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Scientific Paper

Application of edible coatings in conservation of acerola

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Abstract

The acerola is a tropical fruit recognized for its high nutritional value, however, the high pereceability after harvest motivated by its climacteric behavior requires conservation techniques that allow the maintenance of its quality during the storage period. The edible coatings, in this context, are presented as alternatives since they form barriers on the fruits, restricting the gas exchanges, improving the visual aspect without compromising with the fruit flavor. Thus, this study aims to evaluate the application of edible coatings on the post-harvest quality of acerolas cv. Costa Rica during refrigerated storage (10 °C). Fruits of ripe acerolas were harvested in a commercial orchard, sanitized and immersed in three solutions (3%) of cassava starch, arrow starch and gelatine, in addition to the control represented by uncoated fruits for a period of 3 minutes. These were then dried and packed in styrofoam polystyrene trays coated with polypropylene plastic film (PVC) and stored under refrigeration (10 °C) for 12 days. The total fresh solids content (º Brix), titratable acidity (% malic acid), pH, TSS/AT ratio and sensorial analysis on the occurrence of wilting were evaluated every three days, visual appearance and the aroma of the fruits. The experimental design was completely randomized in a factorial scheme of 4x5, that is to say, (4 treatments: control, cassava starch, arrowroot starch and gelatin) and (5 storage times: 0, 3, 6, 9 and 12 days), with five replicates and the experimental plot composed of 100 g trays. During the storage period, no significant difference was observed between the coatings used, however, their action on the fruits contributes to reduce the loss of fresh mass and to allow a better balance in the fruit flavor ratio (SST / AT) after 12 days . The films formed on the fruits did not compromise the chemical quality (soluble solids, titratable acidity and pH) maintaining similar behavior to the fruits of the control treatment. In addition, there was a reduction in the incidence of wilting and the loss of the characteristic aroma of the fruits, contributing to a better visual appearance. Thus, edible coatings based on cassava starch and arrowroot and gelatine are presented as effective alternatives in preserving the quality of acerolas during refrigerated storage.

Keywords: *Malpighia emarginata* DC ., biofilms, postharvest.

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Aplicação de revestimentos comestíveis na conservação de acerolas

Resumo

A acerola é um fruto tropical reconhecido por seu elevado valor nutricional, contudo, a alta perecebilidade após a colheita motivada por seu comportamento climatérico requer técnicas de conservação que permitam a manutenção de sua qualidade durante o período de armazenamento. Os revestimentos comestíveis, nesse contexto, apresentam-se como alternativas uma vez que formam barreiras sobre os frutos restringindo as trocas gasosas, melhorando o aspecto visual sem comprometimento com o sabor dos frutos. Assim, este estudo tem por objetivo avaliar a aplicação de revestimentos comestíveis sobre a qualidade pós-colheita de acerolas cv. Costa Rica durante o armazenamento refrigerado (10 ºC). Frutos de acerolas maduras foram colhidos em pomar comercial, sanitizados e imersos em três soluções (3%) de revestimento com amido de mandioca, amido de araruta e gelatina, além do controle representado pelos frutos sem revestimento por um período de 3 minutos. Em seguida, estes foram secos e acondicionados em bandejas de isopor de poliestireno revestidas com filme plástico de polipropileno (PVC) e armazenados em refrigerador (10 ºC) por 12 dias. A cada três dias foram avaliados a perda de massa fresca (%), conteúdo de sólidos solúveis totais (º Brix), acidez

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titulável (% ácido málico), pH, relação de SST/AT além de análise sensorial sobre a ocorrência de murchamento, aparência visual e o aroma dos frutos. O delineamento experimental adotado foi o inteiramente casualizado em esquema fatorial de 4x5, isto é, (4 tratamentos: controle, fécula de mandioca, fécula de araruta e gelatina) e (5 tempos de armazenamento: 0, 3, 6, 9 e 12 dias), com cinco repetições e a parcela experimental composta por bandejas de 100 g. Ao longo do período de armazenamento não houve diferença significativa entre os revestimentos utilizados, todavia, sua ação sobre os frutos contribui para reduzir a perda de massa fresca e possibilitar um melhor balanço na relação de sabor dos frutos (SST/AT) após 12 dias. As películas formadas sobre os frutos não comprometeram a qualidade química (sólidos solúveis, acidez titulável e pH) mantendo comportamento semelhante aos frutos do tratamento controle. Além disso, houve redução na incidência de murchamento e na perda do aroma característico dos frutos contribuindo para uma melhor aparência visual. Dessa forma, os revestimentos comestíveis a base de amido de mandioca e araruta e gelatina apresentam-se como alternativas eficazes na preservação da qualidade de acerolas durante o armazenamento refrigerado.

