Informador Técnico (Colombia) 81(1) Enero - Junio 2017: 83-91 ISSN 0122-056X | e-ISSN 2256-5035 doi: http://doi.org/10.23850/22565035.722

Conservation of cape gooseberry (*Physalis Peruviana*) by applying a coating based on chitosan and aloe vera, using the spray method

Conservación de uchuva (Physalis peruviana) mediante la aplicación de un recubrimiento a base de quitosano y aloé vera, utilizando el método de aspersión

Received 07- 12 - 2016 Accepted: 20-05-2017

Ana Muñoz[1]
Angie Barbosa[2]
Daniela Bustos[3]
Yenifer Ramírez[4]
Yesenia Vásquez[5]
Jaqueline García[6]
Marcelo Guancha[7]

[1] Colombian Technologist National Learning Service SENA. ASTIN center.

[2] Colombian. Technologist National Learning Service SENA. ASTIN center.

[3] Colombian Technologist National Learning Service SENA. ASTIN center.

[4] Colombian Technologist National Learning Service SENA. ASTIN center.

[5] Colombian Technologist National Learning Service SENA. ASTIN center.

[6] Colombiana. Espc. Servicio Nacional de Aprendizaje SENA. Centro ASTIN. Grupo de Investigación GIDEMP.

[7] Colombian M.Sc. National Learning Service SENA. ASTIN center. Research Group GIDEMP.

Abstract

The objective of this research was to estimate the useful life of the cape gooseberry by the application of a coating based on chitosan and aloe vera using the spray method. The Colombian Technical Standard (NTC 4580) was used to compare the physical characteristics of cape gooseberries, using as indicators of deterioration, weight loss, total carotenoids, and color index. The evaluated samples were maintained under two storage conditions; Under refrigeration (4 °C) and at room temperature of the city of Cali (28 °C), during a period of 21 and 6 days respectively. Four samples were taken for each temperature and the results obtained were used to define the deterioration kinetics. The kinetics were of zero order, with weight loss being the indicator that limited the shelf life. Variables such as pH, acidity and maturity index did not show a significant difference at a significance level of $p < 0.05$. finally, the kinetic model for weight loss showed a 1-day increase for samples stored at room temperature and 2 days for samples refrigerated at 4 °C.

Keywords: coating; shelf life; cape gooseberry; aloe vera; chitosan.

Introduction

Cape gooseberry (Physalis peruviana L.) is a tropical fruit native to the Andean region, belonging to the Solanaceaes family (Carvalho, Villaño, Moreno, Serrano, & Valero, 2015, Caballero, Ortiz, Maldonado, & Rivera, 2011) , is characterized because its fruits are wrapped by a calyx or *capacho* (Caballero *et al*., 2011), being Colombia and South

Africa the largest producer (Carvalho *et al*., 2015). It is one of the most promising exotic fruits due to its nutritional composition since it contains high levels of minerals such as iron, phosphorus, vitamins A and C, as well as carotenoids (Carvalho *et al*., 2015; Mendoza, Rodríguez, & Millan, 2012) . Medicinal properties are attributed to it, such as: purifying the blood, decreasing the albumin of the kidneys, fortifying the optic nerve, cleaning cataracts and relieving throat affections (Novoa, 2006).

The cape gooseberry is exported fresh to Europe with the calyx because it increases its useful life (Carvalho *et al*., 2015), however, the calyx makes it difficult to transport, manipulate, count and exhibit it (Balaguera-López, Martínez, & Herrera-Arévalo, 2014). In Colombia and the US, the fruit is marketed without the calyx (Balaguera-López *et al*., 2014), which generates a reduction in the shelf life due to the acceleration of the ripening process, the production of ethylene, the loss of weight and the maturity index is increased (Balaguera-López *et al*., 2014). Consequently, in order to increase the useful life of the fruit without the calyx, it is necessary to look for alternatives that allow to reduce the processes of degradation and favor the commercialization; one of them is the application of coatings on the surface of fruits, which in various investigations have been used to increase the storage period and preserve quality by providing a barrier that reduces the rate of exchange of oxygen, carbon dioxide and water, as well as protection against microbial agents (Andrade, Skurtys, & Osorio , 2012; Kaviani, Shariati, Joshevska, Tomovska, & Vanaei, 2015; Rojas-Graü, Soliva-Fortuny, & Martín-Belloso, 2009).

