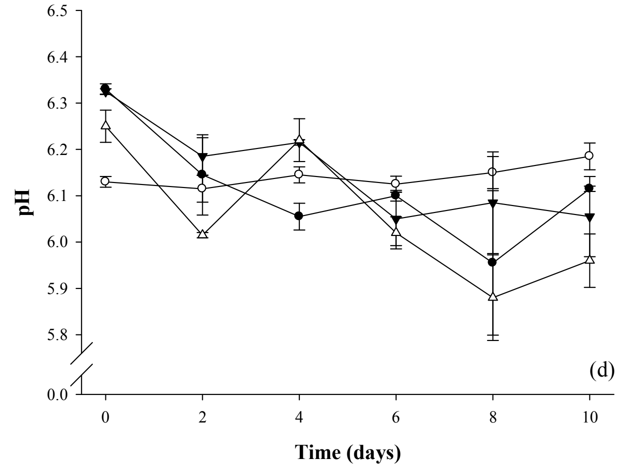
Color

Figure 1b shows changes in color, *angle h** (hue) is the value that represents the true color, which is effective for visualization of appearances of food product colors (**McGuire, 1992**), the h* is the angle in wheel of color of 90º, 180º, 270º and 360º, represent red, yellow, green and blue tone respectively (**Rocha and Morais, 2003**). In figure 1b, it can be observed that there is no significant difference (p≤ 0,05) among the ACT,PCT, and XCT treatments, but it does exists a difference between ACT and WOC which indicates that fruits with no treatment suffered major changes in coloration and the treated fruits with the ACT, PCT and XCT systems present a similar behavior in coloration change. **Geraldine *et al.* (2008**) reported that application of chitosan and acetic acid edible layers on agar base reduced the change of color on garlic cloves.

Appearance changes

Changes in external appearance of pepper are due to water loss that increases during fruits storage. This change was observed in fruits after 10 days of storage, however it can be noticed that the ACT treatment presents less roughness in comparison to PCT and XCT, but these present less levels of deterioration than the control (WOC) which presented the most roughness. **Ochoa *et al.* (2011**) mentioned that use of coatings made from candelilla wax decreased changes of appearance in apples; these changes can be due to modification of the fruit intern atmosphere, with high levels of carbon dioxide and low levels of oxygen, which slows the process of deterioration (**Bosquez-Molina *et al.* 2003; Gonzalez-Aguilar *et al.*, 2005**).





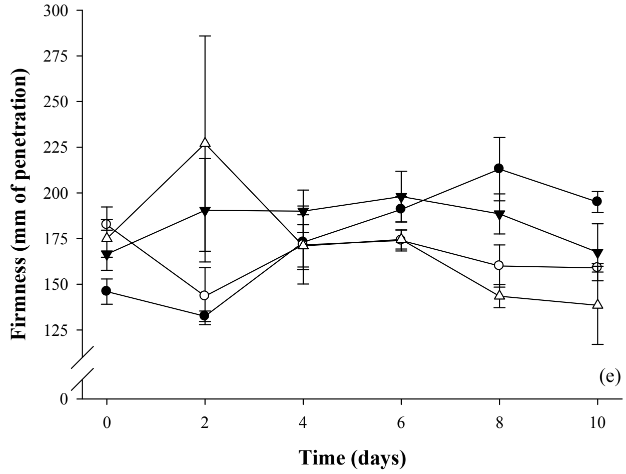


Figure 1 Changes in the quality of green bell pepper after 10 days of storage at room temperature (25±2 °C). with gum arabic-candelilla wax-tar bush extract (ACT), with pectin-candelilla wax-tar bush extract (PCT), with xanthan gum-candelilla wax-tar bush extract (XCT) and without coating (WOC). n = 2.

Total soluble solids

Figure 1c shows changes in TSS. Concentration of total soluble solids did not result significantly affected (p≤0.05) among treatments with a concentration of 4.98±0.12°brix however there is a significant difference from those fruits with edible coating to those with the control treatment, that is because this last one presented a concentration of 5.21°Brix after days of storage under 25±2°C (see Table 3). This can be related to the accelerated deterioration of fruits without coating. In this case volatility of soluble compounds and water can be freed in major proportion in the control treatment due to the lack of a protecting barrier. These can be corroborated in figure 1c, where it was observed that behavior of total soluble solids was similar among treatments detecting a slight increase in fruits without coating, these results match with the ones already reported by **Trejo-Marquez *et al.*** (**2007**), whom mentioned that there was an increase in total soluble solids for strawberries treated during refrigeration. **Rogers** (**1985**) and **Forssell *et al.*** (**2002**) mentioned that mass transference on fruits surface is a predominant factor for respiration.

