Respuestas, 24 (3), September - December 2019, pp. 81-87, ISSN 0122-820X - E ISSN: 2422-5053

Respuestas
Journal of Engineering Sciences

Original Article https://doi.org/10.22463/0122820X.1840

Evaluation of the conservation of minimally processed "golden-honey" pineapple through the application of edible coatings based on cassava starch and *Aloe vera*

Evaluación de la conservación de la piña "oro miel" mínimamente procesada mediante la aplicación de recubrimientos comestibles a base de almidón de casabe y *Aloe vera*

Saúl David Buelvas-Caro[1], Liliana Polo-Corrales[2], Elvis Judith Hernandez-Ramos[3*]

[1] *Agroindustrial Engineering, saul.buelvas@unisucrevirtual.edu.co, ORCID: 0000-0001-5590-788X, Universidad de Sucre, Sincelejo, Colombia.*
[2] *Ph.D Chemical Engineering, liliana.polo@unisucre.edu.co, ORCID: 0000-0003-3702-3137, Universidad de Sucre, Sincelejo, Colombia.*
[3*] *Ph.D Science and Technology of Food and Chemical Engineering, elvis.hernandez@unisucre.edu.co, ORCID: 0000-0002-8091-1968, Universidad de Sucre, Sincelejo, Colombia.*

How to cite: S. Buelvas-Caro, L. Polo-Corrales and E. Hernandez-Ramos, "Evaluation of the conservation of minimally processed "golden-honey" pineapple through the application of edible coatings based on cassava starch and Aloe vera". *Respuestas,* vol. 24, no. 3, pp. 80-86, 2019.

Received on March 10, 2018 - Approved on July 15, 2018

Keywords:

Ascorbic acid,
Cassava starch,
Aloe vera,
Edible coating.

ABSTRACT

In this research the effect of edible coatings based on aloe vera and cassava starch on the physicochemical properties and the kinetic parameters of degradation of ascorbic acid (AA) in pineapple minimally processed during 16 days of storage at 4° C was evaluated. Five treatments (T1, T2, T3, T4 and T5) were tested, pineapple "honey gold" with coating solutions of different aloe vera / starch concentrations (100/0, 75/25, 50/50, 25/75 and 0/100 respectively), and a control treatment (T6) that corresponds to fruit without coating. The coatings were carried out by immersing the fruit previously processed for 1 minute. The results show that the treatment with the best pH values, titratable acidity (AT) and maturity index (IM) was T3 (pH: 3.61, AT: 0.0480, IM: 2.915), in terms of moisture and soluble solids (SS) the T1 treatment (% Moisture: 81.725) and T4 (SS: 11.19) showed the most optimal values. The model that best described the degradative behavior of AA is zero order, being the T4 treatment the most adequate to preserve vitamin C with a value (k: 0.781), a half-life (t ½: 28 days) and a decimal reduction time (D: 93 days).

Palabras clave:

Ácido ascórbico,
Almidón de yuca,
Aloe vera,
Recubrimiento comestible.

RESUMEN

En esta investigación se evaluó el efecto de los recubrimientos comestibles a base de aloe vera y almidón de mandioca sobre las propiedades físico-químicas y los parámetros cinéticos de degradación del ácido ascórbico (AA) en piña mínimamente procesada durante 16 días de almacenamiento a 4ºC. Se probaron cinco tratamientos (T1, T2, T3, T4 y T5), la "miel de oro" de piña con soluciones de recubrimiento de diferentes concentraciones de aloe vera / almidón (100/0, 75/25, 50/50, 25/75 y 0/100 respectivamente), y un tratamiento de control (T6) que corresponde al fruto sin recubrimiento. Los recubrimientos se realizaron por inmersión de la fruta previamente procesada durante 1 minuto. Los resultados muestran que el tratamiento con los mejores valores de pH, acidez titulable (AT) e índice de madurez (IM) fue T3 (pH: 3.61, AT: 0.0480, IM: 2.915), en términos de humedad y sólidos solubles (SS) el tratamiento T1 (% Moisture: 81.725) y T4 (SS: 11.19) mostró los valores más óptimos. El modelo que mejor describe el comportamiento degradativo del AA es el orden cero, siendo el tratamiento T4 el más adecuado para preservar la vitamina C con un valor (k: 0,781), una vida media (t ½: 28 días) y un tiempo de reducción decimal (D: 93 días).

