Preservation Properties: Chitosan-based coatings and *Aloe vera* applied in creole potato (*Solanum phureja*)

Propiedades de conservación: recubrimiento a abase de quitosano y *Aloe vera* aplicado en papa criolla (*Solanum phureja*)

Received: 21- 04 - 2016 Accepted: 31-05-2016

Marcelo Alexander Guancha Chalapud[1]
Carolina Caicedo[2]
Eliana Marcela Ruiz[3]
Maria Fernanda Valencia[4]

[1] Colombian, *Ms.C.*, Servicio Nacional de Aprendizaje – SENA (National Learning Service). Technical Assistance Center to the Industry, GIDEMP Research group. E-mail: marceloguancha@misena.edu.co.

[2] Colombiana, *Ph.D.* Colciencias, Servicio Nacional de Aprendizaje – SENA (National Learning Service). Technical Assistance Center to the Industry. GIDEMP Research group. E-Mail: ccaicedo60@misena.edu.co.

[3] Colombian, Chemical Technologist, Servicio Nacional de Aprendizaje – SENA (National Learning Service). Technical Assistance Center to the Industry. E-Mail: emruiz31@misena.edu.co.

[4] Colombian, Chemical Technologist, Servicio Nacional de Aprendizaje – SENA (National Learning Service). Technical Assistance Center to the Industry. E-Mail: mariafrnanda@misena. edu.co.

Abstract

In this work, some films were developed starting from different mixtures of chitosan and *Aloe vera* (80:20, 70:30 and 60:40) in order to evaluate the properties related to the superficial tension of the layer and thickness. The ratio 80:20 presented a homogeneous appearance for which it was used in the creole potato (*Solanum phureja*) as a coating. This was applied by the dipping and subsequent drying of the tuber, varying the temperature from 40 °C to 70 °C with constant relative humidity (80% R.H.) for48 h. CIELab colorimetric parameters, weight loss and total carotenoids for each treatment were determined. Treatments were arranged in a simple randomized design for 24 h. It is worth mentioning that for the kinetic study variables were found in the zero order, that is, the change of properties depends exclusively on the time. Coating application based on chitosan and *Aloe vera* in a creole potato allowed it to conserve the total carotenoid content by 70% compared to uncoated samples.

Keywords: coatings; *Aloe vera* gel; carotenoids; Polysaccharides.

Introduction

The potato, is an ancient food from the Andean region and of high consume after rice, wheat and corn (Mosquera et al., 2015; http://faostat.fao.org). More than 5,000 species are estimated, and among them is the creole potato (papa criolla) *Solanum phureja* (Hawkes, 1990), this product performs a key role in the food security in Colombia due to the high nutrient content and the exportation potential as an exotic product (Mendoza & Herrera, 2012). Previous studies show that the life span of a creole potato post-harvest is between 5 and 8 days to achieve an optimal commercialization due to its fast germination (Rodríguez & Ramírez, 2011). Currently, different procedures are applied to foods like for example, temperature and water loss procedures (Nourian et. al., 2003), radiations (Kiss & Farkas, 1972), and the application of chemical agents (Luna-Guzmán & Barret, 2000). These treatments cause alteration in the sensorial and nutritional properties. In the last decade different studies have been done about alternative methods such as coatings from renewable natural sources and/or agricultural by-products, where the carbohydrates, proteins and lipids are found. (Cutter, 2006; Campos et al., 2011; Espitia et al., 2014; Alves et al., 2010).

The Chitosan is a natural polysaccharides, copolymer with units of β-(1-4)-2-acetamido-D-glucose and β-(1-4)-2-amino-D-glucose, is the product of chitin deacetylation [poli -β-(1-4)-N-acetyl-2-D-glucosamine], an important compound that is found in shrimp processing. The chitosan is known for its cationic nature, biodegradable, biocompatible, non-toxic and with antibacterial and hemolytic properties (Karlsen, 1991; Younesa et al., 2014). It has been a point of interest for several applications, among them, the conservation of food through fruit and vegetable coating (Kurek et al., 2014; Shen-Li, 2010; García et al., 2004). On the other side, the *Aloe vera* based coatings are very used due to the fact that they are transparent, odorless and tasteless. They are characterized for the easiness that present for forming films and provide microbial protection (Marpudi, 2011; Sogvar, 2016). These compounds have shown a better gases barrier, delaying humidity loss, the process of enzymatic browning and oxidative rancidity in vegetables and fruits due to the decrease of the breathing rate. Likewise, they have favored the stiffness of the surface and improve the sensorial perception such as texture and color (García, 2008; Khoshgozaran- Abras et al., 2012; Sánchez-González et al, 2011; Kaviani et al., 2015; Moreira et al., 2011). In the search of extending the life span of the creole potato, this work is presented that had as objective to evaluate the variation of color, carotenoids content and the weight loss in the potato, using *Aloe vera* coatings and chitosan during its storage in different temperatures.