Palavras-chave: *Malpighia emarginata* DC., biofilmes, pós-colheita.

Aplicación de revestimientos comestibles para la conservación de acerolas

Resumen

La acerola es una fruta tropical reconocida por su alto valor nutricional, sin embargo, la alta perecedera después de la cosecha motivada por su comportamiento climático requiere técnicas de conservación que permitan mantener su calidad durante el período de almacenamiento. Los recubrimientos comestibles, en este contexto, se presentan como alternativas ya que forman barreras en las frutas que restringen el intercambio de gases, mejorando el aspecto visual sin comprometer el sabor de la fruta. Por lo tanto, este estudio tiene como objetivo evaluar la aplicación de recubrimientos comestibles en la calidad poscosecha de acerola cv. Costa Rica durante el almacenamiento refrigerado (10 °C). Las frutas maduras de acerola fueran cosechadas en un huerto comercial, fueran desinfectadas y sumergidas en tres soluciones de recubrimiento (3%) con almidón de yuca, almidón de araruta (arrurruz) y gelatina, además del control de frutas sin recubrimiento durante un período de 3 minutos. Luego se secaron y se colocaron en bandejas de isopor de poliestireno forradas con película de plástico de polipropileno (PVC) y se almacenaron en un refrigerador (10 ºC) durante 12 días. Cada tres días se evaluó la pérdida de masa fresca (%), el contenido total de sólidos solubles (º Brix), la acidez titulable (% de ácido málico), el pH, la relación SST / TA y el análisis sensorial en la aparición de marchitez, aspecto visual y aroma de las frutas. El diseño experimental fue completamente al azar en un esquema factorial 4x5, es decir (4 tratamientos: control, almidón de yuca, almidón de arrurruz y gelatina) y (5 tiempos de almacenamiento: 0, 3, 6, 9 y 12 días), con cinco repeticiones y la porción experimental compuesta de bandejas de 100 g. Durante el período de almacenamiento no hubo diferencias significativas entre los recubrimientos utilizados, sin embargo, su acción sobre las frutas contribuye a reducir la pérdida de masa fresca y permite un mejor equilibrio en la relación de sabor de la fruta (SST / TA) después de 12 días. Las películas formadas en las frutas no comprometieron la calidad química (sólidos solubles, acidez titulable y pH) manteniendo un comportamiento similar a las frutas del tratamiento de control. Además, hubo una reducción en la incidencia de marchitamiento y la pérdida del aroma característico de la fruta, lo que contribuyó a una mejor apariencia visual. Por lo tanto, los almidones de yuca comestibles y los recubrimientos de arrurruz y gelatina son una alternativa efectiva para preservar la calidad de la acerola durante el almacenamiento en frío.

Palabras clave: *Malpighia emarginata* DC., biopelículas, poscosecha.

Introduction

The acerola (*Malpighia emarginata* DC) also known as the Antille cherry or Barbados cherry is a species native to the Antilles, north of South America and Central America (MONTIM, OLIVEIRA and VIEIRA, 2010). It is a tropical fruit with a pleasant taste, being recognized by the nutritional value, mainly as sources of vitamins C, B (thiamine, niacin) and mineral salts (AGOSTINI et al., 2003; FREITAS et al., 2006).

Although the fruit has a great possibility of production in Brazil, one of the major problems faced in its in natura commercialization results from the high pereceability, that is, deteriorating in a few days due to its climacteric maturity pattern (FRAZÃO and MELO, 2008) . In this sense, it is evident the need for technologies that allow the maintenance of quality with reduction of nutritional losses during storage, thus, increasing the time of commercialization.

In this context, refrigerated storage presents as an immediate alternative for in natura conservation, since acerola undergoes rapid changes in color, aroma, flavor and texture after harvest (FREITAS et al., 2006). The use of edible coatings is more a post-harvest preservation technology, due to the potential to avoid food deterioration and the biodegradability characteristic (ASSIS et al., 2008). In general, these techniques stand out for their simplicity of use, easy access and mainly for demonstrating total efficiency with respect to the nutritional and sensorial characteristics of the fruit, allowing to maintain their commercial value (LUVIELMO and LAMAS, 2012).

