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Coating Guava Postharvest With the Use of Starch of Tamarind Seed and Pomegranate Seed Oil

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Abstract

The effect of coatings with different concentrations of tamarind seed starch associated with pomegranate seed oil in 'Paluma' guava was investigated in the present work. The fruits were harvested from an orchard in the morning, packed in containers previously lined with paper, and transported to a laboratory, where they were selected, washed, sanitized, and separated at random for the application of each treatment. The experiment design used was completely randomized, in the 6 × 6 factorial scheme, six coatings and six evaluation periods, with 3 replicates made up of 2 fruits. The treatments were: T1 (control or reference sample), without coating; T2 (0.24 mL of pomegranate seed oil/mL of coating); T3 (2% tamarind starch); T4 (1% tamarind starch); T5 (2% of tamarind starch); T6 (3% tamarind starch), T4, T5 and T6 were associated with 0.24 mL/mL of the pomegranate seed oil. The treatments were applied under immersion of the fruits in the solutions and then stored in a refrigerated chamber at 10±2 °C and 80±5% RH, and the evaluations were performed at intervals of 3 days to 12 days of storage. Due to the maintenance of the quality of the fruits, and without sufficient material, it was decided to extend storage time until the 21 days. Thus, the analyses were performed at 0, 3, 6, 9, 12 and 21 days with evaluations at 0, 3, 6, 9, 12, and 21 days. The T6 treatment (3% tamarind starch + 0.24 mL/mL pomegranate seed oil) was more efficient regarding luminosity (L*) of the fruits and delaying color development , expressed by the values of C*, also showing the higher retention in the loss of firmness, lower mass loss and lower soluble solids content, suggesting that this treatment possibly inhibited the degradation of polysaccharides, delaying the ripening process of the fruits.

Keywords: *Psidium guajava* L, shelf life, storage

1. Introduction

The guava (*Psidium guajava* L.) is a seasonal fruit found in the tropical and subtropical areas of the world. It is an excellent source of dietary fiber, pectin, vitamin A, phosphorus presenting the second largest vitamin content C of all of the fruits belonging to the family Myrtaceae. Also, it is rich in calcium, iron, thiamine, niacin, riboflavin, and carotene (Mangaraj et al., 2014).

The climacteric nature limits shelf life of post-harvest to 3 or 4 days to 25±2 °C, ripening quickly and entering in senescence (Murmu & Mishra, 2017). To minimize this, studies have been accomplished using edible coatings in order to improve the shelf life of these fruits. One of the materials that can be worked in the formulation of those coatings is tamarind seed starch. For being that one polysaccharide it possesses in its composition amylose and amylopectin, which serve as a barrier to gases, antifungal action, being able to preserve mechanical and sensorial properties. It can also present antioxidant actions, due to the fact that the fruit of tamarind rich in phenolic compounds, preventing the action of free radicals (Tremocolde, 2011).

Foodstuff coatings are made mainly of polysaccharides and proteins. When applied to fruits, they delay physiologic processes such as breathing, degradation of the cell wall, and perspiration. The addition of essential oils and fat sources to the formulation enhances that characteristic, as it can be expected from hydrophobic compounds (Fucinos et al., 2017). Pomegranate seed oil has been highlighted as a potential ingredient in the food industry due to its nutritional and medicinal properties, with attributes that are beneficial to health (Verardo et al., 2014).

The benefits of coatings based on starch and other substances associated of the incorporation of essential oils were demonstrated by different authors: Perdones et al. (2012), Sánchez-González et al. (2011), Teodosio et al. (2018), Santos et al. (2017). They studied the postharvest conservation of guava 'Paluma' through tamarind starch based coatings, and they verified that the concentration of 3% of the coating was more efficient regarding the brightness (L*) of the fruits and on delaying the development of the color, expressed for the values of C*, h*, indicating the potential of this product in the retention of the ripening and, consequently, resulting in longer preservation of the covered fruits.

The development of new studies with the objective of proving the effectiveness of this product as coating is of fundamental importance. In this context, the objective of this work was to study the effect of different concentrations of tamarind starch and pomegranate seed oil in formulations of coatings in the preservation and attributes of quality of the guava.