Methodology

Materials

Commercial chitosan was used, provided by the company *Polímeros Naturales S.A.S.*, the mucilaginous gel was extracted from aloe stalk leaves (*Aloe barbadensis* Miller) coming from crops in a farm in the town of Dagua (Valle del Cauca, Colombia), aloe was used in a maximum of 2 days after its post-harvest, which was selected according to health attributes. Later, it was washed and disinfected with sodium hypochlorite at 100 ppm, peeled, liquefied and stabilized, according to the protocol done by Kiviani and partners (2015). Glycerol and Sigma-Aldrich acetic acid was used. The creole potato (*Solanum phureja*) used for the evaluation presented an approx. diameter of 2.5 cm (weighting ~23g) obtained commercially in the city of Cali, Colombia, in the appropriate condition for processing or fresh consumption. The samples were washed with distilled water, and dried at room temperature and stored at 4°C.

Coating preparation

Chitosan solutions were prepared (Q) in acetic acid (1%, v/v) a 2.5% (Q1), 3% and 3.5% (Q2) (p/v), which were mixed with *Aloe Vera* (AV) in different proportions (Qn/AV, v/v) as presented on Chart 1. Glycerol was used as plasticizer at 1.0% in relation to the total of each mixture. The drying conditions for the film collection in the climatic chamber were done at a temperature of 25°C and Relative Humidity (R.H.) of 10% and 30%.

Chart 1. Content of the prepared samples

Sample	Chitosan concentration	Chitosan proportion	Aloe Vera proportion
Q1AV-60:40		60%	40%
Q1AV-70:30	2.5%	70%	30%
Q1AV-80:20		80%	20%
Q2AV-60:40		60%	40%
Q2AV-70:30	3.0%	70%	30%
Q2AV-80:20		80%	20%
Q3AV-60:40		60%	40%
Q3AV-70:30	3.5%	70%	30%
Q3AV-80:20		80%	20%

Source: the authors.

Chemical-physical characterization

Thickness

An analog thickness gauge (Mitutoyo, ABSOLUTE) was used, with which the corresponding average values were registered in 5 random spots of the films.

Contact Angle

ST Industries profile projector was used, the analysis was done adding the substrate of a drop (~20 μL) of distilled water, the image was captured with the software *image J* (Burger, 2009), the angle between the t_0 and t_f times was measured.

Water absorption rate

~3g per simple were weighed, afterwards, 50 mL of water were added and it was manually shaken for 5 minutes. It was resting for 24h at room temperature. The humidity of the films (gel) was registered after drying the water excess with filter paper. The solids were weighed and the swelling capacity (S.C.) was calculated using equation 1, (Anderson et al., 1969):

$$\%S.C = \frac{Humid\ mass - Dry\ mass}{Dry\ mass} \times 10 \quad (1)$$

Differential Scanning Calorimetry

The thermal properties were determined in a Thermogravimetric analyzer TGA/DSC 2 STAR System, *Mettler Toledo*. The samples (10±0.5 mg) were placed in crucibles made of alumina in a temperature ranging between 30°C to 300°C under (50 cm^3/min) nitrogen atmosphere, the analysis were done following the ASTM D3418-12 standard.

Film adequacy and application

For every test, a batch of 10 unities were chosen. Afterwards, it was proceeded to submerge the Chitosan and *Aloe Vera* solution taking in account the homogeneity and drying time. The used film application method was immersion, where each one of the samples is input into a 1L beaker that contained 600 mL of the solution for 10 minutes. Subsequently, the samples were taken into a climatic chamber to 30°C and 25% of R.H.

Weight loss determination, total carotenoids and color measurement

To evaluate the color variation, weight loss and carotenoid content, a unifactorial experimental design was used varying the temperature (40, 50, 60 y 70 °C) and keeping the R.H. constant to 80%. A control sample was used (without coating) for each treatment. The tests were done during 48 h, which was fixed taking in account the preliminary tests under the criteria that at 48 h, the surface of the potato presented brown tones. Samples were taken in intervals of 0.24 and 48 h to determine each one of the answer variables. The weight loss percentage was determined during the storing by weight difference for each temperature in the interval of the established time using an analytical balance. To determine the content of total carotenoids, the potato samples are cut and homogenized in a food processor, and 0.5 g are weighted in a 15 mL glass test tube, besides, 7 mL are added in a 4:3 mixture (hexane : ethanol). The obtained samples are covered with tin foil and shaken for an hour in an ice bath using an orbital shaker. Finally, 1 ml of distilled water is added and it is shaken for 20 additional minutes. For the absorbance measurements, 3ml of the organic phase are taken and the absorbance is measured using hexane white in an spectrophotometer. The concentration is determined according to equation 2 (Cuesta et al., 2013; Ordóñez-Santos et al., 2011; 2014).

$$C[\mu\, g/g - \frac{A_{450mm} Final\ volume\ (ml) 10^4}{2560 test\ weight(g)} \quad (2)$$

Where, C is the carotenoid concentration, A_{450nm} absorbance at a wavelength of 40 nm, 2560 molar extinction coefficient of β-carotene in hexane.

To the samples with and without coating, a superficial color was determined using a CR-400 Minolta colorimeter (D65, 2°, Y=89,5; x=0,3176; y=0,3347). The data was collected in the CIELab space color and the L values (brightness), a (ranged between red and Green) and b (ranged between yellow and blue) were registered during every test in triplicate. Besides, the color intensity was estimated C= $[(a^2 + b^2)]^{0,5}$ and the shade angle h°= tan-1 (b/a) (Ordóñez-Santos et al., 2014).