Introduction

In recent years there has been an increase in the demand for horticultural products with a minimal transformation process. The trend of consumption influenced by lifestyle, has been inclined by fresh products or that have not undergone a significant change during processing, this has generated a greater consumption of IV-range products, especially fruits

*Corresponding author.
E-mail address: elvis.hernandez@unisucre.edu.co (Elvis Judith Hernandez Ramos)

[1]. Among the most consumed fruits is the pineapple (Ananas comosus L), which has a high nutritional value, functional properties and optimal organoleptic characteristics. However, since it is a perishable fruit, it needs a more rigorous postharvest process, which is why it is necessary to apply simple technologies and conservation practices such as edible coatings. These basically are continuous matrices that can be formed by proteins, polysaccharides and lipids, or the combination thereof. [2]. This type of coatings provide the possibility of improving the quality of food by limiting the migration of moisture, fat, oxygen and compounds responsible for flavor, color and aroma [3], helping to extend shelf life [4], [5].

There is a wide variety of materials for the manufacture of edible coatings, being cassava starch one of the most used for this purpose because it does not change the flavor, aroma and transparency of the product [6]. Similarly, Aloe vera gel has the ability to form colloidal solutions allowing the proper development of edible coatings [7]. The latter has been applied in fruits such as: guava, [8] and roma tomato [9]. The objective of this study was to evaluate the effect of edible coatings based on aloe vera and cassava starch on the physicochemical properties and kinetic parameters of degradation of ascorbic acid (AA) in pineapple of IV-range.

Materials and methods

Preparation of raw material

Pineapple variety "honey gold" was used, which was washed, disinfected in chlorinated water (50 ppm) and peeled. Later, with the help of a mold, the pineapple was cut into a rectangular prism measuring 3 * 3 cm. To obtain the gel of aloe vera the leaves were washed, disinfected (sodium hypochlorite at 50 ppm) and they were made a longitudinal cut to separate the shell, once obtained the gel was washed with distilled water in order to eliminate the traces of latex that give it a bitter taste.

Preparation of the solutions and coating of the fruit

The preparation of the edible coatings was carried out according to the formulations established in Table 1. For the elaboration of T1 the methodology carried out by [10] was followed. For the treatments T2, T3 and T4 the starch was subjected to water bath until reaching its point of gelatinization (67 ° C and 1200 rpm), at that time the aloe vera was added for each formulation and it remained in constant agitation for 3 min. at 85 ° C. In the T5 treatment the gelatinization of the starch was carried out at 67 ° C with constant agitation of 670 rpm. The coating of the fruit was carried out by the immersion method for 1 minute, followed by the drying of the samples and the packing (trays of icopor sealed with commercial film of vinyl polychloride). Finally, the samples were stored at a temperature of 4 ° C for a period of 16 days.

Physicochemical Properties

The values of pH, titratable acidity (AT) represented in percentage of citric acid, soluble solids (SS) and index of maturity (IM) were determined according to the Colombian Technical Standards (NTC) 4592, 4623, 4624 and 4103 respectively. Moisture was calculated following the method 925.10 AOAC (2012).

