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Original Paper

Sensory quality of fruits of papaya formosa tainung-01 stored in modified atmosphere

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Abstract

Modified atmosphere is widely used to extending the shelf life of fresh fruits; however, it can alter their quality. The objective of this work was to evaluate the sensory quality of papaya Formosa Tainung-01 fruits coated with cassava starch, or low-density polyethylene film. The treatments consisted of fruits coated with a 3% cassava starch solution (w/v), or low-density polyethylene film (X-tend® 815 PP26), and fruits with no coating as control, stored at a mean temperature of 27.7 °C and air relative humidity of 50%. External appearance, peel color, pulp firmness, soluble solids (SS), titratable acidity (TA), SS to TA ratio, pH, vitamin C, and weight loss were evaluated at 0, 4, 7, 9, and 11 days of storage. A test consisted of ordering of fruits by preference was used for the sensory quality analysis. The fruits coated with cassava starch, or low-density polyethylene film presented low soluble solid contents, which affects negatively their sensory quality. The low-density polyethylene film reduced the weight loss, and vitamin C content of the fruits.

Key-words: *Carica papaya* L., Cassava Starch, Postharvest

Introduction

Papaya (*Carica papaya* L.) is native to tropical America. Its fruits present adequate amounts of reducing and non-reducing sugars, vitamins C and B, β-carotene, and mineral salts such as calcium, iron, and phosphorus. The composition of papaya fruits can vary according to soil nutrient contents, crop season, cultivar, and fruit maturation stage (Conabio, 2007).

Papaya is a climacteric fruit that has high ethylene production, and high to very high respiratory rate, which result in high perishability (Costa and Balbino, 2002). Controlling the maturing of papaya fruits is important to increase their post-harvest quality and shelf-live, especially when these fruits are intended to more distant markets (Oliveira and Vianni, 2004).

The control of temperature, air humidity, luminosity, and gas content through modified atmosphere and controlled storage conditions can increase fruit shelf life. However, modified atmosphere can alter physicochemical characteristics that are important for the acceptance of these fruits by consumers, especially flavor, because it decreases the internal oxygen concentration, which alters sensory quality of the fruits, making them unfit for consumption. Several studies (Oliveira Junior et al., 2006; Pinto et al., 2006; Solon et al., 2005) evaluated

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papaya fruits stored with modified atmosphere and found a positive effect of this storage method on fruit shelf life, but no sensory quality analysis was carried out to verify organoleptic alterations.

Thus, the objective of this work was to evaluate the sensory quality of papaya Formosa Tainung-01 fruits coated with cassava starch, or low-density polyethylene film.

Material and Methods

Fruits of papaya Formosa Tainung-01 were harvested at the WG Company, in Baraúna, state of Rio Grande do Norte, Brazil. The fruits were transported in plastic boxes to a laboratory where they were selected and sanitized with an active chlorine solution (100 ppm).

The experiment was conducted in a completely randomized design, using a 3×5 factorial arrangement. The treatments consisted of fruits coated with a 3% cassava starch solution (w/v); fruits coated with low-density polyethylene film (LDP) (X-tend® 815 PP26), with three fruits packaged together; and fruits with no coating as control. The fruits were stored at a mean temperature of 27.7 °C and relative humidity of 50%, and evaluated at 0, 4, 7, 9, and 11 days of storage, with three replications of three fruits per plot.

The 3% cassava starch solution used consisted of 30 g of cassava starch and one liter of water, which was heated in a water bath up to 70 ºC under constant agitation, and then left at room temperature until reaching a proper temperature for the immersion of the fruits. All fruits were stored in an environment with average temperature of 27.7 ºC and relative humidity of 50% for 11 days.