Kinetic modelling

The color variation, weight loss and carotenoid content in the food, eventually, will answer to kinetic models. Thus, the previous answer variables can be modeled in according to the equation 3 (Román et al., 2013; Ghidouche et al., 2013):

$$-\frac{dC}{dt} = kC^n \quad (3)$$

Where, C is the answer variable (CIELab Color, total carotenoids and weight loss), t is time, k is the velocity constant and n the reaction order. The model is determined according to the highest correlation coefficient value of (R^2) for a determined reaction order.

The temperature effect is evaluated according to the Arrhenius equation, which relates the color variation with temperature.

$$k = Ae^{-Ea/RT} \quad (4)$$

Where, A is the Arrhenius constant, Ea is the activation energy, R the universal constant of ideal gases (1,981 cal/mol.K), and T being absolute temperature.

$$-\frac{dC}{dt} = kC^n = Ae^{-Ea/RT} \quad (5)$$

Results and discussion

Film's thickness measurement, contact angle and swelling capacity

The thickness of the films is a parameter that is found standardized for the measurement of mechanical tests, according to ASTM D882 (≤ 0.25 mm). The biological properties and the life span of a product for coating are severely altered by this parameter. The values found in the mixtures previously prepared, are observed in the Figures 1 and 2.

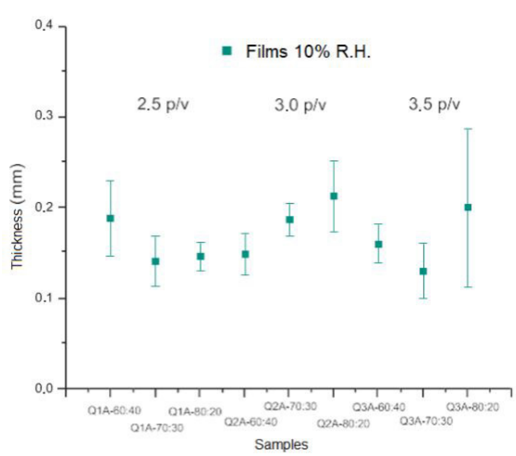


Figure 1. Film thickness with relative humidity at 10%
Source: The authors.

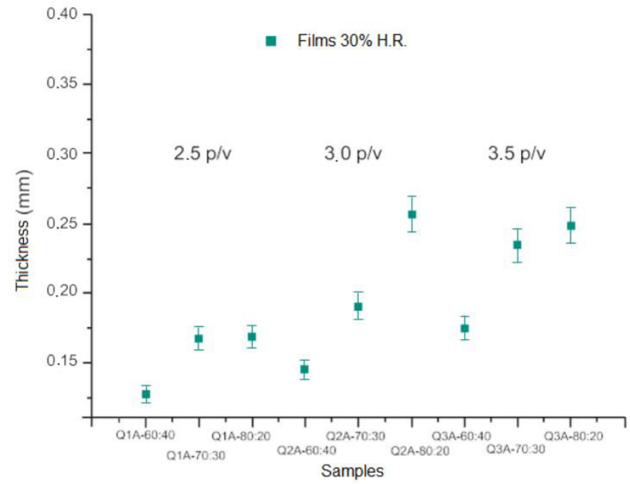


Figure 2. Film thickness with relative humidity at 30%
Source: The authors.

The thickness results were obtained in conditions of extreme relative humidity (10% and 30%) with the goal to favor short drying times for the development of the films. The average thickness values evaluated at 10% R.H. do not present a clear tendency between the different proportions, apart from a high deviation that generated the difficulty in the analysis. All this, due to an acceleration in the dynamic Exchange between the environment and the simple, while the films tested at 30% R.H. showed a relation between the chitosan and thickness directly proportional.

On other hand, in the determination of the hydrophilicity of the samples, the value of the contact angle was obtained (θ) associated to the interaction of the sessile drop exposed over the film's surface. In the data register an immediate time was considered after the formation of the drop (initial, t_0), and other time after 60s passed 60 s (final, t_f) as reported on Chart 2.

Chart 2. Angle contact comparison of the average contact between the mixtures

Sample	θ (°. t_0)	σ	θ (°. t_f)	σ
Q1AV-60:40	59.40	±1.18	59.25	±1.76
Q1AV-70:30	59.22	±1.21	59.15	±1.21
Q1AV-80:20	61.42	±1.12	61.15	±1.39
Q2AV-60:40	59.31	±1.52	58.80	±1.32
Q2AV-70:30	58.21	±1.23	58.33	±1.30
Q2AV-80:20	59.30	±1.18	58.13	±1.32
Q3AV-60:40	57.27	±1.42	57.11	±1.11
Q3AV-70:30	N.A	--	N.A	--
Q3AV-80:20	N.A	--	N.A	--

σ: Standard deviation
Source: The authors.

The results showed a not very meaningful variation in the contact angle for the different mixtures with Q1, due to the reorganization in the surface of hydrophobic and hydrophilic groups (Silva et al., 2013), this interaction favored the mixture between the compounds: chitosan, *Aloe vera* and glycerol. For the case of the Q3 mixtures, the simple does not allow one to calculate the contact angle because the water modifies the measurement points in the film's surface.

Likewise, the obtained values in the determination of the swelling capacity allow to amplify the information about the interaction *Aloe vera* and chitosan of the mixture that results in the raise of the hydrophilicity depending to the chitosan concentration (See figure 3).

