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Research

Analyzing the Texture Profiles and Colorimetric and Microbiological Parameters in Minimally Processed Pineapple Using Edible Coatings

Análisis de perfil de textura, parámetros colorimétricos y microbiológicos en piña mínimamente procesada con recubrimientos comestibles

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Abstract

Context: The conservation of minimally processed fruits is a very important topic in the food industry due to the increased consumption of this type of food. This work studies the effects caused by edible coatings based on aloe vera and cassava starch on minimally processed pineapple.
Method: Properties such as texture and color were evaluated, and microbial analysis was conducted after 12 days of storage at 4 °C. Four treatments (T1, T2, T3, and T4) were tested: Honey Gold pineapple with coating solutions of different aloe vera/starch concentrations (T1:75/25, T2:50/50, T3:25/75), and a control treatment (T4) consisting of the fruit without coating. Coating was carried out by immersing the fruit for 1 min.
Results: The results indicated that the T2 treatment achieved the best texture, and that T4 showed a higher luminosity. The microbiological parameters remained within those established by the Colombian Technical Standard (NTC 4519) for minimally processed fruit during the 12 days of conservation.
Conclusions: Edible coatings can maintain the texture and inhibit the growth of microorganisms in Honey Gold pineapple. However, fruit luminosity may be affected by the use of these edible coatings.

Keywords: color, edible coatings, fresh-cut pineapple, texture, luminosity, antimicrobial activity

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Resumen

Contexto: La conservación de frutas mínimamente procesadas es un tema muy importante en la industria alimentaria debido al incremento en el consumo de este tipo de alimentos. Esta investigación estudia los efectos que provocan los recubrimientos comestibles a base de aloe vera y almidón de yuca en piña mínimamente procesada.
Método: Se evaluaron propiedades como textura y color, y se realizó análisis microbiano después de 12 días de almacenamiento a 4 °C. Se probaron cuatro tratamientos (T1, T2, T3 y T4): piña Oro Miel con soluciones de recubrimiento con diferentes concentraciones de aloe vera/almidón (T1:75/25, T2:50/50, T3:25/75) y un tratamiento control (T4) que consistió en la fruta sin recubrimiento. Los recubrimientos se realizaron sumergiendo la fruta previamente procesada durante 1 min.
Resultados: Los resultados indicaron que el tratamiento T2 obtuvo la mejor textura y T4 mostró una mayor luminosidad. Los parámetros microbiológicos se mantuvieron dentro de los establecidos por la Norma Técnica Colombiana (NTC 4519) para fruta mínimamente procesada durante los 12 días de conservación.
Conclusiones: El recubrimiento comestible puede mantener la textura e inhibir el crecimiento de microorganismos en la piña Oro Miel. Sin embargo, la luminosidad de la fruta puede verse afectada por el uso de estos recubrimientos comestibles.

Palabras clave: color, recubrimientos comestibles, piña recién cortada, textura, luminosidad, actividad antimicrobiana

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1. Introduction

Pineapple is one of the most attractive agricultural products due to its nutritional and sensorial characteristics, which have positioned it as one of the most consumed fruits around the world (1,2). Among the many presentations available, minimally processed pineapple is one of the most popular in many supermarkets and food service chains (3,4). According to (5), the texture, color, and aroma of pineapple are the main criteria for determining its quality. In fact, perception and all these properties are crucial in food process engineering (6,7).

Minimal processing of fruits and vegetables can trigger chemical reactions that affect their acceptability (8). Indeed, an increase in metabolic processes can cause significant changes in the physicochemical properties of texture and color and the microbiological load, thus limiting the shelf life of the food (3, 9). Therefore, sustainable forms of conservation have been developed to extend the shelf life of these products. An example of these methods is edible coating, which is defined as a thin layer of material deposited on food as a cover (10, 11). Edible coatings not only act as packaging systems during storage, but they also delay deterioration, enhance quality attributes, and can act against microorganisms (12, 13).