Some compounds that have been used to obtain coatings are biopolymers such as starches, cellulose derivatives, chitosan, proteins, and lipids, among others (Elsabee & Abdou, 2013). In this work, the use of chitosan was proposed as an alternative to obtaining coatings due to its antifungal and antimicrobial properties, its characteristic of being edible and its non-toxic profile (Elsabee & Abdou, 2013; Vieira *et al*., 2016). Particularly, chitosan coatings have a selective permeability to gases (CO2 and O2) but a high permeability to water vapor, which limits their use in foods with high moisture content (Elsabee & Abdou, 2013), therefore, Among the alternatives to improve the barrier properties of chitosan-based coatings, it was usually used in a mixture with other hydrocolloids as the constituents of the aloe vera gel, which is composed of approximately 99.5 % of water, the 0, The remaining 5 % is the temperature of polysaccharides and other components (Sepulcre, Benítez, Achaerandio, & Pujol, 2015). The most important polysaccharide in aloe vera gel is glucomannan, which is a chemical structure formed by glucose and mannose, which gives it the property of retaining water (Dominguez *et al*., 2012; Sepulcre *et al*., 2015). For this reason, its incorporation in coatings with chitosan would reduce the water vapor permeability and increase the mechanical resistance (Khoshgozaran-Abras, Azizi, Hamidy, & Bagheripoor-Fallah, 2012).

In fruits and vegetables the physical and chemical properties depend on the thickness and homogeneity of the coating, which is why the sprinkling method is the most appropriate technique, this consists of increasing the surface area of the liquid through the formation of small droplets that are they form in a set of nozzles and allow a uniform distribution of the coating solution on the surface of the food and a thickness control (Andrade *et al*., 2012). By contrast, in methods such as immersion can not control the thickness due to lack of homogeneity, by the natural runoff that occurs during drying on the surface of the fruit; In addition, the amounts of coating solution can not be easily controlled, because the fruit has to be immersed in the solution of this (Andrade *et al*., 2012). A high thickness restricts the gas exchange during the respiration of the vegetal tissue causing accumulation of waste gases that bring as the effect the death of the internal tissues of the food (Guancha, Caicedo, Ruiz, & Valencia, 2016). Therefore, in this work we evaluated the effect of the use of a coating of chitosan and aloe vera using the method of spray application on color change, total carotenoids, pH, total acidity, content of soluble solids and weight loss in cape gooseberry during storage at room temperature (TA~28 °C) and in refrigeration (4 °C).

Materials and Methods

Materials

Commercial chitosan was used, supplied by the company Polymers Natural SAS.The mucilaginous gel used was extracted from aloe leaves of aloe (Aloe barbadensis miller) purchased in a supermarket, which were selected according to health attributes, washed and disinfected with hypochlorite. sodium at a concentration of 100 mg / L and stabilized according to the protocol carried out by Kaviani *et al*., (2015). Glycerol was used as a plasticizer and food grade vinegar. The cape gooseberry (Physalis peruviana L.) used for the evaluation had an approximate diameter of 2.5 cm (with a weight between 4 to 5 g) obtained from a farm in the municipality of Silvia (Cauca, Colombia), in

an adequate state for processing or fresh consumption. The cape gooseberries were disinfected with sodium hypochlorite at a concentration of 100 mg / L and washed with distilled water, drying at RT and stored at 4 °C.

Preparation and application of the coating

Chitosan solutions in vinegar (1%, v / v) were prepared at 3.5 %, which were mixed with stabilized Aloe vera in 80:20 proportions. Glycerol 1.0 % was used as a plasticizer with respect to the total mixture (Guancha *et al*., 2016). For each trial, lots of 400 cape gooseberries were selected. 200 units were coated using a pre-sterilized metal airbrush coupled to an air compressor, the size of the nozzle used was 0.5 mm, the compressor pressure was kept at 2.0 bar and an approximate distance was maintained 40 cm between the nozzle and the product, leaving the rest (200 units as a control - without coating). Three cycles of application were carried out, each cycle consisted on the application of the coating and drying for 10 minutes. Finally, the samples were stored in trays, which were distributed in batches of 25 units. 4 coated trays (CR) and 4 uncoated trays (SR) were taken to refrigeration and kept stored for 21 days at 4 °C, the same amount (CR and SR) was stored at 28 °C (average temperature of the city of Cali) for 8 days. The physicochemical parameters were determined every 7 days for the refrigerated samples, and every 2 days for the samples stored at RT. Temperatures and times were taken according to the recommendations reported in (Balaguera-López *et al*., 2014; Pinzón, Reyes, Álvarez-Herrera, Leguizamo, & Joya, 2015).

