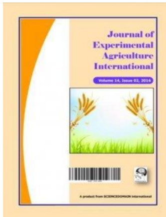

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Influence of Different Coatings on Quality and Shelf-Life of Guava under Different Storage Temperatures

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Authors' contributions

This work was accomplished in collaboration among all of the authors. Authors EAO, JAR, TBQ and BGFLS drove laboratory research, statistical analysis and preliminary sketch. While authors AEMMT, LMO and MHBSR collaborated in the rewriting of the manuscript, improving the bibliographical revision with base in the obtained data. Authors EFM and RHCRA collaborated in the development of the study and they accomplished corrections of the manuscript. In the end, all of the authors read and they approved the final manuscript.

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ABSTRACT

The culture of guava tree (*Psidium guajava* L.) is a cultivation alternative to the Brazilian semiarid region, as well as a source of income for the small farmer. However, after the crop, fruits face a fast deterioration process, leading to the need for methodologies to delay ripening and consequently reduce losses. In this context, this project aimed to evaluate influences of the application of edible coating based on starch, associated arrowroot, or not to the pomegranate oil in the conservation in

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post harvest of the guava tree 'Paluma'. The experiment was designed to be entirely randomised, in a 2 x 4 factorial outline, two storage temperatures (20 ± 2°C for 12 days and 10 ± 2°C for 20 days, both with 85 ± 5% UR) and four types of coatings (T1: without application; T2: 0.3% pomegranate oil; T3: arrowroot until 2% and T4: arrowroot to 2% + 0.3% pomegranate oil, with five repetitions of two fruits). The use of the base arrowroot starch in 2% was shown to be efficient in the control of the ripening of the guavas stored in different temperatures. The coating of arrowroot starch to 2% + 0,3% of pomegranate oil, promoted more the reduction of the breathing tax of guavas, providing the maintenance of the shelf life post harvest of the fruits in both tested temperatures. Moreover, the coating of starch of araruta 2% + 0.3% of pomegranate oil provided a better shelf life in guavas for 20 days of storage the temperature of 10 ± 2°C with 85 ± 5% UR.

Keywords: Psidium guajava L.; arrowroot starch; pomegranate seed oil; post-harvest.

1. INTRODUCTION

The guava (*Psidium guajava* L.) is a fruit cultivated widely in the world, including the Brazilian semiarid region, and is a source of income for small family agriculture farms of the area. This fruit is considered very rich in nutritional elements and commonly consumed in natura [1]. However, post-harvest shelf-life is compromised due to a high breathing tax and consequential the fast ripening [2]. The climacteric nature of the guava limits post-harvest shelf-life between 3 to 4 days when stored in a temperature from 28 to 30°C [3]. After storage, it is necessary to evaluate the use of edible coatings as a method to reduce the losses and maintain the quality of guava during storage [4].

Biodegradable coatings are made mainly of polysaccharides, proteins, with functional additives such as vegetable and essential oils, antimicrobial agents, and antioxidants, could be applied in fruits and vegetables with the purpose of reinforcing the protective action of natural skins to prevent water losses, colouration changes, mechanical lesions and even microbial deterioration, besides providing shine to the surface [5,6].

The coatings used include arrowroot starch, which has great nutritional characteristics, joining lightness, and high digestibility, besides the absence of gluten, which makes it suitable for people with food intolerances [7]. These coatings can also be composed pomegranate seed oil to become an attractive nutraceutical ingredient, since it possesses a phytochemical composition enriched with high punicic acid and antioxidant activity, due to the presence of phenolic compounds, especially ortho-diphenols [8].

The application of edible coatings from starch represents a potential alternative in the conservation of fruits, which has been covered on several studies on the effects of these edible coverings in guava tree [9,10,4,11,12]. However, they are rare the works that treat of the conservation post harvest of fruits using obtained biofilms of rhizomes from arrowroot starch (*Maranta arundinacea* L.), associated or not to pomegranate seed oil.

Another manner of reducing post-harvest losses and to extending fruit shelf-lifeis the use of cooling, which consists of the removal of heat of the atmosphere on the location of storage. This reduces microbial activity and the breathing rates, delaying fruit senescence caused by autocatalytic production of ethylene [13].

In this context, this work aimed to the application of edible coatings of starch of associated arrowroot or not to pomegranate seed oil in the post-harvest conservation of 'Paluma' guava.

