

Post-Harvest Quality Of The Papaya 'Golden' Submitted Different Biodegradable Coatings And Conditions Of Storage

ABSTRACT

The papaya (*Carica papaya* L.) is a climacteric fruit and fragile, standing out for presenting a wide report of problems with pathogens, responsible for significant losses in the production and after the crop, becoming necessary the use of techniques that seek to contain the ripening for a certain period, aiding in the reduction of these losses. In this context it was aimed at to evaluate the conservation post-harvest of papaya fruits 'Golden' submitted the biodegradable coatings the potato starch base, associate or no to essential oil of grass lemon in different storage conditions. The experiment was conducted in a completely randomized design, with two factorial outlines, where the first was 3x6, corresponding to three coating techniques: testifies (T1: without coating), potato starch to 2% (T2), potato starch to 2% with essential oil of grass lemon to 1% (T3) and six evaluation periods (0, 4, 8, 12, 16 and 20 days), stored under cooling ($10 \pm 2^{\circ}\text{C}$ for 12 days and later transferred for condition to adapt of $25 \pm 2^{\circ}\text{C}$ for more 8 days). In the second experiment the factorial outline was adopted 3x4, acted by three coating techniques: (T1), (T2) and (T3) and four evaluation periods (0, 4, 8 and 12 days), stored in condition adapts ($25 \pm 2^{\circ}\text{C}$), with three repetitions of two fruits for portion. The potato starch coating to 2% associated to the essential oil grass lemon and the cooling, controlled the maturation and it still potentiated more his/her efficiency in the control of the anthracnose.

Keywords: *Carica papaya* L.; potato starch; essential oil grass lemon; conservation.

1. INTRODUCTION

The cultivation of the papaya has been growing significantly in Brazil, however, it presents a great challenge in the production of fruits with quality powder-crop. In 2016, the world production of papaya reached 12,85 million tons, being Brazil the second producing largest, with 11% of the world production [9]. The papaya is a climacteric fruit, soon it happens the ripening quickly after the crop of the fruit, caused by the production autocatalytic activity of ethylene and increase of the breathing tax, what turns these perishable fruits after the crop [1,28]. Due that high perishability, the control of the maturation is fundamental for the increase in the useful life after the crop, seeking the internal market and export of fruits.

The cultivar Golden (*Carica papaya* cv. Golden) represents most of the fruits exported to the North American and European markets [11]. The cultivation of the papaya stands out for presenting a wide report of problems with phytopathogens, responsible for significant losses in the production [14]. Among the fungal diseases that cause losses and it reduces the quality powder-crop of papaya fruits stand out, the anthracnose, caused by *Colletotrichum gloeosporioides* and the *Phoma caricae-papayae* caused by the rottenness in the stalk.

The anthracnose is the most important, for causing lesions in the peel that commit the appearance, besides affecting the pulp, carting great damages in the commercialization, due

30 to appearance of the fruits one of the parameters of qualitative evaluation more used by the
31 consumers [5].

32 Several methods are used to inhibit the development of these mushrooms, being the most
33 common the use of synthetic fungicides due to effectiveness in the control, however, not
34 always it is respected the dosage and the period of grace of these products, as well as the
35 active beginning is not registered, offering like this risks and irreparable damages to the
36 atmosphere and the consumer's health [15,20].

37 Before this, some studies were accomplished looking for the use of alternative methods as
38 the application of waxes and of extracted essential oils of plants, constituting like this a
39 viable and desirable alternative for the inhibition of diseases powder-crop, caused by the
40 antifungal properties of the oil, which inhibited the directly pathogen, controlling the
41 diseases, and minimizing the damages to the environment and the public health [20, 21].
42 However, the use of essential oils in the conservation of foods can be limited because of
43 their application costs, intense aroma and the potential toxicity of some composed that are
44 present [27].

45 The main forms used for maintenance of the quality of fruits are the use of polymeric
46 coatings, cooling, modified atmosphere and irradiation [12]. The starch is one of the
47 biopolymers more used for elaboration of coatings, in reason of the smallest cost and high
48 readiness. Besides being biodegradable when thrown in the environment, this way,
49 contributing to a smaller pollution of the nature [13, 2].

50 Along life powder-crop, the papaya when destined for export and internal market, that has
51 certification pass for careful processes, initially in the crop until improvement all of the
52 procedures are accomplished with the fruits stored in room temperature, later after having
53 classified in agreement with quality they are put under cooling until arriving in final destiny, in
54 other words, to the consumer. Before this the use of biodegradable coatings associated with
55 the cooling seeks to maintain the appearance and the prolongation of the quality powder-
56 crop of the fruit in chain logistics.

57 In this context, this work had as objective evaluates the conservation powder-crop of papaya
58 fruits 'Golden' submitted the biodegradable coatings the potato starch base, associate or no
59 to essential oil of grass lemon in different storage conditions.

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62 2. MATERIAL AND METHODS

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64 The experiment was developed in the Federal University of Paraíba (UFPB) in the Center of
65 Technology and Regional Development in the laboratories of physiochemical analysis of
66 foods, microbiology of foods and processing of foods. The papaya fruits (to cultivate
67 'Golden') used in this experiment were coming of the orchards of a located farm in
68 Mamanguape, Paraíba. The essential oil of the grass lemon (*Cymbopogon citratus*) it was
69 acquired of Ferquima Ind. and with. Ltda at Vargem Grande Paulista, São Paulo, Brazil.

70 The crop was accomplished in the period of the morning, where the fruits were in an area
71 that had incidence of contamination for the anthracnose. The maturation of the fruits was
72 determined visually, having been selected those that presented with the following
73 characteristics: fruit that she present changing of color, whose first yellowing signs don't
74 collect more than 15% of the peel. Soon afterwards they were conditioned in only layer, in
75 cardboard boxes with dimensions of (640 x 480 cm) previously covered with the sack bubble
76 to minimize the impact and the attrition among the same ones and transported to the

laboratory where the fruits were selected as for the size uniformity and color, discarding those with defects or apparent offenses due to the transport. The processing began with the wash of the fruits being accomplished with average drinking water and the cleaning with solution chlorinated to 100 ppm of active chlorine by 2 minutes, letting to dry them naturally in paper towel.