Determination of physicochemical parameters

The percentage of weight loss was determined during storage by weight difference for each study temperature in the established interval, using an analytical balance (Guancha *et al*., 2016) and was performed in quintuplicate for each trial. To establish the total carotenoid content, the cape gooseberry samples were homogenized in a juice extractor, then 0.50 g of sample was weighed in a 15 mL glass test tube, 7 mL of a 3: 4 mixture was added (hexane: ethanol). The samples obtained are covered with aluminum foil and stirred for 1 h in an ice bath using an orbital shaker. Finally, 1 mL of distilled water is added and stirred for an additional 20 min. For absorbance measurements, 3 mL of the organic phase is taken and the absorbance is measured using hexane in a spectrophotometer. The concentration (µg / g) is determined using a molar extinction coefficient of 2560 to 450 nm (Ordóñez-Santos, Martínez-Álvarez, & Vázquez-Riascos, 2014, Ordóñez-Santos, Vázquez-Odériz, & Romero-Rodríguez, 2011). The calculations of total carotenoids are determined according to equation 1 (Cuesta, Andrade, Moreno, & Concellón, 2013). The process is done in quintuplicate for each simple.

$$C[\mu g/g] = \frac{A_{450nm}\ \text{final volume}\ (ml)10^4}{2560\,\text{sample weight}\,(g)} \quad (1)$$

Where C is the concentration of carotenoids, At $_{450nm}$ absorbance at a wavelength of 450 nm, 2560 is the molar extinction coefficient of β-carotene in hexane.

The coated and control samples (uncoated) that were used to determine the weight loss were also used to determine the surface color using a Minolta CR-400 colorimeter (D65, 2°, Y = 89.5, x = 0, 3176; y = 0.3347). The data were collected in the CIELab color space and the values of L (brightness), a (oscillate between red and green) and b (oscillate between yellow and blue) were recorded during each trial in triplicate. In addition, the Color Index IC = [1000 * a] / [L * b] (Ordóñez-Santos, Hurtado-Aguilar, Ríos-Solarte, & Arias-Jaramillo, 2014) was estimated.

The total soluble solids are determined in triplicate for each of the samples using an Atago PR-101 digital refractometer and are expressed as °Brix. The titratable acidity was determined in triplicate by titration with 0.1 N NaOH until pH 8.1, using 5 mL of juice extracted from the sample diluted in 50 mL of distilled water, the results are expressed g equivalents of citric acid per 100 g fresh weight. The maturity index (MI) is determined by the ratio between the total soluble solids and the titratable acidity.

Kinetic modeling

La The variation of color, weight loss and carotenoid content in food over time responds to zero-order or first-order kinetic models (García, Chacón, & Molina, 2011). Therefore, the previous response variables can be modeled according to equation 2 (Ghidouche, Rey, Michel, & Galaffu, 2013, Valencia, Cortés, & Román, 2013):

$$-\frac{dC}{dt} = kC^n \quad (2)$$

Where C is the response variable (physicochemical parameters), t is the time, k is the velocity constant and n the order of the reaction. The model is determined according

to the value of the highest correlation coefficient (R2) for a given reaction order.

Statistic analysis

To determine significant differences with the CR and SR samples for each of the temperatures, a 95% correlation was used (Tukey, p <0.05).

Results and Discussion

Physicochemical properties (acidity, °Brix, pH and maturity index (IM)

Table 1 shows the results of the percentage of acidity, °Brix and maturity index for each of the treatments (at 4 °C and at RT, to samples with coating (CR) and without coating (SR).