2. Material and Methods

The experiment was developed in the Federal University of Campina Grande (UFCG), Center of Sciences and Agro-Food Technology (CCTA), in the laboratory of Post-Harvest of Fruits and Vegetables, in the period of November to December 2017. The fruits were obtained from guava orchard, located in the state of Pernambuco, Northeast area of Brazil. The crop was accomplished manually between 6 and 8 hours of the morning, the picked fruits were in the state of maturation II, soon afterwards they were conditioned in a single layer, in containers previously coated with paper pricked to minimize the impact and the attrition among them and they were transported to the laboratory.

In the laboratory, careful selection was made for color size and uniformity, and absence of defects or mechanical imperfections. Afterwards, the fruits were washed with 1% neutral detergent solution and, after rinsing, sanitized with sodium hypochlorite solution containing 100 ppm of free chlorine for fifteen minutes. They were then randomly sorted in batches for the application of the treatments, which were composed of different suspensions based on tamarind starch and pomegranate seed oil. For the preparation of the suspensions and application of the coatings for the preparation of the suspensions and application of the coatings, the tamarind starch had semi-analytical balance weight and was diluted in 800 ml of water, the solutions were heated to 70 °C under constant stirring. The suspensions were cooled at 40 °C and then the pomegranate seed oil was added in the respective formulations. The starch and pomegranate oil used were obtained from Fazenda Águas de Tamanduá, located in the municipality of Santa Terezinha, Paraíba, Brazil.

The experiment was installed in completely randomized design, in the outline of factorial 6 × 6, six coatings and six evaluation periods along the time, with 3 constituted repetitions of 2 fruits. The treatments were the following ones: T1 (control or reference sample), without coating; T2 (oil of the seed of the pomegranate = 0.24 mL/mL); T3 (2% of starch of the tamarind seed); T4 (1% of starch of the seed of tamarind+ 0.24 mL/mL of the oil of the seed of the pomegranate); T5 (2% of tamarind starch + 0.24 mL/mL of the oil of the seed of the pomegranate); T6 (3% of starch of tamarind +0.24 mL/mL of the oil of the seed of the pomegranate). The coatings were applied immersing the fruits during one minute in the suspension, draining the excess, being disposed the same ones in drained containers. The fruits were then stored in a climatic chamber 10±2 °C and 80±5% RH, and the evaluations were performed at intervals of 3 days to 12 days storage. Due to the maintenance of the quality of the fruits, and without sufficient material, the storage was extended until 21 days. Then, the analyses were performed at 0, 3, 6, 9, 12, and 21 days. The following variables were analyzed:

Colorimetry of the Peel: was accomplished being made use of the system L*, a* and b*, done by reflectometry, being used a reflectometer marks Konica Minolta, model Chroma to put CR-400. The readings were accomplished randomly in the equatorial area of the fruit. The measured color parameters regarding to plate-pattern were: brightness (L*), varying from black (0) to white (100); a*, varying from green (-60) to the red (+60) and b*, varying from blue (-60) to yellow (+60). The values of a* and b* are converted into Hue angle (H°), which represents color intensity, and their chromes (C*), that represents color purity according to the equations of Pinheiro 2009 (Pinheiro, 2009).

Loss of Fresh Mass: It was measured in semi analytical scale with±0.01 g accuracy, being used the connection between the mass of the fruit on the day of the crop and in the date of each evaluation. The results were noted in percentages;

Firmness of the Pulp: measured after the removal of the peel of the fruit with a sheet of 10 mm. A digital penetrometer was used coupled to the ferrule measuring 8 mm in diameter. Two evaluations were made for each fruit, in opposite sides in the equatorial area. The results were expressed in N (AOAC, 2006);

Hydrogen Ionic Potential (pH): certain for direct reading in the pulp homogenized through digital pH meter of bench with glass electrode (Marks Digimed DM-2 2), (IAL, 2008);

Titratable Acidity (AT): accomplished through titration of 1g of homogenized pulp diluted in 50 mL of distilled water. Three drops of 1% phenolphthalein were added to the sample, titration was done under constant agitation, with solution of NaOH 0.1 N results were expressed as % of citric acid (IAL, 2008);

Soluble Solids (SS): were measured through direct reading in digital refractometer Digital mark Refractometer (AOAC, 2006);

Relationship between soluble solids and titratable acidity (SS/AT): made by the quotient among the two variables;

Vitamin C: Obtained through titration with a solution of Tillmans, based on the reduction of the color sodic salt of 2.6 dicorofenol indofenol (DFI) for an acid solution of vitamin C. Initially, 1 g of the sample was weighed in an analytical scale, and transferred to an Erlenmeyer, completing the volume for 50 mL with 0.5% oxalic acid, resulting in an even rosy coloration permanent clearing. The results were expressed in mg/100 g % of ascorbic acid (AOAC, 2006);

Statistical Analysis: The data were submitted to variance analysis and regression through the Sisvar Program (Ferreira, 2011).