2. MATERIALS AND METHODS

The experiment was carried at Federal University of Campina Grande (UFCG), in the Center of Sciences and Technology Agro-Food (CCTA), in the laboratory of Fruits and Vegetables FROM November to December 2017. The fruits were obtained of orchards, located in the state of Pernambuco, in the Northeast region of Brazil.

The installation of the experiment was completely randomised, in a 2 x 4 factorial outline, two storage temperatures (10 ± 2°C and 20 ± 2°C, both with 85±5% UR) and four coating types; T1: without application; T2: 0.3% pomegranate seed oil; T3: arrowroot starch to 2% and T4: arrowroot starch to 2% + 0.3% pomegranate seed oil.

The fruit crop was made during the morning, where they were reelected in the field. The ones that showed signs of diseases, presence of pathogens or some mechanical damage were excluded. The samples were conditioned in a single layer, in cardboard box with dimensions of 640 x 480 cm and previously covered with bubble wrap to minimise impact and attrition. The samples were transported to the laboratory, where the fruits were selected according to size uniformity and color, discarding those with defects or apparent dame due to the transport. The samples were cleaned with a detergent solution to 1% and sodium hypochlorite solution 200 ppm of active chlorine, with immersion for 20 minutes, and subsequent rinse in water, and were later dried outdoors on a bench.

The arrowroot starch solution was prepared in a concentration of 2% (w/v), through obtaining gels of the starch that consisted of the heating of the solution to the temperature of 70°C, under constant agitation and cooled afterwards for the coating in the fruits. For the incorporation of the covering in the fruit, 0.3 ML POMEGRANATE SEED OIL WAS USED FOR 1 LITER OF THE SOLUTION OF ARROWROOT STARCH TO EMULSIFY TO MAXIMISE THE plasticisation properties of the coating. Later, the fruits were conditioned in a camera acclimatised 10± 2ºC 85±5% UR, where they stayed for 20 days, and conditioned in a camera acclimatised 20± 2°C 85±5% UR, where they stayed for 12 days, with five repetitions of two fruits per experiment. In the day of the installation of the experiment, analyses were MADE in the guavas for the characterisation of the fruits in the moment of the crop, presenting the following values, according to the Table 1.

Afterwards, the fruits were processed in domestic and appraised centrifuge for the following aspects:

Loss of fresh mass: It was accomplished 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 expressed in percentages;

Firmness of the pulp: took place 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. [14];

Coloration (peel and pulp): it was certain through the system L *, a * and b *, done by reflectometry, using a Konica Minolta reflectometer, model Chroma to put CR-400. The readings were made randomly in the equatorial area by the fruit. The measured color parameters regard to plate-pattern they were: brightness (L *), that it varies of the black color (0) to the white (100); a *, that it varies from green color (-60) to red (+60) and b *, that it varies from blue color (-60) to yellow (+60). Starting from the values L *, a *, b *, they were calculated the angle Hue (°h *) and the saturation index chromes (C *) [15];

Table 1. Initial characterisation of the guava fruits before the application of the different Coatings, UFCG, Pombal, 2018

Initials characteristics	Averages ± DP
Loss of fresh Mass (g)	113.73 ± 1.35
External brightness (L * of the peel)	52.34 ± 2.08
External chromaticity (C* of the peel)	37.39 ± 1.75
External hue angle (Hº of the peel)	180.17 ± 0.20
Internal luminosity (L* of the pulp)	69.69 ± 2.55
Internal chromaticity (C* of the pulp)	25.98 ± 2.12
Internal hue angle (Hº of the pulp)	123.42 ± 9.19
Firmness (N)	122.89 ± 3.97
Soluble solids (%)	6.22 ± 0.73
Titratable Acidity (% citric acid)	0.56 ± 0.06
Ratio	10.75 ± 0.08
Hydrogen potential	4.27 ± 0.09
Vitamin C (mg.100 g^{-1})	17.94 ± 0.83

Hydrogen potential (pH): determined directly in the pulp, in triplicate using a digital potentiometer with a glass membrane electrode, gaged with a solution lid of pH 4.0 and 7.0. (Marks Digimed DM-22), [16];

Titratable acidity (AT): certain through titration of 1 g of homogenised pulp and diluted in 50 ml of distilled water. In the sample, three drops of the phenolphthalein indicator 1% were added, proceeded by titrating under constant agitation with a solution of NaOH 0.1 N, the results were expressed in % of citric acid [16];

Soluble solids (SS): obtained through direct reading in digital refractometer mark Digital Refractometer [14];

Ratio: obtained by separating the values of soluble solids for the values of the titratable acidity.