Edible coatings are biopolyme free of toxicity and form a colorless and glossy film on the vegetable surface reducing moisture loss, respiratory rate and the occurrence of physical damage by maintaining physical integrity with reflection on the appearance of fruits, as well as carrying antioxidant and antimicrobial substances, which improve their characteristics and can be consumed together with the product (HENRIQUE et al., 2008; ASSIS et al., 2009; ASSIS and BRITO, 2014) . Thus, in order to establish the best conditions of use of a post-harvest technology such as the use of edible coatings, it is fundamental to investigate the effects that it exerts on the quality of the fruits. Therefore, the objective of this work is to evaluate the effects of post-harvest application of edible coatings based on starch of cassava, arrowroot starch and gelatin on the physical-chemical and sensorial quality of acerolas during refrigerated storage.

Material and methods

Plant material

Fruits of acerola (*Malpighia emarginata* DC) cv. Costa Rica were purchased at a farm located under the geographical coordinates (02º 26 '35 "S and 54º 42' 30" W) in the municipality of Santarém, Pará. The fruits were transported in plastic boxes to the Laboratory of Phytochemistry of Federal University of Pará - UFOPA, where they were selected for staining (maturation stage) and absence of mechanical injuries and physiological defects followed by sanitization in chlorinated solution (5 $mg.L^{-1}$) for one minute and dried at the temperature the application of the coatings.

Preparation and application of coatings

To prepare the emulsion of cassava starch, arrowroot starch and 3% gelatin, 300 g of the material was suspended in 1L of distilled water, after constant stirring for 5 min under a temperature of 70 °C, the gelling was achieved. The fruits were immersed in the respective solutions for one minute, then inserted in a sieve to remove the excess and placed to dry on a bench, under artificial ventilation for 30 minutes. After drying the fruits were packed in styrofoam polystyrene trays coated with 14 micron polypropylene (PVC) plastic films and stored in a refrigerator (10 ± 2 ºC) for a period of 12 days.

Experimental design

The experimental design was the completely randomized (DIC) in a 4x5 factorial arrangement that corresponds to four coatings/treatments: (control, cassava starch, arrow starch and gelatin 3%) and five evaluation times: (0, 3, 6, 9, 12 days), with five replicates and the experimental plot composed of trays of 100 g of fruit.

Physical-chemical and sensory analyzes

The fresh mass loss was calculated by the difference between the initial mass and the one obtained in each storage period, using an accuracy scale of 0.01 g and the results expressed as a percentage (%).

Soluble solids content was determined using a SKU portable refractometer, model RT-30 ATC, with reading in the range of 0 to 32 ° Brix (AOAC, 2012).

To determine the titratable acidity, the titration method was used with 0.1N NaOH solution and 1% phenolphthalein as the turning point indicator and the results expressed as% of malic acid (AOAC, 2012).

The determination of the pH was carried out with the aid of an AKSO digital particle, model AK 90 with double reading and calibrated with buffer solution 4.0 and 7.0 (AOAC, 2012).

The relationship between total soluble solids content and titratable acidity was obtained by the ratio of the content of SST and AT and the results expressed by means of the absolute value found.

The sensorial quality was determined by the descriptive method through the assignment of notes based on a hedonic scale of five points on the following variables: wilting (1- intense, 2- little intense, 3- moderate, 4- slight and 5- absent) visual appearance (1- extremely poor, high rot, 2- bad, excessive defects, 3- regular, does not limit consumption, 4- good, small defects and 5- excellent, free of defects) and aroma (1- strong odor, 2- a characteristic odor, weak, 3- moderate, 4- none, not typical, and 5- absent, fresh) (MENEZES et al., 2017).

Statical analysis

The data of each variable were submitted to analysis of variance (ANAVA) and the comparison of the means by the Tukey test at the 5% probability level using the statistical software SAEG, version 8.1.

Results and discussion

During the storage period there was a reduction of fresh mass in all treatments, being significantly higher ($p < 0.05$) in the fruits of the control treatment (0.33%) in relation to the coated fruits whose average percentage was around 0.25% after 12 days of storage (Figure 1).

These results corroborate with those observed in table tomatoes (MENEZES et al., 2017), guavas (OLIVEIRA et al., 2017) and (NUNES et al., 2017) where manioc starch and gelatin coatings were efficient in reducing the loss of fresh mass throughout of 12 and 15 days at 10 ºC, respectively when compared to the control.