3. Results and Discussion

In the variance analysis it was observed that there was significant interaction ($p < 0.01$) among the coatings and the time of storage for the variables vitamin C, loss of fresh mass, Luminosity L* and angle hue, demonstrating that the appraised factors influence in the quality post-harvest of guava fruits 'Paluma' (Tables 1 and 2). All the variables had significant difference separately for the time of storage. There was an effect of the treatments for the soluble solids (SS), Relationship SS/AT and pulp firmness.

Table 1. Summary of variance analysis for the color parameters (brightness, chromaticity, and angle hue), loss of fresh mass and firmness of guavas 'Paluma' with and without the application of edible coverings during the storage at 10 °C, UFCG, Pombal-PB, 2017

Variation source	GL	Medium square				
		Brightness (*L)	Chromaticity (C*)	Angle Hue (H°)	Mass loss (%)	Firmness (N)
Coatings (R)	5	104.73**	31.51^{ns}	0.01**	12.21**	1565.90**
Time (T)	5	396.55**	105.02*	0.15**	366.76**	43922.47**
Interaction R × T	25	15.55**	25.67^{ns}	0.006**	1.28**	187.85^{ns}
Error	72	4.14	25.07	0.002	0.45	163.75
CV (%)	-	3.40	12.13	0.05	11.53	18.51

Note. ns: not significant;** significant at 1%;* significant at 5%.

Table 2. Summary of the variance analysis for pH, titratable acidity (AT), soluble solids (SS), Relationship (SS/AT) and vitamin C guava 'Paluma' with and without the application of edible coverings during the storage to 10 °C, UFCG, Pombal-PB, 2017

Variation source	GL	Medium square				
		pH	Titratable acidity (% ácido cítrico)	Soluble solids (°Brix)	Relationship SS/AT	Vitamin C (mg/100 g)
Coatings (R)	5	0.03^{ns}	0.003^{ns}	1.00**	6.94**	12.79**
Time (T)	5	0.49**	0.02**	70.82**	125.66**	2436.15**
Interaction R × T	25	0.01^{ns}	0.001^{ns}	0.11^{ns}	0.86^{ns}	26.23**
Error	72	0.06	0.003	0.10	1.03	0.54
CV (%)	-	6.68	7.59	3.30	6.96	2.65

Note. ns: not significant;** significant at 1%;* significant at 5%.

Regarding the shine of the peel (L*), there was a significant increase, with interaction between the coverings and the time of storage. In the T1coverings (control or reference sample) and T2, there was an increase in the values related to the time of storage, from the 0th to the 12nd day of storage (52.31; 71.14), (52.35; 64.82), respectively, with small reduction at the end of the 21nd day, tending to present shinier fruits. In the treatment T2, the oil might have contributed to a higher brightness of the fruits (Figure 1).

The other treatments presented an increase from the 0th to the 12nd day of storage, (T3 = 52.78; 64.77; T4 = 51.30; 63.72; T5 = 52.32; 63.63; T6 = 51.81; 60.75), with subsequent decrease, with close L values at the end of the period of evaluations. Such results shows the efficiency of the starch based coating in the maintenance of the opacity of the fruits, showing a delay in the ripening of these fruits, being the coating T6 the one that presented the most opaque fruits. According to Guimarães et al. (2017), among the benefits associated to the use of biodegradable coverings in fruits as the starch of the tamarind seed, stands out the maintenance of the appearance, the absence of mushrooms and the decrease of the metabolism delaying the ripening process, maintaining the turgidity and the shine of the fruit.

Costa et al. (2017) observed an increase in the values of L* during storage, and, at the end, the control sample presented a value significantly larger. Santana (2015) verified that at the beginning of the storage of guavas ‘Paluma’ and ‘Cortibel’ the brightness was between 55 and 60 and it reached values between 70 and 72 6 days after the crop, being these very close values to the that happened for the control fruits T1. The treatments with coatings presented lower values, between 50 and 65, indicating the efficiency of the action of the coatings in inhibiting the progression of the color.