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 a solution acid of vitamin C. Initially, 1 g of the sample was weighed in an analytical scale, and transferred later to an Erlenmeyer, completing the volume for 50 mL with oxalic acid 0.5%, obtaining an even rosy coloration permanent clearing. The results were expressed in % of ascorbic acid [14].

The data were submitted to the F test at 5% of significance through variance analysis (ANOVA) and the average Tukey test was applied. The statistical analyses were made using the software SISVAR version 5.6 [17].

3. RESULTS AND DISCUSSION

The variance analysis for the variables brightness, chromaticity, and external hue angle (peel) and internal (pulp) of the guava fruits it was influenced significantly by the different coatings and by storage temperature, showing that both factors influence simultaneously the colorimetry parameters of these fruits (Table 2).

Regarding the brightness (L *) of the fruits, was verified that when stored at 10ºC, the treatments T3 (starch) and T4 (starch + pomegranate seed oil) were more efficient, not differing statistically amongst themselves, presenting intense shine in the whole surface expresses (peel) (Fig. 1B). Both coverings were effective in the shelf life of external visual aspect of the guavas (Table 3). Changes in the coloration of fruits with the ripening happen due to degradation of the chlorophyll and/or of carotenoid synthesis, which were the main evaluation criteria for the maturation stage and maintenance of the color, which are quality attributes, since it contributes to the appearance and has direct influence in the consumer's preference [18].

The fruits without coating and stored at 20°C were subject to a faster process of ripening than the other treatments, demonstrating tone change to yellow (Fig. 1A). Results were found by Oliveira et al. [12] where they observed brightness of 65.00, after 15 days of storage under cooling in the guava fruits 'Paluma' submitted to the covering starch base for 2%. Tavares et al. [19] While studying guava covered with edible covering to the base of O-carboximetilquitosana and essential oil oregano (*Origanum vulgare*), it was observed that the coverings were efficient and contributed to the preservation of fruits presenting an intense shine all over its surface(peel). This confirmed that the total covering of the fruits provided extension of the shelf-life of the guavas after 17 days of storage.

Table 2. Summary of the analysis of variance of brightness (L*), chromaticity (C*) and hue angle (H°) external (peel) and internal (pulp) of guava fruits in function of different coatings and two storage temperatures, UFCG, Pombal, 2018

FV	GL	Medium square					
		External coloration			Internal coloration		
		L*	C*	H*	L*	C*	H*
Coating (R)	3	194.47**	337.9**	383.96**	1134.54**	422.79**	304.25**
Temperatures (T)	1	241.52**	1231.6*	197.04**	920.92**	328.73**	38.12**
R x (T)	3	13.38*	188.9**	126.28**	127.13**	43.36**	45.93**
Residue	32	2.91	7.24	6.69	23.47	13.37	4.60
Total	39						
CV (%)		2.46	5.07	2.90	6.94	7.11	2.37
General average		69.33	53.08	89.23	69.84	51.41	90.72

*ns: Not significant; * significant to 5% of probability for the test F; * * significant at the level of 1% of probability for the test F*

