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Quality of cold-pressed murici juice subjected to different concentrations of ascorbic acid

Calidad del jugo murici prensado en frío sometido a diferentes concentraciones de ácido ascórbico

N. R. Gomes[1]; B. S. Pierre; R. R. Almeida[1]; C. M. A. Morgado[1*]; L. C. Cunha Junior[2]; A. J. Campos[1]

[1]Universidade Estadual de Goiás, Campus Anápolis de Ciências Exatas e Tecnológicas - Henrique Santillo, Programa de Pós-Graduação em Engenharia Agrícola, Rodovia BR 153 Quadra Área Km 99 Zona Rural, 75132-903, Anápolis, GO, Brasil.
[2]Universidade Federal de Goiás, Campus Samambaia, Escola de Agronomia, Rodovia Goiânia-Nova Veneza, Km 0 s/n, 74690-900, Goiânia - GO, Brasil

**cristianemorgado4@yahoo.com.br*
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Murici (*Byrsonima crassifolia (L.) Kunth*) belongs to the *Malpighiaceae* family and is a typical fruit of the Cerrado. Its consumption occurs by local populations, both fresh and processed, such as juices, liqueurs, ice cream, jellies, yogurt, bread, and cakes. In this sense, this study aimed to assess different concentrations of ascorbic acid added to cold-pressed murici juice for the preservation of physical-chemical and bioactive characteristics. The juice was assessed for soluble solids, titratable acidity, pH, ascorbic acid and total extractable polyphenols. The experiment was conducted in a completely randomized design in a 3 × 7 factorial scheme (three concentrations of ascorbic acid × seven days of analysis) to assess three concentrations of ascorbic acid in the preservation of cold-pressed juice (0, 1, and 2%) and seven days of analysis (0, 1, 2, 3, 4, 5, and 6 days), with four replications. The data were submitted to analysis of variance ($P<0.05$) and, when significant, the regression analysis was performed. The concentration of 2% ascorbic acid was the most suitable for cold-pressed juice mainly because it maintains the acceptability characteristics of this product.
Keywords: *Byrsonima crassifolia (L.) Kunth*, processing, pressing.

Murici (*Byrsonima crassifolia (L.) Kunth*) pertenece a la familia *Malpighiaceae* y es una fruta típica del Cerrado. Su consumo se produce en poblaciones locales, tanto frescas como procesadas, como jugos, licores, helados, jaleas, yogurt, pan y pasteles. En este sentido, este estudio tuvo como objetivo evaluar diferentes concentraciones de ácido ascórbico añadido al jugo murici prensado en frío para la preservación de las características físico-químicas y bioactivas. El jugo se evaluó para determinar solidos solubles, acidez titulable, pH, ácido ascórbico y polifenoles extraíbles totales. El experimento se realizó en un diseño completamente al azar en un esquema factorial 3 × 7 (tres concentraciones de ácido ascórbico × siete días de análisis) para evaluar tres concentraciones de ácido ascórbico en la preservación del jugo prensado en frío (0, 1 y 2%) y siete días de análisis (0, 1, 2, 3, 4, 5 y 6 días), con cuatro repeticiones. Los datos se sometieron a análisis de varianza ($P<0,05$) y, cuando fue significativo, se realizó el análisis de regresión. La concentración de ácido ascórbico al 2% fue la más adecuada para el jugo prensado en frío principalmente porque mantiene las características de aceptabilidad de este producto.
Palabras clave: *Byrsonima crassifolia (L.) Kunth*, procesamiento, prensado.

1. INTRODUCTION

The Cerrado has one of the most diversified vegetation in Brazil due to its high environmental heterogeneity [1]. Among the plant species of this biome, the *Malpighiaceae* family covers 65 to 70 genera, according to Gansalves (2002) [2], and Byrsonima is one of the most abundant genera of this family [3].

Murici (*Byrsonima crassifolia (L.) Kunth*) is a typical fruit of the Cerrado region that can be consumed fresh or processed as ice cream, juices, jams, popsicles, among others, and, in addition to consumption, this fruit is also used as a therapeutic, anti-inflammatory, healing [4], and antimicrobial agent [5]. The chemical composition of murici consists of 83% of water, 15% of carbohydrates, 1.3% of lipids, and about 0.7% of proteins [2]. Pulp consumption (100 g) supplies the needs of vitamin C in children, adults, and pregnant women (156, 43, and 46%, respectively), besides contributing to the daily needs of vitamin A (55, 24, and 28%, respectively) [6].