At pH,% Acidity, °Brix and IM no significant differences were observed (P <0.05) during storage and no differences were observed between treatments (CR and SR). That is, the coating is not a factor that influences the pH, acidity, °Brix and IM. However, °Brix results ranged from 13.40 ± 0.10 and 15.43 ± 0.12 for the samples stored at 4 ° C and between 13.90 ± 0.20 and 15.70 ± 0.61 for the samples stored at room temperature, which coincide with those reported in the NTC 4580 (ICONTEC, 1999) whose values oscillate between 14,1 and 15,1 corresponding to states of maturity between 4 and 6 (ICONTEC, 1999). By contrast, the results of the MI ranged between 10.64 and 12.37 for the samples stored at 4 °C and between 10.97 and 16.66 for samples stored at room temperature, values that are above the recommended minimums for the IM according to NTC 4580 (ICONTEC, 1999) whose maximum limit is 9.

Kinetic modeling

The parameters used for the kinetic modeling were the percentage of weight loss, total carotenoids, and color index (CI). To determine the kinetic model of each of the study parameters, zero, first and second order models were evaluated. With regard to the percentage of weight loss, no changes were observed at a level of significance of p <0.05 during storage CR and SR at the two study temperatures. However, the results reveal higher rates of weight loss for uncoated samples. Figure 1 shows the results of the weight loss for the CR and SR samples for the two temperatures evaluated. The results show that zero-order kinetic modeling is the one that best fits the data because it has the highest regression coefficients (R2> 0.90), that is, it has a constant weight loss rate.

According to what was reported by Pinzón and collaborators (Pinzón, Reyes, Álvarez-Herrera, Leguízamo, & Joya, 2015) when the samples exceed losses greater than or equal to 10% of the weight, the freshness of fruits and vegetables disappears. In Figure 1 the storage at 4 °C favored the increase in the useful life of the cape gooseberries since the acceptable range is maintained for a longer time compared to the samples stored at RT. In addition, the effect of the coating is evident since the acceptable range is increased for the two study temperatures. Table 2 shows the results of the kinetic modeling parameters for the weight loss factor.

Table 1. Results of physicochemical properties

Treatment	Day	CR			SR			IM	
		% Acidity	°Brix	Ph	% Acidity	°Brix	pH	CR	SR
4 °C	0	0.943±0.030	13.40±0.10	3.947±0.012	0.943±0.030	13.40±0.10	3.980±0.040	14.40	14.40
	7	1.327±0.020	13.87±0.12	3.937±0.006	1.374±0.007	14.07±0.06	3.883±0.006	10.64	10.43
	14	1.190±0.034	14.50±0.00	3.993±0.015	1.267±0.013	14.10±0.10	3.950±0.010	12.37	11.32
	21	1.242±0.717	13.97±0.06	3.955±0.007	1.382±0.798	15.43±0.12	3.985±0.007	11.44	11.36
TA	0	0.964±0.007	13.90±0.20	4.082±0.006	0.964±0.007	13.90±0.20	4.137±0.025	14.61	14.61
	2	0.875±0.007	14.40±0.26	4.363±0.006	0.969±0.007	13.73±0.06	4.363±0.006	16.66	14.37
	4	1.216±0.111	15.70±0.61	4.637±0.015	0.9600.000±	14.30±0.62	4.640±0.053	13.11	15.09
	6	1.024±0.000	15.33±0.15	4.420±0.036	1.045±6.015	11.27±0.49	4.503±0.032	15.17	10.97

Averages ± standard deviation. SR: Uncoated, CR: with a coating

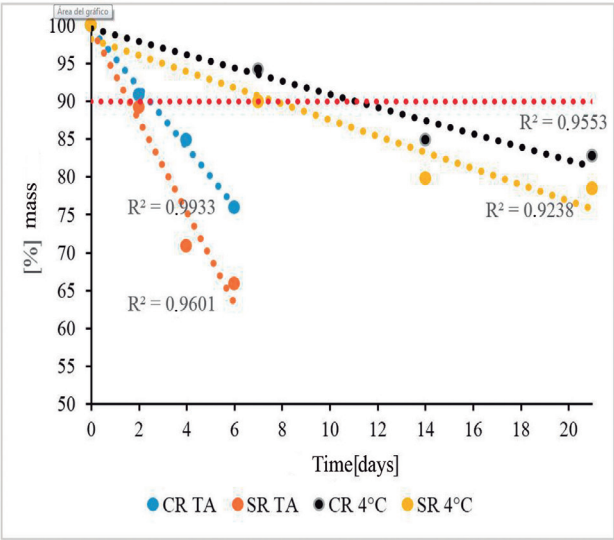

Figure 1. Weight loss variation in time for cape gooseberry

Table 2. Results of kinetic modeling of weight loss

Treatment		R²	K	Time [days]
TA	CR	0.993	-3.910	2.6
	SR	0.960	-6.049	1.7
4 °C	CR	0.955	-0.871	11.5
	SR	0.924	-1.071	9.3