The potato starch solution was prepared in the concentration of 2% (m/v) [18]. Through gelling of the starch that consisted of the heating of the solution to the temperature of 70°C, under constant agitation being cooled later for the coating in the fruits. For the incorporation of the essential oil of grass-lemon to the coatings, 10 mL of the essential oil of grass-lemon was used for each liter of the potato starch solution. The essential oil was mixed with Tween 40 (0,1% mL L-1) and glycerol (1,5% mL L-1) with the purpose of to emulsify and to maximize the plastification properties of the coating [6].

The experiment was conducted in a completely randomized design with two factorial schemes, with two factorial outlines, where the first was 3 x 6, corresponding to three coating techniques: testifies (T1: without coating), potato starch to 2% (T2), potato starch to 2% with essential oil of grass lemon to 1% (T3) and six evaluation periods (0, 4, 8, 12, 16 and 20 days), stored under cooling ($10 \pm 2^\circ\text{C}$ for 12 days and later transferred for condition to adapt of $25 \pm 2^\circ\text{C}$ for more 8 days). In the second the factorial outline 3 x 4 was adopted, acted by three coating techniques: (T1), (T2) and (T3) and four evaluation periods (0, 4, 8 and 12 days), stored in condition adapts ($25 \pm 2^\circ\text{C}$), with three repetitions of two fruits for portion.

Soon afterwards the coating were applied to the fruits by immersion of these for 1 minute, letting to drain the excess on a grating and, after complete drying of the coverings, they were put and stored under two temperatures, being on average of $25 \pm 2^\circ\text{C}$ and $10 \pm 2^\circ\text{C}$ and later $25 \pm 2^\circ\text{C}$ for subsequent evaluation. To each evaluation period, the fruits were processed in it centrifuges maidservant and appraised as for the following aspects:

Loss of fresh mass (PMF): certain for gravimetry in semi scale analytical of precision of $\pm 0,01\text{g}$. The results were expressed in percentile losses, being used the relationship before among the loss mass and after each storage period.

Total titratable acidity (ATT): certain in agreement with methodology recommended by the Instituto Adolfo Lutz (2008), being used 10 grams of homogenized pulp and diluted in 100 mL of distilled water, following by titration with standardized solution of NaOH 0,1N, using as indicator the point of turning point of phenolphthalein. The results were expressed in citric acid g by 100g-1 of the sample.

Total soluble solids (SS): accomplished directly of the homogenized pulp, for reading in digital refractometer (model PR - 100, Palette, Atago Co., LTD., Japan) - expressed in °Brix [4].

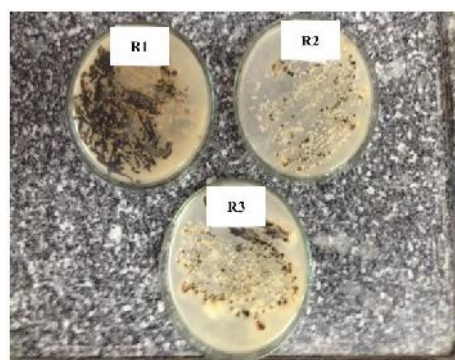
Relationship soluble solids and titratable acidity: calculated the relationship between soluble solids and the acidity titratable acidity (SS/AT). The results were expressed in pure number, with a decimal house.

Hydrogen ionic potential (pH): certain through digital pH meter of having supported for direct reading in the homogenized pulp, accordingly [16].

Total soluble sugars and reducers: they were certain for the method of Lane and Eynon, through titration, based on the reduction of the copper for the groups reducers of the sugars,

121 being used reagent of Fehling, that is composed by a solution A (sulfate of crystalline copper
122 in water) and a solution B (sodium and potassium tartrate and hydroxide of sodium in water)
123 with methylene blue indicator. The results were expressed in percentage of glucose 100g⁻¹,
124 according to methodology of the [16].

125 Isolation and identification of the fungus *C. gloeosporioides*: was isolated directly of the
126 papaya fruits "Golden" with symptoms of the disease and pathogen signals, as presented in
127 the Figure 1. Inside of a flow chapel to laminate, using a loop of sterile platinum on top of the
128 injured fruit with the anthracnose and it was transferred for the petri plate containing the
129 middle of culture BDA. The culture BDA (potato, dextrose, ágar), it was prepared with 250g
130 of potato, 20g of dextrose and 20g of ágar for liter of water. 500 mg was added L-1 of
131 ampicillin antibiotic to avoid the contamination for bacteria. 20 mL of middle of culture were
132 flowed by plate of Petri. Soon afterwards they were incubated to 25°C by five days.



133

134 **Figure 1. *C. gloeosporioides* isolated in plates (different repetitions: R1; R2 and R3)**
135 **polluted papaya fruits of the Farm João Pessoa, UFPB, 2018.**

136 Statistical analysis: The data were submitted to the variance analysis and of regression
137 through the Program Sisvar [10].
138

139 3. RESULTS AND DISCUSSION

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141 The variance analysis for the variables mass loss, pH, total soluble solids, titratable acidity
142 total, relationship soluble solids and titratable acidity, sugar total and reducers in function of
143 the different biodegradable coating during the storage period in two storage conditions, in
144 the Table 1. Observed that there was significant interaction ($p < 0,05$) for all the appraised
145 variables, demonstrating that the appraised factors interfere simultaneously in the
146 conservation powders crop of the papaya fruits 'Golden'.