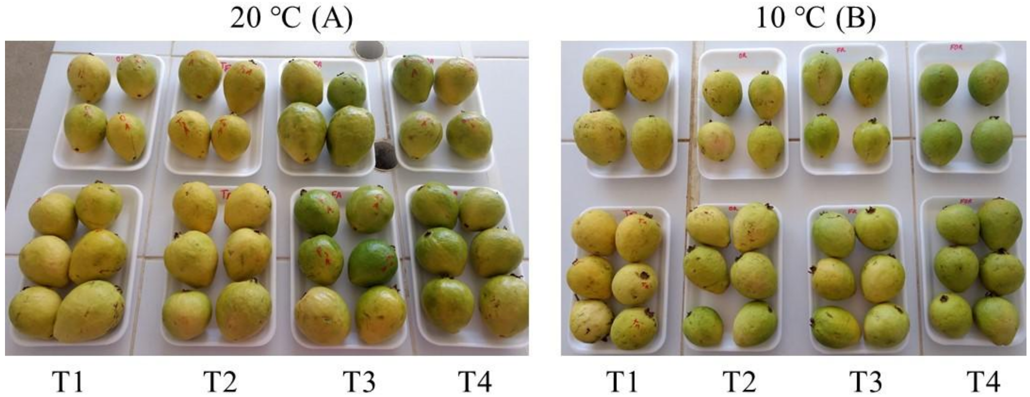

Fig. 1. Visual appearance of stored fruits 20 ± 2°C with 85±5% UR for 12 days (1A) and stored 10 ± 2°C with 85±5% UR for 20 days (1B) in function of different treatments (T1: without application; T2: 0,3% pomegranate seed oil; T3: arrowroot starch to 2% and T4: arrowroot starch to 2% + 0,3% pomegranate seed oil), UFCG, Pombal, 2018

Table 3. Brightness (L*), chromaticity (C*) and hue angle (H°) external (Peel) of guava fruits in function of different coatings and two storage temperatures, UFCG, Pombal, 2018

	Luminosidade E (L*)		Cromaticidade E (C*)		Ângulo Hue E (H°)	
	10ºC	20ºC	10ºC	20ºC	10ºC	20ºC
T1	65.90 Ca	61.45 Cb	46.27 Da	44.11 Ba	80.49 Ba	80.49 Ba
T2	70.22 Ba	66.09 Bb	55.01 Cb	49.54 Aa	97.17 Aa	82.34 Bb
T3	75.95 Aa	67.72 Bb	63.04 Ba	46.82 ABb	93.43 Aa	90.23 Aa
T4	75.09 Aa	72.23 Ab	70.21 Aa	49.67 Ab	94.72 Aa	95.01 Aa

Note. T1: without application; T2: 0.3% pomegranate seed oil; T3: arrowroot starch to 2% and T4: arrowroot starch to 2% + 0.3% pomegranate seed oil. Averages for the same capital letter in the column and lower case in the line do not statistically differ according to the Tukey test at 5% of probability

Regarding the Chromaticity (Chroma) tests, which indicate the intensity or purity of the color, high values were observed about chromes in the fruits stored in temperature to 10ºC in the treatments T3 (starch) and T4 (starch + pomegranate seed oil) expressing larger intensity of the color, what indicates living colors compared to the other appraised treatments. The treatment T1 presented lower values independently to the other treatments of the appraised storage temperature, demonstrating the efficiency of the use of biodegradable bio films and/or foodstuffs the base of arrowroot starch (Table 3). Forato et al. [20] it was demonstrated that coatings with carboxy-methylcellulose delayed the emergence of yellow color in guavas, and the films turn the most opaque fruit and delay the synthesis and the degradation of pigments that do with that the fruit acquires shine, enhancing the delay of the emergence of shine.

The Hue angle, which is related the shade of the fruit, represents the transition of green color for yellow, independent of the storage environment. In this color parameter similar behavior was observed among the evaluated environments, however, the fruits stored 10°C presented superior values compared to the stored 20°C. The treatments T2, T3 and T4 did not differ statistically amongst themselves, when stored 10°C, therefore, the metabolism of the fruit was delayed through the reduction of the breathing and consequently hindering the ripening of the fruits (Table 2). This is a relevant result, since it indicates alterations that are characteristic during the ripening, as break of chlorophyll and development of coloration yellows process that was retarded for the application of the coatings. Oliveira et al. [12] Values of angle hue similar to the found in this work of approximately 90° in guava fruits 'Paluma' were observed, after 15 days storage under cooling (12ºC and 80% UR) and covered with cassava starch at 2%.

For the internal luminosity (pulp) of the guava fruits, it was demonstrated that the treatments T2 and T4 present higher values, differing statistically of the other appraised treatments, when stored in temperature of 10ºC, being in this storage condition, still verified, higher values than the observed in the fruits stored 20°C (Table 4). This behavior demonstrates that the storage under cooling (10ºC) harnessed to the use of coverings is efficient, and contributes to the preservation of the pulp, and the slowing down in the process of maturation of the guavas, compared to the fruits without covering.