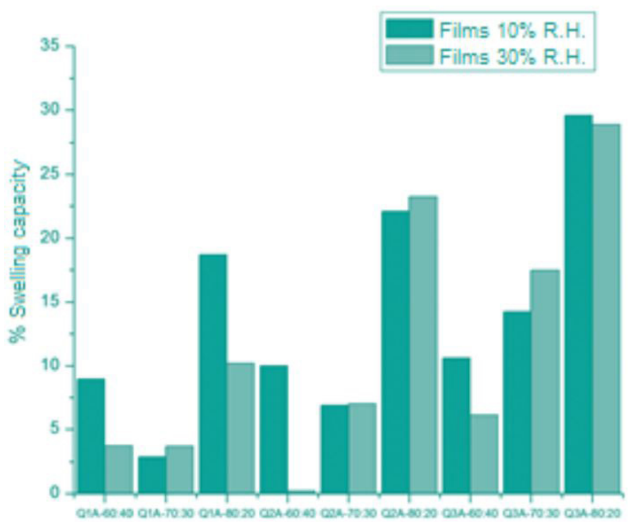


Figure 3. Swelling capacity in percentage of the different film concentrations
Source: The authors.

It is worth to mention, that the associated results to thickness, contact angle and swelling capacity as indicator for this homogeneity project, allowed to select the ideal concentration of chitosan in the solution. The samples with Q1 and Q3 present scattered associated values to premature losses of humidity and lump formations, respectively.

Thermal properties of the films

The thermal result associated with the Differential Scanning Calorimetry for the Q2 films with 2.5% p/v of chitosan present phase transitions related to the melting point, which decrease in 4.5% with the incorporation of the gel, as shown in Figure 4.

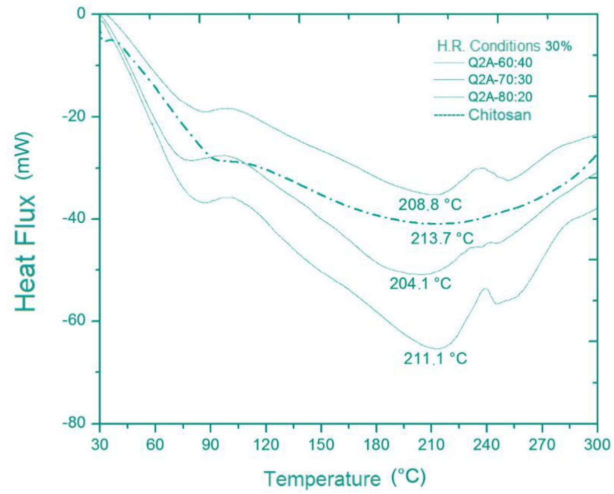


Figura 4. Thermography by differential scanning Calorimetry (DSC) of the Q2A films
Source: The authors.

Kinetic modelling

To determine the kinetic model of each one of the answer variables, several zero, first and second order models were evaluated. The results show that the zero order model is the one that best suits to the data since that it presents the highest regression coefficients, the results are show on Chart 3. The parameters for the Arrhenius equation of the colorimetric parameters, total carotenoids and loss weight are shown on Chart 4.

According to the results of the kinetic parameters in the creole potato, the correlation coefficient (R^2) for the majority of the treatments, is above 0.90, thus, the zero order model describes the kinetic behavior for each one of the studied variables in this work. Although in the literature, there are no reported data with kinetic behavior in the fresh creole potato, the results can be compared to those reported by Nourian and partners (2003) who report kinetic parameters for the potato variety *Solanum commersonii*. The *k* values for the L parameter range between 0.0295 and 0.197 and for b* between 0.0227 and 0.0910 for temperatures between 4 and 20°C, the activation energy ranges between 12 and 15 kcal/mol. The mentioned authors highlight in the L and b* colorimetric parameters, due to the fact that L is related with luminosity; a brightness loss indicates a decrease in the b* parameter, thanks to enzymatic activity of the peroxidase present in the potato which increases the velocity of color degradation (Mendoza & Herrera, 2012). The effect upon the decrease of L and b* is higher because of the increase of temperature, besides, high k values indicate higher velocity of color degradation. As it can be observed in Chart 4, the k values were always lesser to the k values of the samples with coating. Then, it can be said that the addition of the coating in the creole potato decreases the velocity of color degradation, the weight loss and the loss of total carotenoids.

Chart 3. Kinetic parameters for the zero order model in the creole potato

Answer variable	Parameters lineation	40 °C		50 °C		60 °C		70 °C	
		W/OC	WC	W/OC	WC	W/OC	WC	W/OC	WC
Carotenoides	K	0.020	0.014	0.025	0.010	0.018	0.011	0.013	0.005
	[µg/g.min]								
	R^2	0.859	0.987	0.836	0.979	0.984	0.865	0.974	0.855
Weight loss	K[min^{-1}]	0.417	0.381	0.819	0.545	1.482	1.133	1.142	0.857
	R^2	0.987	0.990	0.916	0.964	0.985	0.989	0.923	0.910
L	K	0.505	0.217	0.563	0.285	0.607	0.408	0.542	0.425
	R^2	0.941	1.000	0.907	0.683	0.914	0.818	0.819	0.695
a*	K	0.074	0.056	0.056	0.046	0.030	0.010	0.038	0.027
	R^2	0.968	0.959	0.983	1.000	0.719	0.349	0.707	0.939
b*	K	0.384	0.247	0.601	0.322	0.564	0.529	NR	0.041
	R^2	0.998	0.885	0.895	0.874	0.911	0.836	NR	0.805
c*	K	0.285	0.219	0.552	0.294	0.455	0.478	0.458	0.443
	R^2	0.998	0.821	0.911	0.893	0.885	0.831	0.746	0.651
h°	K	0.729	0.729	1.016	0.317	1.172	0.592	NR	0.141
	R^2	0.984	0.999	0.994	0.969	0.999	0.904	NR	0.497

W/OC: Samples without coating, WC: Samples with coating

Source: The authors.