Content and kinetics of degradation of ascorbic acid (AA)

The determination of the concentration of vitamin C in the samples was carried out by the method AOAC 967.21 / 90 titration with 2,6-dichlorophenol-indophenol, the results were expressed in mg of vitamin C per 100 g of sample. For the calculation of the kinetic parameters, the data obtained were subjected to a regression analysis with the kinetic models expressed in equations ¨(1)¨,¨(2)¨,¨(3)¨, ¨(4)¨ and ¨(5)¨ [11], [12].

$$\text{Zero order kinetics: } C=C_0+(-k_0)t \quad (1)$$

$$\text{Kinetics of first order: } C=C_0 \exp(-K_1)t \quad (2)$$

$$\text{Zero order kinetics: } t½=C_0/2K_0 \quad (3)$$

$$\text{Kinetics of first order: } t½=\ln2/K \quad (4)$$

$$\text{Decimal reduction time: } D=Ln(10)/K \quad (5)$$

Where:

C= concentration of AA (mg/100 g) in the time t.
Co= concentration of ascorbic acid in t = 0.
Ko y K1= Rate constants of AA degradation (mg/100 g/days).

t= Storage time (days).
D= decimal reduction time.
t ½= half-life time (días).

Sensory test

A sensory analysis was performed on all the treatments in which color, aroma and flavor were qualified. The analysis was carried out through a satisfaction test with a hedonic scale of 5 points, taking as judges a group of 60 untrained consumers.

Statistic Analysis

A Completely Randomized Design (CRD) was used, with 6 treatments in triplicate, in a factorial arrangement A x B, factor A corresponds to treatments and factor B to time in days. The study of the behavior of the variables was carried out by analysis of variance and Tukey test at a level of significance of 5% using software STATGRAPHICS Centurión XVI.I.

Results and Discussion

pH

Graph 1 shows the behavior of the pH for each of the treatments evaluated during the storage time. A decrease in pH was observed up to day 6 in all treatments, of 9.53% in T1, 6.96% in T2, 13% in T3, 9.58% in T4, 8.30% in T5 and 9.16% in T6. From day 8, fluctuations occurred in all treatments, increasing on day 16 in treatments T2, T3 and T4. The decrease in pH could be explained by the acidification of the cytoplasm, the production and partial dissolution of CO_2 in the water of cellular tissues causes the decrease of the pH of the medium [13]. The increase of this variable is attributed to the stage of senescence of the fruit, because it uses the organic acids present in it for respiration [14]. The oscillatory behavior presented was probably generated by the origin of the sampling areas. [15]. Taking into account the stability of the food, the final pH values analyzed are adequate because they are lower than 4.0 since this value does not provide risks of pathogenic microbiological growth in the pineapple [16], [17]. The results obtained agree with those reported by [10], [18] and the [19].

Tritable Acidity (AT)

Graph 2 shows a slight decrease in acidity in all treatments during the first 6 days of storage with respect to the initial acidity. It is evident that by day 10 the T1, T2, T4 and T5 treatments had an average increase of 22.62%, 29.21%, 45.67% and 39.08% acidity with respect to the T6 control treatment, while T3 showed a decrease of 5.36. %. From the 10th to the 14th there were fluctuations in the treatments T1, T2, T4, and T6, while the T3 treatment followed a growing linear trend, reporting an increase of 82.63% on day 14 and only a decrease of 32.48% for the day 16. Otherwise it was obtained for treatment T5 where there was a decreasing linear trend with a decrease of 31.35% and only an increase of 36.18% for day 16. The preservation of the acidity could be associated to the creation of a modified atmosphere generated by the coatings and the PVC film. The polymer matrix found in the coatings forms molecular networks cohesive by a high interaction between their molecules, these confer good mechanical and gas barrier properties (O_2 and CO_2), slowing respiration and aging of the fruit [20]. Additionally, the metabolic process of the fruit is slowed down and consequently the degradation of organic acids in sugars is delayed during the ripening process[21]. These results are similar to those reported by [8], [22], [23],[24].