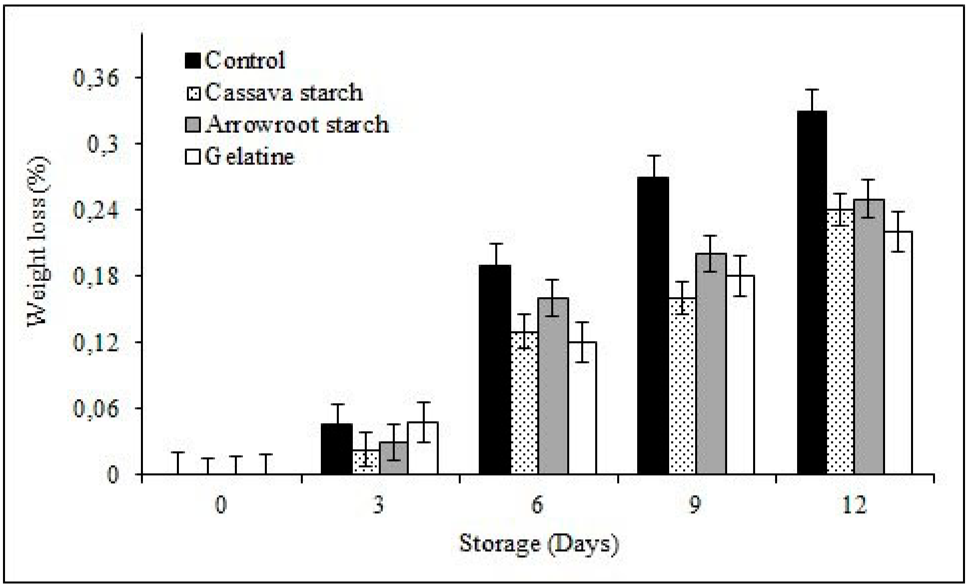

Figure 1. Weight loss (%) in acerolas coated with edible films during 12 days refrigerated storage (10 ± 2 ºC). Means presented with standard deviation show significant difference at the 0.05% probability level.

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The occurrence of the mass loss is directly related to the movement of water in the product after harvest, as the transpiration process causes a deficit and the product loses water to the environment initiating a water stress that has the characteristics of loss of turgidity and reduction of fresh weight (CHITARRA and CHITARRA, 2005; SANCHES et al., 2017). In this context, the films present physical properties that prevent water vapor retention, the loss of water, thus, the smaller loss of fresh mass observed in the coated fruits is due to the physical barrier created over the reducing the rate of transpiration and, consequently, the loss of water to the environment.

Soluble solids content increased between day zero (5.6 º Brix) and the 12 days of storage (~ 7.0 º Brix), without significant difference ($p > 0.05$) between treatments (Figure 2).

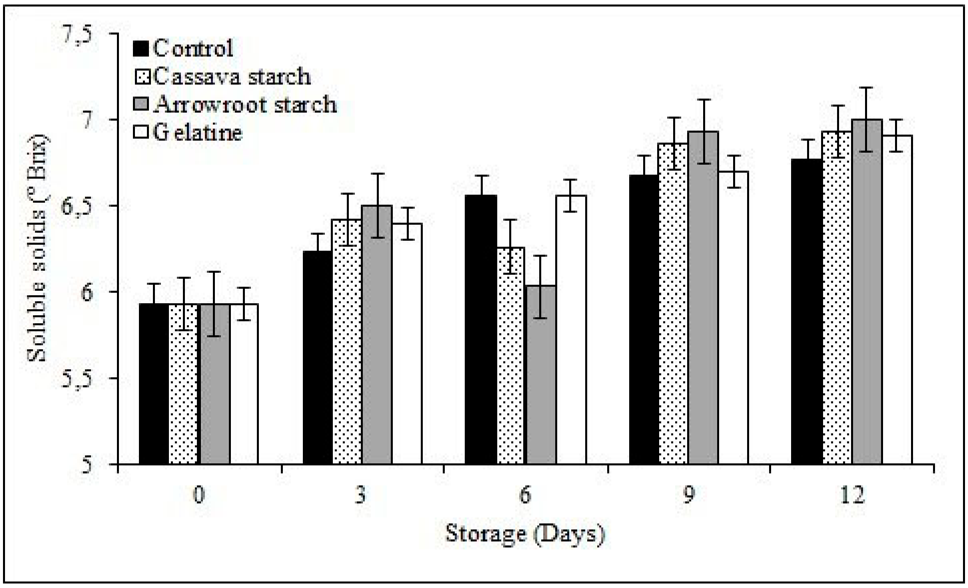

Figure 2. Soluble solids (º Brix) in acerolas coated with edible films during 12 days refrigerated storage (10 ± 2 ºC). Means presented with standard deviation show significant difference at the 0.05% probability level.

Soluble solids indicate the amount of solids (acids, vitamins, pectins, and especially sugars) that are dissolved in fruit juice or pulp and tend to increase during fruit maturation due to the degradation of polysaccharides (starch) or through the loss of water that results in its concentration (CHITARRA and CHITARRA, 2005). Thus, the increase in SST content observed in this work may be a reflection of the loss of fresh mass accumulated in the tissues.

