Scientia Horticulturae 217 (2017) 276–284

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

Postharvest behavior of camu-camu fruits based on harvesting time and nutraceutical properties

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ARTICLE INFO

Article history:
Received 7 October 2016
Received in revised form 13 January 2017
Accepted 17 January 2017
Available online 10 February 2017

Keywords:
Myrciaria dubia
Functional components
Shelf-life
Industry
Consumption

ABSTRACT

This work aimed to evaluate the postharvest behavior of camu-camu fruits, harvested at 74; 81; 88; 102 and 116 days after anthesis (DAA). The fruits were collected nearly of the borders of Cauamé River located in the State of Roraima, Brazil. After harvest, the fruits were freeze-dried and kept at −20 °C for functional compounds analyzes at the Plant Bioactive & Bioprocessing Research Laboratory – TAMU/USA. Fresh fruits were used for the physicochemical analysis, performed at Food Technology Laboratory/UFRR/Brazil, keeping the fruits under cold storage at 15 ± 1 °C and 95 ± 3% of RH. The harvest performed at 88 DAA resulted in the highest shelf-life period, up to 10 days, while premature harvests, performed at 74 and 81 DAA, provided to the fruits only 5 days of shelf-life. In this sense, fruits harvested at 88 DAA presented the highest values for the total phenolic compounds and ascorbic acid contents, as for the ORAC and DPPH assays, adequate enzymatic pattern, and the best results for total and reducing sugars, total and soluble pectins and starch contents. However, fruits harvested at 102 DAA were more appropriate for fresh consumption according to the sensory analysis, showing as well, high levels of the main physicochemical characteristics and a satisfactory shelf-life period (up to 8 days). Fruits harvested at 116 DDA, despite adequate sensory results, showed only 6 days of shelf-life under cold storage conditions.

1. Introduction

Native to the Amazon region, the camu-camu fruit [*Myrciaria dubia* H. B. K. (McVough)] has a high antioxidant capacity, not only because of the high contents of vitamin C, but also to providing considerable amounts of phenolic compounds, what can turn it as a functional food (Chirinos et al., 2010).

The camu-camu fruit has raised the interest of various industrial sectors such as medicine, cosmetic, alimentary and natural preservatives. For example, from the skin extracts of camu-camu it is possible to get the natural pigment as anthocyanins. Furthermore, many researches has proven that the kind of vitamin C found aplenty in the camu-camu fruits is not destroyed by the heat (Metzker, 2001; Neves et al., 2015a,b; Yuyama and Valente, 2011).

Changes in the content and profiles of phytochemicals in the camu-camu fruits, such as vitamin C, carotenoids and phenolic compounds are also evident, because the stage of maturation has a significant effect on the physical characteristics and chemical composition of these fruits (Chirinos et al., 2010). As for the other fruits, the determining factor from the ideal point of harvest for the camu-camu, in most cases, is the type of product to be processed and the final destiny location that the fresh fruit must to be transported (Neves, 2009). So, based on these conditions, the optimal maturation stage for harvest should be established by each market purpose, transport conditions and cold storage operations to be held.

The chemical and functional characterization of camu-camu fruits during various stages of development may be used to establish the optimal harvest periods when the chemical and functional components of the fruit are maximized (Neves et al., 2015a). The ideal time of harvest is determined by the interpretation of the curve of maturation and the ripening of the fruits, taking in consideration the enzymatic activity and the respiration as responses to the biochemical and physiological metabolisms (Andrade et al., 1995).

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http://dx.doi.org/10.1016/j.scienta.2017.01.030
0304-4238/

In addition the postharvest studies, it is recommended to observe the changes in the biochemical components during the fruit maturation in the plant through physical, chemical and physiological analysis, elaborating metabolic curves for each chemical constituent that show significant changes (Andrade et al., 1995). Thus, the maximum or minimum concentration of the nutritional and functional constituents, and the correlation between them, may allow the establishment of the ideal time of harvest for the fresh fruits aimed at immediate marketing and/or storage, in the case for the industrialized production of extracts (Amarante and Megguer, 2008).

By the fact there is no proper guidance yet for handling and cold storage for camu-camu fruits, it is necessary to perform cold storage trials right after harvesting, in order to determine the relationship between temperature and storage periods to extend the fruit shelf-life (Carrillo et al., 2011).

The knowledge of ripening behavior of camu-camu fruits and factors related to the nutritive characteristics may help to determine the best time to harvest them, as well to establish the maximum period of cold storage during postharvest, what can encourage the development of new technologies and marketing. Therefore, the objective of this work was to study the time of harvest of camu-camu fruits and its implications on the postharvest behavior and biochemical components stability, for both processing and fresh markets.