Aloe vera gel is used to produce edible coatings due to its ability to form colloidal solutions and its antimicrobial properties (14, 15). In addition, this material has been demonstrated to be adequate for preserving the physicochemical properties of texture, the microbiological load, and colorimetric parameters of pineapple (16). For instance, a previous study reported the effectiveness of aloe vera combined with cassava starch to preserve the physicochemical properties and concentration of vitamin C in IV-range pineapple (17).

The main objective of this research is to evaluate the effect of the edible coatings based on aloe vera and cassava starch for preserving texture, color, and microbiological parameters in minimally processed pineapple.

2. Materials and methods

2.1. Raw material preparation

Pineapples of the Honey Gold variety were selected, washed, and disinfected in 50 ppm of chlorinated water. Afterwards, they were peeled and cut into 3 cm^2 x 3 cm rectangular prisms. Aloe vera leaves were washed, disinfected with sodium hypochlorite at 50 ppm, and peeled to obtain the gel. The gel was washed with distilled water, triturated, and homogenized.

2.2. Preparation of the solutions and coating of the fruit

The edible coatings for three treatments (T1, T2, and T3) were prepared following the formulations in Table I. The starch was heated and agitated in a water bath until it gelatinized at a temperature of 67 °C at 1.200 rpm. After that, aloe vera was added to the starch under agitation at 85 °C until a homogenized solution was obtained. The samples were covered by immersion for 1 min in the prepared solutions. The coated samples were air-dried at room temperature and packed in polystyrene trays. Finally, the samples were sealed with a commercial film (polyvinyl chloride) and stored at 4 °C for 16 days.

2.3. Texture profile

A texture analyzer (TA-XT model plus, Stable MicroSystems, Vienna Court, England) with a uniaxial compression strength of 75 % and a speed of 1 mm/s was used for the measurements. The Texture Expert

Table I. Formulation of the evaluated treatments' solutions

Treatments	Aloe vera	Starch	Glycerol (%w/w)	Tween 80 (%w/w)	Olive oil (%w/w)
T1	75	25	1 %	0,05 %	0,7 %
T2	50	50	1 %	0,05 %	0,7 %
T3	25	75	1 %	0,05 %	0,7 %
T4	0	0	0	0	0

Software analyzed the data for hardness, cohesiveness, springiness, adhesiveness, and chewiness. The samples were analyzed on the 16th day of storage and performed in triplicate.

2.4. Colorimetric parameters

The color was measured directly with a Minolta CR-400 chroma meter (Konica Minolta Sensing, INC., Osaka, Japan), using the CIE color space L*, a*, and b*. The equipment was set up for illuminant D65 at a 2° observer angle and calibrated using a standard white reflector plate (18).

2.5. Microbiological test

Microbiological parameters were analyzed by counting according to the corresponding Colombian Technical Standards (NTC): aerobic mesophilic bacteria (NTC 4519) (19), total coliforms and fecal coliforms (NTC 4516) (20), and yeasts (NTC 4132) (21).

2.6. Statistical analysis

In order to process the analysis results, a Completely Random Design (CRD) with three treatments and a control sample was used. All analyses were carried out in triplicate. The behavior of each variable was measured via an analysis of variance (ANOVA) and a Tukey test at a significance level of 5 %. The STAT_GRAPHICS Centurion XVI.I statistical software was used.

3. Results and discussion

3.1. Texture profile analysis

The texture profile analysis is depicted in Table II. The T2 treatment obtained values close to the control (T4). Likewise, the statistical analysis of this treatment (T2) showed no significant differences in parameters such as adhesion and elasticity when compared to the control. T2 reported a higher hardness (103,35 N) during the storage time, which indicates that a greater force is required to compress it. This value is closely related to cohesiveness, as the particles in the food require greater force to be compressed (*i.e.*, the cohesion showed a behavior that is proportional to hardness).