Soluble Solids (SS)

Graph 3 shows the behavior of the soluble solids present in IV range pineapple during storage. An increase is observed for all treatments during the 16 days. This could be due to the effect of slowing the respiration of the fruit that is attributed to the coatings, this variable being dependent on the consumption of organic acids or another bioenergetic source that is used as a substrate. In effect, as the available substrate in the fruit is consumed during its metabolic processes, the ° brix increase progressively. These results agree with those reported by [25] who applied an aloe vera coating in combination with ascorbic acid, reporting the stability of SS in strawberry during 15 days of storage. Similarly, [26] ound that SS in cranberries treated with aloe vera and chitosan remain stable during storage with slight variations. Otherwise, it was reported by [27], which found an increase of SS in aubergines when coated with aloe vera (0.1%, 0.5% and 1%) during a storage time of 12 days.

Maturity index (IM)

Regarding the maturity index (graph 4), all treatments showed an increase during the first eight days of storage with a maximum growth for T1. The increase was 93.83% in T1, (81.16%) in T2, (54.54%) in T3, (72.72%) in T4, (86.36%) in T5 and (112.01%) in T6 with respect to day zero. During the last eight days, the useful life index of each of the evaluated treatments represents a decrease in the average of 68.64% with respect to day zero. This result is related to the behavior of the titratable acidity (AT) of the fruit, and for the days indicated (10 and 16), the fruit presents the maximum values of acidity. The lower maturity index, through a lower evolution of the soluble solids and a maintenance of the acidity in general, has been observed in the different results, in the different materials, such as: cellulose, carnauba wax or sucrose ester in mango [28], [29], likewise in avocado fruits coated with beeswax or carnauba wax [30] and chitosan in litchi [31].

Moisture

The coatings used were effective to control the gaseous exchange fruit-environment, as can be seen in graph 5. The results show tolerable variations in humidity for the treatments T1, T2, T3, T4, T5 and for the control T6 not greater than 6%. This can be explained by the effect of the addition of the lipid component to the coating, thus compensating, the deficit that has the polymeric matrix. The lipid used (olive oil) improves the moisture resistance and water barrier properties of the coating [32], [33], [34]. Additionally the packaging material could have prevented the deterioration of the food, decreasing the interaction in the loss or gain of humidity [35].

Table 2 shows the means of physicochemical properties. It is observed that for the pH there are significant differences between the treatments and that the T3 treatment is the best treatment because it has a lower pH value. As for the acidity, there are no significant differences between T3 and T2, showing these the best values. For the soluble solids it could be determined that the T4 treatment has a lower value of SST followed by the T2 treatment. In the evolution of the maturity index, it was found that T3 is the most effective because it presents a lower maturity index (IM) followed by the T2 treatment. Regarding humidity, the T1 treatment showed a lower moisture value followed by the T3 treatment.

Content and kinetics of degradation of ascorbic acid (AA)

Graph 6 shows the behavior of vitamin C (mg / 100gr) in the treatments applied during the 16 days of storage. A decrease is shown for all treatments. During the first 9 days, treatments T1, T2 and T4 obtained lower values than the T6 control treatment, equivalent to 38.68%, 15.89% and 28.02% respectively. Otherwise, it was found for T3 and T5, which showed higher values of 10.42% and 6.96% with respect to T6.

The decrease in vitamin C is a product of the senescence of the fruit caused by the oxidation of L-dehydro ascorbic acid [36]. In addition, factors such as: temperature, storage time, presence of light, enzymes, pressure, oxygen, metal ions, reducing sugars, pH and water content facilitate the degradation of ascorbic acid [37]. On the other hand [38] point out that in the fruits of the IV range, the cutting operation promotes the synthesis of ethylene, accelerating the processes of senescence of the product, being very susceptible to tissue degradation, when exposed to different factors leading to oxidation of bioactive compounds such as AA.