Table 1 Component and concentration used for the preparation of edible coating systems.

edible coating systems	biopolymers (%) W/V	Candelilla wax (%) W/V	glycerol (%) W/V	tar bush extract (ppm)
ACT	3.00	1.5	0.15	500
PCT	0.80	1.5	0.15	500
XCT	0.05	1.5	0.15	500

Table 2 Statistical differences (ANOVA) for weight loss in green bell pepper during storage at room temperature (25±2 °C)

		Weight loss (%)	
Source	**DF**	**Mean**	**Pr > F**
Trat	3	1007.6550	<.0001
Rep	1	7168.7408	<.0001
Trat-rep	3	4657.2669	<.0001
Time	5	2208.6148	<.0001
Trat-time	15	20.2385	0.0126
Error	20	137.0383	6.85192
Total	47	35647.1966	
Coef Var 1.6585			

Table 3 Statistical differences (ANOVA) in total solids soluble (TSS or °Brix) in green bell pepper during storage at room temperature (25±2 °C)

		TSS (°Brix)	
Source	**DF**	**Mean**	**Pr > F**
Trat	3	1.3091	0.0009
Rep	1	0.2408	0.0447
Trat-rep	3	0.6091	0.0248
Time	5	2.3841	0.0001
Trat-time	15	2.7458	0.0051
Error	20	1.0500	0.0525
Total	47	8.3391	
Coef Var 4.6017			

pH values

Values of pH slightly decreased during the storing period without presence of significant differences (see Table 4) among treatments (p≤0.05), however the XCT treatment kept values very similar during the storing period and can be observed in figure 1d that fruits without treatment presented a pH relatively minor in those fruits with biopolymer and wax treatments, **Rico *et al.*** (**2010**) reported that this could be attributed to an increase of dry matter content during storing and depolymerization of pepper polysaccharides. Coating fruits presented a similar performance; this could be the result of the applied edible coatings that do not alter physicochemical properties such as pH. **Rico *et al.*** (**2010**) mention that decrease in pH during the pepper storage is probably due to a major quantity of organic acids liberated during irradiation and vapor treatments.

Firmness

Results obtained for this trait can be interpreted by the graphic in figure 1e, in which is possible to observe a slight decrease in the penetration of all treatments, being more noticeable in fruits without coating, this can be explained because during the storing period, pepper flaccidity is diminished and its cuticle became flexible which generates more resistance to penetration during the measurements and this way it is possible to notice that it keeps itself firmer not respecting a significant difference (see Table 5).

General appearance of green bell peppers was significantly improved and their shelf life quality was prolonged up to 10 days with the formulated emulsion with arabic gum - candelilla wax - tar bush extract in comparison of green bell peppers without edible coating (Figure 2).

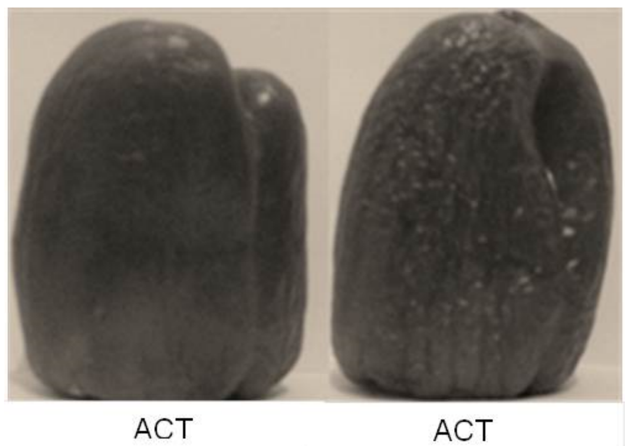


Figure 2 Changes of general appearance of green bell pepper after 10 days of storage at room temperature (25±2 °C). with gum arabic-candelilla wax-tar bush extract (ACT), without coating (WOC).

Table 4 Statistical differences (ANOVA) in changes of pH on green bell pepper during storage at room temperature (25±2 °C)

	pH		
Source	**DF**	**Mean**	**Pr > F**
Trat	3	0.0961	0.266
Rep	1	0.0168	0.3972
Trat-rep	3	0.0826	0.3278
Time	5	0.4710	0.0092
Trat-time	15	0.4526	0.2671
Error	20	0.4508	0.022541
Total	47	1.5701	
Coef Var 2.4602			

Table 5 Statistical differences (ANOVA) for firmness (mm) in green bell pepper during storage at room temperature (25±2 °C)

	Firmness (mm)		
Source	**DF**	**Mean**	**Pr > F**
Trat	3	706.5208	0.267
Rep	1	428.5208	0.2407
Trat-rep	3	164.9097	0.803
Time	5	386.8375	0.5782
Trat-time	15	1411.0708	0.0157
Error	20	9966.2500	498.3125
Total	47	36409.3125	
Coef Var 12.8431			

CONCLUSION

Edible coatings generated with biopolymers (Arabic, xanthan and pectin gums) candelilla wax and tar bush extract, applied to pepper, maintained quality physicochemical parameters of green bell peppers such as: weight loss, appearance, color changes, pH, total soluble solids and texture. Better results were obtained with the treatment which had arabic gum (ACT) because it presented less damages in fruit appearance in comparison to the remaining treatments (PCT, XCT and WOC) prolonging shelf life during storage of green bell pepper at 25±2ºC for a maximum period of 10 days.

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