The fruit characteristics evaluated at 0, 4, 7, 9, and 11 days of storage were: i) external appearance based on a visual, subjective analysis considering the absence or presence of defects, and fungal attack symptoms using a scale of grades—extreme fruit deterioration (1), severe fruit deterioration (2), medium fruit deterioration (3), mild fruit deterioration (4), and absence of spots, wilting, or depressions (5)—considering fruits with scores lower than 3 unfit for consumption; ii) peel color determined by reflectometry, using a MiniScan EZ colorimeter calibrated to ideal conditions, with readings made in parts of the fruit that presented different color to obtain the mean, and results expressed as hue angle [tangent arc (b */a*)] (Mcguire, 1992); iii) pulp firmness determined with a manual penetrometer, with results expressed as Newton (N); iv) soluble solids (SS) content determined in filtered juices of the fruits with a digital refractometer, with result expressed as °Brix (AOAC 1992); v) titratable acidity (TA) determined by titration of an aliquot of the pulp with NaOH solution (0.1N), with results expressed as percentage of citric acid (IAL 1985); vi) SS to TA ratio (SS/TA); vii) pulp pH determined with a digital potentiometer (pH Meter Tec-2), according to methodology of the Adolfo Lutz Institute (1985); vii) vitamin C determined by titration, with result expressed as milligrams of ascorbic acid per 100 grams of pulp, according to Strohecker & Henning (1967); and viii) weight loss evaluated daily up to the 10^{th} day by the difference between the initial fruit weight and the fruit weight at each time of storage evaluated, with result expressed as percentage.

The fruits were taken to a laboratory on the 11^{th} day of storage for sensory quality analysis. Sample of the three treatments were analyzed through a test of ordering of fruits by preference. Forty non-trained tasters in individual booths with white light tasted the samples in 20 mL glass cups coded with three-digit random numbers. The tasters ordered the samples according to their preference and justified the reason for their preference for a sample.

The data were subjected to analysis of variance and regression analysis, using the Table Curve program (Jandel Scientific, 1991).

Results and discussion

The interaction between the factors evaluated were significant for soluble solids (SS) content, SS/TA, and pH. The coating had isolated effects on weight loss, titratable acidity (TA), and vitamin C; and time of storage had isolated effects on weight loss, external appearance, TA, vitamin C, and pulp firmness.

The mean scores attributed to external appearance of the fruits decreased from 5.0 (day 0) to 1.7 (11 days of storage) (Figure 1A). According to these scores, the fruits were unfit for trade from 9 days of storage. Control fruits showed lower scores for external appearance, mainly due to senescence spots, wilting, and fungal attack symptoms, but with no statistical differences (p<0.05) from treatments with coating (Figure 1B).

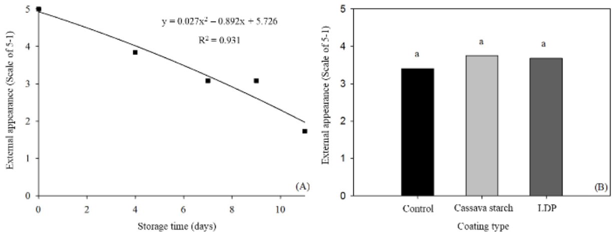

Fig. 1. Effects of time of storage (A) and coating type (B) on external appearance of papaya Formosa Tainung-01 fruits coated with different types of coatings and stored for 11 days under average temperature of 27.7 °C and 50% relative humidity, using a scale of grades of 1 to 5.

Similar results were found by Solon et al. (2005) in papaya Formosa, and by Moura et al. (2005) in cashew; they found that fruits coated with plastic films had better external appearance scores throughout the storage period.

The hue angle (ºh) of the fruit peels decreased throughout the storage period, denoting fruit ripening (Figure 2). The initial mean ºh was 106.92, which decreased to 70.37 (control), 74.84 (cassava starch), and 70.69 (LDP) at the last day of storage. Reduction in ºh with ripening of papaya was also found by Pereira et al. (2009) from the zero (112) to the fifth (84) ripening stage.

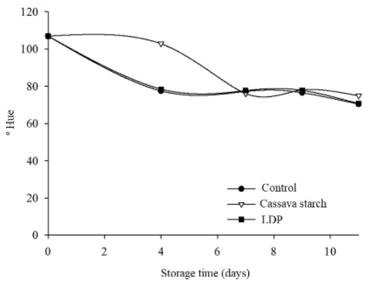

Fig. 2. Peel color (ºh) of papaya Formosa Tainung-01 fruits coated with different types of coatings and stored for 11 days under average temperature of 27.7 °C and 50% relative humidity.