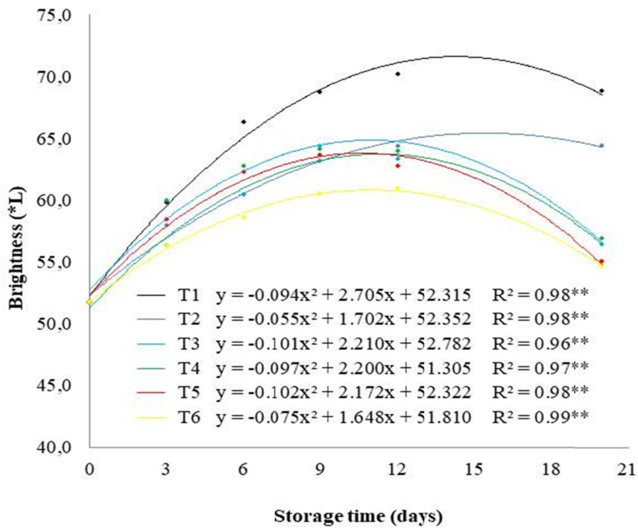

Figure 1. Brightness (L*) of guava fruits’ ‘Paluma’ covered with tamarind starch and oil of the pomegranate seed during the storage to 10±2 °C, 80±5% RH, UFCG, Pombal-PB, 2017

Regarding Chromaticity (C*), there was significant effect of separately time. All of the treatments showed an increase until the ninth day of storage (Figure 2). The control and T2 coating samples presented higher values showing an early ripening, during the storage period. The other coverings T4, T3, T5 and T6 respectively, presented a decrease at the end of the storage (21st day). Therefore, the treatments were not efficient in delaying the intensity and progression of the color of the current fruits of the ripening. In a similar way, Siqueira (2012) also observed an increase of this index along with the storage, indicating a progress of the shade of the coloration of the peel and of the pulp of the fruits, independently of the treatments in guavas and passion fruit-acidity samples with edible coatings.

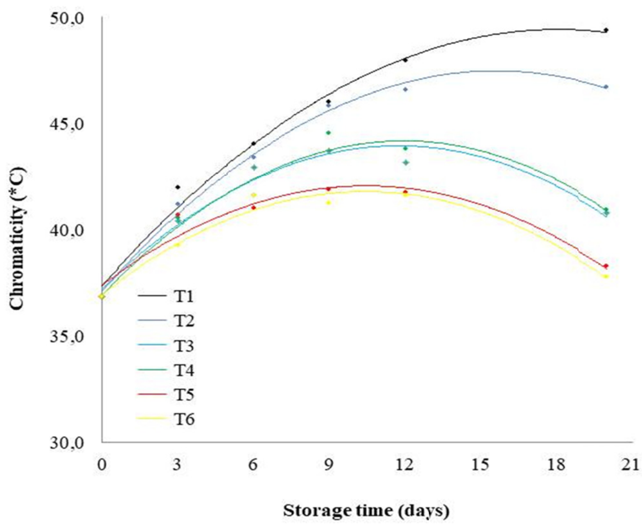

Figure 2. Chromaticity (C*) of guava fruits 'Paluma' covered with tamarind starch and oil of the pomegranate seed during the storage to 10±2 °C, 80±5% RH, UFCG, Pombal-PB, 2017

Regarding the intensity of the color (h*), there was a significant interaction between the treatments and the storage period, with decrease of values of the 0 to the 12th day of storage (Figure 3). (T1 = 90.49 – 90.18; T2 = 90.50 – 90.23; T3 = 90.47 – 90.24; T4 = 90.49 – 90.23; T5 = 90.50 – 90.29; T6 = 90.48 – 90.27). Later, the treatments T5 and T6 had larger increase, indicating larger development of the color in those fruits. Among the treatments with covering, T2 (Oil of the seed of the pomegranate, 0.24 mL/mL) had the best results delaying the development of the color, however, this result was observed on fruits that had already turned yellow at the end of the period of evaluations. Santana (2015), submitting samples to a temperature of (25±1 °C) it observed higher values than those registered in this work, where the angle h* of the peel it differed among them cultivate ('Paluma' and 'Cortibel') when the fruits reached two days of storage after the crop.