147 **Table 1. Summary of the analysis of variance of the mass loss (PM), pH, total soluble**
148 **solids (SST), titratable acidity total (ATT), sugars total and sugars reducers, in**
149 **function of different biodegradable coatings in the conservation powders crop of**
150 **papaya fruits 'Golden', during the storage to $10 \pm 2^\circ\text{C}$ for 12 days and later transferred**
151 **for $25 \pm 2^\circ\text{C}$ (Refrigerated / Environment until 20 days and $25 \pm 2^\circ\text{C}$ (Environment),**
152 **UFPB, 2018.**

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Fruits stored in condition adapts (without cooling)								
FV	GL	Medium square						
		PM	pH	SST	ATT	SS/AT	Sugars total	Sugars reducers
Coatings (R)	2	371,29**	0,01*	9,47**	0,66**	10,80**	2,23**	4,13**
Times (T)	3	8335,6**	0,53**	141,91**	2,16**	16,28**	5,05**	10,56**
R x T	6	277,1**	0,03**	3,29**	0,46**	13,58**	0,34**	0,65**
Residue	24	0,29	0,07	0,01	0,01	0,83	0,01	0,007
CV (%)	-	1,50	0,97	1,08	7,65	14,44	3,33	3,25

Fruits stored under refrigerated / environment								
FV	GL	Medium square						
		PM	pH	SST	ATT	SS/AT	Sugars total	Sugars reducers
Coatings (R)	2	41,19**	0,21**	14,16**	0,33**	2,47**	0,13**	0,61**
Times (T)	5	5227,99**	1,74**	132,61**	4,30**	7,65**	7,24**	13,42**
R x T	10	41,48**	0,10**	6,53**	0,63**	2,47**	0,22**	0,49**
Residue	36	1,74	0,004	0,01	0,01	0,09	0,008	0,009
CV (%)	-	4,97	1,20	1,43	6,78	5,50	2,39	3,23

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158 ** significant (P <0,01); * significant (P <0,05); ns: no significant

159 In relation to the data of loss of fresh mass, growing lineal behavior was observed during the
160 storage period and that in both temperature conditions the largest losses were registered for
161 the fruits without covering application (T1) 61,22% and 80,03% (Figure 2A and 2B). The
162 smallest losses were verified in the treatment T3 (potato starch to 2% with essential oil of
163 grass lemon to 1%) to the temperature when associates the cooling (Figure 2A), which
164 reached inferior values to 30,86% to the 12 days of storage and later transferred for 25 ±
165 2°C up to 20 days with 54,43%, while the fruits stored under room temperature the smallest
166 values of loss of fresh mass were obtained in the treatment T2 (potato starch to 2%) with
167 56,11% (Figure 2B).

168 The treatment T2 promoted the largest mass loss, while the treatment T3 presented to
169 smallest, as presented in the Figure 2A. That result is associated the non addition of the
170 glycerol and Tween 40 in the treatment T2, which adhered to the fruit working as barrier
171 reducing like this the loss of water for the perspiration. Results fellow creatures were
172 observed by Azeredo et al. [6] to the they evaluate the quality of the mango 'Tommy Atkins'
173 covered with cassava starch associated to essential oils and chitosan, they verified that
174 when the fruits were submitted to 24°C, covered with starch and associated to essential oil
175 they showed to smallest mass loss in relation to the other coatings.

176 The uses of the biodegradable coatings restrict the diffusion of the steam of water and
177 create an atmosphere saturated between the film and the surface of the fruits, reducing the
178 perspiration, however, due to the character hydrophilic of the coatings to the polysaccharide-
179 based, these don't usually constitute barriers to the steam of water [24].

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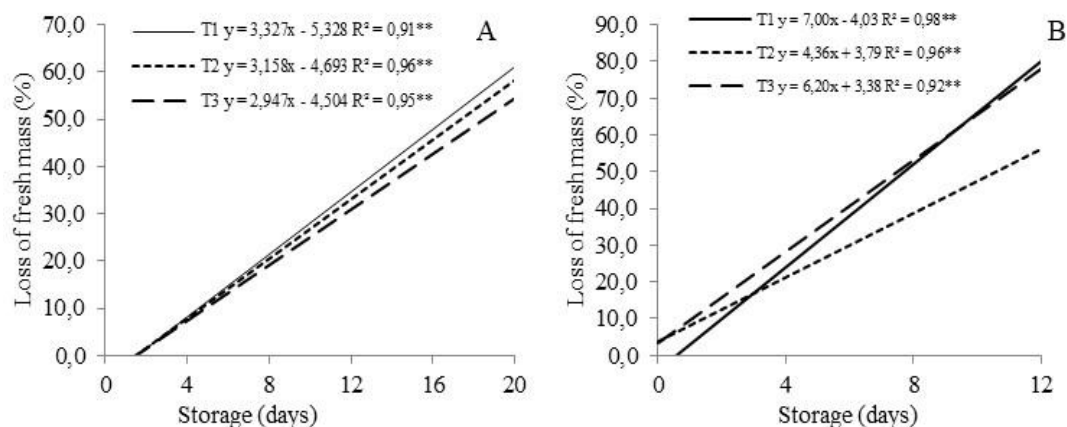


Figure 2. Loss of fresh mass of papaya fruits submitted the different coatings (T1: without coating; T2: potato starch to 2% and T3: potato starch to 2% with essential oil of grass lemon to 1%), stored under refrigerated / environment (A) and in room temperature (B) and in function of the storage, UFPB, 2018.

In the pH of the papaya fruits 'Golden' stored under cooling was observed that the data were not adjusted an equation of polynomial regression, happening oscillation in the medium values in function of the storage, with decrease in the first days of storage, following by an increase with subsequent decline starting from the 16^o day of storage in the respective treatments T1 (5,0), T2 (5,1) and T3 5,1, soon afterwards happened an increase of the medium values of pH of 5,9, 5,9 and 6,3 for the treatment T1, T2 and T3, respectively (Figure 3A). That decline of the pH happened due to formation of organic acids and sugar in relationship with the breathing, increasing the metabolism with the increase of the temperature.