When applying the equations of order zero and first order, it was obtained that the zero order model describes in a more exact way the degradative behavior of the AA, since it presented the lowest values of mean square error (ECM) with average adjustment of 84% (Table 3). This result differs from that reported in investigations carried out by [12] and [39], where they show that the first-order model describes in a more exact way the degradation of ascorbic acid. It was also observed that the lowest values of k are those of T4 (K = 0,781), the rest of the treatments have a higher k value with respect to the control treatment T6 (K = 1,101) indicating that the degradation of AA is faster.

In the same way, parameters such as average life (t ½) and time of decimal reduction (D) were determined, these parameters give us the time necessary for the concentration of a reagent to fall to half its original value and the necessary time to reach 10% of the initial concentration of the compound of interest. Table 4 shows that the T4 treatment would be the most optimal to preserve the AA since it has an approximate time of 28 days to reduce half the initial concentration and 93 days to reach the 90% reduction, followed by the control treatment T6 with a t ½ = 17 days and a D = 56.

Sensory Test

The sensory test (Graph 7) showed that the treatment with greater acceptance in general terms was T4 (25/75 aloe vera / starch). On the other hand, consumers rated less favorably treatments that were in pure state (T1 and T5). In the same way it was evidenced that the treatments that had aloe vera / starch concentrations had a higher acceptance than the T1 and T5 treatments, they were only slightly surpassed by the control (T6) except for T4.

Conclusions

The coatings based on aloe vera / cassava starch as well as being a low cost alternative for the conservation of products of the IV range allow to maintain the physicochemical characteristics of the fruit for long periods. Being, the treatment T3 the one that provides better value of pH, AT and IM (pH: 3.61, AT: 0.0480, IM: 2.915), as far as the humidity and the SS the T1 treatment (% Humidity: 81.725) and T4 (SS: 11.19) showed the most optimal values. The model that best described the degradative behavior of CA is zero order, being the T4 treatment the most adequate to preserve vitamin C with a degradation rate of (k = 0.781), a half-life (t1 / 2 = 28 days) and a decimal reduction time of (D = 93 days).

References

[1] D. Rico, A. Martín, C. Barry, J. Frías and G. Heneha, "Optimization of steamer jet-injection to extend the shelf life of fresh-cut lettuce", *Postharvest biology and technology*, vol. 45, no. 1, pp. 97- 107, 2007.

[2] J. Quintero, V. Falguera and A. Muñoz, "Peliculas y recubrimientos importancia y tendencia recientes en la cadena hortofrutícola", *Tumbaga*, vol. 1, no. 5, pp. 93-118, 2010.

[3] R. Avila and A. López, "Aplicación de sustancias antimicrobianas a películas y recubrimientos comestibles", *Temas selectos de ingeniería*, vol. 2, no. 2, pp. 4-13, 2008.

[4] G. Oms, M. Rojas, L. Alades, et al., "Recent approaches using chemical treatments to preserve quality of fresh-cut fruit", *Postharvest biology and technology*, vol. 57, no. 3, pp. 139-149, 2010.

[5] C. Amarante, N. Banks and S. Ganesh, "Characterising ripening behaviour to fruit internal atmosphere", *Postharvest biology and technology*, vol. 23, no. 1, pp. 51-59, 2001.

[6] M. Chiumarelli and M. hubinger, "Evaluation of edible films and coatings formulated with cassava starch, glicerol, carnauba wax and stearic acid", *Food hydrocolloid*, vol. 38, pp. 20-27, 2014.

[7] M. Pinzón, O. ibargüen and I. Arbelaéz, "Elaboración y caracterización de películas comestibles a base del gel de aloe vera (*Aloe barbadensis* miller l)", *Revista alimentos hoy*, vol. 23, no. 36, pp. 133-149, 2015.

[8] G. García, C. Salas and H. Canales, "Natural edible coating based on *Aloe vera* as a conservation strategy of *Psidium guajava*", *Revista Científica,* vol. 30, no. 3, pp. 224-236, 2017.