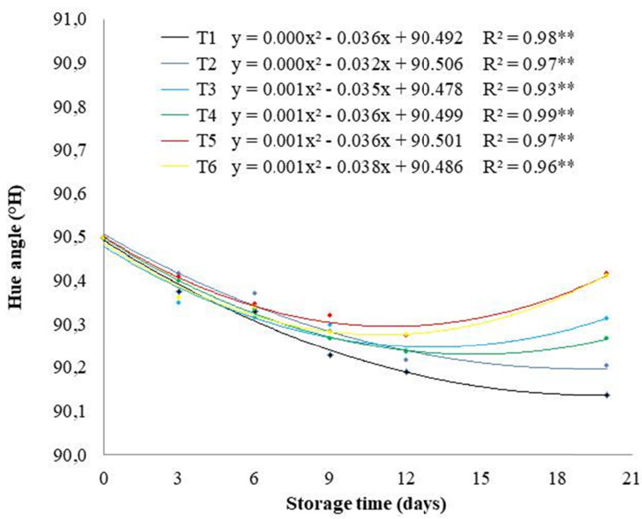

Figure 3. Angle Hue (ºH) of guava fruits 'Paluma' covered with tamarind starch and oil of the pomegranate seed during the storage to 10±2 °C, 80±5% RH, UFCG, Pombal-PB, 2017

The loss of fresh mass gradually increased over the storage period and in both treatments (Figure 4). The fruits submitted to the T2 treatment presented the highest mass losses, followed by the uncovered fruits (control or reference sample), with values around 15.44% and 14.83%, respectively, after 21 days of storage. The lower mass losses were obtained for the T3 treatment, such behavior can be justified by the formation of a protective film, which adhered to the surface of the fruit, thus avoiding loss of water origin, perspiration and respiration thereof. This behavior can be explained by Luvielmo and Lamas (2012), who states that the carbohydrate-based coatings allow the gas changes between the plants and the external atmosphere, but this respiratory process occurs through a lower quotient, thus reducing the loss of fresh pasta. Similarly to that observed in this study, Oshiro et al. (2012) and Cerqueira et al. (2011) also observed higher values of loss of mass in the control fruits, when compared to the fruits submitted to the coatings in guavas Pedro Sato and Kumagai, respectively).

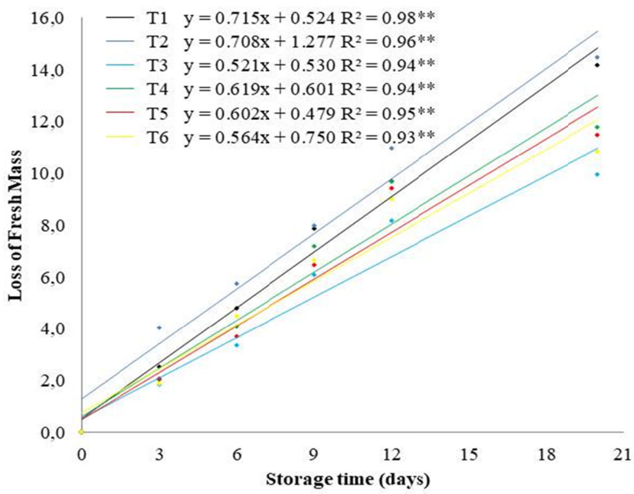

Figure 4. Loss of Fresh Mass of guava fruits 'Paluma' covered with tamarind starch and oil of the pomegranate seed during the storage to 10±2 °C, 80±5% RH UFCG, Pombal-PB, 2017

For the firmness of the pulp there was not significant among the appraised factors (covering x storage period). However, there was significance for the factors when studied isolated. The firmness decreased with the time of evaluation and independently of the covering of the fruits to the 12nd day of storage, being this more accentuated in the first 6nd day (Figure 5). The concentrations of the coverings maintained the control of the degradation of the cellular wall and consequently, they reduced the softening of the fruits starting from the 12nd day, maintaining until the end of the period of evaluations. The fruits treated with the covering T6 were the ones that presented larger retention in the loss of firmness, with firmer fruits in relation to the others, indicating efficiency of the coverings when reducing the effects of the maturation and of the breathing process. Although with at the end of the storage it is observed that the treatment T1 (control or reference sample) had fruits with lower firmness, probably due to maturation during storage.

A similar result was observed by Costa et al. (2017) studying edible coatings (to the base of cassava starch, sodium alginate, or carboxymethylcellulose) in 'Pedro Sato' guava stored at 10 °C.