A significant difference was found in the internal chromaticity index (pulp) was among the storage temperatures, where it verified that the treatments, T2 (57.98) and T4 (59.52), they presented higher values of chromes, presenting significant difference to the other appraised treatments, when stored under conditions of refrigerated storage of 10ºC. The data reveals that higher values to the found under storage conditions to 20ºC, as presented in the Table 4. During the ripening, a consequent increase of the color index was observed and of the content of total soluble solids and this process feels initially until when the peel of the guava becomes partially yellow when there is an increase accentuated in the content of soluble solids to the beginning of the senescence.

A significant difference was observed that for Hueº of the pulp that there was between the storage temperatures and the types of appraised coatings, presenting better result in the experiment under storage conditions refrigerated to 10ºC, where it is observed that presented values of higher hue in comparison with the other treatments in the treatments of T2 and T4. Therefore, it was noticed that was observed in relation to pulp that the treatments T2 (pomegranate seed oil) and T4 (arrowroot starch + pomegranate seed oil), those preserved more the fruit, acting in the process of maturation for the guavas (Table 4). The results corroborate with introduced them for Araújo and Shirai [21], Chevalier et al. [22] for edible coverings to the hitosan-based in minimally processed broccolis and melon, respectively, whose coatings contributed for a reduction of the senescence of the fruits. Tavares et al. [19] When studying guava covered with an edible covering to the base of O-carboximetilquitosana and essential oil oregano (*Origanum vulgare*), it was observed that the coverings were efficient, and they contributed to the interior preservation of the fruits providing the slowing down in the process of maturation of the guavas.

Table 5 shows that all these variables were influenced significantly by the appraised factors (storage temperature and different coatings), except for pH, which did not present variation related to the treatments.

Table 4. Brightness (L*), chromaticity (C*) and hue angle (H°) internal (pulp) of guava fruits in function of different coatings and two storage temperatures, UFCG, Pombal, 2018

	Brightness I (L*)		Chromaticity I (C*)		Angle Hue I (H°)	
	10ºC	20ºC	10ºC	20ºC	10ºC	20ºC
T1	55.59 Ca	56.21 Ca	45.01 Ba	39.62 Cb	91.72 Ba	84.76 Cb
T2	82.78 Aa	68.99 ABb	57.98 Aa	46.32 Bb	95.95 Aa	98.54 Aa
T3	72.58 Ba	62.49 BCb	54.61 Aa	52.43 ABa	84.34Ca	84.74 Ca
T4	87.61 Aa	72.49 Ab	59.52 Aa	55.81 Ab	94.74 ABa	90.94 Bb

Note. T1: without application; T2: 0.3% pomegranate seed oil; T3: arrowroot starch to 2% and T4: arrowroot starch to 2% + 0.3% pomegranate seed oil. Averages for the same capital letter in the column and lower case in the line do not differ statistically amongst themselves for the test of Tukey to 5% of probability

Table 5. Summary of the analysis of variance of the loss of fresh mass (PM), firmness (F), Vitamina C (VIT C), titratable acidity (AT), ratio and pH of guava fruits in function of different coatings and two storage temperatures, UFCG, Pombal, 2018

FV	GL	Medium square						
		PM	F (N)	SS	VIT C	AT	*RATIO*	pH
Coating (R)	3	46.43^{**}	222.23^{**}	1.47^{**}	2182.49^{**}	0.03^{**}	11.61^{**}	0.05^{ns}
Temperatures (T)	1	24.74^{**}	295.33^{**}	17.03^{**}	12681.07^{**}	4.38^{**}	395.38^{**}	0.08^{ns}
R x (T)	3	5.84^{*}	65.19^{**}	1.23^{**}	1231.22^{**}	0.02^{**}	12.16^{**}	0.10^{ns}
Residue	32	0.44	0.67	0.17	5.80	0.001	0.89	0.29
Total	39							
CV (%)		6.18	3.76	3.72	2.64	3.77	8.04	13.53
General average		10.76	21.77	11.11	91.41	1.04	11.74	4.02

*ns: No significant; * significant to 5% of probability for the test F; * * significant at the level of 1% of probability for the test F*

Regarding the loss of fresh mass of the guava fruits, it was observed that the largest mass loss were in the treatments T2 (pomegranate seed oil) and T1 (without bio film application) when stored in a temperature of 20°C. The treatments T3 (starch) and T4 (starch + pomegranate seed oil) reduced the loss of mass of the fruits significantly compared to other treatments. However, they did not differ statistically amongst themselves, independently of the temperature of which the fruits were stored (Table 6). This behaviour is related to use of the biodegradable covering such as arrowroot starch, due to 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 [23,24,25].

