

Influence of glucomannan edible coating in guava quality during storage
Influência da cobertura comestível de glucomanano na qualidade da goiaba durante o armazenamento

Influencia de la cubierta comestible de glucomanano en la calidad de la guayaba durante el almacenamiento

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Abstract

Guava (*Psidium guajava*) is a highly perishable fruit and is considered as climacteric. Therefore, some alternatives are studied to prolong post-harvest conservation, one of them being the application of edible coatings, which are based on polysaccharides. The objective of this study was to evaluate the post-harvest conservation of uncoated (control – T0) guavas and with edible coating containing 0.5% (T0.5) and 1.0% (T1.0) of konjac glucomannan. The fruits were immersed in the solutions and stored under refrigeration at 4 ° C for analysis at 7 and 15 days of storage. The main parameters evaluated in relation to fruit quality during storage were firmness and color, and with the coating application it was possible to observe a

maintenance of these parameters when compared to the control ($p < 0.05$). Besides that, the fruits with coating presented a lower loss of mass. The other parameters evaluated were not influenced by coating addition ($p > 0.05$), such as pH, acidity, soluble solids, ascorbic acid, luminosity and redness of the peel and color of the pulp. Therefore, coatings made with glucomannan from Konjac may be an alternative to guarantee the quality of fruits during its commercialization, increasing its shelf life.

Keywords: *Amorphophallus konjac*; Conservation; Post-harvest; Color; Texture.

Resumo

A goiaba (*Psidium guajava*) é uma fruta altamente perecível e considerada climatérica. Portanto, algumas alternativas são estudadas para prolongar a conservação pós-colheita, sendo uma delas a aplicação de coberturas comestíveis, à base de polissacarídeos. O objetivo deste trabalho foi avaliar a conservação pós-colheita de goiabas não revestidas (controle - T0) e com cobertura comestível contendo 0,5% (T0,5) e 1,0% (T1,0) de glucomanano do konjac. Os frutos foram imersos nas soluções e armazenados sob refrigeração a 4 ° C para análise aos 7 e 15 dias de armazenamento. Os principais parâmetros avaliados em relação à qualidade dos frutos durante o armazenamento foram firmeza e cor, sendo que com a aplicação da cobertura foi possível observar uma manutenção desses parâmetros quando comparados ao controle ($p < 0,05$). Além disso, os frutos com cobertura apresentaram menor perda de massa. Os demais parâmetros avaliados não foram influenciados pela adição da cobertura ($p > 0,05$), como pH, acidez, sólidos solúveis, ácido ascórbico, luminosidade e vermelhidão da casca e cor da polpa. Portanto, os revestimentos à base de glucomanano de konjac podem ser uma alternativa para garantir a qualidade dos frutos durante sua comercialização, aumentando sua vida útil.

Palavras-chave: *Amorphophallus konjac*; Conservação; Pós-colheita; Cor; Textura.

Resumen

La guayaba (*Psidium guajava*) es una fruta muy perecedera y se considera climatérica. Por ello, se estudian algunas alternativas para prolongar la conservación postcosecha, una de las cuales es la aplicación de recubrimientos comestibles, a base de polisacáridos. El objetivo de este trabajo fue evaluar la conservación postcosecha de guayabas sin recubrir (testigo - T0) y con cobertura comestible que contienen 0.5% (T0.5) y 1.0% (T1.0) de glucomanano de konjac. Los frutos se sumergieron en las soluciones y se almacenaron en refrigeración a 4 ° C para su análisis a los 7 y 15 días de almacenamiento. Los principales parámetros evaluados en relación a la calidad de los frutos durante el almacenamiento fueron firmeza y color, y con la

aplicación de la cobertura se pudo observar un mantenimiento de estos parámetros al compararlo con el testigo ($p < 0.05$). Además, los frutos recubiertos mostraron menor pérdida de masa. Los demás parámetros evaluados no fueron influenciados por la adición de cobertura ($p > 0.05$), como pH, acidez, sólidos solubles, ácido ascórbico, luminosidad y enrojecimiento de la piel y color de la pulpa. Por tanto, los recubrimientos de glucomanano de konjac pueden ser una alternativa para garantizar la calidad de los frutos durante su comercialización, aumentando su vida útil.

Palabras clave: *Amorphophallus konjac*; Conservación; Postcosecha; Color; Textura.