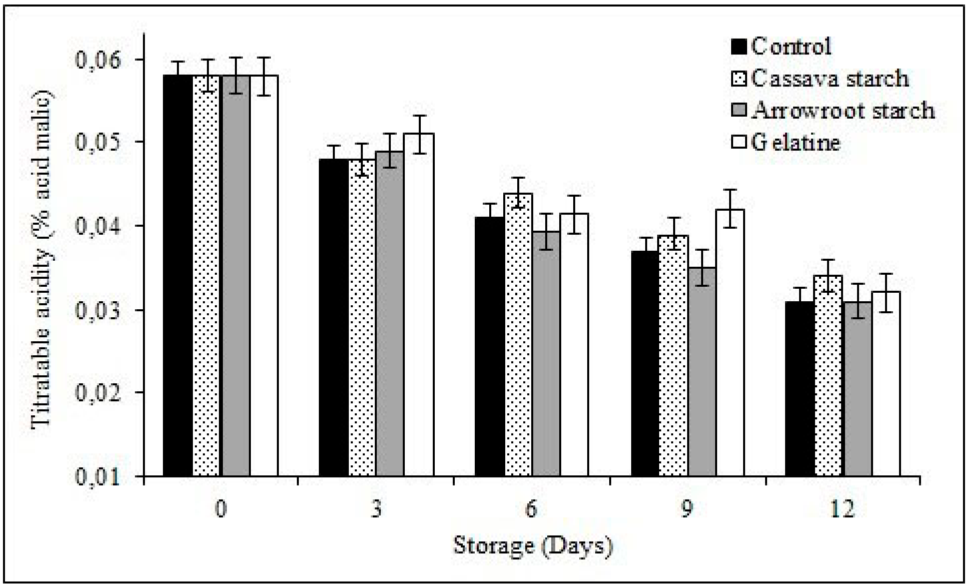

Figure 3. Titratable acidity (% malic acid) in acerolas coated with edible films during 12 days refrigerated storage (10 ± 2 ºC). Means presented with standard deviation show significant difference at the 0.05% probability level.

Similarly, Oliveira et al. (2015) also observed an increase in SST concentration in 'Perinha' and 'Mascot' tomato fruits during 12 days of refrigerated storage (12 ºC) independent of the concentration of cassava starch used.

The titratable acidity levels in the fruits pulp decreased with storage time from 0.060% malic acid at day zero to 0.031 to 0.035% malic acid after 12 days without significant difference (p> 0.05) between treatments (Figure 3).

According to Etienne et al. (2013) titratable acidity (AT) is an important component in the organoleptic quality of fruits and the accumulation of these acids is the result of several interconnected processes that occur in different compartments of the cell and appear to be under the control of several factors. During the maturation of the fruits, the concentration of these acids tends to decrease once they are solubilized to sugars by different metabolic processes, being the main one in the respiration where they serve as substrate (ATP) to maintain its useful life (CHITARRA and CHITARRA, 2005). In this work, the reduction in AT contents may be associated to the use of organic acids as an energetic substrate for respiration and the low efficiency of the coatings in preventing the degradation of these compounds is mainly due to the concentration of the biofilm.

The pH values (Figure 4) did not show significant differences (p>0.05) in relation to storage time and treatments used. After initial stability, there was a reduction in mean values after the sixth day of storage (~ 3.25) until the 12 day (3.01).