With respect to the results of the constant k (absolute value), this is greater for the SR samples (6,049, 1,071) compared to the CR samples (3,910, 0,871), which translates into a greater loss rate. Keep in mind that if the limit of weight loss is 10 % for the treatment at RT would increase from 1.7 to 2.6 days due to the addition of the coating (approximately 1 day). For the treatment at 4 °C the increase in time would be from 9.3 to 11.5 days.

Figure 2 shows the results of the variation of the total carotenoids with the storage time for each of the study temperatures (a) and the kinetic modeling (b). There are no significant differences at a level of significance of P <0.05 for the samples stored at RT. On the other hand, for the samples stored at 4 °C, significant differences were observed in the third sampling (day 14) between the CR and SR samples.

According to Figure 2 (a) for the samples stored at 4 ° C an increase in the total carotenoid content is estimated over time. However, by day 14 an inflection point is observed for the SR samples. Likewise, for the samples stored at room temperature, the inflection point is presented on the day 2. Therefore, these inflection points are taken as a limit value to perform the kinetic modeling, which is presented in Figure 2 (b) and it is shown as the percentage variation of carotenoid content as a function of storage time. The inflection point occurs when the total carotenoid content has been increased by 34.7 % for samples stored at 4 °C and 69.2 % for samples stored at room temperature. The results reveal that the zero order kinetic modeling is the one that best fits the data since it presents the highest regression coefficients (R2> 0.80) for the samples stored at 4 °C, for the samples stored at TA the regression was performed only to have a comparison criterion since there are only two points when inflection occurs. Table 3 shows the results of the kinetic modeling parameters for total carotenoids.

With respect to the results of the constant k, this is greater for the SR samples (34.63 and 2.48) compared to the CR samples (26.74 and 1.28), which translates into a higher speed in the increase of total carotenoids. Taking into account the minor inflection point (34.7 % for the treatment at room temperature), the useful life increased from 1.0 to 1.3 days due to the addition of the coating. For treatment at 4 °C, the time increased from 13.97 to 27.19 days.

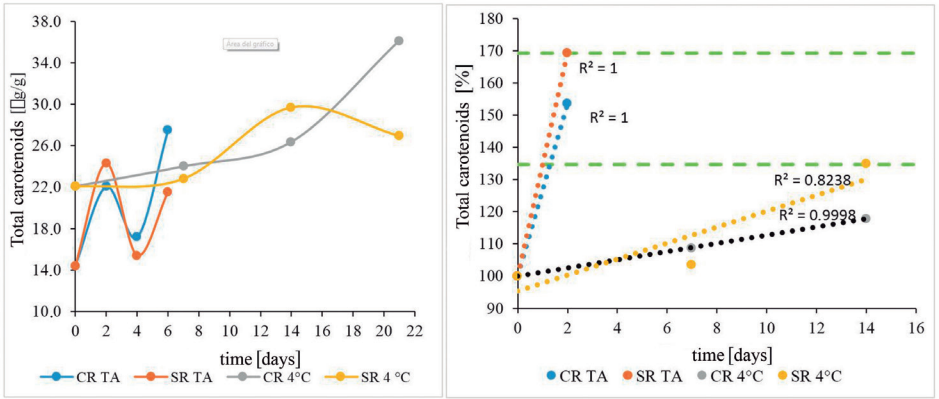

Figure 2. Result of the variation of total carotenoids **(a)** Variation of total carotenoids with storage time **(b)** Kinetic modeling

Table 3. Parameters of kinetic modeling for total carotenoid

Treatment		R^2	K	Time [days]
TA	CR	1.0000	26.74	1.30
	SR	1.0000	34.63	1.00
4 °C	CR	0.9998	1.28	27.19
	SR	0.8238	2.48	13.97

According to what was reported by Cajamar (2014), the variation of the CI between 2 and 20 indicate colors that range from pale yellow to intense orange. In this work, the CI varied between 5.99 and 6.58 for CR samples and between 5.23 and 8.38 for SR samples at a storage temperature of 4 °C. Likewise, for storage at RT the IC varied between 7.15 and 10.22 for SR samples and 7.38 and 8.75 for CR samples. These values are close to those reported by Pinzón and collaborators (Pinzón *et al*., 2015) whose average value at 4 °C is 7.54, corresponding to yellow fruits with high luminosity. It is also reported that CI values greater than 8 are fruits of color yellow orange, overripe and low luminosity; said values are presented for SR samples.