Table II. Minimally processed pineapple texture profile coated with aloe vera/starch

Treat-ments	Hardness (N)	Cohesiveness	Springiness	Adhesiveness (N)	Chewiness (N)
T1	83,89±0,9^{a}	0,10±0,01^{a}	0,51±1,05^{a}	-0.60±0,02^{a}	4,28±1,32^{a}
T2	103,34±0,8^{b}	0,18±0,05c	0,43±0,58^{a}	-1,30±0,12^{b}	8,00±1,05^{c}
T3	84,75±1,1^{a}	0,11±0,80^{a}	0,47±0,79^{a}	-0,66±0,34^{a}	4,38±0,02^{a}
T4	102,9±0,4^{a}	0,15±0,12^{a}	0,44±0,31^{a}	-1,22±0,08^{b}	6,81±0,16^{b}

Note: Lowercase letters correspond to the Tukey test, and values that share an equal letter indicate that there is no statistically significant difference.

Similarly, T1 and T3 were found to have the highest elasticity values. Regarding the adhesion values, a negative force was observed, which demonstrates the sticky behavior of the sample on the palate. It was also found that T2 and T4 were the least adhesive, which means that a lower force is required to remove the food from the palate. Finally, the chewiness values were higher in T2 (8,0N) and T4 (6,81N). The texture profile analysis showed that the 50/50 ratio was the most efficient in comparison with the control.

The studies reported by (22) established that the changes in the hardness of pineapple are due to the increase of polygalacturonase and the activity of β-galactosidase and pectin methylesterase. Similarly, factors such as the loss of pressure from the cellular turgor, the loss of extracellular air, and the denaturation or degradation of the cell wall constituents cause the fruit to soften (23). Likewise, the type of packaging used in fourth range products can contribute to the loss of texture (22), and the loss of water during storage leads to further deterioration (16).

However, it has been demonstrated that the use of edible coatings such as those applied by (16) and (24) can maintain the texture of fruits for a longer storage time in comparison with non-coated ones. In previous studies, we demonstrated the effects of edible coatings on water loss control while maintaining the texture of minimally processed pineapple (17).

3.2. Colorimetric parameters

Table **III** shows the results obtained for the coordinates L*, a*, and b*, where significant differences in T2 regarding L* are evidenced with respect to the other treatments. For the a* coordinate, significant differences between the different treatments can be observed in comparison with the control (T4). All the treatments except the control sample had negative values, indicating a light green coloration. The b* coordinate showed no significant differences between treatments. The T4 treatment showed the best luminosity (L*) value, with an average value of 64,65. Similar results were reported in (16). This study found that edible-coated samples had lower L* values, attributing this effect to the opacity of the pineapple's surface, which depends on the concentration of aloe vera gel in the coating. The chromatic coordinates a* and b* for the treatments T3 and T1 showed optimal mean values (a*=-0,898 for T3 and b*=-37,58 for T1). It has been demonstrated that luminosity is associated with the action of the enzyme polyphenol oxidase, the gradual loss of water, or the surface dehydration of the fruit (25). Similarly, the changes in coordinates a* and b* are likely related to the acceleration of metabolic processes in the fruit, causing undesirable reactions such as enzymatic browning (26, 27). Finally, according to the results shown in Table III, the colorimetric parameters of the samples are not significantly affected by the concentration of cassava starch.

Table III. Colorimetric analysis of IV-range pineapple coated with the different treatments

Treatments	L*	a*	b*
T1	60,61±0,21 a	-0,283±0,03 a	37,58±0,58 a
T2	62,74±0,13 b	-0,724±0,12 a	35,93±0,76 a
T3	62,58±0,08 a	-0,898±0,17 a	33,41±0,45 a
T4	64,65±0,15 a	0,048±0,12 b	37,48±1,02 a

Note: Lowercase letters correspond to the Tukey test, and values that share an equal letter indicate that there is no statistically significant difference.

