Cactus Mucilage as a Coating Film to Enhance Shelf Life of Unprocessed Guavas (*Psidium guajava* L.)

J.A. Zegbe and J. Mena-Covarrubias
INIFAP-Campo Experimental Zacatecas
Apartado Postal No. 18
Calera de Víctor Rosales
Zacatecas, C.P. 98500
Mexico

V.S.I. Domínguez-Canales
Instituto Tecnológico Superior Zacatecas Norte
Apartado Postal No. 178
Río Grande, Zacatecas, C.P. 98400
Mexico

Keywords: *Opuntia ficuis-indica*, fruit quality, weight loss

Abstract

Annual pruning of cactus pear cladodes provides an opportunity for adding value to this crop by extracting mucilage from which to create edible films and coatings for perishable fruits such as guavas (*Psidium guajava* L.). The objective of this research was to create mucilage films and assess their effects on quality and shelf life of guava cultivar 'Media China'. Cactus pear cladodes were peeled, cubed, and homogenized in distilled water. Mucilage was precipitated using ethanol, then dried and ground. The experimental films tested were: no films as control (C), mucilage plus glycerol (T_1), and mucilage plus glycerol and polyethylene glycol (T_2). Two experiments were conducted with two different concentrations of mucilage, glycerol, and polyethylene glycol. Guavas were harvested from local farmers and treated with a fungicide before coating. The treated fruit was stored for eight or six days at room temperature (28°C and 20% RH or 27°C and 20% RH, respectively). In the first trial, the T_2 film increased fruit weight loss more than C and TI film. Both films delayed fruit skin colour and maintained higher firmness (F), total soluble solids concentration (TSSC), and dry matter concentration (DMC) than C fruit. In the second trial, T_1 and T_2 films reduced fruit weight loss and delayed fruit skin colour more than C fruit. Firmness, TSSC, and DMC of fruit were similar among treatments. Overall, the experimental mucilage films showed a tendency to prolong shelf life and maintain some quality attributes of guava. Further research is needed to understand the mucilage potential as an edible film at cold room conditions.

INTRODUCTION

In Mexico, 56,000 ha are used to cultivate cactus pear (*Opuntia ficus-indica*). In Zacatecas, Mexico, annual pruning of cactus pear cladodes produces 10-15 t ha^{-1} of fresh pads. These are primarily used for animal feed, left between orchard rows, or incorporated into the soil. This annual pruning waste provides an excellent opportunity for adding value to this crop by extracting mucilage from the pads for industrial purposes (Sepúlveda et al., 2007; Iturriaga et al., 2009; Pichler et al., 2012). Another mucilage application is production of edible films and coatings for highly perishable fruits such as guava (*Psidium guajava* L.). Guava is a climacteric fruit, delicate, highly perishable, susceptible to mechanical damage and weight loss, and with a short life after harvest, especially when stored at room temperature (Jacomino et al., 2001). The physiological state of fruits (partially ripe or mature) is important for successful storage at cold room or controlled conditions (Reyes and Paul, 1995). Therefore, films and coatings prepared from cactus mucilage could improve postharvest life of this fruit for distant markets. The objective of this research was to create mucilage films and assess their effect on quality and shelf life of guava cultivar 'Media China'.

MATERIALS AND METHODS

The experiment was conducted at the Postharvest Lab of the Campo Experimental Zacatecas, Calera de Víctor Rosales, Zacatecas, Mexico (lat. 22°54'N, long. 102°39'W,

elevation 2,197 m) from March to May of 2011.

The mucilage extraction protocol was: 1) cactus pads were weighed, treated with a solution of distilled water, 1% chloride, and 2.5 ml/L copper sulphate, then peeled and sliced into 1 cm cubes; 2) cubes were placed into water (1:7, v/v), warmed to 80°C for 30 s, cooled to 16°C for 24 h, and filtered; 3) the supernatant was concentrated at 75°C for 24 h, then cooled to room temperature; 4) mucilage was precipitated with 1:3 v/v ethanol; 4) and finally, mucilage was dried and ground.

Sixty guava fruits with yellowish-green skin colour were harvested from local farmers and treated with a solution of 1% chloride and 2.5 ml/L copper sulphate before setting up the experiments. In the first experiment, 42 uniform fruits were selected and three groups of 14 fruits each were randomly allocated to three treatments. The same number of fruit was used in the second experiment.

Experiment I. The experimental treatments tested were: no films as a control (C), 1.0 g mucilage and 0.84 ml glycerol in 20 ml distilled water (T_1), and 1.0 g mucilage, 0.68 ml glycerol, and 0.2 g polyethylene glycol in 20 ml distilled water (T_2). The treated fruit was stored for eight days at 20% relative humidity (RH) and room temperature (28°C).

Experiment II. The experimental films tested were: no films as control (C), 0.5 g mucilage and 0.42 ml glycerol in 40 ml distilled water (T_1), and 0.4 g mucilage, 0.34 ml glycerol, and 0.1 g polyethylene glycol in 10 ml distilled water (T_2). The treated fruit was stored for six days at room temperature (27°C and 20% RH).