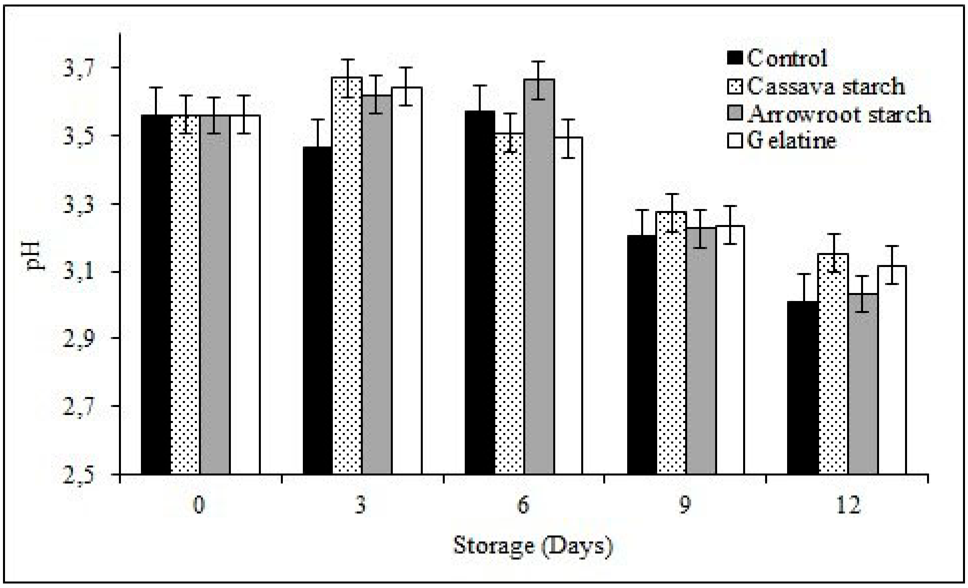

Figure 4. pH in acerolas coated with edible films during 12 days refrigerated storage (10 ± 2 ºC). Means presented with standard deviation show significant difference at the 0.05% probability level.

The acerola as a slightly acidic fruit is normal low pH values as a function of the release of organic acids during ripening. In the present study, it was observed that the highest pH values were observed during the characterization of ripe acerola 3.40 (MUSSER et al., 2004), 3.45 (MENEZES et al., 2009) and 3.90 (TIMÓTEO et al., 2012), or values close to the one found in this study (3.50). For Gondim et al. (2013) low pH values is an interesting feature, because when it comes to post-harvest conservation this allows a longer storage period, since it limits the development of microorganisms.

The relationship between SST and AT is the most important parameter among those analyzed in the post-harvest period, because it determines the extent to which the product has the ideal organoleptic characteristics for consumption through the equilibrium between sugar and acid contents in the fruit pulp and vegetables (CHITARRA and CHITARRA, 2005).

According to Figure 5, a significant effect was observed between storage time and coatings (p<0.05) on fruit flavor.

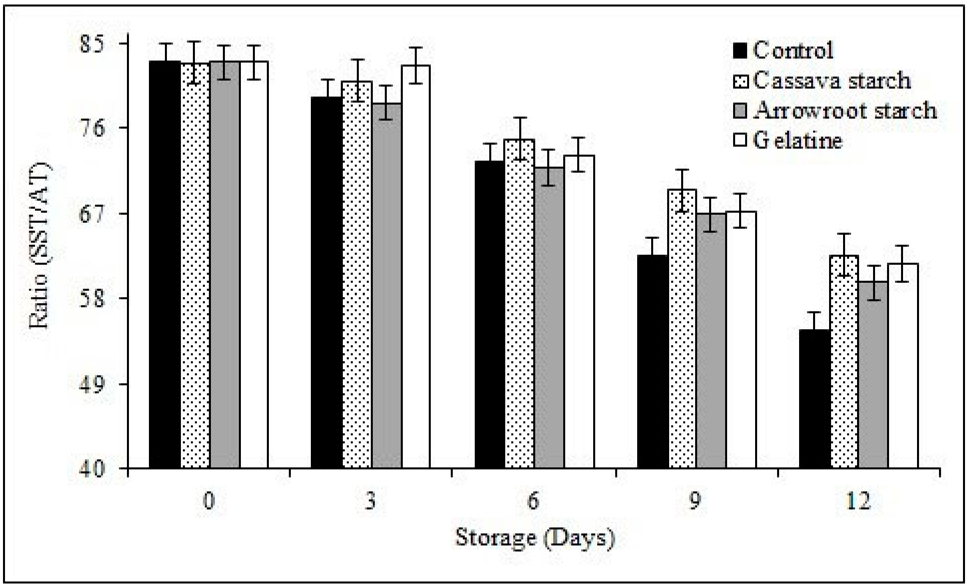

Figure 5. TSS/AT ratio in acerolas coated with edible films during 12 days refrigerated storage (10 ± 2 ºC). Means presented with standard deviation show significant difference at the 0.05% probability level.

The TSS/AT values decreased with storage time, ie 83.0 at day zero and mean value 60.0 after 12 days. This fact is due to the consumption of both organic acids and sugars in the respiratory metabolism of fruits in order to maintain their useful life. Regarding the treatments, fruits coated with cassava starch, arrowroot and gelatine did not differ from each other at the end of 12 days observing average values of 62.0, 59.0 and 61.0, respectively. However, they were significantly higher when compared to control (54.0). This allows to infer that the physical barrier caused by the coatings delayed the degradation of sugars and organic acids, thus allowing a better quality of flavor throughout the storage when compared to the control fruits.

These results corroborate those observed in 'Magali' peppers (MOREIRA et al., 2017) and 'TY' table tomatoes (MENEZES et al., 2017) whose use of coatings, including cassava starch, contributed to a greater TSS/AT ratio after 12 days of storage at 25 ºC, that is, a higher flavor ratio in the fruits.