On the other hand, Figure 3 shows the variation of the CI in percentage with the storage time (a) and the kinetic modeling (b) for the study temperatures. No significant differences were observed at a level of significance of $P < 0.05$ for the samples stored at room temperature. On the other hand, for the samples stored at 4 °C, significant differences were found in the third sampling (day 14) between the CR and SR samples. According to Figure 3 (a) for the samples stored at 4 °C an increase in the IC content is observed with time. However, by day 14 an inflection point is observed for the CR samples. Likewise, for samples stored at room temperature, the inflection point is presented on day 2 for the SR sample and on day 4 for the CR sample. Therefore, these inflection points are taken as a limit value to perform the kinetic modeling which is presented in Figure 3 (b) and is shown as the percentage variation of the IC as a function of the storage time. The lowest inflection point occurs when the IC is 12.47 % for samples stored at room temperature SR and 10.00% for samples stored at 4 °C CR. The results reveal that zero-order kinetic modeling is the one that best fits the data because presents the highest regression coefficients (R2> 0.80). Table 4 shows the results of the kinetic modeling parameters for the CI.

With respect to the results of the constant k, this is greater than the SR samples (6,419 and 4,293) compared to the CR samples (3,227 and 0,715), which translates into a greater speed in the increase of IC. Taking into account the inflection point of 12.47 % for the treatment at room temperature, it increased from 2.0 to 4.0 days due to the addition of the coating (approximately 2 days). For treatment at 4 ° C, the time was increased from 3.03 to 18.19 days (approximately 15 days).

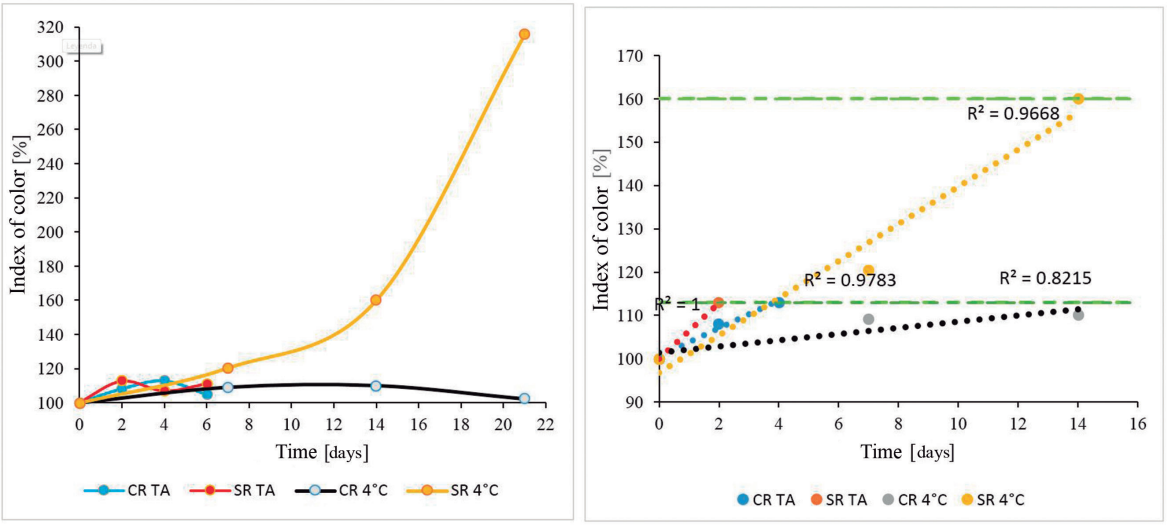

Figura 3. Resultado de la variación de IC **(a)** Variación de IC con el tiempo de almacenamiento **(b)** Modelamiento cinético

Tabla 4. IC Kinetic Modeling Parameters

Treatment		R^2	K	Time [days]
TA	CR	0.9783	3.227	4.03
	SR	1.0000	6.419	2.03
4 °C	CR	0.9998	0.715	18.19
	SR	0.8238	4.293	3.03

Conclusions

The kinetics of loss of color in cape gooseberry can be modeled through zero-order kinetics for parameters such as weight loss, total carotenoids and color index at 4 °C and room temperature. In addition, the application of coating based on chitosan and aloe vera in cape gooseberry in the conditions of this work allows to increase the conservation of total carotenoids, the IC and reduces the speed of weight loss.