A ccording to the CIELAB Diagram, the greater the ºh, which varies from 0 to 180, the greener is the fruit; the smaller the ºh, the redder is the fruit. Thus, the fruits were greenish yellow (mean ºh of 106.92) at the beginning of the experiment; and the fruits coated with cassava starch were yellow (mean ºh of 74.84) at the end of the experiment, with higher ºh than the control (mean ºh of 70.37) and LDP (mean ºh of 70.69) fruits, which were orangish yellow. The longer maintenance of the green color can be attributed to the low penetration of oxygen in the fruits, which reduces ethylene synthesis and, consequently, synthesis of chlorophyllase enzymes that degrade chlorophyll pigments.

Fruit pulp firmness decreased with storage time; it had initial mean of 103.55 N and final mean of 1.62 N (Figure 3A), denoting the fruit softening and the consumption point of the fruits. The coatings had no significant effect (p<0.05) on fruit pulp firmness. However, fruits coated with cassava starch had higher pulp firmness (34.64 N) than the fruits of other treatments (Figure 3B).

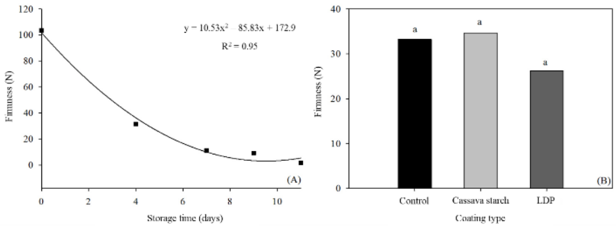

Fig. 3. Effects of time of storage (A) and coating type (B) on pulp firmness of papaya Formosa Tainung-01 fruits coated with different types of coatings and stored for 11 days under average temperature of 27.7 °C and 50% relative humidity.

Pereira et al. (2006), observed reductions in pulp firmness loss in Papaya Formosa fruits coated with 1% or 3% cassava starch solutions throughout storage. Decreases in pulp firmness denote the ripening of fruits. According to Pereira et al. (2009), papaya pulp firmness decreases with maturation stages, presenting firmness of approximately 70 N at the zero stage (green fruits), 3 N at the fifth maturation stage (ripe fruits).

All treatments presented a slight increase in soluble solids (SS) throughout the storage period, presenting SS of 9.2 °Brix at the beginning of the experiment, and 11.4 (control), 10.4 (cassava starch), and 10.1 °Brix (LDP) at the end of the experiment (Figure 4).

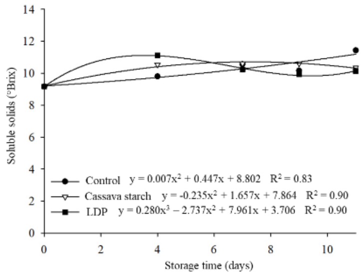

Fig. 4. Soluble solids (°Brix) of papaya Formosa Tainung-01 fruits coated with different types of coatings and stored for 11 days under average temperature of 27.7 °C and 50% relative humidity.

Despite the increases found for soluble solids, according to Queiroz (2009), papaya fruits have no starch reserves and, therefore, their soluble sugar contents cannot increase after harvest. Moreover, according to Jacomino et al. (2003), papaya does not accumulate starch during maturation, and must be kept in the plant to accumulate sugars, thus, the sugar content does not have significant post-harvest variations. These authors report that the internal part of the mesocarp has a minimum soluble solids content of 11.5 °Brix, and the main sugars present in the papaya are sucrose, glucose, and fructose.

The titratable acidity of the fruits varied throughout the storage period; it increased up to the 9th day of storage, and decreased after this point (Figure 5A). Bron (2006), and Oliveira Júnior et al. (2006) also observed variation in titratable acidity throughout the storage period in papaya fruits harvested at different maturation stages, and in fruits packed with LDP.

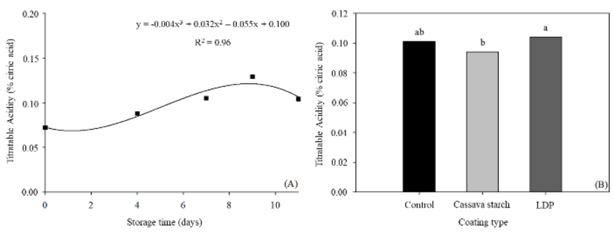

Fig. 5. Effects of time of storage (A) and coating type (B) on the titratable acidity (% citric acid) of papaya Formosa Tainung-01 fruits coated with different types of coatings and stored for 11 days under average temperature of 27.7 °C and 50% relative humidity.