It was discovered that although the temperature of storage of 10°C was efficient in the reduction of the loss of fresh mass (Table 6), what can be explained for Sandri et al. [26] is that the synthesis of compositions during the ripening process can vary according to storage and environment. Cooling provides an increase of shelf-life compared to room temperature, the intermediate products of the breathing metabolism of the fruit, as well as organic acids, modify the flavor, the aroma, the color, the stability in the reduction of the loss of fresh mass and, consequently, the quality of the fruit.

Regarding the firmness of the fruits, it was observed that the temperature of 10°C associated to the treatments T3 and T4 lead to fruits with higher firmness, while to the lowest firmness was observed in the treatment T1 in the two appraised storage temperatures. This demonstrates that the coatings associated to the cooling as soon as in the appropriate temperature to delay the breathing and consequently the metabolisms of the guava fruits, making this a viable alternative in the maintenance of the quality powders crop of these fruits (Table 6).

According to Botelho et al. [11], the firmness of the fruits can reduce the firmness in the post-harvest period, as a consequence of the action of enzymes such as pectinamethylesterase, polygalacturonase, cellulose, and others that act attacking the structural carbohydrates responsible for the firmness of the vegetable fabrics that act at cellular wall level, during the ripening, decomposing macromolecules such as pectins, cellulose, hemicellulose, and starch. Therefore, the use of the starch the base of associated arrowroot or not to the pomegranate oil can reduce the performance of these enzymes enhancing the quality of the fruits. Similar behavior was obtained for [12] studying the use of edible coverings to the base of cassava starch associated to cooling in the quality of post-harvest guava "Paluma", verifying that the use of the covering acts as physical barrier delaying the loss of firmness of the fruits compared to other fruits without this biofilm application.

Regarding content soluble solids, data shows that the treatments (T1, T2, T3 and T4) did not differ statistically when stored in the temperature of 20°C, however, when stored at 10°C, it was observed that the treatment T2 and T3 presented the lowest and highest content of soluble solids, respectively. The fruits stored under cooling (10°C) presented a smaller content of soluble solids compared to storage at 20°C (Table 6). The smallest content of soluble solids observed in the fruits stored in suave temperature (10°C) associated to the coatings it is related with the reduction of the breathing rates and of the mass loss due to lower impermeability to the humidity and gases (CO_2 and O_2), consequently reducing metabolic rates and therefore favoring the maintenance of the content of soluble solids [24]. Oshiro et al. [9] Evaluating the post-harvest shelf-life of guavas 'Pedro Sato' in modified environment, associated or not to the cooling and the use of arrowroot starch, it was observed for the content of soluble solids of

Table 6. Loss of fresh mass, firmness, and soluble solids of guava fruits regarding different coatings and two storage temperatures, UFCG, Pombal, 2018

	Loss of fresh mass (%)		Firmness (N)		Soluble solids (°Brix)	
	10ºC	20ºC	10ºC	20ºC	10ºC	20ºC
T1	11.49 Bb	13.13 Aa	17.93 Ca	15.71 Db	10.34 Bb	11.90 Aa
T2	12.77 Aa	13.07 Aa	19.06 Ca	18.36 Ca	9.62 Cb	11.80 Aa
T3	8.04 Cb	10.19 Ba	28.62 Ba	21.83 Ab	11.33 Ab	11.96 Aa
T4	7.62 Cb	9.82 Ba	32.36 Aa	20.32 Bb	10.80 ABb	11.66 Aa

Note. T1: without application; T2: 0.3% pomegranate seed oil; T3: arrowroot starch to 2% and T4: arrowroot starch to 2% + 0.3% pomegranate seed oil. Averages for the same capital letter in the column and lower case in the line do not statistically differ amongst themselves for the test of Tukey at 5% of probability

Table 7. Vitamin C, titratable acidity and ratio of the guava fruits regarding different coatings and two storage temperatures, UFCG, Pombal, 2018