Convenience and salubrity represent two important trends in the food sector, and consumers are increasingly demanding products that combine health benefits and practicality. Juice has high market potential, as it is a natural food that meets current trends [7] and also allows the consumption of fruits that usually would not be consumed fresh, either due to geographical or climate impossibility and off-season reasons [8].

Cold pressing is a new technology used in the manufacture of healthier juices [9] rich in nutrients [10]. Cold pressing is an all-natural method that maintains the nutritional benefits of each ingredient. Fruits are cold-pressed, bottled in their final packaging, and, due to the absence of heat, the original nutrients are not compromised, and freshness is maintained [11]. In addition, there is no water added, allowing a high concentration of fruits and vegetables, resulting in a product of high nutritious density. Khaksar et al. (2019) [12] tested three juice extraction methods, including the cold pressing, and observed that the physical-chemical properties, antioxidant activity, and contents of bioactive compounds remained unchanged in these juices for 5 days of storage at 4 °C.

Usually, cold pressing is carried out using a manual press, which has the advantage of the ease of operation and low cost of acquisition and maintenance. The main disadvantage is the pressing time, which is much longer than the time spent in the hot pressing (30 to 60 minutes), thus generating less productivity. Because juices are obtained from fresh, ripe fruits washed by an appropriate industrial process, they cannot be diluted or contain a strange odor or taste, or even any indication of fermentation. Its stabilization depends on some authorized physical or chemical treatment or additives to guarantee its preservation and better durability [13].

In this regard, ascorbic acid is used as an additive (acidulant and antioxidant) in the food industry in the manufacture of soft drinks, juices, desserts, canned fruits, jellies, sweets, and wines. It prevents turbidity, assists in retaining carbonation, enhances preservatives, gives a characteristic fruity flavor, prolongs the stability of vitamin C, reduces color changes, enhances aromas, and buffs the medium [14].

Thus, the use of supporting agents, with the addition of ascorbic acid in these juices, has been of great interest for both food producers and consumers, as the recommended daily intake of this vitamin is 25 mg for children, 75 mg for women, and 90 mg for men [15]. In this context, this study aimed to assess different concentrations of ascorbic acid added to cold-pressed murici juice for the preservation of physical-chemical and bioactive characteristics.

2. MATERIAL AND METHODS

Murici fruits were harvested in January 2018 on the rural property Córrego do Meio, located in the municipality of Diorama, GO, Brazil, with geographical coordinates 16°14′02” S and 51°15′21” W, with 506 m of altitude. Harvest was carried out manually when fruits were at the physiological maturation stage, used for commercial consumption, i.e., when the peel has a yellowish-green color.

After harvesting, these fruits were transported in high-density polyethylene (HDPE) trays to the Laboratory of Drying and Storage of Vegetable Products of the Agricultural Engineering course, at the Anápolis Campus of Exact and Technological Sciences Henrique Santillo (CCET) of the State University of Goiás (UEG), Anápolis, Goiás, Brazil.

In the laboratory, murici fruits were washed, sanitized with 200 mg L^{-1} sodium hypochlorite solution for 10 minutes, rinsed with distilled water, selected for no damage or rot, pulped manually, and cold-pressed. Pressing was carried out using a MARCONI press (with a stainless steel pressing chamber), with a manually operated hydraulic system, a 15-ton pressure gauge, a drag pointer, and a hydraulic hand pump.

The experimental design used was completely randomized with a 3 × 7 factorial scheme (three ascorbic acid concentrations × seven days of analysis), with four replications.

After cold pressing, three concentrations of ascorbic acid (AA) were added to juice samples, corresponding to the following treatments: 0% (control), 1%, and 2%. Then, 52 mL of juice was added to each polyethylene terephthalate (PET) plastic bottle with a polypropylene (PP) cap model PG283, an internal ethylene-vinyl acetate (EVA) screw sealing seal, and a capacity of 120 mL. Subsequently, the packages were stored in BOD (Biochemical Oxygen Demand) incubators at 2±1 °C and 50±3% relative humidity (RH) for 6 days, and analyzed daily for soluble solids content, titratable acidity, pH, total extractable polyphenols, and ascorbic acid content.