Fruit quality at harvest and after storage was determined by fruit skin colour (sphere spectrophotometer model SP60 X-Rite, Inc., Isenburg, Germany), firmness (penetrometer model FT 327, Wagner Instruments, Greenwich, CT, USA), total soluble solids concentration (digital refractometer model PR-32α, Atago, Co. Ltd., Tokyo, Japan), dry matter concentration as a percentage of fresh weight, and fruit weight loss as a percentage of initial fresh weight.

Data were analysed using a completely randomised model and the GLM procedure of SAS software (SAS Institute ver. 9.1, 2002-2003). Treatment means were compared and separated by Tukey's test at 5%.

RESULTS AND DISCUSSION

In the first experiment, T_2 guava fruits consistently lost more weight than control and T_1 fruits (Fig. 1A). In the second experiment, T_1 and T_2 both reduced weight loss more than the control (Fig. 1B).

In the first experiment, T_1 and T_2 both significantly delayed fruit skin colour development in guavas (Fig. 1C). The same occurred in the second experiment, but by the end of the experiment, the treated guavas were close to the typical yellow colour of this fruit (Fig. 1D).

The treatments also affected fruit quality changes during the eight days in storage at room temperature. For all fruit categories in the first experiment, firmness (F) and total soluble solids concentration (TSSC) were reduced by 75 and 14%, respectively, while dry matter concentration (DMC) was 45% higher than directly after harvest (Table 1). The same pattern held for the second experiment except for TSSC, which stayed 6% higher on average than in fruit at harvest (Table 1).

In experiment I, T_1 and T_2 fruits maintained higher F, TSSC, and DMC than control fruits. However, in the second experiment, these results held only for F and DMC on T_2, while TSSC tended to maintain higher in control fruit than in T_1 and T_2 (Table 1).

Cactus pear mucilage is a polysaccharide (Matsuhiro et al., 2006) that has been used recently as a coating to improve shelf life of minimally processed strawberries (Del Valle et al., 2005; Sepúlveda et al., 2007). Like other polysaccharides, it is hydrophilic, which may create a poor barrier against water loss and gas exchange (Lin and Zhao, 2007; Bourtoom, 2008). The coating thickness may affect the functionality of the film, and thus could adversely affect weight loss and gas exchange (Bashir et al., 2003; Lin and Zhao, 2007). This may have occurred in the first experiment, because the mucilage

coating increased weight loss and delayed fruit skin colour development (Fig. 1). Besides, firmness, the total soluble solids concentration and dry matter concentration of fruit stayed higher in T_1 and T_2 fruits than in control fruits, which could be a dilution effect due to water loss in the mucilage-treated fruit. The opposite effects were observed in the second experiment, where reformulated coatings were used (Table 1).

CONCLUSIONS

The experimental mucilage films tended to prolong shelf life and maintain some quality attributes of guava. However, further research is needed to fully exploit the potential of mucilage as a coating, particularly testing under cold room or controlled atmosphere conditions (Sing and Pal, 2008).

ACKNOWLEDGEMENTS

This research was funded in part by the Fundación Produce Zacatecas A.C., No. Ref.: 02/FPZ/2001 and the Consejo Nacional de Ciencia y Tecnología, No. Ref.: 0007-2005-1_12448. We thank Pedro Castañón Hernández, Cintia Aracely Juárez Ibarra, and Mr Jorge Martínez, the owner of guava orchard. We are grateful to Dr. Mary Lou Mendum from the University of California at Davis for her assistance in editing the manuscript. We thank also the positive comments of the anonymous reviewers.

Literature Cited

Bashir, H.A., Bakr, A. and Goukh, A. 2003. Compositional changes during guava fruit ripening. Food Chem. 80:557-563.

Bourtoom, T. 2008. Edible films and coating: characteristics and properties. Int. Food Res. J. 15:237-248.

Del-Valle, V., Hernández-Muñoz, P., Guarda, A. and Galotto, M.J. 2005. Development of a cactus-mucilage edible coating (*Opuntia ficus-indica*) and its application to extend strawberry (*Fragaria ananassa*) shelf-life. J. Food Chem. 91:751-756.

Iturriaga, L., Quinzio, C., Corvalan, M. and Mishima, B. 2009. Study of the stability at coalescence in mucilage emulsions. Acta Hort. 811:427-431.

Jacomino, A.P., Kluge, R.A., Sarantópoulos, C.L.G.d.L. and Sigrist, J.M.M. 2001. Evaluation of plastic packages for guava refrigerated preservation. Packag. Technol. Sci. 14:11-19.

Lin, D. and Zhao, Y. 2007. Innovations in the development and application of edible coatings for fresh and minimally processed fruit and vegetables. Comp. Rev. Food Sci. Technol. 6:60-75.

Matsuhiro, B., Lillo, L.E., Sáenz, C., Urzúa, C.C. and Zárate, O. 2006. Chemical characterization of the mucilage from fruit of *Opuntia ficus indica*. Carbohyd. Polym. 63(2):263-267.

Pichler, T., Young, K. and Alcantar, N. 2012. Eliminating turbidity in drinking water using the mucilage of a common cactus. Water Sci. Technol. Water Supp. 12:179-186.