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The occurrence of wilting through the visual analysis of the fruits is presented in Figure 6. In general, the fruits presented different levels of wilting along the storage time and the coatings ($p < 0.05$).

In relation to the storage time, there is a reduction in assigned scores from 5 (absent) on day zero to 1 and 2 (intense and not very intense) after 12 days. The incidence of wilting is associated with the intense loss of fresh fruit mass (Figure 1) due to the lower turgidity of the cells. Regarding to the treatments, the presence of the coatings allowed a lower incidence of fruit wilting, which were characterized with a note 2 (not very intense) after 12 days of storage differing significantly ($p < 0.05$) from the control fruits (intense). In this way, the film formed by the coatings on the fruits controlled the transpiration rate thereby reducing the loss of water and consequently the wilting.

The appearance is evaluated by different attributes such as degree of freshness, size, shape, color, hygiene, maturity and absence of defects, being a determinant factor in the choice of fruits by consumers (MELO et al., 2016).

In this study, the visual appearance of the acerolas was significantly ($p<0.05$) compromised both by the storage time and by the coatings used (Figure 7).

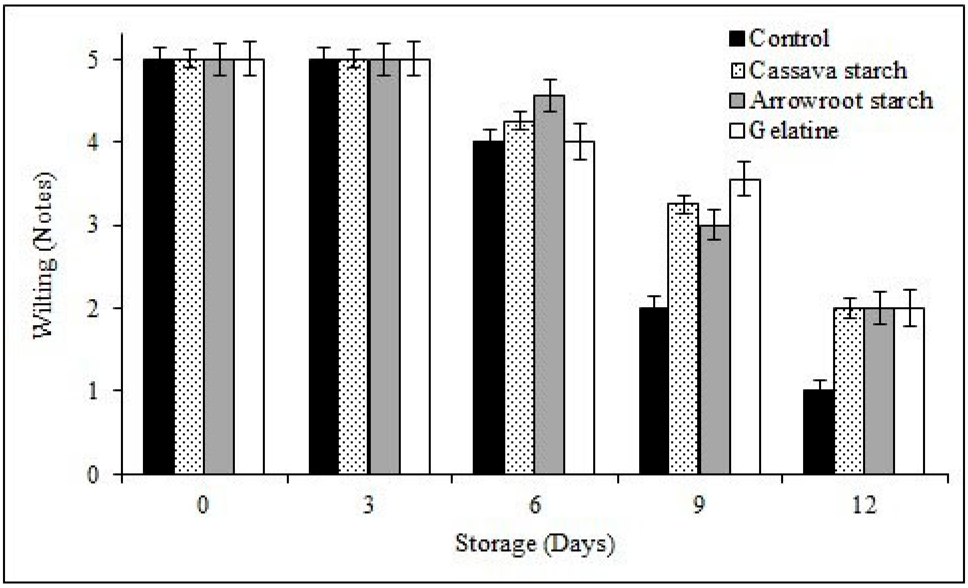

Figure 6. Wilting (notes) in acerolas coated with edible films during 12 days refrigerated storage (10 ± 2 ºC). Means presented with standard deviation show significant difference at the 0.05% probability level.