1. Introduction

Guava (*Psidium guajava*) belongs to the Myrtaceae family and is cultivated in many tropical and subtropical regions (Singh, Prasad, & Singh, 2017). Commercially it is a very important fruit in several countries due to availability throughout the year, nutritional value and affordable price (Forato, Britto, Rizzo, Gastaldi, & Assis, 2015). Guava is considered as a climacteric fruit (Nair, Saxena, & Kaur, 2018; Vishwasrao & Ananthanarayan, 2016) and very perishable (Hong, Xie, Zhang, Sun, & Gong, 2012), with a short shelf life due to its rapid maturation, which consists in a series of physical and biochemical processes that result in the synthesis and degradation of pigments, conversion of starch to sugar, reduction of firmness and production of volatile compounds (Nazaré Silva Botelho, Alvarenga Rocha, Aparecida Braga, Silva, & Abreu, 2016). The control of maturation is indispensable to increase the shelf life after harvest, reach distant markets and improve the commercialization process. Therefore, it is necessary to find new alternatives for post-harvest conservation (Mitra, Devi, Chakraborty, Pathak, 2012).

A viable alternative to increase the shelf life of fruits and vegetables that is being increasingly disseminated is the application of edible coatings, which aim to contribute to the preservation of texture and nutritional value, reduce gas exchange and loss or gain of water together with conventional packaging and the use of cold (Assis & Britto, 2014). The coatings can be made using polysaccharides: starch, starch derivatives, cellulose, pectin, alginate, proteins: gelatin, casein, wheat gluten, zein, soy protein and lipids: beeswax, acetylated monoglucons, among others (Andrade, Skurtys, & Osorio, 2012; Galus & Kadzińska, 2015). The studies carried out with the application of edible coatings on fruits shows that this is a technique capable of preserving them for longer periods (Luvielmo & Lamas, 2012) and guava is a fruit in which the application of edible coatings can be studied (Santos et al., 2018).

Studies with chitosan; (Almeoni et al., 2011), milk protein (Cerqueira, Jacomino, Sasaki, & Alleoni, 2011), starch and alginate (Fonseca, Soares, Barboza, Carvalho, & Neves Júnior, 2016), manioc starch and pectin (Quirino, Costa, Neto, Costa, & Sánchez-Sáenz, 2018), gum arabic and sodium caseinate (Murmu & Mishra, 2017) were performed to analyze the influence in the conservation of guavas, however, new alternatives must be studied to meet the demand for products with an extended shelf life.

The konjac glucomannan (KGM) is a polysaccharide extracted from tubers of the *Amorphophallus konjac* plant (Yang et al., 2017; Yildiz, 2010; Yuan et al., 2017), has linear structure, high molecular weight and is soluble in water (Leuangasukrer, Phupoksakul, Tananuwong, Borompichaichartkul, & Janjarasskul, 2014; Meng, Zheng, Wang, Liang, & Zhong, 2014). Konjac belongs to the Araceae family, and has been cultivated for centuries in Asian countries (Ansil et al., 2011; Behera & Ray, 2016) and widely consumed in India, Indonesia and Malaysia (Singh & Wadhwa, 2014). Regarding its structure, it is mainly composed of D-glucose and D-mannose residues bound by β -1,4 linkage with a ratio of 1: 1.6 (Behera & Ray, 2016; Dai, Jiang, Shah, & Corke, Wang et al., 2017, Yildiz, 2010, Yuan et al., 2017, Zhang, Chen, & Yang, 2014). It is considered a good natural raw material for coatings formulations because it has excellent film forming capacity and is biodegradable (Lu, Wang, & Xiao, 2008).

Thus, the present work aims to evaluate the post-harvest conservation of guavas using the konjac glucomannan edible coatings.

2. Material and Methods

2.1. Materials

2,6 dichloroindophenol sodium salt hydrate was purchased from Sigma; sodium hydroxide and L-ascorbic acid were obtained from Synth and crystal oxalic acid from Dynamic. The guavas (cultivar Sassaoka), glucomannan of konjac, sorbitol and sodium hypochlorite were purchased in local market in the city of Maringá-PR.

2.2. Preparation of the fruit for analysis

The guavas acquired were taken to the Laboratory of Tecnologia de transformação e conservação de produtos agropecuarios, at the Universidade Estadual de Maringá. The fruits

were washed and sanitized in sodium hypochlorite solution (100 ppm) for 10 minutes and then exposed to room temperature for drainage.

