Physical quality of 'Palmer' mango coated with cassava starch

Qualidade física da manga 'Palmer' revestida com fécula de mandioca

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Abstract

The objective of this study was to evaluate changes in the physical attributes of 'Palmer' mango coated with cassava starch biofilm. The fruits were selected, washed, sanitized and coated with the biofilm in the concentrations of 1%, 2% and 3% starch, except for the control (0%), being subsequently stored at 10 ± 0.5 °C and 60% relative humidity for 20 days. Assessments were made every five days to check weight loss, length and diameter, fruit firmness, solute leakage and color of the peel and pulp. The experiment was conducted in a completely randomized design in a factorial 4x5 (coating concentrations x storage periods), with four replications. The results were submitted to analysis of variance and comparison of means by Tukey test at 5% probability. The cassava starch coating was characterized as a good alternative for maintaining the postharvest quality of the 'Palmer' mango in the concentrations from 2%, since it reduced the weight loss of the fruits and kept higher the firmness values, also being efficient in delaying the development of fruit peel color.

Additional keywords: biofilm; Mangifera indica L.; postharvest quality.

Resumo

Objetivou-se com este trabalho avaliar alterações de atributos físicos da manga ‘Palmer’ revestida com biofilme de fécula de mandioca. Os frutos foram selecionados, lavados, sanitizados e revestidos com o biofilme nas concentrações de 1%, 2% e 3% de fécula, com exceção do controle (0%); em seguida, foram armazenados a 10 ± 0.5 °C e 60% de umidade relativa, por 20 dias. A cada cinco dias, foram realizadas avaliações de perda de massa, comprimento e diâmetro, firmeza do fruto, extravasamento de solutos e cor da casca e da polpa. O experimento foi conduzido em delineamento experimental inteiramente casualizado, em esquema fatorial 4x5 (concentrações de revestimento x períodos de armazenamento), em quatro repetições. Os resultados foram submetidos à análise de variância, e a comparação das médias, pelo teste de Tukey, a 5% de probabilidade. O revestimento à base de fécula de mandioca caracterizou-se como uma boa alternativa para manter a qualidade pós-colheita da manga ‘Palmer’ na concentração a partir de 2%, uma vez que reduziu a perda de massa dos frutos e manteve maiores os valores de firmeza, sendo eficiente também no retardo do desenvolvimento da coloração da casca dos frutos.

Palavras-chave adicionais: biofilme; Mangifera indica L.; qualidade pós-colheita.

Introduction

Currently, Brazil is one of the largest producers of mango (Mangifera indica L.) in the world, being in seventh place in terms of production and in second as an exporter of this fruit. In numbers, the national production in the 2014/2015 season reached about 1.2 million tons of fruit (OCDE, 2015) and the quantity exported was 133,033 tons (Reetz et al., 2015). The northeast region has become the main producer of mango in the country, especially the São Francisco Valley, more specifically the cities of Juazeiro and Petrolina located, respectively, in the states of Bahia and Pernambuco, which account for over 80% of the production in the 2014/2015 season.
total exported by the country (Correia & Araújo, 2010).

In the São Francisco Valley, among the cultivated varieties of mango, those that stand out in terms of production and harvesting are 'Tommy Atkins', 'Palmer', 'Kent' and 'Keitt'. However, 'Palmer' has grown in importance for being a late variety, well accepted in the domestic market, which has good preservation capacity and good prospects for exportation (Teixeira & Durigan, 2011).

The search for new postharvest technologies is growing, being primarily focused on the physiology of the fruit, more precisely its metabolism, maturity and senescence. These techniques include the use of harvest and postharvest practices that allow to maintain fruit quality and control metabolic processes such as respiration, ethylene production, chemical, biochemical and physiological processing (Sigrist, 2014).

In order to ensure the postharvest quality of the mango, the use of edible biofilms has been employed in order to extend the useful life and improve the appearance of the fruits. The coating acts on the suspension of a thickener, which forms a film around the fruit, reducing the migration of water vapor and the gas exchange with the environment, increasing the surface gloss and contributing to the reduction of infections (Pereira et al., 2006).

For the composition of these coatings, in addition to proteins and lipids, cellulose and amylose derivatives (both carbohydrates) have been used as raw materials, for being biodegradable and edible while in the fruit. In mangoes, coatings of cassava starch, corn starch, chitosan and carnauba wax have been tested in order to contribute to weight loss reduction and increased useful life of the fruit (Guedes, 2007; Scanavaca Júnior et al., 2007). The application of the cassava starch coating may be an alternative for the conservation of 'Palmer' mango in natura, without generating waste to the environment, besides having the advantage of being edible and easy to remove.