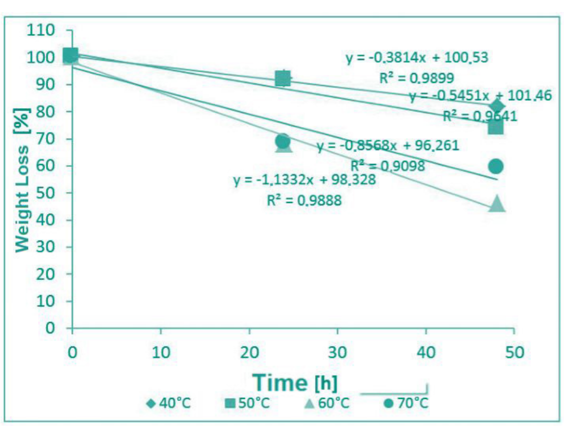
Chart 4. Parameters for the Arrhenius equation

Trat.	Carotenoids [µg/g]			Weight loss [%]			L			a			b		
	K	Ea [kcal/mol]	R^2	K	Ea [kcal/mol]	R^2	K	Ea [kcal/mol]	R^2	K	Ea [kcal/mol]	R^2	K	Ea [kcal/mol]	R^2
SR	1738.76	3.45	0.54	3943.52	7.84	0.75	317.77	0.63	0.25	2809.70	5.58	0.73	2037.07	4.05	0.65
CR	3328.29	6.61	0.69	0.96	5.38	0.96	-2706.10	5.38	0.96	4094.93	8.14	0.41	5055.55	10.05	0.30

Source: The authors.

On Figure 5, are shown the graphics of the kinetic weight loss in function of time (a) and the linearization process for the Arrhenius equation for the L parameter (b).

(a)



(b)

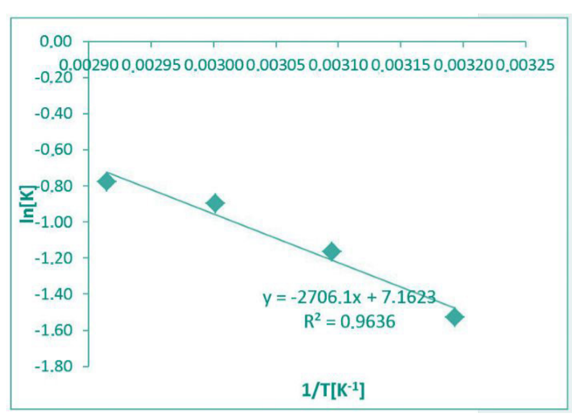


Figure 5. Results of the kinetic modelling for the variable of weight loss in the creole potato. (a) Kinetic weight loss (b) Arrhenius equation for the L parameter

Source: the authors.

In the Charts 5 and 6 are shown the results of the average variables of evaluated variables (L, a, b, c, h°, weight loss [%] and total carotenoids) for tests done at an inferior temperature (40 °C) and superior temperature (70 °C), each treatment was done in triplicate. An ANOVA analysis was held with a significance level of $p<0.005$.

The colorimetric values obtained for the creole potato before being submitted to a climatic chamber treatment (time zero) are close to the ones reported by Urrutia and Wilmer (2010): L (60.99), a* (9.60) y b* (39.24). Likewise, the carotenoid values are close to the ones reported by Bianeth-Peña & Restrepo (2013), which range is between 0.97 and 2.92 μg/g of fresh weight that corresponds to a variety of creole potato with low concentrations of zeaxanthin, lutein and violaxanthin, and relatively high concentrations of de β-carotene (0.27μg/g fresh weight).

Although the differences are not statistically meaningful it is observed that the colorimetric parameters (L, a*, b*, c, h°) decreased along time and with the treatment temperature. The effect is more pronounced in the b* parameter, since it presented a higher grade of temperature decrease in relation to the others, due to the fact that the browning tones that were developed in the surface of the simple during the treatments. This tendency is higher for the samples without a coating where the b* parameter takes negative values at temperatures of 60 and 70°C. The colorimetric results contrast with the results of the total carotenoids, which values were higher for the times of 24 and 48 h for each one of the study temperatures. For the samples with coating, the concentration of total carotenoids remains between 45 y 70% in relation to the initial value, while for the simple without coating the total carotenoid concentration keeps itself between 10 and 15% in relation to the initial value. Besides, the higher total carotenoids values for each one of the treatments (after 24 h) are higher to temperatures of 40 and 50°C and lesser for the treatments with temperatures of 60 and 70°C. This demonstrates the positive effect of the coating upon the color preservation in the samples of creole potato.