Verified, in the Figure 3B, that the pH of the fruits presented quadratic behavior for all of the appraised treatments with dear minimum of 5,09, 5,42 and 5,37 both to the 6 days of storage for the treatments T1, T2 and T3, respectively. Similar behavior was observed by Nunes et al. [19] evaluating the conservation of the beautiful papaya obtained values of pH 5,3 for the witness, 5,4 for the fruits treated with biofilm of cassava starch to 2% and of 5,4 for the ones of the biofilm of cassava starch to 4% under temperature of $10 \pm 2^{\circ}\text{C}$ during the period of 12 days.

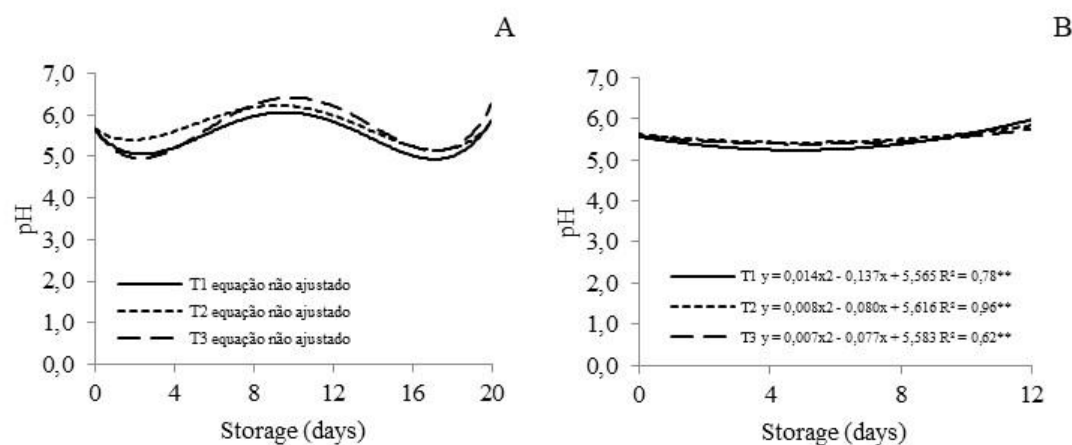


Figure 3. pH of papaya fruits submitted the different coatings (T1: without coating; T2: potato starch to 2% and T3: potato starch to 2% with essential oil of grass lemon to 1%), stored under refrigeration / environment (A) and in room temperature (B) and in function of the storage, UFPB, 2018.

The tenor of solids soluble total is in the Figure 4A and B. Verified that the treatments maintained in the two storage conditions presented growing lineal behavior with increase of 11,3°Brix, 9,7°Brix and 11,0°Brix, in the treatments T1, T2 and T3, respectively, among the first and evaluation period, when stored under cooling, while the fruits stored in conditions atmosphere increased 15,3 °Brix in the treatment T1, 13,7°Brix in the treatment T2 and 15,3°Brix for the treatment T3. The treatments T2 and T3 delay the ripening of the fruits owed reduction of the breathing tax, and when combined the cooling $10 \pm 2^\circ\text{C}$ starts to have larger efficiency in the reduction of the soluble solids (Figure 4A). In the room temperature $25 \pm 2^\circ\text{C}$ increased the index of soluble solids with the storage period, in other words, they reached much faster the maturation in the treatments T1, T2 and T3 with dear values of 15,9°Brix, 15,2°Brix and 13,9°Brix (Figure 4B). The use of the cooling and the coating of the potato starch reduces the breathing activity, causing smaller hydrolysis of reservation's carbohydrates accumulated during the growth of the plant and production of you sugar soluble and, consequently, smaller ripening [17]. Ali et al. [1] also verified that covered fruits of chitosan during the refrigerated storage presented small decrease in the concentration of soluble solids along the time of storage.

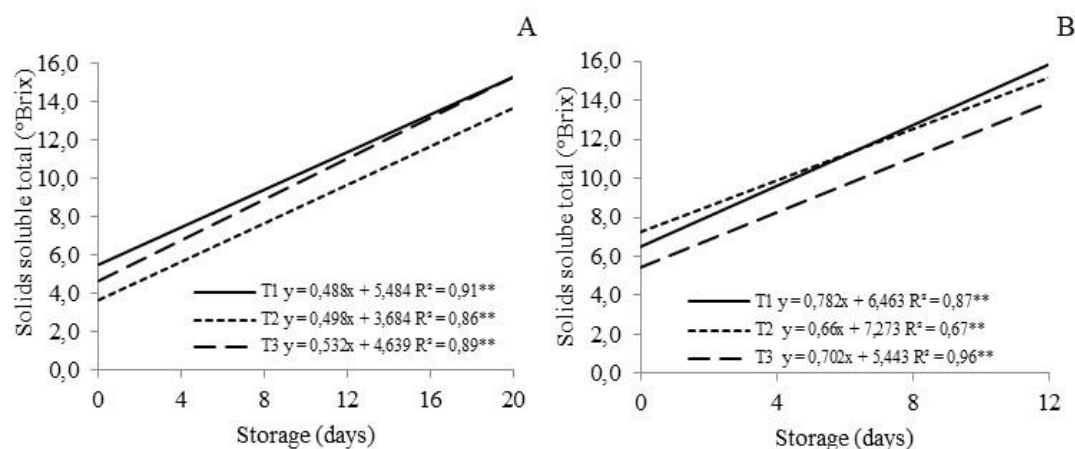


Figure 4. Solids soluble total of papaya fruits submitted the different coatings (T1: without coating; T2: potato starch to 2% and T3: potato starch to 2% with essential oil of grass lemon to 1%), stored under refrigeration / environment (A) and in room temperature (B) and in function of the storage, UFPB, 2018.