3.3. Microbiological test

The microbiological results regarding aerobic mesophilic bacteria and coliforms were within those established by the Colombian Technical Standard (NTC 6005) for minimally processed fruit (29). For coliforms, the values obtained for all the samples during the experiment were at a good quality level (<10) (according to the NTC, the values for m and M are 10^1 to 10^2, respectively). Similarly, no significant growth of aerobic mesophilic bacteria was evidenced in the samples, since, in this study, the maximum value obtained was $4{,}7\text{x}10^5$ (according to the NTC, the values for m and M are 10^5 to 10^6, respectively). However, in treatments with a higher concentration of aloe vera (T1 and T2), the presence of microorganisms was lower in comparison with T3, which had a higher amount of starch. This behavior is most likely due to the polymer matrix, which increases the bioavailability of the substrate while also stimulating the growth of microorganisms (27). In addition, it has been reported that acemannan is the main active compound with antimicrobial activity present in aloe vera (30). Therefore, the lower growth of aerobic mesophilic bacteria and coliforms can be attributed to the active components of aloe vera gel (31). These findings are consistent with previous studies (16, 32, 33).

The values obtained for yeast were above those established in Colombian regulations (34). In particular, for the fruit pulp category, the maximum value at an acceptable level is 3.000. In this study, the results showed higher values in all the treatments. However, while comparing T1 to T2 and T3 on day 6, the results showed that a higher concentration of aloe vera inhibited the growth of this type of microorganism. Likewise, it has been demonstrated that the presence of yeasts in minimally processed pineapple is not only the result of microbiological contamination during processing, but that these microorganisms are also part of the endophytic microbiota of pineapple (28). Moreover, despite being washed with a chlorinated solution, certain microorganisms can survive within cells or in areas where the solution cannot penetrate (35, 36).

Table IV. Microbiological analysis of IV-range pineapple coated with the different treatments

Day 0				
Analysis/Treatments	**T1**	**T2**	**T3**	**T4**
Aerobic mesophilic bacteria CFU/g	<10	<10	<10	<10
Yeasts CFU/g	<10	<10	<10	<10
MNP Fecal coliforms CFU/g	<3	<3	<3	<3
MNP Total coliforms CFU/g	<3	<3	<3	<3
Day 6				
Analysis/Treatments	**T1**	**T2**	**T3**	**T4**
Aerobic mesophilic bacteria CFU/g	12.600	19.000	29.700	35.000
Yeasts CFU/g	5.000	9.300	11.000	10.000
MNP Fecal coliforms CFU/g	<3	<3	<3	<3
MNP Total coliforms CFU/g	<3	<3	<3	<3
Day 12				
Analysis/Treatments	**T1**	**T2**	**T3**	**T4**
Aerobic mesophilic bacteria CFU/g	14.000	15.000	18.000	47.000
yeasts CFU/g	8.600	10.000	12.400	25.000
MNP Fecal coliforms CFU/g	<3	<3	<3	<3
MNP Total coliforms CFU/g	<3	<3	<3	<3

4. Conclusions

Edible coatings are an option for preserving minimally processed pineapple. This type of packaging allows maintaining certain properties of the fruit for long periods of time. In this study, it was demonstrated that a coating with 50 % starch and 50 % aloe vera can ensure a good texture profile in Honey Gold pineapple for 12 days, achieving a firmer product with higher values of hardness and cohesion when compared to uncoated pineapple. However, the coatings can decrease the luminosity of samples, as seen in comparison with the control. In addition, good activity against microorganisms such as mesophiles and fecal and total coliforms was evidenced, but the activity against yeast was weak.

5. Author contributions

All authors contributed equally to the research.