Reyes, M.U. and Paul, R.F. 1995. Effect of storage temperature and ethylene treatment on guava fruit ripening. Postharvest Biol. Technol. 6:357-365.

Sepúlveda, E., Sáenz, C, Aliaga, E. and Aceituno, C. 2007. Extraction and characterization of mucilage in *Opuntia* spp. J. Arid Environ. 68:534-545.

Singh, S.P. and Pal, R.K. 2008. Controlled atmosphere storage of guava (*Psidium guajava* L.) fruit. Postharvest Biol. Technol. 47:296-306.

Tables

Table 1. Quality attributes of guava cultivar 'Media China' fruit coated with cactus pear mucilage after storage at room temperature for eight (Experiment I) or six (Experiment II) days. T_0 = control fruit, T_1 = mucilage plus glycerol treatment, T_2 = mucilage plus glycerol plus polyethylene glycol treatment. The TSSC is the total soluble solids concentration and FW is the fresh weight.

Treatment	Experiment I			Experiment II		
	Firmness (N)	TSSC (%)	Dry matter (mg g^{-1} FW)	Firmness (N)	TSSC (%)	Dry matter (mg g^{-1} FW)
			At harvest			
Harvest	44.0 ± 6.2[w]	10.3 ± 0.3	148.1 ± 3.2	78.9 ± 8.2	10.2 ± 0.4	158.2 ± 4.0
			After storage			
Control	05.2b[x]	8.4b	197.3b	7.9a	11.3a	195.8a
T_1	12.7a	8.7ab	212.6ab	7.8a	10.4a	194.0a
T_2	14.7a	9.5a	232.8a	9.6a	10.7a	198.8a
MSD[y]	3.2	0.9	24.2	3.4	1.1	15.2
CV[z] (%)	63.8	13.4	14.8	52.5	13.7	10.1

[w] Mean ± once the standard deviation.
[x] Mean separations within a column at harvest or storage condition were by Tukey's test at 5%. Mean values followed by the same lower-case letter are not significantly different.
[y] Minimum significant difference.
[z] Coefficient of variation.

Figures

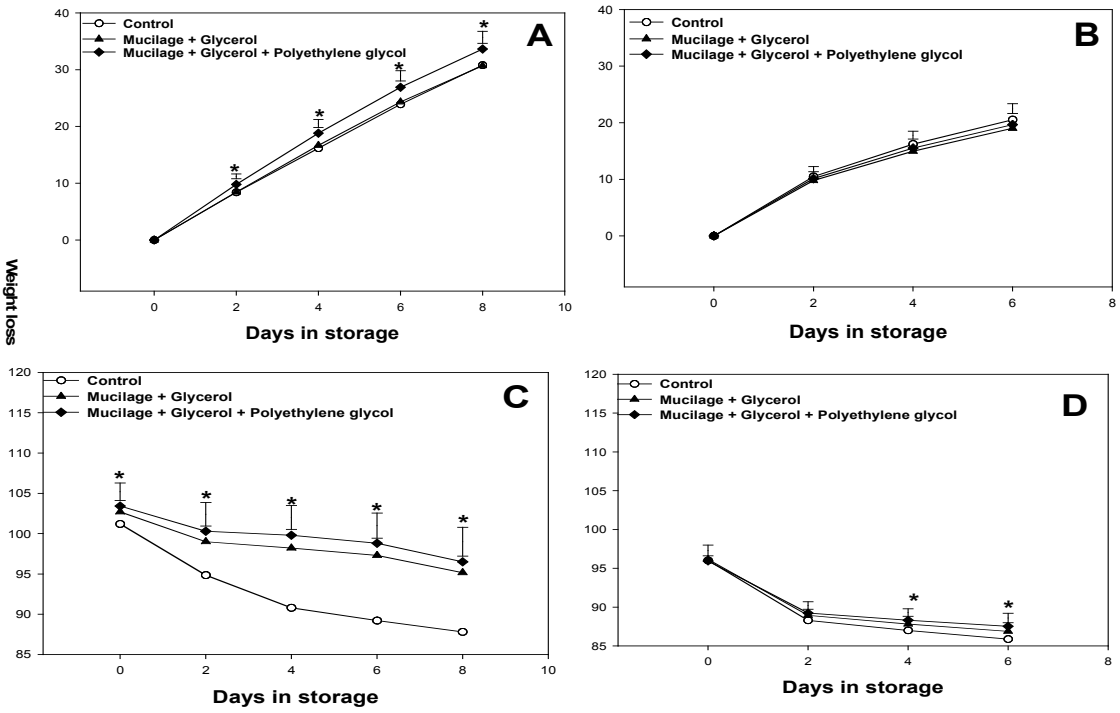

Fig. 1. Cumulate weight loss (A and B) and fruit skin colour (C and D) of cultivar 'Media China' guava fruit coated with cactus pear mucilage and stored for eight or six days at room temperature in the first (A and C) or second experiment (B and D), respectively. For each sampling date, vertical bars represent the minimum significant difference and the asterisks indicate significant differences by Tukey's test at 5%.