The total titratable acidity of the papaya fruits 'Golden' stored under cooling presented quadratic behavior for all of the appraised treatments, which the treatment T1 and T2 reached dear minimum of 0,74% and 0,56% to the 2 and 6 days, respectively, increasing after this period, while the treatment T3 presented light increase in function of the evaluation periods, as maximum of 1,24% to the 20 days (Figure 5A). However, the fruits stored in condition adapts also presented quadratic effect with dear maximum of 1,86% and 1,47% in the treatments T1 and T2, respectively, to the 12 days of storage. The treatment T3 stored in these same conditions presented behavior inversely proportional to the other treatment with dear maximum of 1,18% to the 8 days, reducing later in function of the storage (Figure 5B).

The increase observed in the total titratable acidity is related with to the loss of water and the largest concentration of acids. This increase also the degradation of the pectin is associated and to the formation of acidsgalacturonics, as the cellular wall was degraded in the ripening process [19].

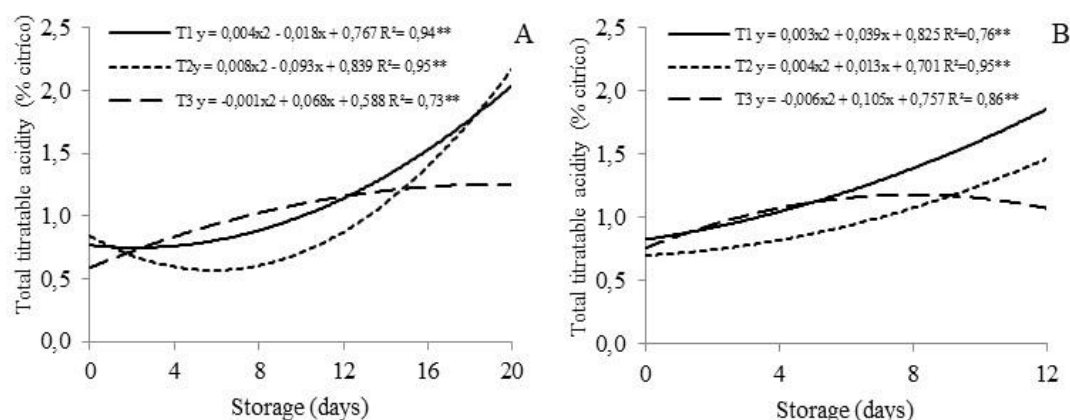


Figure 5. Total Titratable Acidity of papaya fruits submitted the different coatings (T1: without coating; T2: potato starch to 2% and T3: potato starch to 2% with essential oil of grass lemon to 1%), stored under refrigeration / environment (A) and in room temperature (B) and in function of the storage, UFPB, 2018.

The relationship soluble solids and titratable acidity presented quadratic behavior in the treatments T1, T2 and T3, increasing in function of the storage with dear maximum of 6,03, 6,29 and 17,23 to the 10, 11 and 20 days after this period reduction of this relationship was observed when stored under cooling (Figure 6A). In the Figure 6B it was verified that the relationship soluble solids and titratable acidity of the fruits stored without cooling presented quadratic behavior with dear maximum of 6,84 and 10,05 to the 7 and 6 days of storage, in the treatments T1 and T2, respectively, reducing after this period, however the treatment T3 increased until the end of the storage, period in that it presented maximum of 8,10. Therefore it can be affirmed that the treatment T3 maintained the largest degree of sweetness if compared to the other treatments at the end of the storage period in both storage conditions (Figure 6A and B). Zillo et al. [27] evaluating the carboxymethylcellulose covering associated to the essential oil of rosemary (*Lippia sidoides*) in the conservation of the papaya, it also observed that the relationship soluble solids and titratable acidity increased during the storage up to 9 days with maximum of 11,50 when the treatment associated with the essential oil was had.

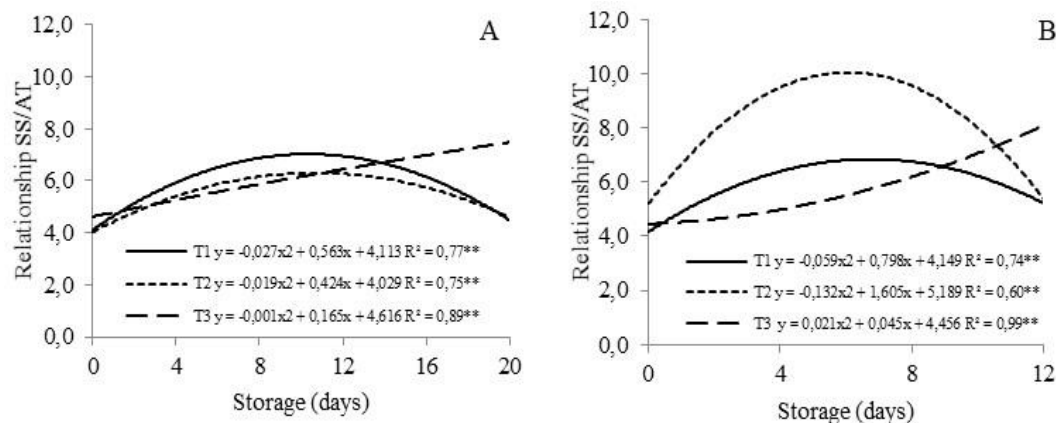


Figure 6. Relationship soluble solids and titratable acidity of papaya fruits submitted the different coatings (T1: without coating; T2: potato starch to 2% and T3: potato starch to 2% with essential oil of grass lemon to 1%), stored under efrigeration / environment (A) and in room temperature (B) and in function of the storage, UFPB, 2010.

Analyzing the tenor of you sugar total of the papaya fruits 'Golden' submitted the different biodegradable coatings, increase was verified in function of the progress of the storage in all of the treatments independently of the conditions in that the fruits were stored. The treatments T1, T2 and T3 when stored under cooling presented lineal behavior with increase of $41,81g.100g^{-1}$, $47,94g.100g^{-1}$, and $44,07g.100g^{-1}$, respectively, between the beginning and the end of the storage period (Figure 7A). The fruits stored without cooling presented behavior similar to the stored under cooling, with superior values in the treatments T1 and T2 with increase of $41,45g.100g^{-1}$ and $37,77g.100g^{-1}$, already the treatment T3 presented the smallest increase $21,82g.100g^{-1}$ in the tenor of sugar (Figure 7B).