References

[1] C. Leneveu-Jenvrin, B. Quentin, S. Assemat, M. Hoarau, J.-C. Meile, and F. Remize, "Changes of quality of minimally-processed pineapple (*Ananas comosus*, var. 'Queen Victoria') during cold

storage: Fungi in the leading role," Microorg., vol. 8, no. 2, 2020. https://doi.org/10.3390/microorganisms8020185 ↑2

[2] P. C. Carvalho Lima, B. Sarzi de Souza, and S. Fyfe, "Influence of storage temperature and different packaging on the physicochemical quality of fresh-cut 'Perola' pineapple," *Idesia*, vol. 37, no. 2, pp. 13-19, 2019. http://dx.doi.org/10.4067/S0718-34292019000200013 ↑2

[3] S. Dussán-Sarria, M. C. Rivera, and C. A. García-Mogollón, "Almacenamiento refrigerado de piña mínimamente procesada. Cambios en atributos físico-químicos y sensoriales," *Inf. Tecnol.*, vol. 31, no. 2, pp. 11-18, 2020. http://dx.doi.org/10.4067/S0718-07642020000200011 ↑2, 3

[4] C. Leneveu-jenvrin *et al.*, "Changes of quality of minimally-processed pineapple (Ananas comosus, var. 'queen victoria') during cold storage: Fungi in the leading role", *Microorg.*, vol. 8, no. 2, p. 185, 2020. https://doi.org/10.3390/microorganisms8020185 ↑2

[5] D. S. George, Z. Razali, and C. Somasundrum, "Physical and physiochemical changes that occurs during growth and development of the Sarawak pineapple (Ananas comosus L. Merr. Cv Sarawak)," *J. Agri. Sci. Techn.*, vol 18, pp. 491-503, 2016. https://www.re-searchgate.net/publication/287207753_Physical_and_physiochemical_changes_that_occurs_during_growth_and_develop-ment_of_the_Sarawak_pineapple_Ananas_comosus_L_Merr_Cv_Sarawak ↑2

[6] C. L. Vargas-Serna, V. González, C. Ochoa-Martínez, and C. Vélez-Pasos, "Conservación de piña mínimamente procesada: evaluación de parámetros fisicoquímicos," *Ingeniería*, vol. 27, no. 1, 2021, art. 17862. https://doi.org/10.14483/23448393.17564 ↑2

[7] T. J. Gutiérrez, *Polymers for Food Aplications*, 1st edición, Cham, Germany: Springer, 2018. https://link.springer.com/book/10.1007%2F978-3-319-94625-2 ↑2

[8] G. Olivas and Barbosa-Cánovas, Gustavo, "Edible films and coatings for fruits and vegetables," in *Edible Films and Coatings for Food Applications*, M. E. Embuscado and K. C. Huber, eds., New York, NY, USA: Springer Science+Business Media, 2009, pp. 211-244. ↑3

[9] M. del Nobile, A. Conte, C. Scrocco, and I. Brescia, "New strategies for minimally processed cactus pear packaging," *Innov. Food Sci. Emerg. Techn.*, vol. 10, no. 3, pp. 356-362, 2009. https://doi.org/10.1016/j.ifset.2008.12.006 ↑3

[10] A. Prakash, R. Baskaran, and V. Vadivel, "Citral nanoemulsion incorporated edible coating to extend the shelf life of fresh cut pineapples," *LWT*, vol. 118, art. 108851, 2020. https://doi.org/10.1016/j.lwt.2019.108851 ↑3

[11] S. Pizato, R. C. Chevalier, M. F. dos Santos, T. S. da Costa, R. Arévalo-Pinedo, and W. R. Cortez-Vega, "Evaluation of the shelf-life extension of fresh-cut pineapple (Smooth cayenne) by application of different edible coatings," *Br. Food J.*, vol. 121, no. 7, pp. 1592-1604, 2019. https://doi.org/10.1108/BFJ-11-2018-0780 ↑3

[12] A. López-Córdoba and A. Aldana-Usme, "Edible coatings based on sodium alginate and ascorbic acid for application on fresh-cut pineapple (*Ananas comosus* (L.) Merr)," *Agron. Colomb.*, vol. 37, no. 3, pp. 233-238, 2019. https://doi.org/10.15446/agron.colomb.v37n3.76173 ↑3

[13] S. Paidari *et al.*, " Edible coating and films as promising packaging: a mini review," *J. Food Meas. Char.*, vol. 15, pp. 4205-4214, 2021. https://doi.org/10.1007/s11694-021-00979-7 ↑3