Soluble solids contents (°Brix), titratable acidity (% citric acid), and pH were determined according to the AOAC (2016) [16] methodology, methods 932.12, 942.15 and 981.12, respectively. The ascorbic acid content was determined using the 2.6-dichlorophenol-indophenol 0.02% titration method, described by AOAC (2016) [16]. The results were expressed as mg 100 mL^{-1} juice. Total extractable polyphenols were determined by the Folin-Ciocalteu's reagent [17]. Results were expressed as mg gallic acid equivalent (GAE) 100 g^{-1} juice.

The data obtained from the analyzed variables were subjected to analysis of variance ($P<0.05$), and, when significant, a regression analysis was performed (quantitative data). The software SISVAR 5.6 [18] was used for statistical analysis.

3. RESULTS AND DISCUSSION

Due to the scarcity of data in the literature, the behavior of cold-pressed murici juice obtained in the present study was compared to those found by authors who studied juice from other fruits. The contents of soluble solids during the 6 days of storage showed an increasing tendency for the lower concentrations of ascorbic acid added to the juice. The treatment with 2% ascorbic acid had contents practically constant (Figure 1), with values at the end of the study similar to the initial values. This treatment can be considered the most appropriate due to the maintenance of soluble solids during storage.

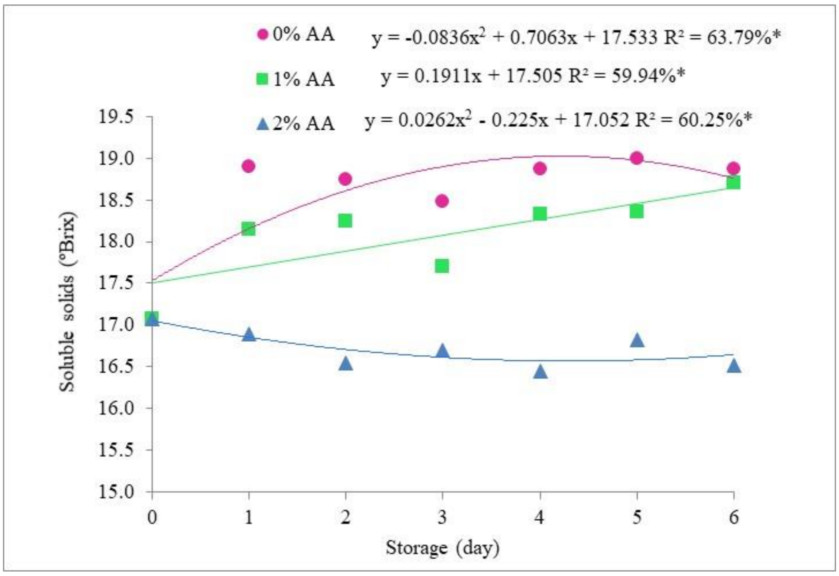

*Figure 1: Contents of soluble solids (°Brix) of cold-pressed murici juice with different concentrations of ascorbic acid (AA) and stored for 6 days. UEG, Anápolis, 2018. *Significant at 5% probability.*

The treatment with 0% AA showed an increase in the contents of soluble solids during juice storage, with the highest contents between treatments. Similarly, Pimentel et al. (2011) [19] studied peach nectar with inulin addition and found an increase in the content of soluble solids during storage at 4 °C.

The increase in soluble solids contents in the treatment with 0% ascorbic acid may have occurred because the cold-pressed juice has characteristics of a natural juice, in order to preserve the enzymes and nutrients as close to their in natura form [10]. Thus, in the murici pulp, according to Morzelle et al. (2015) [6] carbohydrates are present, which may have been degraded through enzymatic actions, increasing the soluble solids content. In the other juices that received the different concentrations of ascorbic acid, there was possibly a contribution of this so that there was no such enzymatic degradation, and consequently, an increase in the levels of soluble solids.

According to Normative Instruction 37 [20], the quantity of soluble solids present in murici juice must be at least 4.4 °Brix. Therefore, the results found in this study were within the minimum value provided for in this normative instruction.

Concentrations of 0 and 1% ascorbic acid showed significant interaction with days of analysis for titratable acidity contents (Figure 2), while the concentration of 2% had no significant interaction. The values of titratable acidity of cold-pressed murici juice during the storage period decreased at concentrations of 0 and 1%, which is in line with the increase in pH values (Figure 3) until the third day of storage.