2.3. Preparation of the coating solution

The glucomannan powder was diluted in two different concentrations: F0.5 (0.5%) and F1.0 (1.0%) in distilled water, these concentrations were determined by previous tests. The solution was homogenized on magnetic plate and heated to 50 °C. When the temperature was reached, sorbitol (0.5%) was added. After, the coating-forming solution was heated to 90 °C and then cooled (25 ° C) to the fruits immersion (Bezerra, Santos, Farias, & Cavalcanti, 2019)

2.4. Application of the coating solution

The fruits were immersed for 30 seconds in the coating solution, then they were left to drainage in an appropriate support at room temperature. The guavas of the control treatment were not coated. The fruits were stored in plastic trays and stored at 4 °C. The analyzes were performed at day 0, 7 and 15 of storage.

2.5. Physical-chemical analysis and guava firmness

The physical-chemical analyzes were performed after crushing the fruits of each replicate in a mixer and sieving to remove the seed, using only the pulp for these analyzes. Analyzes of pH, acidity, soluble solids, and ratio followed the IAL (2008) methodology.

1) pH - was determined with a digital pHmeter (Digimed), calibrated with the 7.0 and 4.0 buffer, inserting the pHmeter probe into the homogenized sample; 2) Titratable acidity (TA) – was determined by titration using phenolphthalein as indicator, expressed as mg citric acid 100g⁻¹. 10 g of sample was weighed and diluted in 100 mL of distilled water and then titrated with 0.1M NaOH. The results were obtained by the following equation:

$\text{mg ácido cítrico } 100\text{g}^{-1} = \frac{V \times F \times M \times PM}{10 \times P \times n}$, where: V is the volume used in the titration; F = 1.0;

MW = 192g; n = 3; M = 0.1; P = mass of the sample used; 3) Total Soluble Solids (TSS) – was measured using the pulp in a digital refractometer. Values were expressed as ° Brix; 4) Ascorbic acid (AA) – was determined by the modified Tillman's method (Aquino, Carnelossi, & Castro, 2011): 5 g of sample were diluted in 50 mL of oxalic acid (1%), then the mixture

was titrated with DCFI (2,6-Dichloroindophenol sodium salt hydrate: 0.2%). An ascorbic acid standard diluted in oxalic acid was also titrated. The AA value was calculated as follows:

$$AA = \frac{100 \cdot x \cdot n'}{n \cdot P}, \text{ where: } n = \text{volume of DCFI used in titration of the sample; } n' = \text{volume of DCFI}$$

used in titration of the standard solution and P = mass of the sample in grams; the result was expressed as mg 100 g⁻¹; 5) Ratio (TSS / TA) - given by the ratio of total soluble solids and titratable acidity; 6) Mass loss - determined by the difference between the weight of fruit at day 0 and during storage (7 and 15 days), the results were expressed as a percentage; 7) Firmness of fruit - the firmness was evaluated using the Brookfield CT3 Texturometer using cylindrical probe, with a test speed of 5 mm s⁻¹ and 2mm s⁻¹ of pre-test. The measurements were performed at two points of each fruit and the values were expressed in Newton (N).

2.6. Guava peel and pulp color

The coloration of the peel and pulp was performed using the Konica Minolta colorimeter (Cr400 / 410 model), using the CIElab method, measuring L* (lightness), a* (redness) and b* (yellowness). In each fruit two measurements were made.

2.7. Statistical analyzes

This study was developed according to scientific norms The guava parameters were evaluated by analysis of variance using the general linear model (GLM) with the SPSS program (see SPSS Statistics, SPSS Inc., Chicago, USA). Mean, standard deviation and / or standard error were calculated for each variable. The type of film and storage time were considered fixed factors in a factorial design, with four replicates per experimental unit and four units per treatment. The experiment was repeated twice. When significant differences were found, Tukey's test was applied (p = 0.05). Principal components analysis was used to verify the relationships between the treatments and the analyzes performed.