2. Material and methods

2.1. Harvest of fruits

The camu-camu fruits (*Myrciaria dubia*) were collected in different ripening stages nearby the borders of Caumé River, one of the most important located in the State of Roraima, Brazil (1°45′29″N and 61°35′49″W). After the formation of the flower buds, these were identified and marked for harvest to be performed according the schedule of harvest time. Thus, 40 trees were identified and 155 ± 5 flower buds per tree were marked. During and after the development of the camu-camu fruits, the harvests were performed at 74; 81; 88; 102 and 116 days after anthesis (DAA). At the beginning of the experiment, it was tried to establish a ripening color standard, however, in all harvests fruits were found with skin color ranging from yellowish green to deep red. Thereby, aiming the selection and standardization of the samples, it was used a criteria based on the phytosanitary health of the fruits, as well in the size and caliber of them. The experiment was carried out in a complete randomized design with 3 replications and 390 ± 5 g of fruits in each harvest time (42–52 fruits per plot).

2.2. Installation the experiment

After harvesting, the fruits were transported to the Food Technology Laboratory at Roraima Federal University, Brazil, and once again the fruits were selected for absence of visible damage and decay, standardized by size/caliber and skin color, and then washed in sodium hypochlorite (NaOCl) solution at 2.5% L^{-1} water for 30 min (Milanez et al., 2016). The fruits were rinsed in distilled water and dried on perforated trays and exposed to for 2 h to room temperature (25 ± 2 °C, 70 ± 3% RH). Thus, the seeds of the fruits were removed from the peel and pulp using a stainless steel knife. The samples (peel and pulp) were processed in a Turrax for 3 min, and each sample was then homogenized.

The fruits were then dry-freezed and kept at −20 °C, for the analysis of the functional compounds at the Plant Bioactive & Bioprocessing Research Laboratory TAMU/USA. Fresh fruits were used for the physical-chemical analysis, performed at LTA/UFRR/Brazil, keeping the fruits under cold storage at 15 ± 1 °C and 95 ± 3% of RH in different times, depending of each harvest time and based on the postharvest potential that each fruit showed during the experiment.

2.3. Analysis performed

For each harvest time, it was estimated different times of cold storage, always following the same conditions to all the fruits (15 ± 1 °C and 95 ± 3% of RH). Initially, it was estimated 10 days of cold storage to the fruits harvested at 74 and 81 DAA, and 15 days to the fruits harvested at 88; 102 and 116 DAA. However, during the experiment, the fruits harvested at 77 and 81 DAA only could be analyzed until the 5th day of cold storage. The fruits harvested at 88 DAA presented an adequate shelf-life until the 10th day of cold storage, and the fruits harvested at 102 and 116 DAA presented, respectively, 8 and 6 days of cold storage within the quality criteria based on firmness, turgor and external appearance of the fruit. For these reasons, the analyses comprise data up to 10 days of cold storage. The following analyses of camu-camu fruits were performed:

2.3.1. Pectinmethylesterase (PME)

it was determined according to Jen and Robinson (1984), where it was examined the ability of the enzyme to catalyze the demethylation of pectin corresponding to 1 μmol of NaOH per minute under the test conditions. The results were expressed as UAE g min^{-1}.

2.3.2. Polygalacturonase (PG)

it was determined according to Pressey and Avants (1973), where it was examined the ability of the enzyme to catalyze the formation of 1 μmol of reducing sugars per minute per gram. The results were expressed as UAE g min^{-1}.

2.3.3. Total and soluble pectins

these variables were analyzed according to Mccready and Mccomb (1952) and determined colorimetrically by the reaction with carbazole, using the technique of Bitter and Muir (1962). The contents of total and soluble pectins were expressed as percentage (%) of galacturonic acid. 100 g^{-1} of pulp.

2.3.4. Total and reducing sugars

These characteristics were determined according to the method of Nelson (1944) and the results were expressed in mg of glucose. 100 g^{-1} of pulp

2.3.5. Starch

The fruit starch content was determined according to IAL (2008). Thus, 1.0 g of sample was weighed and previously dried in a 250 mL erlenmeyer flask. Then, 50 mL of hydrochloric acid (HCl) 1 M (8.5 mL HCl in 1 L of distilled water) were added. Then, the erlenmeyers were sealed with cotton plugs wrapped in plastic film self-adhesive. The vials containing the samples were placed in plastic container to microwave with water in the background enough to prevent drying. The erlenmeyers remained in the microwave for 20 min at full power. After this period, the starch turns into sugars and a few drops were removed for the test with lugol (iodine in potassium iodide), making the solution yellow. Then, the sample was neutralized with 10% NaOH (100 gL^{-1} NaOH in water solution) using 3 drops of phenolphthalein as indicator until the color of the solution turns into pink. The results were expressed as mg of glucose.100 g^{-1} of pulp.

2.3.6. Soluble solids

the soluble solids content was determined by refractometry, using a Shimadzu® refractometer with temperature correction,