Given the importance of studies on the use of postharvest techniques that minimize losses and increase the fruit conservation period, making it necessary to meet the changes of these vegetables during storage, the aim of this study was to evaluate changes in the physical attributes of 'Palmer' mango coated with cassava starch biofilm.

### Material and methods

The mangoes used were from a farm located on the N11 project in the city of Petrolina, in the maturity stage 2, characterized by external fruit appearance with 75% green color and pulp color at least 70% cream (Assis, 2004). The fruits were taken to the laboratory where they were selected, washed in tap water, sanitized with a sodium hypochlorite solution at 1% for 15 minutes and dried at room temperature.

After the separation in batches of twenty fruits for each cassava starch solution, in the concentration of 1, 2 and 3%, the mangoes were immersed for one minute and placed on trays to dry under artificial ventilation for 30 min. The obtention of solutions was performed through the gelification of starch in water heated to 70 °C, under constant stirring for 15 minutes, according to Santos et al. (2011). After drying, the fruits were stored under refrigeration at a temperature of 10 ± 0.5 °C and 60% of relative humidity (RH) for a period of 20 days. Analyses were performed every five days of storage.

Weight loss was determined with the aid of a semi-analytical balance with 0.01g precision and the results were expressed as a percentage. Length and diameter measurements were carried out using a digital caliper, and are expressed in millimeters (mm).

The color of the peel and pulp were analyzed using a portable digital colorimeter, brand Konica Minolta DP-400, and expressed in three parameters: L* (0 = dark/opaque and 100 = white); Chroma, C, which expresses the saturation or intensity of color (0 = impure color and 60 = pure color); and Hue angle, θH (color angle; 0° = red; 90° = yellow; 180° = green; 270° = blue and 360° = black).

To determine fruit firmness, it was used the digital penetrometer Instrutherm, model PTR-300, with an 8 mm diameter cylindrical probe. The measurements were performed in the equatorial region of the fruits, being expressed in Newton (N). Solute leakage was determined according to the methodology described by Serek et al. (1995) and expressed as a percentage.

It was used a completely randomized design with four replications, each consisting of a fruit, in a 4x5 factorial, which represents the four concentrations of the cassava starch solution (0, 1, 2, 3%) and five storage periods (0, 5, 10, 15 and 20 days). The results were submitted to analysis of variance and comparison of means by Tukey test at 5% probability, using the Assistat software, Version 7.7 beta (Silva, 2014).
According to Scanavaca Junior et al. (2007), who consider 10% weight loss for mango as a reference value to make the fruit unfit for consumption, the fruits of the control treatment lasted about 18 days in their work, while the fruits coated with 1, 2 and 3% starch remained suitable for the twenty days analyzed.

As observed for the weight loss of the fruits, the length and diameter of the mangoes with and without coating decreased as a function of increasing storage time (Figure 2). However, the fruits coated with the highest concentrations of cassava starch (2% and 3%) had a greater maintenance of their dimensions until the 20th day of analysis, possibly because of the lower water and mass loss.

Fruit firmness decreased during storage for all treatments regardless of the use of cassava starch biofilms (Figure 3). Maturation is characterized by changes in the texture associated with the metabolism of cell wall carbohydrates, through the increase in the enzymatic activity associated with other processes such as water loss, which lead to decreased fruit firmness (Vilas Boas et al., 2004). Miguel et al. (2013) observed that the fruits of cv. ‘Palmer’ kept at 12 ºC showed softer pulp from the 7th day of refrigeration, verified by decreased firmness.

In the concentrations of 2 and 3% starch, mangoes had less firmness loss, about 11.4 and 11.7%, respectively, compared to the control (0%), with 26.8%. This indicates that the firmness loss during the ripening was changed with the increase in the barrier, represented by the increase in the concentration of cassava starch during the gas exchange, decreasing the metabolism and the changes in the texture of fruits (Silva et al., 2015). Similar results were found by Guedes (2007), who, evaluating the firmness of the ‘Rosa’ mango coated with different concentrations of cassava starch biofilms, noted that in the concentrations of 3% and 4% there was a smaller reduction in firmness values, slowing the fruit maturation process for a longer time.