[14] M. U. Hasan et al., "Potential of aloe vera gel coating for storage life extension and quality conservation of fruits and vegetables: An overview", *J. Food Biochem.*, vol. 45, no. 4, e-13640, 2021. https://doi.org/10.1111/jfbc.13640 ↑3

[15] R. Passafiume, R. Gaglio, G. Sortino, and V. Farina "Effect of three different aloe vera gel-based edible coatings on the quality of fresh-cut 'hayward' kiwifruits," *Foods*, vol. 9, no. 7, pp. 2-17, 2020. https://doi.org/10.3390/foods9070939 ↑3

[16] E.M. Buitrago-Dueñas. "Conservación de piña oro miel (Ananas comosus) mínimamente procesada: efecto del tipo de corte, tipo de envase y recubrimiento comestible." Master's thesis, Agroind. Eng. A., Dept. Eng. Adm., Universidad Nacional de 6olombia, Palmira, Colombia, 2017. ↑3, 5, 6

[17] S. D. Buelvas-Caro, L. Polo Corrales, and E. J. Hernández-Ramos, "Evaluation of the conservation of pineapple 'honey gold' minimally processed through the application of edible coatings based on aloe vera-cassava starch", *Respuestas*, vol. 24, no. 3, pp. 84-91, 2019. https://doi.org/10.22463/0122820X.1840 ↑3, 5

[18] M. Montero-Calderón, M.A Rojas-Graü, I. Aguiló-Aguayo, R. Soliva-Fortuny, and O. Martín-Belloso, "Influence of modified at- mosphere packaging on volatile compounds and physicochemical and antioxidant attributes of fresh -cut pineapple," *J. Agric. Food Chem.*, vol. 58, no. 8, pp. 5042-5049, 2010. https://doi.org/10.1021/jf904585h ↑4

[19] Icontec, *NTC-4519, microbiología de los alimentos para consumo humano y animal. Método horizontal para el recuento de microorganismos. Técnica de recuento de colonias a 30 °C,*" vol. 4519, Bogotá, Colombia: Instituto Colombiano de Normas Técnicas, 2009. ↑4

[20] Icontec, *NTC-4516, microbiología de alimentos y productos de alimentación animal. Método horizontal para la detección y enumeración de coliformes. Técnica del número más probable*, Bogotá, Colombia: Instituto Colombiano de Normas Técnicas, 2009. ↑4

[21] Icontec, *NTC-4132, microbiología: Guía general para el recuento de Mohos y Levaduras. Técnica de recuento de colonias a 25 °C*, vol. 4132, Bogotá, Colombia: Instituto Colombiano de Normas Técnicas, 1997. ↑4

[22] S. Remón, M. E. Venturini, P. Lopez-Buesa, and R. Oria, "Burlat cherry quality after long range transport, optimization of packaging conditions," *Inno. Food Sci. Emerg. Tech.*, vol. 4, no. 4, pp. 425-434, 2003. https://doi.org/10.1016/j.ifset.2003.07.002 ↑5

[23] S. Benítez, M. Chiumenti, F. Sepulcre, I. Achaerandio, and M. Pujolá, "Modeling the effect of storage temperature on the respiration rate and texture of fresh cut pineapple," *J. Food Eng.*, vol 113, no. 4, pp. 527-533, 2012. https://doi.org/10.1016/j.jfoodeng.2012.07.022 ↑5

[24] J. Zambrano, A. Varela, M. Maffei, W. Materano, I. Quintero, and K. Graterol, "Efecto de un recubrimiento comestible formulado con mucilago del cactus (*Opuntia elatior* Mill) sobre la calidad de los frutos de piña mínimamente procesados," *Bioagro.*, vol. 29, no. 3, pp. 129-136, 2017. https://www.researchgate.net/publication/317571591_EFECTO_DE_UN_RECUBRIMIENTO_COMESTIBLE_FORMU-LADO_CON_MUCILAGO_DEL_CACTUS_Opuntia_elatior_Mill_SOBRE_LA_CALIDAD_DE_FRUTOS_DE_PINA_MINIMAMENTE_PROCESADOS ↑5