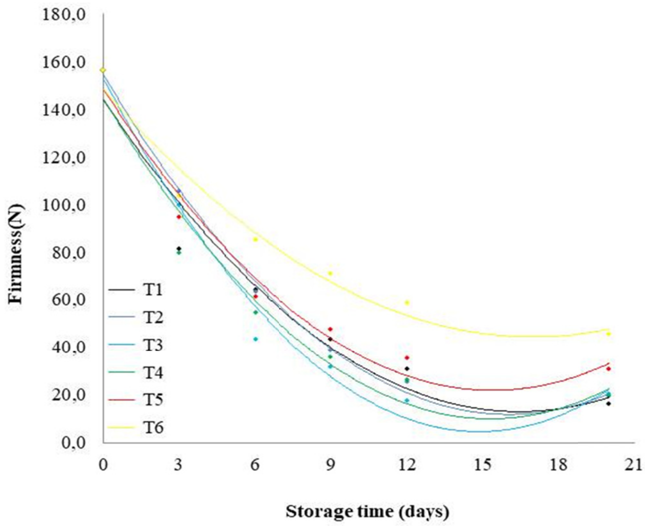

Figure 5. Firmness of guava fruits 'Paluma' covered with tamarind starch and oil of the pomegranate seed during the storage to 10±2 °C, 80±5% RH, UFCG, Pombal-PB, 2017

Regarding pH, there was no significant interaction among the studied factors (coating × storage period). However, there was significance for isolated time of storage, in which all of the coverings had an observed reduction of values of the 0 (3.88) up to the 12th day (3.62) of storage, with a subsequent increase up to the 21st (3.69) days of storage (Illustration 6). According to Chitarra and Chitarra (2005), the reduction of the pH related to storage is caused by the degradation of organic acids due to the breathing of the fruits. Costa et al. (2017) evaluated the application of different edible coatings in the post-harvest conservation of guavas (*Psidium guajava* L.). They verified that in all treatments, excluded control samples, there was a significant increase of the pH value. Oliveira et al. (2017), evaluating the influence of different concentrations of coatings based on cassava starch in the quality post-harvest guava 'Paluma', related to storage periods, maintained under cooling (12 °C and 80% relative humidity), a reduction was verified in the pH values independently of coating content at the 9th day of storage.

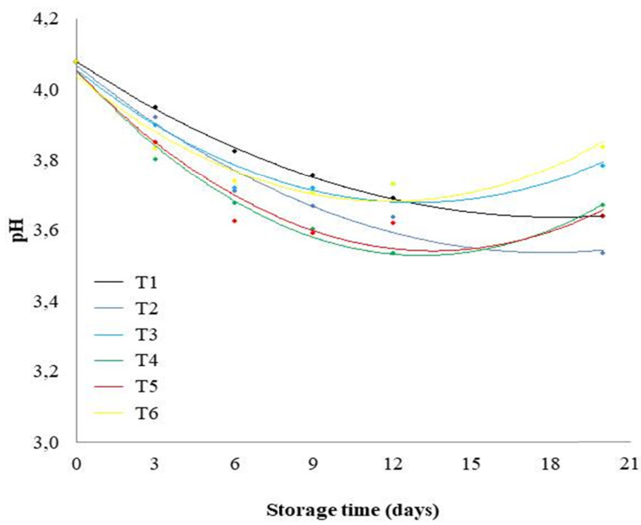

Figure 6. pH of guava fruits 'Paluma' covered with tamarind starch and oils of the pomegranate seed during the storage to 10±2 °C, 80±5%RH, UFCG, Pombal-PB, 2017

Analyzing Figure 7, it is verified that in accordance with the pH graph, there was increase in the titratable acidity of the 0 (0.63% citric acid) up to the 12th day (0.71% citric acid), in all of the treatments, resulting in fruits with higher acidity. A reduction was observed afterwards, with values of 0.65% citric acid at the end of the storage, as a result of the process of ripening of the fruits.

After the crop and during the storage, the concentration of the organic acids usually due to the use of these composed as substrate in the breathing, however, that alteration varies with the fruit (Chitarra, 2005). Mendonça et al. (2007) observed a lineal increase in the percentage of acidity of guavas 'Cortibel 1' and 'Cortibel 4' after 16 days of storage, with values passing from 0.51% to 0.95% of citric acid.

The increase of the acidity during the ripening can be attributed to the formation of coming organic acids of the degradation of the cell wall (Pereira et al., 2005). With the break of the structure of the pectin polymers due to the action of enzymes PME and PG, there a release of soluble galacturonic acids in water and, consequently, the increase of the acidity.