3. Results and discussions

3.1. Physical-chemical analyzes, weight loss and guava firmness

Evaluate the physical-chemical parameters is of great importance to determining the quality of the fruits during the post-harvest conservation. Table 1 presents the results for the

pH, titratable acidity (TA), total soluble solids (TSS), ascorbic acid (AA), ratio (TSS / TA), mass loss and firmness. In general, the pH values found remained around 4.00 (Table 1) and did not present differences between treatments and the storage time when evaluated separately ($p > 0.05$). When the interaction was considered (Table 2), the pH of the treatment control reduced at the 7th day of analyze ($p < 0.012$), different from the other treatment where the pH remained stable. Pereira, Carlos, Oliveira, and Monteiro (2005) verified that the pH decreased throughout the storage and the acidity increased in guavas of cv. Cortibel. This reduction of pH may have occurred due to the formation of organic acids resulting from cell wall degradation (Pereira, Carlos, Oiveira, & Monteiro, 2008) and as a consequence there is an increase in acidity.

Table 1. Physic-chemical analyzes, mass loss and texture of guava coated with glucomannan during storage.

Analyzes	Treatment			Storage time			SEM ⁴	Pt ⁵	Pd ⁶	Ptxd ⁷
	T0 ¹	T0.5 ²	T1.0 ³	0	7	15				
pH	4.02	4.01	4.05	4.05	4.00	4.03	0.01	0.124	0.053	0.042
Acidity ⁷	0.52	0.51	0.52	0.45 ^C	0.53 ^B	0.55 ^A	0.00	0.440	<0.001	0.001
TSS ⁸	9.38	9.46	9.39	8.71 ^C	9.37 ^B	9.97 ^A	0.07	0.685	<0.001	0.421
AA ⁹	61.82	69.85	67.62	62.08 ^B	60.85 ^B	75.59 ^A	1.57	0.058	<0.001	0.227
SS/TA ¹⁰	19.21	18.41	17.84	19.15 ^A	17.64 ^B	17.93 ^B	0.15	0.131	<0.001	0.001
PM ¹¹	13.00 ^a	10.78 ^b	11.45 ^b	-	8.27 ^B	15.19 ^A	0.59	0.004	<0.001	0.583
Firmness ¹²	54.66 ^b	59.42 ^{ab}	68.65 ^a	91.89 ^A	60,31 ^B	37.55 ^B	3.29	0.048	<0.001	0.263

Results are presented as means. Different lowercase letters on the same line indicate significant difference between treatments ($p < 0.05$). Different uppercase letters on the same line indicate significant difference between days of storage ($p < 0.05$). ¹T0 - Control treatment, without coating; ²T0.5 - guavas coated with 0.5% of glucomannan; ³T1.0 - guavas coated with 1.0% glucomannan; ⁴SEM - Standard error of the mean; ⁵Pt - treatment effect; ⁶Pd - days effect; ⁷Ptxd - interaction between treatment and day; ⁷Acidity expressed in mg citric acid 100g⁻¹; ⁸TSS - Total soluble solids expressed in ° Brix; ⁹AA - Ascorbic acid expressed in mg 100g⁻¹; ¹⁰SS / TA - Ratio between soluble solids and titratable acidity; ¹¹ML - mass losses expressed as percentage; ¹²Firmness expressed in Newton. Source: authors.

As mentioned above, it is important to note in this Table 1 the differences between treatments and days (related to physical analyses), in addition to the interaction between them.

Table 2. Interaction between treatments and storage time in the pH of guava coated with glucomannan

	T0 ¹	T0.5 ²	T1.0 ³	P valor
0	4.09±0.02 ^{aA}	4.03±0.07 ^b	4.03±0.02 ^{ab}	0.028
7	4.00±0.09 ^B	4.00±0.07	4.02±0.06	0.578
15	4.00±0.07 ^{bB}	4.00±0.08 ^b	4.09±0.09 ^a	0.021
P value	0.012	0.604	0.082	

The results are presented as means and standard deviation. Different uppercase letters in the same column indicate significant difference ($p < 0.05$). Different lowercase letters on the same line indicate significant difference ($p < 0.05$). ¹T0 - Control treatment, without coating; ²T0.5 - guavas coated with 0.5% glucomannan; ³T1.0 - guavas coated with 1.0% glucomannan. Source: authors.

It's possible to observe in Table 2 the interaction between treatment and storage time ($p < 0.042$) related to pH, how each treatment behaves over time.

In relation to acidity, the coating application did not influence this parameter, however, during storage time, a significant difference between days was observed ($p < 0.001$), with values varying from 0.45 to 0,55 mg citric acid 100g⁻¹. The same behavior was observed by Morgado, Durigan, Lopes, and Santos (2010) in the conservation of guavas Kumagai at 10 °C and values from 0.45 to 0.65 g citric acid.100g⁻¹ of pulp was obtained. Cunha, Souza, Batista, Lima, and Silva (2012) observed the variation in citric acid content from 0.644% in the harvest period to 0.775% at the eighth day of guava storage at room temperature. Analysis of the acidity results also showed an interaction between storage and treatments (Table 3). All treatments showed an increase in acidity during storage, and this drop was more pronounced for the control treatment ($p < 0.01$), corroborating with the pH result.