Chart 5. Results of the superficial color in the creole potato

Temp. [°C]	Trat	Time (h)	L	a*	b*	C	h°
	SR	0.0	63.43±0.82^{a}	10.55±0.40^{abc}	27.48±1.14^{abcde}	28.37±1.02^{bc}	69.00±1.31^{abc}
40	SR	24.0	46.05±10.51^{cde}	9.34±1.12^{abcde}	17.60±12.26^{defgh}	21.03±10.94^{cdefg}	62.05±17.08^{abcd}
	SR	48.0	39.17±9.58	7.01±1.72^{cdefg}	9.07±13.44^{fghi}	14.67±10.74^{efgh}	52.30±32.66^{abcd}
	SR	0.0	61.43±2.69^{a}	7.42±0.68^{cdefg}	26.71±2.44^{abcde}	27.72^{a}±2.53^{bcd}	74.47±0.08^{ab}
70	SR	24.0	37.84±1.68^{e}	5.48±0.16^{g}	0.62±1.50^{i}	5.65±0.11^{h}	6.49±15.37^{ef}
	SR	48.0	35.43±1.09^{e}	5.58±0.44^{fg}	0.07±1.66^{i}	5.75±0.35^{h}	0.75 ±17.15^{f}
	CR	0.0	60.61±6.12^{ab}	12.33±3.02^{a}	41.60±5.18^{a}	42.68±4.08^{a}	73.49±7.92^{ab}
40	CR	24.0	55.53±0.49^{abc}	9.51±0.43^{abcde}	31.96±0.75^{abcd}	33.19±0.82^{abc}	73.43±0.36^{ab}
	CR	48.0	50.19±1.60^{abcd}	8.17±0.49^{bcdefg}	29.73±2.36^{abcd}	32.18±2.34^{abc}	74.63±1.01^{ab}
	CR	0.0	62.42±1.06^{a}	5.91±0.34^{efg}	3.43±0.81^{hi}	31.27±0.83^{abc}	30.13±0.55^{bcdef}
70	CR	24.0	42.01±2.06^{de}	6.84±0.82^{defg}	3.58±2.48^{hi}	7.18±1.05	27.61±20.12^{cdef}
	CR	48.0	40.50±7.37^{e}	7.20±3.04^{cdefg}	5.41±8.72^{ghi}	10.02±6.98^{fgh}	36.92±14.19^{abcdef}

Source: The authors.

Chart 6. Results of the weight loss and the total carotenoids per creole potato

Temp. [°C]	Treat.	Weight loss [%]	Carotenoids [μg/g]
40	SR	100.00±0.00^{a}	1.30±0.02^{abc}
	SR	88.02±4.24^{abc}	0.49±0.02^{fghij}
	SR	79.98±3.80^{bcd}	0.35±0.02^{hij}
70	SR	100.00±0.00^{a}	0.75±0.14^{defg}
	SR	58.85±6.69^{fgh}	0.36±0.08^{hij}
	SR	45.17±10.73^{hi}	0.14±0.02^{j}

40	CR	100.00±0.00[a]	1.30±0.02[ab]
	CR	92.44±1.87[ab]	0.80±0.01[defg]
	CR	81.69±6.02[bcd]	0.64±0.01[defgh]
70	CR	100.00±0.00[a]	0.75±0.14[defgh]
	CR	68.22±8.56[def]	0.56±0.29[efghi]
	CR	58.87±8.33[fgh]	0.53±0.27[efghij]

Inside of each column the values with different letters represent meaningful differences (Tukey, p <0,05). Means ±standard deviation. W/OC: Without coating, WC: With coating
Source: The authors.

Despite the carotenoid content drop and the weight loss percentage being lesser in comparison to the samples without coating, there is a notable loss of firmness due to the application effect of the coating. The Firmness, although is not a measurement in this work, it could be observed qualitatively, and it was notorious unlike the samples without coating. According to Rojas-Grau and partners (2009), one of the drawbacks of using the coatings over the food matrixes, is the thickness, since it restricts the gas exchange during the tissue respiration, causing gas waste accumulation that can lead to the death of internal tissue of the food. On other side, according to what was reported by Nourian and partners (2003), the temperature increase leads to texture changes, due to the acceleration in the physicochemical changes developed in the inside of the food matrix, such as starch gelatinization, pectin degradation and cellular wall rupture. According to the mentioned authors, storage temperature has a significant effect upon the starch conversion and pectin to reducing sugars, which affects the texture and the color degradation acceleration. Besides, it is reported that for storing temperatures between 16 and 20°C, the potato variety degraded or ended up unacceptable at 35 days, while at storing temperatures of 4 and 8°C the products keeps suitable even for 130 days. This, to confirm the effect of this temperature upon the firmness and the color degradation, a control test was held (with and without coating) at lab conditions (27°C and approximately 70% of relative humidity), and the colorimetric parameters, weight loss and total carotenoids every 120 h during 360 h that lasted the test. The results are shown on Chart 7.