[9] I. Molocho and l. Orbegoso, "Evaluación de un recubrimiento a base de sábila (aloe vera) y aceite esencial de canela (cinnamomum verum) en el tiempo de vida útil del tomate (*Lycopersicum esculentum* mill) roma", *Tesis de pregrado, Universidad Señor de Sipán*, Chiclayo, 2016.

[10] E. Buitrago, "Conservación de piña oro miel *(Ananas comosus)* mínimamente procesada: efecto del tipo de corte, tipo de envase y recubrimiento comestible", *Tesis de Maestria, Universidad Nacional de Colombia*, 2017.

[11] F. Lui, Y. Wang, R. Li, X. Bi and X. Liao, "Effects of high hydrostatic pressure and high

temperature short time on antioxidant activity, antioxidant compounds and color of mango nectars", *Innovative Food Science and Emerging Technologies*, vol. 21, pp. 35- 41, 2014.

[12] L. Ordóñez and L. Yoshioka, "Cinética de degradación térmica de vitamina c en pulpa de mango (*Mangifera indica L)", Vitae*, vol. 19, no. 1, pp. 81-83, 2012.

[13] E. Rodríguez, "Uso de agentes antimicrobianos naturales en la conservación de frutas y hortalizas", *Ra Ximhai*, vol. 7, no. 1, pp.153-170, 2011.

[14] R. Ortiz, "Formulación de un recubrimiento comestible antifúngico a base de gelatina, glicerol y natamicina encapsulada en liposomas de fosfatidilcolina para su aplicación en fresa", *Tesis de Pregrado, Escuela Politécnica Internacional, Quito*, 2017.

[15] L. Torri, N. Sinelli and S. Limbo, "Shelf life evaluation of fresh-cut pineapple by using an electronic nose", *Postharvest Biology and Technology*, vol. 56, no. 3, pp. 239-245, 2010.

[16] L. Azeredo, D. Freire, R. Soares, S. Leite and R. Coelho, "Production and partial characterization of thermophilic proteases from Streptomyces sp. isolated from Brazilian cerrado soil", *Enzyme Microbiology Technology*, vol. 34, pp. 354-358, 2004.

[17] A. Ramírez and de D. Pacheco, "Composición química y compuestos bioactivos presentes en pulpas de piña, guayaba y guanábana", *Interciencia*, vol. 36, no. 1, pp. 71-75, 2011.

[18] M. Treviño, S. García, N. Heredia, et al., "Layer-by-layer edible coatings based on mucilages, pullulan and chitosan and its effect on quality and preservation of fresh-cut pineapple *(Ananas comosus)", Postharvest Biology and Technology*, vol. 128, pp. 63-75, 2017.

[19] USDA, "Nutrient database for standard reference", *U. S. Food and Drug Administration*, 2011. [online]. Disponible en: https:// www.ams.usda.gov/

[20] A. Piedrahita and C. Villegas, "Efecto de la aplicación de un recubrimiento comestible en la conservación de las características sensoriales y tiempo de almacenamiento de la mora castilla *(Rubus glaucus Benth.)* sin espinas Poscosecha*", Universidad Tecnológica de Pereira*, 2016.

[21] D. Rangel, B. Espinoza, C. Jorge, et al., "Efecto del 1-metilciclopropeno (1-MCP) y de una película comestible sobre la actividad enzimática y calidad poscosecha del mango "Ataulfo", *Revista Fitotecnia,* vol. 32, no. 1, pp. 53-60, 2009.

[22] A. Pérez, I. Aristizábal and J. Restrepo, "Conservación de mango Tommy Atkins Mínimante procesado mediante la aplicación de un recubrimiento de *Aloe vera (Aloe barbandesis miller)", Vitae*, pp. 65-77, 2016.

[23] S. Dussán, P. Reyes and J. Hleap, "Efecto de un Recubrimiento Comestible y Diferentes Tipos de Empaque en los Atributos Físico-Químicos y Sensoriales de Piña \`Manzana´ Mínimamente Procesada", *Información Tecnológica*, vol. 25, no. 5, pp. 41-46, 2014.