Titratable acidity values found in the treatment with 0% ascorbic acid ranged from 1.26 to 0.66% citric acid, while in the treatment with 1% ascorbic acid, they ranged from 1.26 to 0.85% citric acid (Figure 2), which was similar to that found by Karadeniz et al. (2006) [21] in murici pulp from Palmas, TO, Brazil (1.05% citric acid) and higher than that found by Morzelle et al. (2015) [6] in fruits harvested in Barra do Garças, MT, Brazil (0.17% citric acid).

These variations may be related both to the degree of fruit maturation and to the characteristics of the soil where fruits were grown. Also, Morzelle et al. (2015) [6] mentioned that Cerrado fruits, such as murici, are non-domesticated species, which can cause frequent differences in chemical composition and nutrients.

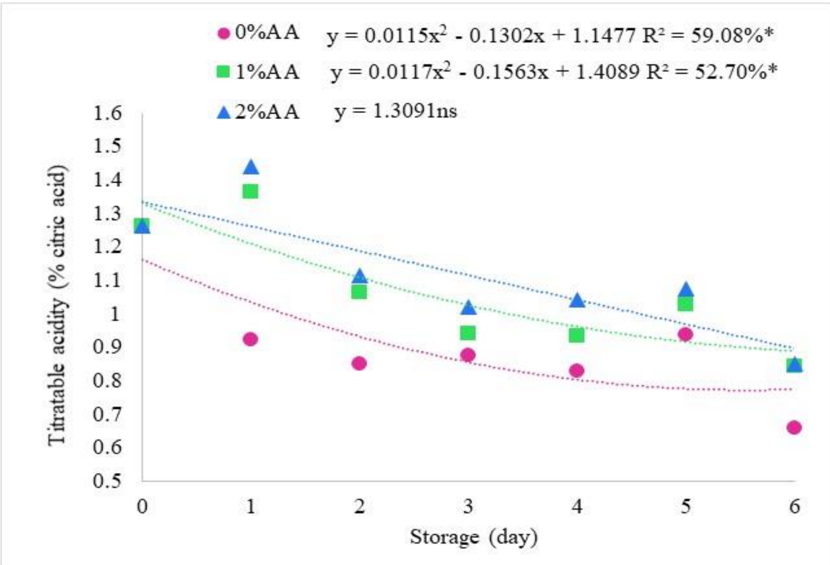

*Figure 2. Contents of titratable acidity (% citric acid) of cold-pressed murici juice with different concentrations of ascorbic acid (AA) and stored for 6 days. UEG, Anápolis, 2018. *Significant at 5% probability. ^{ns}Not significant at 5% probability.*

The treatments with 0 and 1% ascorbic acid showed maximum pH values on the third and second days of storage, respectively (Figure 3). This increase during the storage period may be related to the decrease in the titratable acidity contents [22]. After this peak, there was a decrease until the end of storage. The treatment with 2% ascorbic acid, on the other hand, maintained a downward trend over the storage period, which is due to the fact that ascorbic acid has high water solubility and reduces the pH [14].

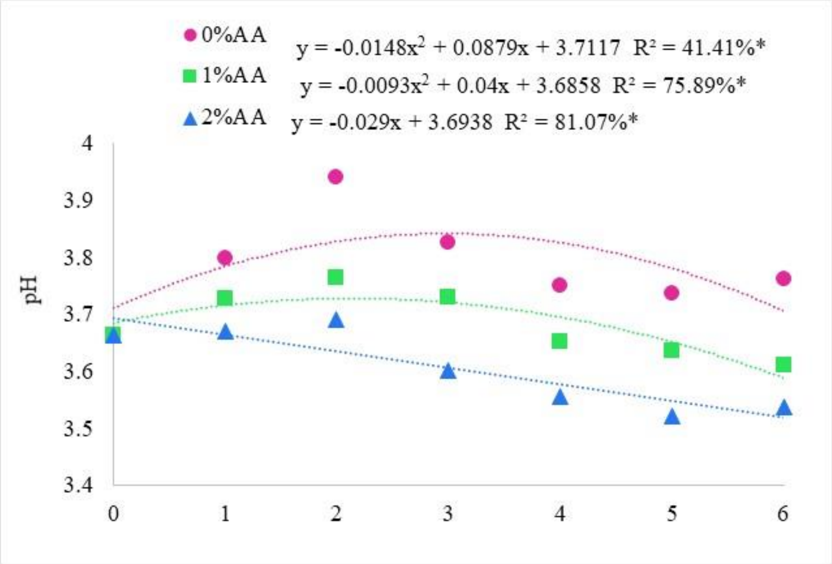

*Figure 3. pH values of cold-pressed murici juice with different concentrations of ascorbic acid (AA) and stored for 6 days. UEG, Anápolis, 2018. *Significant at 5% probability.*