Soares et al. (2011) verified higher values for the titratable acidity in the pulp of guavas 'Pedro Sato' of the treatment it controls, regarding those covered with a starch film and chitosan 1.5%, after 12 days of storage at 22 °C. Oshiro et al. (2012) studying the preservation of guavas 'Pedro Sato' stored under modified atmosphere and with use of verified that the provided a better conservation of the guavas, which presented a lower variation of acidity.

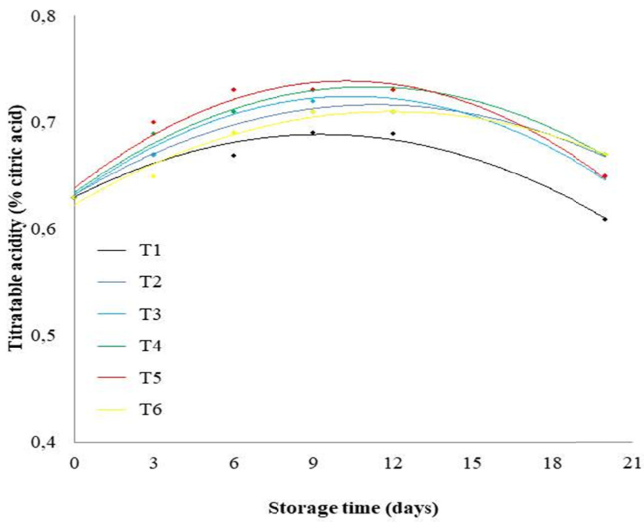

Figure 7. Titratable acidity of 'Paluma guava fruits coated with tamarind starch and pomegranate seed oil during the storage at 10±2 °C, 80±5% RH, UFCG, Pombal-PB, 2017

In general, the content of soluble solids constantly increased after 12 days, (Figure 8). A more significant increase was observed after 12 days, for all of the treatments, reaching values around 11 °Brix. The highest values for that characteristic were observed in the fruits that received T5 treatment after 21 days of storage, with 12 °Brix, indicating a larger ripening speed. The fruits that received T6 treatment presented a lower content of soluble solids, suggesting that this treatment inhibited the degradation of polysaccharides. The results of this research are corroborated by those found by Oshiro et al. (2012). This increase in SS can be justified by the degradation of polysaccharides, when there is conversion of starch in soluble sugars due to the ripening, besides, the mass loss, observed in that period (Figure 8). It might also have contributed to an increase in the concentration of sugars in the pulp (Siqueira, 2012).

Soares et al. (2011) verified that guavas covered with starch basedfilms, together with chitosan, had their content of soluble solids preserved for up to 8 days, a similar result to fruits that received T6 treatment that presented the smallest levels of soluble solids, suggesting the treatment possibly inhibited the degradation of polysaccharides.

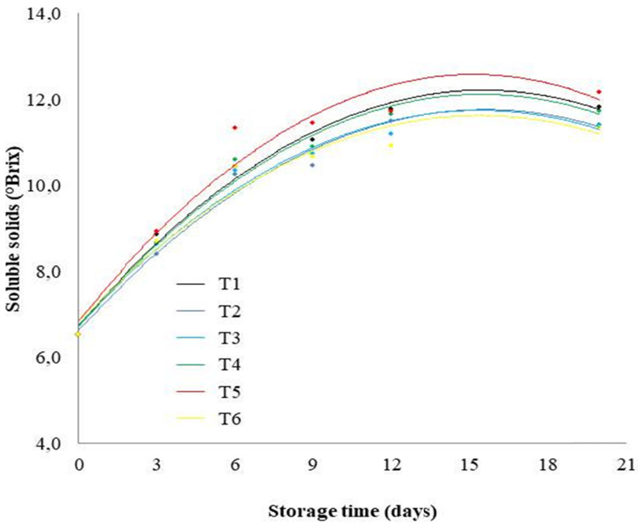

Figure 8. Soluble solids of guava fruits 'Paluma' covered with tamarind starch and pomegranate seed oil during storage at 10±2 °C, 80±5% RH, UFCG, Pombal-PB, 2017

As for Relationship SS/AT values, an increase was observed during the storage, caused by the increase in the soluble solids and decrease in the acidity in that period (Figure 9). Overall, all the treatments presented a similar behavior for that characteristic, however the control fruits T1 presented the highest values for that characteristic. At the end of the storage the fruits that received the T6 treatment presented the lowest values for that characteristic. Divergent behavior to that observed in this study was reported by Oshiro et al. (2012), who observed a reduction in the ST/AT ratio with storage, probably as a function of the LA averages that increased in this period, causing this relation to decrease. Differently of the behavior observed this study, Siqueira (2012) observed that guava fruits covered with chitosan at 0.5% and 1.0% presented a tendency to decrease in the values of the relationship SS/AT with the time of storage.