[24] N. Mantilla, M. Castell, C. Gomes and R. Moreira, "Multilayered antimicrobial edible coating and its effect on quality and shelf-life of fresh-cut pineapple *(Ananas comosus)*", *LWT - Food Science and Technology*, vol. 51, pp. 37-43, 2013.

[25] O. Banin, M. Koushesh and A. Emamifar, "Aloe vera and ascorbic acid coatings maintain postharvest quality and reduce microbial load of strawberry fruit", *Postharvest Biology and Technology*, vol. 114, pp. 29-35, 2016.

[26] J. Vieira, M. Flores, D. Jasso de Rodríguez, et al., "Effect of chitosan– Aloe vera coating on postharvest quality of blueberry (*Vaccinium corymbosum*) fruit", *Postharvest Biology and Technology*, vol. 116, pp. 88-97, 2016.

[27] S. Amanullah, M. Muzammil, R. Muhammad, et al., "Aloe vera Coating Efficiency on Shelf Life of Eggplants at Differential

Storage Temperatures”, *Journal of Northeast Agricultural University*, vol. 23, no. 4, pp. 15-25, 2016.

[28] E. Baldwin, J. Burns, W. Kazokas, et al., “Effect of two coatings with different permeability characteristics on mango (*Mangífera índica L.*) ripening during storage”, *Postharvest Biology and Technology*, vol. 17, no. 3, pp. 215-226, 1999.

[29] I. Cáceres, T. Mulkay, J. Rodríguez, et al., “Influencia del encerado y tratamiento térmico en la calidad postcosecha del mango”, *FAO*, 2003.

[30] O. Feygenberg, V. Hershkovitz, R. Ben-arie, et al., “Postharvest use of organic coating for maintaining bio-organic avocado and mango quality”, *Acta Horticulturae*, vol. 682, no. 3, pp. 507-512, 2005.

[31] Y. Jiang, J. Li and W. Jiang, “Effects of chitosan coating on shelf life of cold-stored litchi fruit at ambient temperature”, *LWT - Food Science and Technology*, vol. 38, pp. 757-761, 2005.

[32] D. Parra, C. Tadini, P. Ponce and A. lugao, “Mechanical properties and water vapor transmission in some blends of cassava starch edible films”, *Carbohydrate*, vol. 58, pp. 475-481, 2004.

[33] J. Han, G. Seo, I. Park, G. Kim and D. Lee, “Physical and mechanical properties of pea starch edible films containing beewax emulsion”, *Journal Food Sciencie*, vol. 71, no. 6, pp. E290-E296. 2006.

[34] R. Dahall, “Advances in edible coatings for fresh fruits and vegetables: a review”, *Critical Review in Food Science and Nutrition*, vol. 53, pp. 435-450, 2013.

[35] M. Aguilar, ”Propiedades Fìsicas y mecànicas de Peliculas Biodegradables y su empleo en el recubrimiento de fruto de aguacate”, *Tesis de Maestria, Instituto Politècnico Internacional, Mexico D.F.*, 2005.

[36] O. Fenema, “Química de los alimentos”, *España: Zaragoza*, 2010.

[37] F. Saci and I. hayette, ¨Effect of storage on the nutritional quality,carotenoid and ascorbic acid contents of two commercial beverages”, *International journal of chemical and biomolecular science*, vol. 1, no. 2, pp. 49-53, 2015.

[38] M. Robles, S. Gorinstein, O. Martín, et al., “Frutos tropicales mínimamente procesados: potencial antioxidante y su impacto”, *Revista interciencia*, vol. 32, no. 4, pp. 227-232, 2007.

[39] F. Mendoza, M. Arteaga and O. Pérez, “Degradación de la vitamina C en un producto de mango (Mangifera indica L.) y lactosuero”, *Ciencia y Tecnologia Agropecuria*, vol. 18, no. 1, pp. 125-137. 2017.