Weight loss is found in the critical variables since according to the results of this study it is observed that a loss of 10 % by weight indicates non-acceptability of the product, although the variables such as Total carotenoids and color index are maintained within the established ranges.

The properties of PH, °Brix, acidity, evaluated IM do not show significant differences between the fruits with and without coating, therefore it is not recommended to use them for evaluar evaluate the incidence of the coating on fruits such as cape gooseberry.

The results of the kinetic modeling are not conclusive, so it is recommended for further investigations to increase the number of measurements and ensure greater homogeneity of the samples to be evaluated.

Acknowledgments

This work was developed thanks to the support of the ASTIN-SENA Center, the Research Group on Materials and Products Development (GIDEMP) especially to Carolina Caicedo and the Fruits and Vegetables Laboratory of the Faculty of Engineering and Administration of the *Universidad Nacional de Colombia* - Palmira headquarters for facilitating the performance of the colorimetric tests.

References

Andrade, R. D., Skurtys, O., & Osorio, F. A. (2012). Atomizing Spray Systems for Application of Edible Coatings. *Comprehensive Reviews in Food Science and Food Safety*, 11, 323-337. doi: https://doi.org/10.1111/j.1541-4337.2012.00186.x

Balaguera-López, H. E., Martínez, C. A., & Herrera-Arévalo, A. (2014). Role of the calyx in the post-harvest behavior of cape gooseberry *(Physalis peruviana L.)* ecotype Colombia. *Colombian Journal of Horticultural Sciences*, 8 (2), 181-191. doi: https: // doi. org / 10.17584 / rcch.2014v8i2.3212

Caballero P, L.A., Ortiz G, L., Maldonado O, Y. & Rivera, M.E. (2011). Assessment of the physical characteristics of the cape gooseberry *(Physalis peruviana L.)* commercialized in the municipality of Pamplona. *Alimentech Science and Food Technology*, 9 (1), 49-55.

Cajamar (2014). Parameters of external quality in the agri-food industry. Carvalho, C. P., Villaño, D., Moreno, D., Serrano, M., & Valero, D. (2015). Alginate Edible Coating and Cold Storage for Improving the Physicochemical Quality of Cape Gooseberry (*Physalis Peruviana L.). Journal of Food Science and Nutrition*, 1 (1), 7.

Cuesta, L., Andrade, M. J., Moreno, C., & Concellón, A. (2013). Content of antioxidant compounds in three stages of maturation of tree tomato (*Solanum betaceum Cav)*. Cultivated at different heights (msnm). *Equinoctial Technological University*, 4 (1) 32-49.

Dominguez, R., Arzate, I., Chanona, J., Welti, J., Alvarado, J., & Calderón, G. (2012). Aloe

vera gel: structure, chemical composition, processing, biological activity and importance in the pharmaceutical and food industry. *Mexican Journal of Chemical Engineering*, 1, 23-43.

Elsabee, M. Z., & Abdou, E. S. (2013). Chitosan based edible fi lms and coatings: A review. *Materials Science & Engineering* C, 33 (4), 1819-1841. doi: https://doi.org/10.1016/j.msec.2013.01.010.

García, C., Chacón, G., & Molina, M. (2011). Evaluation of the shelf life of a tomato paste by accelerated temperature tests. *Engineering*, 21 (2), 31-38.

Ghidouche, S., King, B., Michel, M., & Galaffu, N. (2013). A Rapid tool for the stability assessment of natural food colors. *Food Chemistry*, 139 (1-4), 978-985. doi: https: // doi. org / 10.1016 / j.foodchem.2012.12.064.