Regarding pH, foods can be classified as low acid (pH higher than 4.5), acid (pH between 4.0 and 4.5), and very acid (pH lower than 4.0), being low-acid foods the most conducive to microbial multiplication and, therefore, deterioration [23]. The pH values found in the murici juice ranged from 3.50 to 3.99, being classified as very acid and, therefore, interesting from the microbiological point of view. However, the very low pH values found in cold-pressed murici juice are in accordance with the characteristics and composition determined by Normative Instruction No. 37 [20], in which murici juice has to present a minimum pH value of 2.8.

An increase in the contents of ascorbic acid was found up to the 3rd day of storage, followed by a subsequent reduction (Figure 4), except only for the treatment with 0% ascorbic acid, which showed a reduction from the 2nd day of analysis. According to Karadeniz et al. (2006) [21], this reduction in vitamin C, mainly in the control treatment, is due to possible chemical oxidation during juice storage.

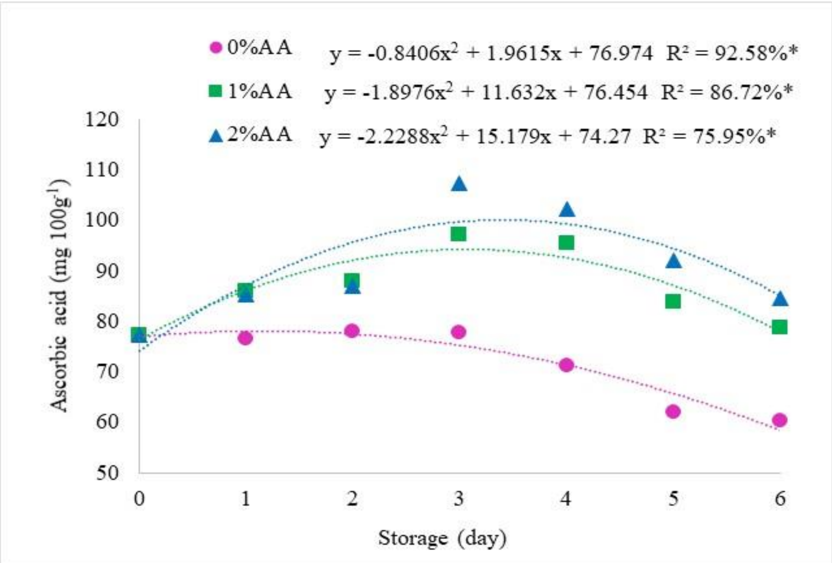

*Figure 4. Contents of ascorbic acid (mg ascorbic acid 100 g^{-1} juice) of cold-pressed murici juice with different concentrations of ascorbic acid (AA) and stored for 6 days. UEG, Anápolis, 2018. *Significant at 5% probability.*

Croda et al. (2017) [24] assessed a mixed juice of juçara palm with peanut butter fruit before and after processing and during storage (under refrigeration and freezing) and found a reduction in the contents of ascorbic acid during the 45 days of refrigerated (7 to 10 °C) or frozen storage (-18 °C), which was similar to that found in this study.

Freire et al. (2013) [25] worked with the frozen pulp of acerola, cashew, strawberry, and guava and also noticed a reduction in the ascorbic acid content, which was attributed to the effect of storage, as vitamin C is susceptible to degradation. Moreover, other factors can influence the degradation of this vitamin, such as oxidation, which may have occurred in murici juice, justifying this reduction over the days.

The treatment with 2% ascorbic acid presented the highest mean value for vitamin C content, followed by treatments with 1 and 0% (control), thus showing that an increase in the concentration of this antioxidant was effective in maintaining the ascorbic acid content present in the juice. Couto and Canniatti-Brazaca (2010) [26] explained that a high amount of vitamin C protects against uncontrolled oxidation in the aqueous medium of the cell due to its high reducing power.

The contents of total extractable polyphenols increased in all treatments during the storage period, providing a quadratic behavior. Polyphenols in treatments with 1 and 2% ascorbic acid remained similar until the second day of storage. The treatment with 0% ascorbic acid showed higher levels of total extractable polyphenols than other treatments (Figure 5), which could be explained by the reducing action of ascorbic acid, which is widely used in fruits and juices to prevent darkening. In addition, ascorbic acid also acts as an inhibitor of oxidative enzymes by reducing pH [27].