The results of the analysis of variance showed that for solute leakage, there was an independent effect between coating and storage time, i.e., the interaction between factors was not significant (Table 1).
Figure 3 - Firmness of ‘Palmer’ mangoes coated with cassava starch, in the concentrations of 0% (control), 1%, 2% and 3%, as a function of the refrigerated storage period, at 10 ± 0.5 ºC and 60% RH.

Table 1 - Analysis of variance for the solute leakage of ‘Palmer’ mangoes as function of coatings (0%, 1%, 2% e 3% cassava starch), storage time (20 days), and interaction coating x time.

<table>
<thead>
<tr>
<th>Sources of variation</th>
<th>Degrees of freedom</th>
<th>Mean square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coating</td>
<td>3</td>
<td>866.47**</td>
</tr>
<tr>
<td>Time</td>
<td>4</td>
<td>3192.74**</td>
</tr>
<tr>
<td>Coating X Time</td>
<td>12</td>
<td>156.10 ns</td>
</tr>
<tr>
<td>Residue</td>
<td>40</td>
<td>98.57</td>
</tr>
</tbody>
</table>

C.V. (%) = 15.99

** = significant at 1% probability and ns = non-significant; C. V. = coefficient of variation.

The difference in the solute leakage presented between the cassava starch concentrations demonstrated that the coatings used reduced electrolyte loss during the storage period (Figure 4A).

Figure 4 – Solute leakage of ‘Palmer’ mangoes as a function of the concentrations of cassava starch coating (0%, 1%, 2% and 3%) (A) and the refrigerated storage period, at 10 ± 0.5 ºC and 60% RH (B).

Furthermore, it was observed for all treatments an increasing leakage percentage over time (Figure 4B), being inferred that cell membranes had lost part of the selective permeability during storage. It is inferred that this may be related to the higher degree of ripening of the fruits.

The results of the analysis of variance showed that for the variables Luminosity (L) and Hue angle (ºH) of the peel, there was no significant interaction between factors, as can be seen in the table below:
Table 2 - Analysis of variance for the variables Luminosity, Chroma and Hue angle of the peel of ‘Palmer’ mangoes as function of coatings (0%, 1%, 2% and 3% cassava starch), storage time (0, 5, 10, 15 and 20) and interaction coating X time.

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>Luminosity</th>
<th>Chroma</th>
<th>Hue angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coating</td>
<td>5.85*ns</td>
<td>50.32**</td>
<td>156.92**</td>
</tr>
<tr>
<td>Time</td>
<td>87.47**</td>
<td>93.81**</td>
<td>825.45**</td>
</tr>
<tr>
<td>Coating X Time</td>
<td>27.87**</td>
<td>7.43*ns</td>
<td>93.26**</td>
</tr>
<tr>
<td>Residue</td>
<td>8.53</td>
<td>6.72</td>
<td>15.23</td>
</tr>
<tr>
<td>C.V. (%)</td>
<td>7.49</td>
<td>11.69</td>
<td>3.58</td>
</tr>
</tbody>
</table>

** = significant at 1% probability; ns = non-significant; C. V. = coefficient of variation.

According to the test for comparison of means (Table 3), in treatments 2% and 3%, there was no significant variation in the Luminosity of fruits throughout the study period, unlike the treatments 0% and 1%, in which the increase in Luminosity indicated a greater whitening of the outer portion of the fruits. This fact confirms what was pointed out by Jha et al. (2006), i.e., the Luminosity of the peel of mango fruits increases during ripening, when there is yellow color exposure. Thus, at the end of the 20 days of storage, the increase in the coating concentration resulted in fruits with lower Luminosity values, reflecting the lower incidence of lighter shades during the ripening of fruits.