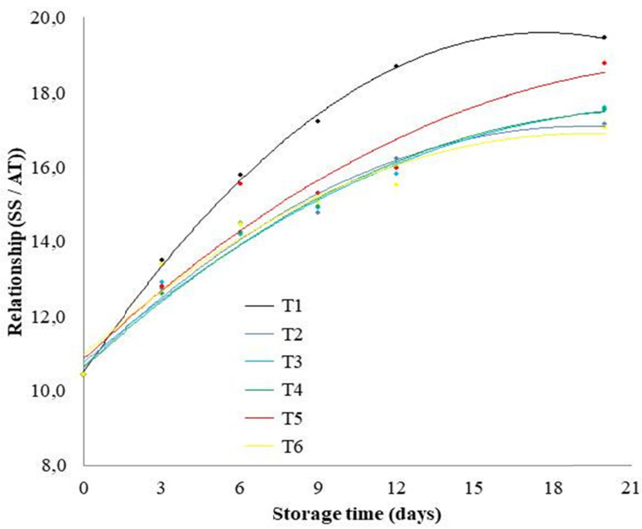

Figure 9. Relationship SS/AT of guava fruits 'Paluma' covered with tamarind starch and pomegranate seed during the storage to 10±2 °C, 80±5% RH, UFCG, Pombal-PB, 2017

An increase in vitamin C content was observed to the 9th day of storage, with similar results observed among the tested coatings (Figure 10).

The highest value was observed in the period of 9 days in the treatment T3. After that, there was a decrease in vitamin C content for T6 treatment up to 21 days, however, the treatment T2 (42.99 mg/100 g) maintained higher values compared to other treatments. The vitamin C content in guavas tends to increase during the ripening, and could decline with senescence. During the ripening, the increase in ascorbic acid content in guavas can be associated to the synthesis of metabolic intermediates as the degradation of polysaccharides of the cell wall. During senescence, a content reduction is measured due to the oxidation of these compounds as substrate for breathing (Siqueira, 2012).

Different from the behavior observed in this study, Fonseca et al. (2016) did not observe significant effect of the treatments and interaction among variables and the conservation period on the ascorbic acid content in guavas ‘Pedro Sato’.

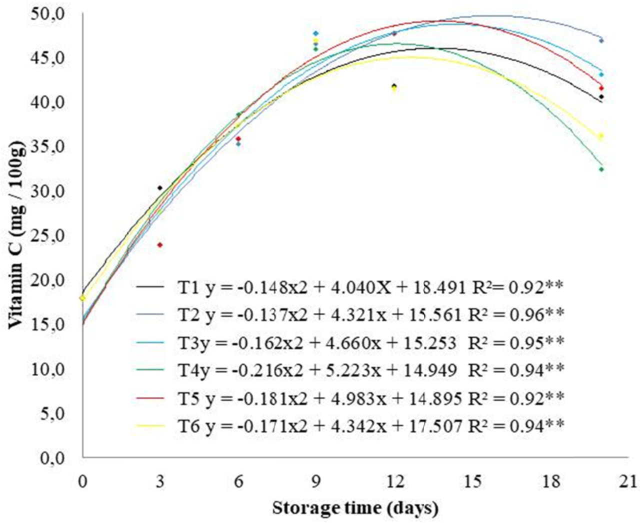

Figure 10. Vitamin C of guava fruits ‘Paluma’ covered with tamarind starch and pomegranate seed oil during the storage to 10±2 °C, 80±5% RH, UFCG, Pombal-PB, 2017

4. Conclusions

The guava coating ‘Paluma’ prepared with 3% of tamarind seed starch associated to 0.24 mL/mL of pomegranate seed oil was the most efficient method to preserve fruit maintained by 21 days to 10 ºC and 80% RH. The fruit with this coating presented ripening retention, lower loss of fresh mass, greater firmness, and soluble solids.

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