	Vitamin C (mg 100^{-1})		Titratable acidity (% citric acid)		Ratio	
	10ºC	20ºC	10ºC	20ºC	10ºC	20ºC
T1	108.27 Ba	50.20 Bb	1.50 Aa	0.75 Ab	7.93 Ab	13.76 BCa
T2	103.48 Ca	52.58 Bb	1.30 Ba	0.75 Ab	9.07 Ab	12.81 Ca
T3	110.89 Aba	97.75 Ab	1.36 Ba	0.74 Ab	8.81 Ab	15.30 Ba
T4	114.24 Aa	93.93 Ab	1.36 Ba	0.61 Bb	8.59 Ab	17.68 Aa

Note. T1: without application; T2: 0.3% pomegranate seed oil; T3: arrowroot starch to 2% and T4: arrowroot starch to 2% + 0.3% pomegranate seed oil. Averages for the same capital letter in the column and lower case in the line do not statistically differ themselves for the test of Tukey at 5% of probability

the fruits stored with a coating of 3% of arrowroot starch at 10°C presented 12,58 °Brix.

The vitamin data C of the guava fruits regarding the coatings and of the storage temperatures demonstrated higher values when stored at 10°C compared to those stored at 20°C. The largest vitamin C content was observed in the treatment T3 followed by T4, differing statistically of the other appraised treatments, when stored at 20°C, and the lowest value was observed in the treatment T1 in this same temperature. Though stored at 10°C, it was verified that the treatment T4 presented results higher than other treatments (Table 7). Lima et al. [27], when evaluating the use of bio-organic coatings, found that the degradation of vitamin C (ascorbic acid) can be minimised through the use of these coatings, since fruits treated with starch and sweet herb present a larger content of this vitamin compared to control groups (without application of the covering), after 15 days of storage at 10°C. Similar behaviour was observed for Oliveira et al. [12] that studying different concentrations of edible coatings associated to the cooling in the post-harvest quality of guava fruits, they verified higher values of vitamin C in the fruits that were covered with a 2% concentration of cassava starch compared the control group (without bio film application).

Analysing the titratable acidity of the guava fruits, it was verified that there was no significant difference among the appraised treatments when stored at 10°C, however, at 20°C, it was obtained higher values in the treatments T1, T2, and T3, not statistically differing amongst themselves, and the treatment T4 presented the smallest values in the same storage conditions (Table 7). Cerqueira et al. [18] To evaluate the covering of guavas with protein films and chitosan in different concentrations, no significant differences in the titratable acidity of the covered fruits was identified, compared to control groups (without covering). The content of organic acids, with few exceptions, decreases with maturation, due to the breathing process or of his/her conversion in sugars. A similar effect was observed for [28] to the evaluate the post-harvest shelf-life of guavas 'Kumagai', they verified reduction of the acidity in the pulp of these fruits when stored 21°C and when stored under cooling presented higher values. This result is related the intensity of the breathing process. Soares et al. [29] verified higher values for the titratable acidity of the pulp of guavas 'Pedro Sato' when stored without coating (control group), in relation to those covered with film of starch and chitosan 1.5%, after 12 days of storage at 22ºC.

In the results of the ratio, it was observed that fruits stored at 10°C presented lower values to the stored in a temperature of 20°C, however, the appraised coatings didn't differ amongst themselves when stored 10 °C. The largest value of this ratio was verified in the treatment T4, when stored 20°C, and the smallest value was obtained in the treatment T1 when stored at 10°C (Table 7). The ratio is very important since it provides indicative of the flavour of the product, consequence of the variation among the representatives with a sweet and acid flavour of the product [30]. Oliveira et al. [12], when evaluating different concentrations of starch associated with cassava cooling, verified lower values than the observed in this work for ratio. Demonstrating that the use of the arrowroot starch associated to the use pomegranate seed oil contributes to the maintenance of high content of this ratio.

4. CONCLUSION

The use of coating based on arrowroot starch to 2%, was shown to be efficient in the control of the ripening of the guavas stored in different temperatures.

Moreover, the coating of arrowroot starch to 2% + 0.3% pomegranate seed oil was more efficient in the reduction of the breathing rate of guava fruits, providing the maintenance of the post-harvest shelf-life of the fruits in both temperatures.

The coating of arrowroot starch 2% + 0.3% pomegranate seed oil provided a better shelf life in guavas for 20 days of storage the temperature of 10 ± 2°C with 85±5% UR.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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