In relation to the total soluble solids, there was no interaction between storage time and treatments ($p < 0.05$) and a significant increase could be observed during the storage period, being 8.71 °Brix on the first day and 9.97 °Brix at the 15th day of storage. This result may suggest a higher ripening velocity (starch hydrolysis) and be related to the higher loss of mass, which concentrates the amount of total soluble solids in the guava pulp (Costa, 2017).

Table 3. Interaction between treatments and storage time in the acidity of guava coated with glucomannan.

	T0 ¹	T0.5 ²	T1.0 ³	P valor
0	0.46±0.02 ^C	0.44±0.03 ^B	0.45±0.03 ^B	0.268
7	0.51±0.02 ^{bB}	0.53±0.02 ^{bA}	0.56±0.03 ^{aA}	0.001
15	0.57±0.03 ^A	0.56±0.03 ^A	0.54±0.02 ^{2A}	0.180
P value	<0.001	<0.001	<0.001	

The results are presented as means and standard deviation. Different uppercase letters in the same column indicate significant difference ($p < 0.05$). Different lowercase letters on the same line indicate significant difference ($p < 0.05$). ¹T0 - Control treatment, without coating; ²T0.5 - guavas coated with 0.5% glucomannan; ³T1.0 - guavas coated with 1.0% glucomannan. Source: authors.

The Ratio (TSS/TA) was higher for day 0, due to the lower acidity found. Table 4 represents the interaction between treatment and storage time for this parameter, and it can be observed that there was a significant difference between treatments only at the day 7 of storage ($p < 0.002$). In relation to storage time, it did not influence the sample T0 ($p > 0.05$), the sample T1.0 presented variations in the periods, however at the end of the storage period the ratio was similar to day zero and for the treatment T0.5 there was a reduction in the value ($p < 0.001$).

Table 4. Interaction between treatments and storage time in the SS/TA ratio of glucomannan-coated guavas during storage.

	T0 ¹	T0.5 ²	T1.0 ³	P valor
0	18.67±1.27	20.00±1.05 ^A	18.76±1.62 ^A	0.110
7	18.57±1.43 ^a	17.88±1.18 ^{abB}	16.56±0.87 ^{bB}	0.002
15	17.45±0.95	17.78±0.98 ^B	18.43±1.23 ^A	0.127
P valor	0.074	<0.001	0.001	

The results are presented as means and standard deviation. Different uppercase letters in the same column indicate significant difference ($p < 0.05$). Different lowercase letters on the same line indicate significant difference ($p < 0.05$). ¹T0 - Control treatment, without coating; ²T0.5 - guavas coated with 0.5% glucomannan; ³T1.0 - guavas coated with 1.0% glucomannan. Source: authors.

For the ascorbic acid content, a significant difference ($p < 0.001$) was observed only during storage, where the highest content was 75.59 mg 100g⁻¹ on the last day. A similar result was found by Cerqueira et al. (2011), who observed an increase in the ascorbic acid

content of all treatments applied in guava during storage of 8 days at 22 °C. Vila et al. (2007) evidenced a decrease in ascorbic acid content during storage in all treatments applied to 'Pedro Sato' guavas. In the fruits, the ascorbic acid content increases during ripening and when they are mature, it decreased significantly (Vazquez-Ochoa and Colinas-Leon, 1990). Fruits in an advanced maturation stage present higher levels of vitamin C and this is due to the need of the synthesis of antioxidant compounds to the maintenance of the fruit metabolism (Pereira et al., 2005). Cunha et al. (2012) observed that the vitamin C content increased during the ripening of guavas until the 6th day and decreased at the 8th day, since during that period the fruit was in senescence.

The loss of fruit mass is also an important variable when the fruit quality was considered and occur mainly due to fruit transpiration (Bessa et al., 2015). It can be observed in Table 1 that there was no interaction between the variables of time and treatment ($p < 0.583$). The control treatment showed the highest loss of mass (13.00%) when compared to the other two treatments, which did not differ among them ($p > 0.05$). Thus, the added coatings acted as protective barriers, reducing the perspiration of the fruits, and consequent loss of mass in the storage period.