According to Costa and Balbino (2002), increases in acidity of papaya fruits can be attributed to the formation of galacturonic acid in the process of cell wall degradation that occurs during ripening, even in small amounts. However, decreases during the storage period occur because organic acids are widely used as substrates in the respiratory process, and transformation of sugars in some fruits (Chitarra and Chitarra, 2005). Fruits coated with cassava starch presented lower titratable acidity than those in the control, and LDP, presenting a mean percentage of citric acid of 0.094%, but no significant difference (p<0.05) from control fruits (Figure 5B).

The SS/TA decreased throughout the fruit storage period, but presented a slight increase from the 9th to the 11th day of storage (Figure 6). SS/TA is related to the balance between sugars and acids present in the fruits, and is an important indicator of flavor. The establishing of this relationship must consider that some fruits containing low levels of soluble acids and solids have high SS/TA, since it can lead to misinterpretations regarding fruit quality.

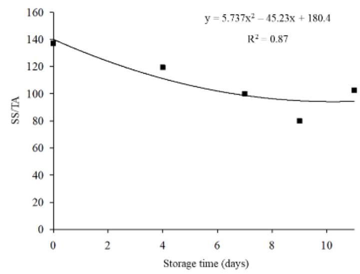

Fig. 6. Soluble solids to titratable acidity ratio (SS/TA) of papaya Formosa Tainung-01 fruits coated with different types of coatings and stored for 11 days under average temperature of 27.7 °C and 50% relative humidity.

The pH of fruits coated with cassava starch had a slight increase throughout the storage, whereas the other treatments (control and LDP) presented a decrease in pH by the end of the experiment (Figure 7). According to results obtained by other authors, the pH of papaya fruits is generally higher than 5, due to their low organic acid content.

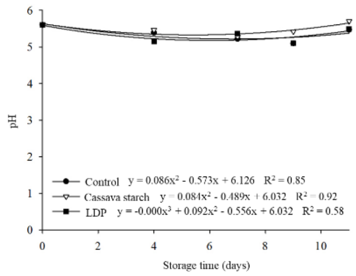

Fig. 7. pH of papaya Formosa Tainung-01 fruits coated with different types of coatings and stored for 11 days under average temperature of 27.7 °C and 50% relative humidity.

Papaya has a lower acidity than other tropical fruits. It is a nutritional advantage that allows its consumption by sensitive people to acidic fruits. However, this low acidity is often a problem for fruit processors, since its high pH favors the activity of enzymes and growth of microorganisms.

The vitamin C contents increased throughout the storage period, reaching 73.82 mg of ascorbic acid per 100 grams of pulp at the end of the experiment (Figure 8A). Different from most fruits, papaya has a gradual increase in vitamin C until complete ripening (Selvaraj et al., 1982). The control fruits presented higher vitamin C contents (Figure 8B) than those in the other treatments. This result may be related to the more rapid maturation of these fruits, possibly because of their direct contact with oxygen. The use of coatings reduced the concentration of oxygen in contact with the fruit and might have delayed the biosynthesis of vitamin C.

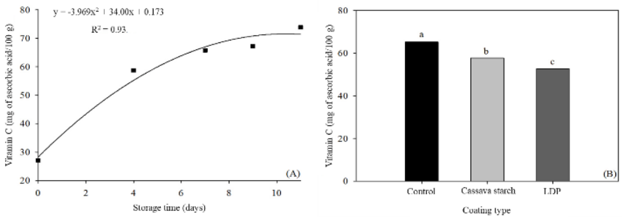

Fig. 8. Effects of time of storage (A) and coating type (B) on the vitamin C (milligrams of ascorbic acid per 100 grams of pulp) of papaya Formosa Tainung-01 fruits coated with different types of coatings and stored for 11 days under average temperature of 27.7 °C and 50% relative humidity.

Souza et al. (2005) found similar vitamin C contents in Papaya Formosa fruits, with average of 76.7 mg of ascorbic acid per 100 g of pulp. According to Gebhardt and Thomas (2002), papaya is one of the fresh fruits that contains the highest vitamin C contents.