Chart 7. Results surface color, mass loss and total carotenoids for Creole potato at environmental conditions

	Tiempo (h)	L	a*	b*	C	h°	Pérdida de peso [%]	Carotenoides [µg/g]
SR	0	66.73±0.83	8.32±1.98	33.94±5.96	35.24±5.21	75.06±5.99	100.00±0.00	1.445±0.740
	120	61.02±4.10	8.84±1.48	35.03±4.30	36.19±3.75	75.84±4.22	98.07±1.43	0.836±0.118
	240	54.61±7.48	9.06±1.86	21.43±9.32	23.28±8.36	68.78±10.67	84.24±4.10	0.797±0.070
	360	52.23±10.69	10.51±0.85	19.31±11.12	22.79±8.39	61.45±22.39	61.32±5.11	0.461±0.129
CR	0	65.10±0.80	10.70±0.86	37.45±2.25	25.80±2.36	77.39±0.45	100.00±0.00	1.445±0.543
	120	62.33±5.60	10.13±0.65	37.08±2.80	26.47±2.39	76.17±0.95	97.88±0.91	1.250±0.036
	240	57.87±6.02	9.13±0.60	23.34±7.41	38.02±2.80	65.37±7.72	91.91±6.64	1.070±0.329
	360	55.89±2.18	8.38±0.35	24.43±2.65	38.54±6.75	67.48±2.74	81.57±1.49	0.953±0.218

Means ±standard deviation.
Source: The authors.

According to the results in Chart 7, the colorimetric paramters are similar to the samples with and without coating. However, the final total carotenoid content of the test keeps in a 66% for samples with coating, while the samples without coating keeps in 32% with reference to the initial content. Besides, qualitatively the control texture without coating is affected in a higher grade in comparison to the samples without coating, so we can claim that that there is a meaningful in the modification of respiration rate, due to the thickness of the coating over the surface of the creole potato. Nonetheless, in the samples with coating superficial browning is not developed and the sprout growth is inhibited

Conclusions

The results obtained in the characterization of the films suggest the incorporation of a 20% *Aloe Vera* gel in chitosan mixtures at a 2.5% p/v, due to it presenting an acceptable homogeneity. The kinetic through the color loss of the creole potato can be modeled through a kinetic zero order and the Arrhenius equation in a temperature range between 40 and 70°C. On the other hand, the application of the coating based with chitosan and *Aloe vera* in the creole potato allows to preserve the total carotenoid content up to a 70% in comparison to the samples without coating. Yet, it is important to evaluate *Aloe vera* and chitosan mixtures that allow to improve the gas exchange in the food matrix and its environment. Besides, it is important to evaluate the effect of the coating at ledge storage temperatures (temperatures less to 10°C), since at high temperatures, the biochemical processes can influence in the results of the variables that are being evaluated.

Acknowledgements

This work was developed thanks to the support of the *Centro Astin-SENA*, to the *Grupo de Investigación en Desarrollo de Materiales y Productos* (GIDEMP)-Research Group in Development of Materials and Products (RGDMP), and the apprentices of Chemical technology applied to the industry and analysis of chemical samples. Likewise, the *Tecnoparque* Department of Biotechnology Nodo Cali. C. C. thanks the financial support of the contingent finance funding No. FP44842- 259-2015, *COLCIENCIAS-SENA.*

Bibliography

Alves, V. D., Costa, N., & Coelhoso, I. M. (2010). Barrier properties of biodegradable composite films based on kappa-carrageenan/pectin blends and mica flakes. *Carbohydrate Polymers*, *79*(2), 269-276.

Anderson, R., Conway, H.F., Pheiser, V.F. y Griffin, E.L. 1969. Gelatinisation of corn grits by roll and extrusion cooking. *Cereal Science Today*, 14: 4-12.

Baldizón, C. G., Córdoba, M. E. M., & Valle, G. C. (2012). Evaluation of the life span of a tomato paste through accelerated tests by temperature. *Ingeniería*, *21*(2), 31-38.

Bianeth Peña, C., & Restrepo, L. P. (2013). Phenolic compounds and carotenoids in the potato: check. *Actual. nutr*, *14*(1), 25-32.

Burger, W., Burge, M. J., Burge, M. J., & Burge, M. J. (2009). *Principles of Digital Image Processing* (p. 221). London: Springer.

Campos, C. A., Gerschenson, L. N., & Flores, S. K. (2011). Development of edible films and coatings with antimicrobial activity. *Food and Bioprocess Technology*, *4*(6), 849-875.

Cuesta, L., Cuvi, M. J. A., Guerrero, C. M., & Concellón, A. (2013). Antioxidant compound content in three states of ripeness of tree tomato (Solanum betaceum Cav.) harvested at different temperatures (msnm). *Enfoque UTE*, *4*(1), pp-32.

Cutter, C. N. (2006). Opportunities for bio-based packaging technologies to improve the quality and safety of fresh and further processed muscle foods. *Meat science*, *74*(1), 131-142.

Espitia, P. J. P., Du, W. X., de Jesús Avena-Bustillos, R., Soares, N. D. F. F., & McHugh, T. H. (2014). Edible films from pectin: Physical-mechanical and antimicrobial properties-A review. *Food Hydrocolloids*, *35*, 287-296.

García, M. A., Díaz, R., Puerta, F., Beldarraín, T., Castillo, A., González, J., & Duarte, C. (2008). Envasado activo de embutidos. *Ciencia y Tecnología de Alimentos, 18*(2), 1-7.

García, M. A., Pinotti, A., Martino, M. N., & Zaritzky, N. E. (2004). Characterization of composite hydrocolloid films. *Carbohydrate Polymers*, *56*(3), 339-345.