According to Chitarra & Chitarra [7] the increases of total sugars are associated to the increases happened with the tenor of soluble solids, although the measurement of these, doesn't represent the exact tenor of the sugars, because other substances also one find dissolved in the vacuolar sap (vitamins, phenolic, pectins, organic acids, etc.), however, among those, the sugars are the most representative, getting to constitute up to 85-90% of the soluble solids. Teodosio et al. [26] to the they evaluate the effect of the biodegradable coatings based on microalgae and oil of the seed of the pomegranate in the conservation powder-crop of the papaya 'Golden' under controlled temperature of $18^{\circ}C$, for 15 days, did they verify that the fruits presented the largest tenors of sugar total at the end of the experimental period.

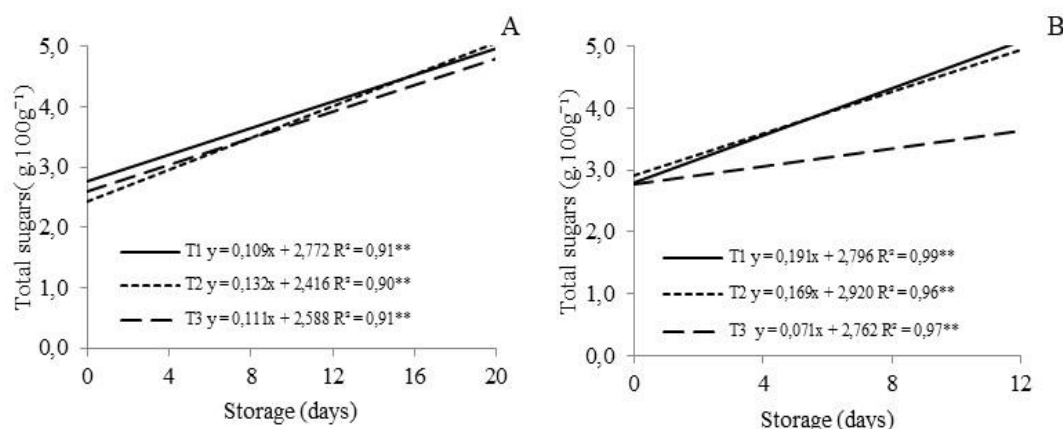
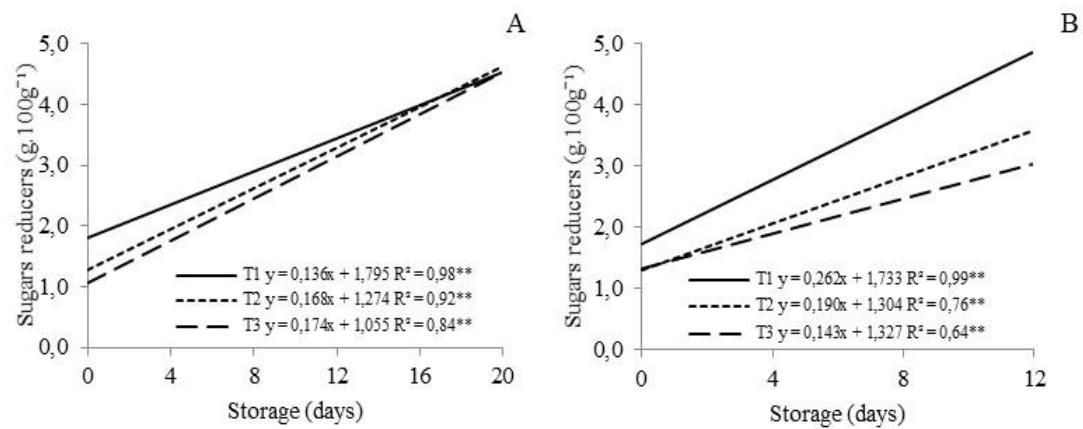


Figure 7. Total sugars of papaya fruits submitted the different coatings (T1: without coating; T2: potato starch to 2% and T3: potato starch to 2% with essential oil of grass lemon to 1%), stored under refrigeration / environment (A) and in room temperature (B) and in function of the storage, UFPB, 2018.

In the tenor of sugar reducers growing lineal behavior was verified in both appraised treatments in the two storage conditions, however, when stored under cooling presented increase of 4,53g.100g⁻¹, 4,64g.100g⁻¹ and 4,54g.100g⁻¹, in the treatments T1 and T2 and T3, respectively, between the beginning and the end of the storage (Figure 8A). The fruits stored in condition adapts, in other words, without cooling they presented lineal behavior with increase of T1 4,88g.100g⁻¹, T2 3,59g.100g⁻¹ and T3 3,05 g.100g⁻¹ until the last appraised period (12 days), demonstrating that you value superiors in T1 if compared to the other treatments (Figure 8B).

This behavior observed in the tenor of you sugar reducers can be associated to the fact of the papaya fruits be climacteric fruits, be picked before the beginning of the storage, and they only reach that phase, when they cross the breathing pick of the climacteric. Before this, considerable modifications are verified in the tenors of sugar of the fruits, which increase after the crop and during storage [7]. Reis [22] to the they evaluate the conservation powder-crop of Beautiful papaya "Tainung 1" under storage refrigerated in camera to 10°C, for 21 days, verified that the treatments (testifies, chitosan 2%, chitosan 4%) provided the largest tenors of sugar reducers and total at the end of the storage period.



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321 **Figure 8. Sugars reducers of papaya fruits submitted the different coatings (T1:**
 322 **without coating; T2: potato starch to 2% and T3: potato starch to 2% with essential oil**
 323 **of grass lemon to 1%), stored under refrigeration / environment (A) and in room**
 324 **temperature (B) and in function of the storage, UFPB, 2018.**

325 **Identification of the fungus *C. gloeosporioides***

326 Its identification was made through preparations in sheets and observation to the light
 327 microscope, the *C. gloeosporioides*, was identified basing on their morphologic
 328 characteristics in agreement with [25].