[25] M. Montero-Calderón, M.A Rojas-Grau, and O. Martín-Belloso, "Effect of packaging conditions on quality and shelf-life of fresh-cut pineapple (*Ananas comosus*)," *Postharv. Biol. Tech.*, vol. 50, no. 2-3, pp. 182-189, 2008. https://doi.org/10.1016/j.postharvbio.2008.03.014 ↑6

[26] M. Chiumarelli, L. Pereira, C. Ferrari, C. Sarantópoulos, and M. Hubinger, "Cassava starch coating and citric acid to preserve quality parameters of fresh-cut 'Tommy Atkins' mango,"*J. Food Sci.*, vol. 75, no. 5, pp. 297-304, 2010. https://doi.org/10.1111/j.1750-3841.2010.01636.x ↑6

[27] P. J. Chien, F. Sheu, and F.H. Yang, "Effects of edible chitosan coating on quality and shelf life of sliced mango fruit," *J. Food Eng.*, vol. 78, no. 1, pp. 225-229, 2007. https://doi.org/10.1080/15538362.2021.1906825 ↑6

[28] L. Antoniolli, B. Benedetti, B, M. Souza, and M. Borges, "Evaluation of vanillin as an antimicrobial agent on fresh-cut 'Pérola' pineapple," *Ciênc. Tecnol. Aliment.*, vol. 24, no. 3, pp. 473-477, 2004. https://doi.org/10.1590/S0101-20612004000300029 ↑6

[29] Icontec, *NTC-6005, Alimentos mínimamente procesados*, Bogotá, Colombia: Instituto Colombiano de Normas Técnicas, 2013. ↑6

[30] A. M. Villar del Fresno and B. de las Heras, "Aloe vera," *Farm. Prof.*, vol. 20, no. 8, pp. 64-67, 2006. https://www.elsevier.es/es-revista-farmacia-profesional-3-articulo-aloe-vera-13092627 ↑6

[31] A. A. Maan et al., "The therapeutic properties and applications of aloe vera: A review," *J. Herb. Med.*, vol. 12, pp. 1-10, 2018. https://doi.org/10.1016/j.hermed.2018.01.002 ↑6

[32] N. Mantilla, M. E. Castell-Pérez, C. Gomes, and R. G. Moreira. "Multilayered antimicrobial edible coating and its effect on quality and shelf-life of fresh-cut pineapple (*Ananas comosus*)," *LWT Food. Sci. Tech.*, vol. 51, no. 1, pp. 37-43, 2013. https://doi.org/10.1016/j.lwt.2012.10.010 ↑6

[33] V. Bierhals, M. Chimurelli, and M. Hubinger, "Effect of cassava starch coating on quality and shelf life of fresh-cut pineapple (Ananas comosus L. Merril cv 'Pérola')," *Journal of Food Science*, vol. 76, no. 1, pp. 62-72, 2011. https://doi.org/10.1111/j.1750-3841.2010.01951.x ↑6

[34] Resolución 3929 del Ministerio de Salud y Protección Social, de 2 de Octubre de 2013 ↑6

[35] A. E. Watada and L. Qi. "Quality control of minimally-processed vegetables", *Acta Hortic.*, vol. 483, no. 23, pp. 209-220, 1999. https://doi.org/10.17660/ActaHortic.1999.483.23 ↑6

[36] J. F. Cuevas-Mena, "Influencia del tipo de empaque y aplicación de ácidos orgánicos sobre la estabilidad de un genotipo comercial de zapallo (*Cucurbita moschata* Duch. ex Poir.) mínimamente procesado", Master's thesis, Agroind. Eng. A., Dept. Eng. Adm., Universidad Nacional de Colombia, Palmira, Colombia, 2020 ↑6

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