Ghidouche, S., Rey, B., Michel, M., & Galaffu, N. (2013). A rapid tool for the stability assessment of natural food colors. *Food chemistry*, *139*(1), 978-985.

Hawkes, J. G. (1990). *The potato: evolution, biodiversity and genetic resources*. Belhaven Press.

Karlsen, J., & Skaugrud, O. (1991). Excipient properties of chitosan. *Manufacturing chemist*, *62*(6), 18-19.

Kaviani, M., Shariati M.A., Josevska, E., Tomovska, J., Vanaei, M. (2015). Effects of Chitosan and Aloe Vera Gel Coating on Quality Characters of Pistachio. *J Nutr Health Food Eng 2*(1): 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.

Kiss, I., & Farkas, J. (1972). Radiation preservation of fruit juices in combination with freeze-concentration. *The International journal of applied radiation and isotopes*, *23*(4), 161-171.

Kurek, M., Galus, S., & Debeaufort, F. (2014). Surface, mechanical and barrier properties of bio-based composite films based on chitosan and whey protein. *Food Packaging and Shelf Life*, *1*(1), 56-67.

Luna-Guzmán, I., & Barrett, D. M. (2000). Comparison of calcium chloride and calcium lactate effectiveness in maintainingshelfstability and quality of fresh-cut cantaloupes. *Postharvest Biology and Technology*, *19*(1), 61-72.

Marpudi, S. L., Abirami, L. S. S., Pushkala, R., & Srividya, N. (2011). Enhancement of storage life and quality maintenance of papaya fruits using Aloe vera based antimicrobial coating. *Indian Journal of Biotechnology*, *10*(1), 83-89.

Mendoza, R., & Herrera, A. O. (2012). Kinetic of the inactivation of the peroxidase enzyme, color and texture in the creole potato (*Solanum tuberosum* Grupo phureja) submitted to three conditions of blanching. *Información tecnológica*, *23*(4), 73-82.

Moreira, M. D. R., Pereda, M., Marcovich, N. E., & Roura, S. I. (2011). Antimicrobial effectiveness of bioactive packaging materials from edible chitosan and casein polymers: assessment on carrot, cheese, and salami. *Journal of Food Science*, *76*(1), M54-M63.

Mosquera, T., Cuéllar, D., Álvarez, M., Angarita, M., Delgado, M., & Juyó, D. (2013). *Genética de la papa frente a la gota.* Universidad Nacional de Colombia, Bogotá.

Nourian, F., Ramaswamy, H. S., & Kushalappa, A. C. (2003). Kinetics of quality change associated with potatoes stored at different temperatures. *LWT-Food Science and Technology*, *36*(1), 49-65.

Ordoñez-Santos, L. E., Aguilar, P. H., Solarte, O. D. R., & Jaramillo, M. E. A. (2014). Concentration of the total carotenoids in the residues of tropical fruits. *Producción+ Limpia*, *9*(1), 91-98.

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 (Montecillo)*, *48*(4), 377-385.

Ordóñez-Santos, L. E., Vázquez-Odériz, M. L., & Romero-Rodríguez, M. (2011). Micronutrient contents in organic and conventional tomatoes (*Solanum lycopersicum* L.). *International Journal of Food Science & Technology*, *46*(8), 1561-1568.

Rodríguez, D. R., & Ramírez, L. N. (2011). The industry of the creole potato in Colombia. Current situation and challenges for its development. *Gestión & Sociedad*, *4*(2), 17-30.

Román, M.O.,Valencia,F.E.,&Rodríguez,M.C.(2013). Kinetic of the color during storage and soft gooseberry candies with added calcium and without sucrose. *Revista Lasallista de Investigación*, *9*(2).

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.

Sánchez-González, L., Cháfer, M., Hernández, M., Chiralt, A., & González-Martínez, C. (2011). Antimicrobial activity of polysaccharide films containing essential oils. *Food Control*, *22*(8), 1302-1310.

Shen, X. L., Wu, J. M., Chen, Y., & Zhao, G. (2010). Antimicrobial and physical properties of sweet potato starch films incorporated with potassium sorbate or chitosan. *Food Hydrocolloids*, *24*(4), 285-290.

Sogvar, O. B., Saba, M. K., & Emamifar, A. (2016). Aloe vera and ascorbic acid coatings maintain postharvest quality and reduce microbial load of strawberry fruit. *Postharvest Biology and Technology*, *114*, 29-35.

Silva, S. S., Popa, E. G., Gomes, M. E., Cerqueira, M., Marques, A. P., Caridade, S. G., & Reis, R. L. (2013). An investigation of the potential application of chitosan/Aloe-based membranes for regenerative medicine. *Acta biomaterialia*, *9*(6), 6790-6797.

Urrutia, O., & Wilmer, J. (2010). Conditioning operations and treatments for the improvement of the quality of the yellow potato (Solanum phureja) minimally processed. *Ciencia Y Tecnologia Alimentaria*, (2), 44–48

Younesa, I.; Hajji, S.; Frachet, V.; Rinaudo, M.; Jellouli, K.; Nasri, M. (2014). Chitin extraction from shrimp shell using enzymatic treatment. Antitumor, antioxidant and antimicrobial activities of chitosan. *International Journal of Biological Macromolecules*, 69, 489–498.