329 In relation to the coloration of the colonies, all the isolated of *Colletotrichum* spp. they came
 330 plenty heterogeneous, varying of white the dark ash, indicating that such an isolated ones
 331 are *C. gloeosporioides* (Figure 1). Andrade et al. [3] they characterized twenty-nine cultures
 332 of *Colletotrichum*, isolated of papaya tree fruits. The characterization was based, among
 333 other aspects, in the morphology of the conidia, coloration and growth of the colonies. With
 334 base in the morphology of the conidia the isolated 29 were identified as *C. gloeosporioides*,
 335 tends most of the isolated cylindrical conidia and/or oblaced, in contrast with *C. acutatum*,
 336 isolated of strawberry, that presented fusiform conidia.

337 **Presence of visual symptoms of diseases post-harvest in the fruits**

338 During the 20 days of transport of the experiment, the fruits were accompanied being
 339 observed the development of characteristic symptoms of diseases that attack the powder-
 340 crop of fruits, being considered that these fruits are originating from of Farm João Pessoa,
 341 which the great incidence of diseases powder-crop is described. The development of the
 342 anthracnose was observed in the treatment T1 when stored in condition adapts ($25 \pm 2^\circ\text{C}$),
 343 meantime in the treatments T2 and T3, was not verified any accuse of the anthracnose.
 344 Before this, is possible affirms that the use of associated potato starch or not to the oil of
 345 grass lemon it was efficient and viable in the control of fungal diseases, because the
 346 pathogen present in the fruit, possibly, stayed in latent state, not activating their factors of
 347 pathogenicity and, with that, not committing the visual aspect of the fruit.

348 The efficiency in the control of the incidence of anthracnose in the fruits covered to the base
 349 of the potato starch felt for the interference of the film on the maturation process in the fruits,
 350 maintaining them resistant for more time [7].

351 Oliveira et al. [21] to the they evaluate the effectiveness of the chitosan associated to the
 352 essential oil (*Cymbopogon citratus*) for the control of the *Colletotrichum gloeosporioides* in
 353 papaya, mango and guava, it verified that the inhibition of the development of the anthracnos
 354 in the covered fruits was larger than observed in fruits treated with synthetic fungicides.

355 The fruits stored under cooling ($10 \pm 2^\circ\text{C}$) they didn't present any growth of the anthracnose
 356 during the 12 days of storage, however, when submitted the temperature of $25 \pm 2^\circ\text{C}$ by
 357 eight days, the anthracnose development was observed in the treatment T1, however in the
 358 treatment T2 and T3 or be the fruits covered with associated potato starch or not to the
 359 essential oil grass lemon it didn't develop any accuse of the anthracnose.

360 Ribeiro et al. [23] evaluating the use of natural products in the control of the anthracnose
 361 caused by *Colletotrichum gloeosporioides* in papaya fruits, it was observed that most of the
 362 natural products used against the anthracnose in the papaya were efficient in the reduction

363 of the symptoms of the same, being verified the sizes of lesions significantly smaller in
364 relation to the witness.

365 It is worth to stand out that the treatment just containing fruits covered with potato starch, it
366 totally controlled the anthracnose in the two temperatures, showing that the covering to the
367 potato starch base, with or without incorporation of the essential oil grass lemon, it formed a
368 barrier impeding the development of typical symptoms of diseases of *C. gloeosporioides* in
369 the papaya tree fruits, what increased the sanity powder-crop.

370

371 4. CONCLUSION

372

373 The potato starch coating to 2% associated to the essential oil grass lemon and the cooling,
374 controlled the maturation and it still potentiated more his/her efficiency in the control of the
375 anthracnose.

376

377

378 REFERENCES

379

380 1. Ali A, Muhammad MTM, Sijam K, Siddiqui, Y. Effect of chitosan coatings on the
381 physicochemical characteristics of Eksotika II papaya (*Carica papaya* L.) fruit during
382 cold storage. Food Chemistry. 2011; 124(2): 620-626.
383 <https://doi.org/10.1016/j.foodchem.2010.06.085>

384 2. Almeida DM. Biofilm of blends of potato starch and bacterial cellulose in minimally
385 processed fruit preservation. 2010. 283f. Thesis (Ph.D. in Biotechnological Processes) -
386 Post-graduation in Agroindustrial Biotechnological Processes, Federal University of
387 Paraná, Curitiba. Portuguese.

388 3. Andrade EM, Uesugi CH, Ueno B, Ferreira, MASV. Morphological and molecular
389 characterization of isolates of *Colletotrichum gloeosporioides* pathogenic to papaya.
390 Brazilian Phytopathology. 2007; 32 (1): 21-31. Portuguese.

391 4. AOAC – ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS. Official Methods of
392 Analysis of the Association of Official Analytical Chemists. 18^a ed. Gaithersburg,
393 Maryland, 2006.

394 5. Ayón-Reyna LE, González-Robles A, Rendón-Maldonado JG, Báez-Flores ME, López-
395 López ME, Veja-Garcia MO. Application of a hydrothermal-calcium chloride treatment to
396 inhibit postharvest anthracnose development in papaya. Postharvest biology and
397 technology. 2017; 124: 85-90. <https://doi.org/10.1016/j.postharvbio.2016.10.009>

398 6. Azeredo LPM, Silva AM, Lima MAC, Dantas RL, Pereira WE. Quality 'tommy atkins'
399 mango from integrated production coated with manioc starch associated with essential
400 oils and chitosan. Revista Brasileira de Fruticultura. 2016; 38 (1): 141-150. Portuguese.

401 7. Chitarra MIF, Chitarra AB. Post-harvesting of fruits and vegetables: physiology and
402 handling. 2. ed. Lavras: UFLA Publishing House. 2005. Portuguese.