The fruit weight loss had a gradual increase throughout the storage period (Figure 9A), with a maximum of 7.69% at the 10^{th} day of storage. The fruits stored in LDP presented the lower weight loss, with a mean of 2.04% (Figure 9B). This result is important from the commercial point of view, since a low weight loss indicates less economic loss (Waghmare and Annapure, 2013).

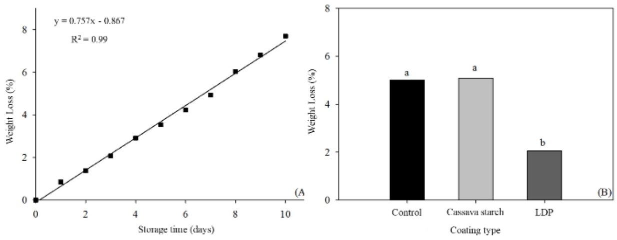

Fig. 9. Effects of time of storage (A) and coating type (B) on the fruit weight loss of papaya Formosa Tainung-01 fruits coated with different types of coatings and stored for 11 days under average temperature of 27.7 °C and 50% relative humidity.

No significant difference (p<0.05) in fruit weight loss was found between fruits coated with cassava starch (5.08%) and control fruits (5.00%). The weight loss of fruits coated with LDP was probably due to reductions in respiratory rates, and because it forms a significant barrier for water loss.

According to Chitarra and Chitarra (2005), the use of hydrophilic coatings such as starch has limitations on water vapor barrier properties; and the maximum acceptable weight loss to avoid hindering the appearance of fruits and vegetables is 10%. Fernandes et al. (2010) evaluated the quality of papaya Taiwan stored under passive atmosphere and found smaller reductions in fruit weight loss in fruits packaged in LDP, when compared fruits coated with carnauba wax. Morreti and Pineli (2005) evaluated different atmospheres for eggplant stored at 12 ºC and found lower weight loss when using LDP singly or combined with $CaCl_2$ when compared to the control.

Regarding the treatments applied, the sensory quality analysis showed a significant difference (p<0.05) between the control and LDP, and between cassava starch and LDP, and no significant difference between the control and cassava starch (p<0.05) (Table 1). According to the answers of the forty non-trained tasters, 20 of them preferred the control, 14 preferred the fruits coated with cassava starch, and 6 preferred those coated with LDP. Thus, control fruits had greater acceptance by the tasters and were characterized as sweeter compared to the others.

Table 1. Sensory quality analysis (test of ordering of fruits by preference) of papaya Formosa Tainung-01 fruits coated with different types of coatings and stored for 11 days under average temperature of 27.7 °C and 50% relative humidity.

Sample	Coating	Sum
A	Control	99a
B	Cassava starch	82a
C	LDP	59b

*Means followed by the same letter do not differ by the Tukey's test at 5% probability.

The cassava starch coating had no effect on organoleptic attributes, presenting fruits with good sensory acceptance by the tasters, whereas fruits coated with LDP had low acceptance probably due to their lower sweetness, which was probably due to the delay in fruit ripening caused by the modified atmosphere. According to Guevara et al. (2003), modified atmospheres cause decreases in O_2 concentration, respiration rate, and ethylene production, chlorophyll degradation, loss of fruit texture, ripening delay, and senescence in some vegetables.

According to the physicochemical characteristics of the papaya Tainung-01 fruits, evaluated at the 11th day of storage, the control fruits had higher soluble solids contents, confirming the results of the sensory quality analysis. The fruits coated with LDP had a lower soluble solids content and a higher acidity, confirming their lower sensory acceptance by the tasters.

Conclusion

The use of low-density polyethylene film for coat papaya Formosa Tainung-01 fruits is efficient in reducing fruit weight loss throughout the storage period. However, it reduces the vitamin C contents.

Fruits coated with cassava starch are greener throughout the storage period.

Fruits coated with cassava starch, or low-density polyethylene film, have lower soluble solids contents after 11 days of storage.

The use of low-density polyethylene film has negative effects on the sensory quality characteristics of papaya fruits, especially soluble solids, and titratable acidity.

Conflict of interest: All authors declare no conflict of interest.

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