Table 3 - Luminosity and Hue angle of the peel of ‘Palmer’ mangoes coated with cassava starch biofilms in the concentrations of 0%, 1%, 2% and 3%, stored under refrigeration at 10 ± 0.5 ºC and 60% RH.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Parameter</th>
<th>Storage (days)</th>
<th>C.V.</th>
<th>SMDcolumns</th>
<th>SMDlines</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>Luminosity</td>
<td>0% 5 10 15 20</td>
<td>7.49</td>
<td>5.4633</td>
<td>5.8139</td>
</tr>
<tr>
<td>1%</td>
<td></td>
<td>35.67 abB 37.67 abB 38.24 abB 39.81 abB 46.19 aA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2%</td>
<td></td>
<td>35.67 abB 36.98 abB 37.01 abB 37.47 aA 44.57 aA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3%</td>
<td></td>
<td>35.67 abA 37.21 aA 38.98 aA 41.14 aA 40.73 aB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0%</td>
<td>Hue Angle</td>
<td>0% 5 10 15 20</td>
<td>3.58</td>
<td>7.2976</td>
<td>7.7659</td>
</tr>
<tr>
<td>1%</td>
<td></td>
<td>117.81 aA 113.46 aA 112.67 aA 92.76 bB 92.10 cB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2%</td>
<td></td>
<td>117.81 aA 110.51 aAB 109.54 abB 105.62 abB 95.97 bcC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3%</td>
<td></td>
<td>117.81 aA 114.79 aA 111.04 aA 110.49 aB 99.95 aB</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Means followed by the same lowercase letter in the column and uppercase letter in the line do not differ by Tukey test at 5% probability; C.V. = coefficient of variation; SMD = Significant minimum deviation.

Through the Hue angle results, it was found that from the 15th day, the mangoes of the control treatment showed a more yellowish color compared to the fruits coated with cassava starch biofilm. Souza et al. (2011), who coated ‘Tommy Atkins’ mangoes with chitosan, also found that the coating used could delay the development of fruit color and thus the ripening of mangoes.

As for the variable Chroma there was no significant interaction between factors (Table 3), one can analyze coatings and storage period (time) independently (Figure 5). In this case, it was observed that the uncoated mangoes had a faster ripening compared to the coated ones, thus showing more vivid colors, indicating increased saturation of yellow colors and lower retention of the green color of fruits, with Chroma value of 24.30. It was further found that the time factor has provided a significant effect on the Chroma of the mango peel, raising it during the storage period.
Figure 5 - Chroma of the peel of ‘Palmer’ mangoes, as a function of the concentrations of cassava starch coating (0%, 1%, 2% and 3%) (A) and the refrigerated storage period, at 10 ± 0.5 ºC and 60% RH (B).

The analysis of variance (Table 4) for the color of the pulp of ‘Palmer’ mangoes showed no significant effect for the interaction coating x time in all variables analyzed. In addition, both the storage period and the coatings were not significant for Chroma and Hue angle, showing that in the storage conditions analyzed, the use of cassava starch coating did not influence the saturation/intensity and the Hue angle of the mango pulp.

Table 4 - Analysis of variance for the variables Luminosity, Chroma and Hue angle of the pulp of ‘Palmer’ mangoes as function of coatings, storage time and interaction coating X time.

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>Luminosity Mean Square</th>
<th>Chroma Mean Square</th>
<th>Hue angle Mean Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coating</td>
<td>43.16*</td>
<td>39.45ns</td>
<td>10.07ns</td>
</tr>
<tr>
<td>Time</td>
<td>141.86**</td>
<td>57.53ns</td>
<td>18.91ns</td>
</tr>
<tr>
<td>Coating x Time</td>
<td>19.19ns</td>
<td>7.51ns</td>
<td>4.92ns</td>
</tr>
<tr>
<td>Residue</td>
<td>14.37</td>
<td>24.79</td>
<td>8.27</td>
</tr>
<tr>
<td>C.V. (%)</td>
<td>6.04</td>
<td>11.26</td>
<td>3.15</td>
</tr>
</tbody>
</table>

** = significant at 1% probability, * = significant at 5% probability and ns = non-significant; C.V. = coefficient of variation.

The values for the Luminosity of the fruits pulp increased when the fruits were coated with cassava starch biofilm in the concentration of 3%, indicating that the increase of the coating concentration resulted in fruits with lower pulp browning, which may be related with higher water content, promoting greater reflection of the incident light (Figure 6A). Moreover, for all coatings, the increased storage period resulted in fruits with lower Luminosity of the pulp (Figure 6B), as observed by Serpa et al. (2014), the pulp of the mangoes has become darker during storage, using cassava starch prepared with cloves and cinnamon extract.

Figure 6 - Luminosity of the pulp of ‘Palmer’ mangoes as a function of the concentrations of cassava starch coating (0%, 1%, 2% and 3%) (A) and the refrigerated storage period, at 10 ± 0.5 ºC and 60% RH (B).
Conclusions

The cassava starch coating was characterized as a good alternative for maintaining the post-harvest quality of the ‘Palmer’ mango in the concentrations from 2%, since it reduced the weight loss of the fruits and kept higher the firmness values, also being efficient in delaying the development of fruit peel color.

References