403 8. Costa FB, Menezes JB, Alves RE, Nunes GHS, Maracajá PB. Refrigerated storage of
404 'Golden' papaya produced in the Chapada do Apodi-RN-Brazil. Green Magazine on
405 Agroecology and Sustainable Development. 2010; 5 (4): 37-54. Portuguese.

- 406 9. FAOSTAT, Production and harvest of papaya. 2018.
407 <http://www.fao.org/faostat/en/#data/QC>
- 408 10. Ferreira DF. Sisvar: a guide for its bootstrap procedures in multiple comparisons.
409 Science and Agrotechnology. 2014; 38 (2): 109-112. Portuguese.
- 410 11. Gomes BL, Fabi JP, Purgatto E. Cold storage affects the volatile profile and expression
411 of a putative linalool synthase of papaya fruit. Food Research Internacional. 2016; 89:
412 654-660. <https://doi.org/10.1016/j.foodres.2016.09.025>
- 413 12. Hamzah HM, Osman A, Tan CP, Ghazali, FM. Carrageenan as an alternative coating
414 for papaya (*Carica papaya* L. cv. Eksotika). Postharvest Biology and Technology. 2013;
415 75: 142-146. <https://doi.org/10.1016/j.postharvbio.2012.08.012>
- 416 13. Henrique MC, Cereda MP, Sarmento SBS, Physical characteristics of biodegradable
417 films produced from modified cassava starches. Food Science and Technology. 2008;
418 28 (1): 231-240. Portuguese.
- 419 14. Hernadez-Montiel LG, Gutierrez-Perez ED, Murillo-Amador B, Vero S, Chiquito-
420 Contreras RG, Rincon-Enriquez G. Mechanisms employed by *Debaryomyces hansenii*
421 in biological control of anthracnose disease on papaya fruit. Postharvest Biology and
422 Technology. 2018; 139: 31-37. <https://doi.org/10.1016/j.postharvbio.2018.01.015>
- 423 15. Hu M, Yang D, Huber DJ, Jiang Y, Li M, Gao Z, Zhang Z. Reduction of postharvest
424 anthracnose and enhancement of disease resistance in ripening mango fruit by nitric
425 oxide treatment. Postharvest Biology and Technology. 2014; 97: 115-122.
426 <https://doi.org/10.1016/j.postharvbio.2014.06.013>
- 427 16. IAL - Instituto Adolfo Lutz. Physicochemical methods for food analysis. 4th ed. São
428 Paulo: Adolfo Lutz Institute; 2008.
- 429 17. Mota WF, Solomon LCC, Neres CRL, Mizobutsi GP, Neves LLM. Use of carnauba wax
430 and polyolefin plastic bag in post-harvest conservation of yellow passion fruit. Revista
431 Brasileira de Fruticultura. 2006; 28 (2): 190-193. Portuguese.
- 432 18. Birth DN. Postharvest conservation of Italian tomato of the "venus" cultivar coated with
433 potato starch. 2012. 51f. Dissertation (Master in Agronomy) - Federal University of Acre.
434 Portuguese.
- 435 19. Nunes ACD, Figueiredo Neto A, Nascimento IKS, Oliveira FJV, Mesquita RVC. Stored
436 papaya 'formosa' coated with cassava starch base. Journal of Agricultural Sciences.
437 2017; 40 (1): 254-263. <http://dx.doi.org/10.19084/RCA16048>
- 438 20. Oliveira BF, Cruz AF, Alves E. Cassava starch coatings for postharvest control of
439 papaya anthracnose. Phytopathologia Mediterranea. 2016; 55(2): 276-284.
440 http://dx.doi.org/10.14601/Phytopathol_Mediterr-15214
- 441 21. Oliveira PDL, Oliveira KAR, Vieira WAS, Câmara MPS, Souza EL. Control
442 of anthracnose caused by *Colletotrichum* species in guava, mango and papaya
443 using synergistic combinations of chitosan and *Cymbopogon citratus* (D.C.
444 ex Nees) Stapf. essential oil. International Journal of Food Microbiology.
445 2018; 266: 87-94. <https://doi.org/10.1016/j.ijfoodmicro.2017.11.018>

- 446 22. Reis HF. Post-harvest conservation of papaya formosa (*Carica papaya* L.) and
447 alternative in vitro and in vivo control of *Colletotrichum gloeosporioides*. 2014. 130 f.
448 Thesis (Doctorate) - Post-graduation in Agronomy - Plant Production, Federal University
449 of Grande Dourados, Dourados.
- 450 23. Ribeiro JG, Serra IMRS, Araújo MUP. Use of natural products to control anthracnose
451 caused by *Colletotrichum gloeosporioides* in papaya. *Summa Phytopathologica*. 2016;
452 42(2):160-164. <http://dx.doi.org/10.1590/0100-5405/2023>
- 453 24. Siqueira APO. Use of edible toppings in the post-harvest conservation of guava and
454 passion fruit. 2012. 91f. Dissertation (Master's Degree in Plant Production) -
455 Universidade Estadual do Norte Fluminense. Campos dos Goytacazes-RJ. Portuguese.
- 456 25. Sutton BC. *The Coelomycetes*. Kew: Commonwealth Mycological Institute, 1980.
- 457 26. Teodosio AEMM, Rocha RHC, Lima JF, Onias EA, Ferreira APN, Santos BGFL,
458 Rodrigues MHBS, Oliveira LM, Oliveira AMF, Medeiros MLS, SILVA KG. Effect of the
459 Biodegradable Coatings the Base on Microalgae and Oil of the Seed of the
460 Pomegranate in the Conservation Powder-Crop of the Papaya 'Golden'. *Journal of*
461 *Agricultural Science*. 2018; 10(10).
- 462 27. Zillo RR, Silva PPM, Oliveira J, Glória EM, Spoto MHF. Carboxymethylcellulose coating
463 associated with essential oil can increase papaya shelf life. *Scientia Horticulturae*.
464 2018; 239: 70-77. <https://doi.org/10.1016/j.scienta.2018.05.025>