Guancha Chalapud, M., Caicedo, C., Ruiz, E., & Valencia, M. (2016). Conservation properties: coating based on chitosan and aloe vera applied in Creole potato *(Solanum phureja). Technical Informer*, 80 (1), 9-19. doi: https: // doi. org / 10.23850 / 22565035.325

Mendoza, J.H., Rodríguez, A., & Millán, P. (2012). Physicochemical characterization of the cape gooseberry (*Physalis peruviana*) in the region of Silvia Cauca. *Biotenology In the agricultural and agro-industrial sector,* 10 (2), 188-196.

ICONTEC. (1999). NTC 4580 Fresh fruits. Uchuva, specifications.Kaviani, M., Shariati, M. a., Joshevska, E., Tomovska, J., & Vanaei, M. (2015). Effects of Chitosan and Aloe Vera Gel Coating on Quality Characters of Pistachio. *Journal of Nutritional Health & Food Engineering*, 2(1). doi: https://doi.org/10.15406/jnhfe.2015.02.00042

Khoshgozaran-Abras, S., Azizi, M. H., Hamidy, Z., & Bagheripoor-Fallah, N. (2012). Mechanical, physicochemical and color properties of chitosan based-films as a function of Aloe vera gel incorporation. *Carbohydrate Polymers*, 87(3), 2058–2062. doi: https://doi.org/10.1016/j.carbpol.2011.10.020

Novoa, R. H. (2006). La madurez del fruto y el secado del cáliz influyen en el comportamiento poscosecha de la uchuva, almacenada a 12°C (*Physalis peruviana l.*). *Agronomía Colombiana*, 24(1), 77–86.

Ordóñez-Santos, L. E., Martínez-Álvarez, G. M., & Vázquez-Riascos, A.M. (2014). Effect of processing on the physicochemical and sensory properties of mammee apple (*Mammea americana l.*) fruit. *Agrociencia*, 48(4), 377–385.

Ordóñez-Santos, L. E., Hurtado-Aguilar, P., Rios-Solarte O.D. & Arias-Jaramillo, M.E. (2014). Concentración de carotenoides totales en residuos de frutas tropicales*. P*roducción + Limpia*, 9(1), 91–98. doi: https://doi.org/10.22507/pml.v9n1a7

Ordóñez-Santos, L. E., Vázquez-Odériz, M. L., & Romero-Rodríguez, M. A. (2011). Micronutrient contents in organic and conventional tomatoes *(Solanum lycopersicum L). International Journal of Food Science and Technology*, 46(8), 1561–1568. doi: https:// doi. org/10.1111/j.1365-2621.2011.02648.x

Pinzón, E. H., Reyes, A. J., Alvarez-herrera, J. G., Leguizamo, M. F., & Joya, J. G. (2015). Behavior of the cape gooseberry fruit *(Physalis peruviana L*), under different storage temperatures. *Journal of Agricultural Sciences*, 32 (2), 26-35. doi: https: // doi.org/10.22267/rcia.153202.10

Rojas-Graü, M. A., Soliva-Fortuny, R., & Martín-Belloso, O. (2009). Edible coatings to incorporate active ingredients to fresh-cut fruits: a review. *Trends in Food Science & Technology*, 20(10), 438–447. doi: https://doi.org/10.1016/j.tifs.2009.05.002

Sepulcre, F., Benítez, S., Achaerandio, I., & Pujol, M. (2015). LWT - Food Science and Technology Aloe vera as an alternative to traditional edible coatings used in fresh- cut fruits : A case of study with kiwifruit slices. *LWT - Food Science and Technology*, 61, 184–193. doi: https://doi.org/10.1016/j.lwt.2014.11.036

Valencia, F., Cortes, M., & Roman, M. (2013). Cinética del color durante el almacenamiento de caramelos blandos de uchuva adicionados de calcio y sin sacarosa. *Revista Lasallista de Investigacion*, 9(2), 11–25.

Vieira, J. M., Flores-lópez, M. L., Jasso, D., Rodríguez, D., Sousa, M. C., Vicente, A. A., & Martins, J. T. (2016). Postharvest Biology and Technology Effect of chitosan – Aloe vera coating on postharvest quality of blueberry (*Vaccinium corymbosum*) fruit. *Postharvest Biology and Technology*, 116, 88–97. doi: https://doi.org/10.1016/j.postharvbio.2016.01.011