Regarding the effect of storage on guavas, on day 15, the loss of mass was higher (15.19%) when compared to day 7 (8.27%), which was expected due to the ripening and senescence of the fruit ($p < 0.001$). A similar result was found by Cerqueira et al. (2011), where guavas with chitosan coating (6%) had a lower loss of mass than the control treatment during 8 days. Oliveira, Santos, Leite, Aroucha, and Silva (2018) applied manioc starch-based coatings added with beeswax in guavas and also observed a delay in loss of mass. Starch and starch/zeolite films reduced guava transpiration after eight days of storage. Thus, the films were able to assist in increasing the commercialization period of the fruits (Bessa et al., 2015).

The firmness of the fruit is one of the most important parameters that consumers evaluate at the purchase time and consumption and is of great importance in post-harvest quality (Batista Silva et al., 2018; Hong et al., 2012). The changes of firmness in the pulp are indicative of the transformations that are occurring in the cellular structure (Chitarra & Chitarra, 2005). Both, treatment and storage time, influenced on firmness, and the treatment with 1.0% glucomannan presented the highest firmness (68.65 N) differing from the control ($p < 0.048$). The last day of storage had the lowest firmness (37.55 N), and can be explained by the degradation of pectin. With the advancement of maturation, the loss of structural integrity of the tissues, degradation and solubilization of the pectins occurs, which contributes to the tissues softening (Chitarra & Chitarra, 2005). Batista Silva et al. (2018) have observed

the efficacy in preventing the decrease of guava firmness with the application of chitosan coatings (3%) and have concluded that the coating can be used to preserve fruit quality during storage at room temperature.

In guavas coated with protein and chitosan films, Cerqueira et al. (2011) observed that the firmness of the fruits decreased with storage in all treatments, however in a lower proportion in guavas coated with chitosan (6%). Thus, the glucomannan coating was also effective in reducing fruit softening during 15 days of storage, which may increase the post-harvest shelf life for commercialization, as well as to allow its transport for longer periods and with greater resistance to mechanical damage.

3.2. Guava color

According to Chitarra and Chitarra (2005), the coloration is used as parameter for the selection of many products and the quantification of the pigments and other constituents can be used as indicators of the quality of the product. Table 5 presents the color parameters evaluated in the peel and pulp of the guavas. There was no interaction between storage time and treatment for the L* (lightness) and the a* (-green, +red) parameters of the peel and only significant difference in relation to storage time ($p < 0.001$) was observed for these parameters. Pereira et al. (2005) observed for guavas values of L* close to 60 during 29 days of storage, and in this study, values were around 62 and 65. It can be observed an increase in L* during the storage, this fact can be related to the reduction of the pigments of the peel, like the chlorophyll, during the maturing of the fruit.

For the parameter a*, there was an increase in the values during the storage, which results in the loss of green coloration, result of the maturation of the fruits. This behavior also corroborates with that found by Pereira et al. (2005). As for b* (-blue, + yellow), there was a significant difference between treatment and storage time and an interaction between these variables, as can be observed in Table 6. Regarding storage time, there was a significant increase in Abreu, Santos, Abreu, Pinheiro, & Corrêa, 2012), as mentioned above, there is a reduction, a fading of the green coloration and a more pronounced appearance of the yellow color, characteristic of maturation of climacteric fruits.

Table 5. Color (L*, a* and b*) of guava (peel and pulp) coated with glucomannan during refrigerated storage.

Analyzes	Treatments			Storage days			SEM ⁴	Pt ⁵	Pd ⁶	Ptxd ⁷
	T0 ¹	T0.5 ¹	T1.0 ³	0	7	15				
L* peel	63.87	63.60	62.69	62.28 ^B	61.68 ^B	65.95 ^A	0.48	0.549	0.001	0.773
a* peel	-10.66	-10.68	-11.48	-11.97 ^A	-11.19 ^{AB}	-9.92 ^{AB}	0.29	0.561	0.015	0.312
b* peel	42.18 ^a	39.41 ^b	35.73 ^c	35.59 ^C	39.44 ^B	41.31 ^A	0.45	<0.001	<0.001	<0.001
L* pulp	65.03	65.31	65.78	65.57	64.37	66.26	0.38	0.827	0.120	0.857
a* pulp	27.37	27.29	26.77	25.51 ^B	26.44 ^B	29.09 ^A	0.23	0.201	<0.001	0.274
b* pulp	22.99	22.80	22.63	21.44 ^B	21.83 ^B	24.84 ^A	0.21	0.690	<0.001	0.044