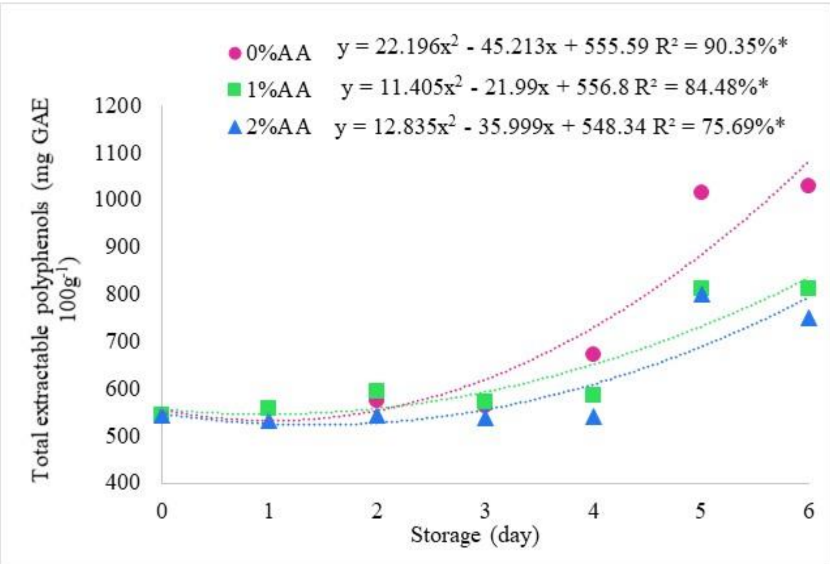

*Figure 5. Contents of total extractable polyphenols (mg gallic acid 100 g^{-1} juice) of cold-pressed murici juice with different concentrations of ascorbic acid (AA) and stored for 6 days. UEG, Anápolis, 2018. *Significant at 5% probability.*

The determination of phenolic compounds in fruit juices aims to assess the darkening potential during or after processing, in addition to the possibility of the influence of these contents on flavor due to the astringency characteristic of some of them [28]. Furthermore, phenolic compounds are important antioxidants and, therefore, have a high functional appeal. Thus, the fact that these contents have increased in murici juice during storage for 6 days may show that, in cold-pressed juice, enzymes such as phenylalanine ammonia-lyase (PAL) may still be present, which acts on secondary metabolism forming other phenolic compounds [29].

Phenylalanine ammonia-lyase catalyzes the deamination of L-phenylalanine with the production of trans-cinnamic acids, which are considered precursors for a wide variety of phenolic compounds, such as coumaric, caffeic, and chlorogenic acids. Its increased activity indicates that some biotic or abiotic stress, such as injuries, has occurred [30], which would justify its performance, as there was a rupture and/or injury of cells during murici processing for juice manufacturing.

Phenolic compounds are antioxidant agents linked to stress processes [31], and, therefore, high phenolic contents are expected in injured tissues, which was found in the 0% treatment (control). Thus, ascorbic acid addition may have been effective in reducing this oxidation. Vitti et al. (2019) [32] reported that lower PAL activity in minimally processed potatoes to which different combinations of ascorbic acid were added, indicating that the addition of antioxidant treatments is effective in reducing enzymatic darkening.

This result can be useful for the juice industry as a starting point for the development of tastier juices, considering that several beneficial health effects have been attributed to phenolic compounds present in fruits, vegetables, teas, juices, and wines [33]. Therefore, even though food processing can cause several effects on different components, such as ascorbic acid, polyphenols, and carotenoids, not all of them lead to losses in quality and health characteristics.

4. CONCLUSIONS

Treatment with 2% ascorbic acid was the most appropriate in this experiment mainly for maintaining for a longer period the important characteristics for the acceptability of cold-pressed murici juice, such as soluble solids, pH, and vitamin C.

Cold-pressed murici juices with ascorbic acid addition can be consumed until the 3rd day of storage, as it still maintains the characteristics inherent to murici and commercial quality, such as increase in ascorbic acid and pH levels to this day.

Cold pressing is an interesting alternative for the food industry, since cold pressed juice maintains the biological and sensory characteristics of the fruit, preserving enzymes and nutrients as close to their in natura form.

5. ACKNOWLEDGMENTS

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