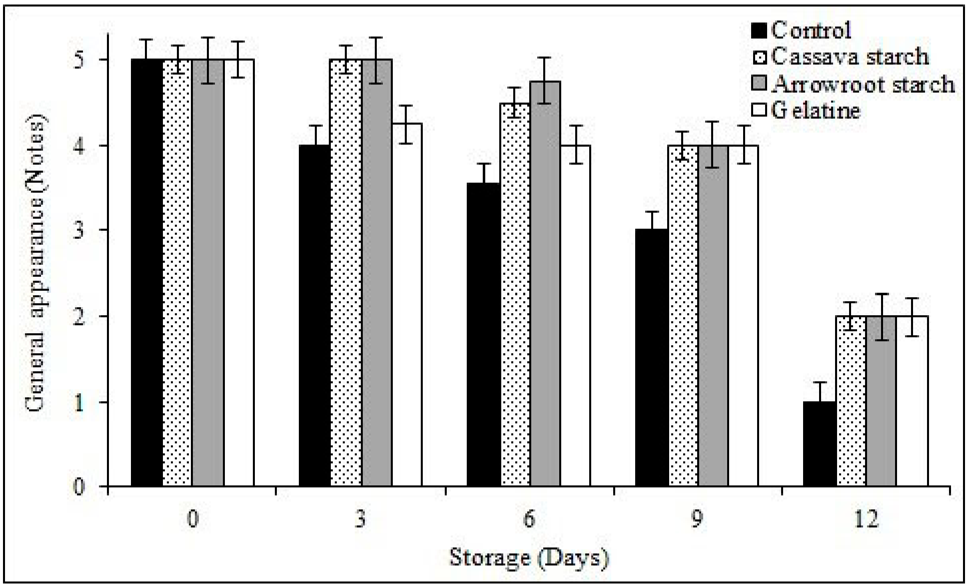

Figure 7. General appearance (notes) in acerolas coated with edible films during 12 days refrigerated storage (10 ± 2 ºC). Means presented with standard deviation show significant difference at the 0.05% probability level.

Due to processes linked to maturation, such as color intensification, water loss and gloss the notes regarding the visual appearance of acerolas reduced with storage time and all treatments. However, the presence of the coatings ensured a better visual quality of the fruits, especially until the ninth day of storage when they were characterized with a note 4 (good, small defects coated) differing ($p < 0.05$) from the control treatment whose note for the same period was 2 (very bad, too much defects). At the end of 12 days of storage the visual quality of the fruits were compromised.

Assis and Brito (2014) report that the presence of the coating in addition to reducing the rates of perspiration and respiration gives a bright aspect, improving the commercial aspect and consequently of quality, this fact justifies the best visual appearance when the fruits were coated with manioc starch, arrowroot starch and gelatine throughout the storage period.

This positive effect of coatings on the preservation of fruit visual appearance has also been observed in 'Tommy Atkins' mangoes (SANTOS et al., 2011), minimally processed papaya (TRIGO et al., 2012), pepper 'Magali' (MOREIRA et al., 2017) and on table tomatoes 'TY' (MENEZES et al., 2017), corroborating with the results obtained in this research.

The aroma in the fruits is characterized by the synthesis of volatile compounds resulting from processes linked to the sweetening. Figure 8 shows the distribution of notes on the aroma exhaled by the fruits during the storage period. In summary, significant effect ($p<0.05$) of storage time and coatings on this variable were observed.

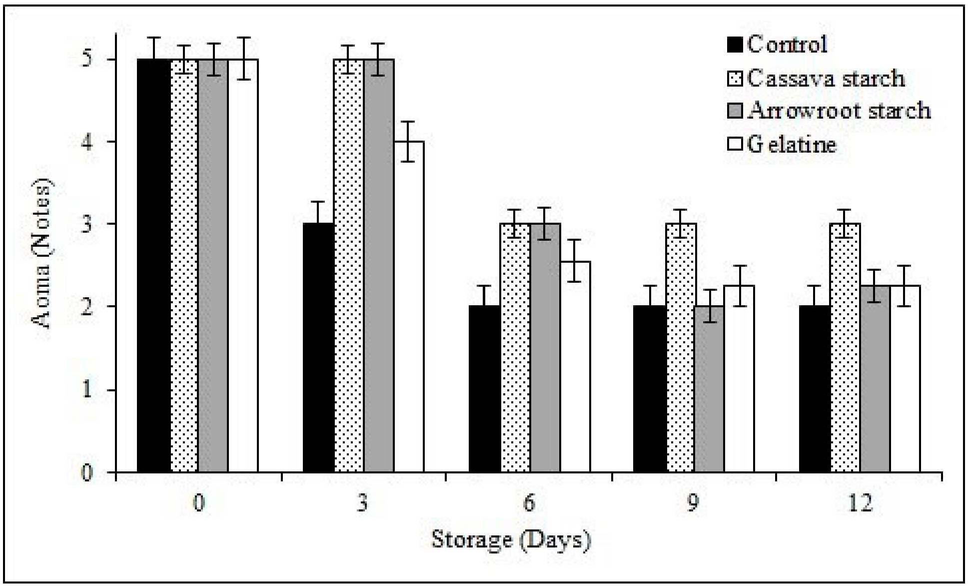

Figure 8. Aroma (notes) in acerolas coated with edible films during 12 days refrigerated storage (10 ± 2 °C). Means presented with standard deviation show significant difference at the 0.05% probability level.

In general, the characteristic aroma of the mature fruit reduced with the storage time being associated with the production of volatile compounds linked to senescence. However, the cassava starch coating ensured the preservation of this quality attribute since the fruits were characterized with note 3 (moderate) after 12 days of storage differing significantly ($p<0.05$) from the other treatments.

Conclusion

The coatings based on cassava starch and arrowroot and gelatine are efficient alternatives in the preservation of the physical-chemical and sensorial quality of acerolas during refrigerated storage (10 °C).

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