Results are presented as means. Different lowercase letters on the same line indicate significant difference between treatments ($p < 0.05$). Different uppercase letters on the same line indicate significant difference between days of storage ($p < 0.05$). ¹T0 - Control treatment, without coating; ²T0.5 - guavas coated with 0.5% of glucomannan; ³T1.0 - guavas coated with 1.0% glucomannan; ⁴SEM - Standard error of the mean; ⁵Pt - treatment effect; ⁶Pd - days effect; ⁷Ptxd - interaction between treatment and day. Source: authors.

The color changes of the peel result mainly from a decrease in chlorophyll concentration and increase in carotenoids (Jain, Dhawan, Malhotra, & Singh, 2003). The control showed the highest value of b*, which represents a more yellow coloration and the treatment with 1.0% glucomannan, the lowest value, that is, there was a maintenance of the coloration, a lower degradation of chlorophyll (Chitarra & Chitarra, 2005) with coating application. The same result was observed by Quirino, Costa, Costa, and Neto (2015), where the guavas that received coating had less color variation. A similar result was observed by Coelho et al. (2013), the color change in guava was lower in those coated with cassava starch when compared to the control treatment.

In relation to the color of the pulp, it can be observed that for the L*, there was no significant difference in both factors (time and treatment) ($p > 0.05$) and for a* ($p < 0.015$) and b* ($p < 0.001$) a significant difference was observed in relation to storage time. For the 15th day, a higher value was observed for these two parameters, that is, the pulps became redder and yellowish. The same behavior was found by Quirino et al. (2015). This change in coloration from pink to deep red pulp probably occurs due to the lycopene biosynthesis which is present in fruits (Salunkhe & Kadam, 1995).

Table 6. Interaction between treatments and storage time for color (b*) of guava peel coated with glucomannan.

	T0	T0.5	T1.0	P valor
0	36.54±2.15 ^C	36.12±2.03 ^B	34.12±2.03 ^B	0.225
7	42.65±2.90 ^{aB}	40.61±3.54 ^{bA}	35.05±2.94 ^{cAB}	<0.001
15	46.18±3.01 ^{aA}	40.62±2.51 ^{bA}	37.59±1.57 ^{cA}	<0.001
P value	<0.001	<0.001	0.026	

The results are presented as means and standard deviation. Different uppercase letters in the same column indicate significant difference ($p < 0.05$). Different lowercase letters on the same line indicate significant difference ($p < 0.05$). ¹T0 - Control treatment, without coating; ²T0.5 - guavas coated with 0.5% glucomannan; ³T1.0 - guavas coated with 1.0% glucomannan. Source: authors.

Only for b* an interaction between treatment and time was observed, as shown in table 7. The control treatment presented greater variation in the yellow coloration of the pulp during storage than the coated samples, and on day 7 a difference between the treatments ($p < 0.007$) was observed, and guava from the control treatment had a more yellowish coloration.

Table 7. Interaction between treatments and storage time on the pulp color (b*) of guava coated with glucomannan.

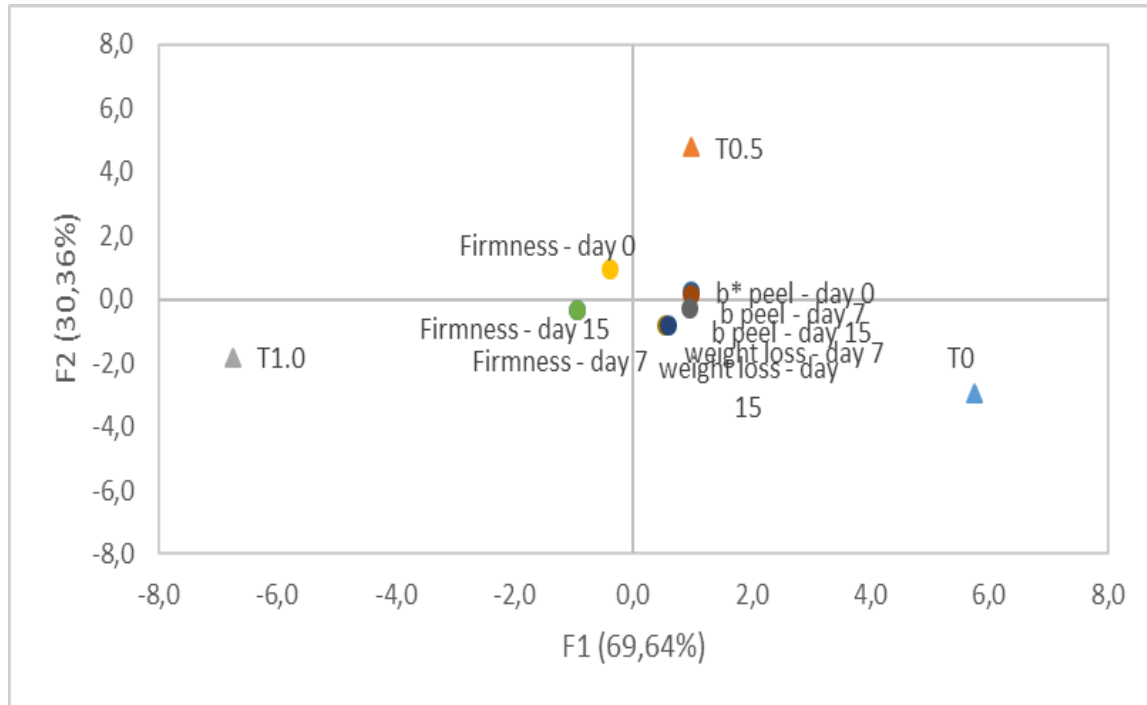
	T0 ¹	T0.5 ²	T1.0 ³	P valor
0	20.73±1.11 ^C	21.73±1.42 ^B	21.85±1.44 ^B	0.207
7	22.65±0.93 ^{aB}	21.60±0.93 ^{bB}	21.26±1.09 ^{bB}	0.007
15	25.18±0.93 ^A	24.78±1.35 ^A	24.58±1.93 ^A	0.643
P valor	<0.001	<0.001	<0.001	

The results are presented as means and standard deviation. Different uppercase letters in the same column indicate significant difference ($p < 0.05$). Different lowercase letters on the same line indicate significant difference ($p < 0.05$). ¹T0 - Control treatment, without coating; ²T0.5 - guavas coated with 0.5% glucomannan; ³T1.0 - guavas coated with 1.0% glucomannan. Source: authors.

3.3. Principal component analysis

Information about treatments and analysis of loss of mass, texture and color (b*) of the peel are graphically demonstrated in Figure 1.

Figure 1. Principal component analysis of the guava coated with glucomannan associated with loss of mass, texture and yellow color of peel. T0 – uncoated guavas; T0.5 - guavas with edible coating containing 0.5% of konjac; T1.0 - guavas with edible coating containing 1.0% of konjac.



Source: authors.

The two axes explain 100% of the total variation of the analysis. Fruit loss of mass is presented on the right side of the graphic and in the same quadrant as the control (T0), indicating a correlation between them, being inversely related to T1.0 (1% glucomannan). The texture analyzes, on the other hand, are located on the left side of the graph next to the treatment with 1% glucomannan (T1.0) and the other treatments are inversely related to this attribute (presented on the right side). Regarding the yellow color (b*) of the guava peel, it is presented on the right side of the graphic, being related to the control and T0.5 (5% glucomannan). Thus, in agreement with the results already presented, a positive correlation between the use of the glucomannan coating at the concentration of 1% with the maintenance of the guava's quality during storage, as the maintenance of the initial weight, the texture, and peel's color, being these parameters of great importance for the conservation, selection and commercialization of fruits.

4. Final Considerations

The use of glucomannan coating at concentrations of 0.5% and 1.0% led to a reduction in fruit mass loss in addition to maintaining firmness, being this last parameter with better results for coating with 1.0 % glucomannan. In addition, the use of the coating also kept the coloration of the peel less yellowish without altering other parameters associated with fruit quality (pH, acidity, soluble solids, ascorbic acid, luminosity and redness of the peel and color of the pulp). Thus, the application of glucomannan coating may be an alternative to increase the post-harvest conservation of fruits, since the improved parameters are of great interest for commercialization. In addition, new technologies for the elaboration of coating must be studied, in order to improve the processes, guarantee the quality and safety of the product and increase its time to market, especially the active ones, which may contain compounds with different activities, such as antioxidants, which in addition to maintaining product quality add value to it.

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