

**ARTIGO CIENTÍFICO**

**REFRIGERATED STORAGE OF FRESH-CUT MAROLO (*ANNONA CRASSIFLORA MART.*)**

**Armazenagem refrigerada de Marolo (*Annona crassiflora MART.*)  
minimamente processado**

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**RESUMO:** O marolo é uma fruta típica da savana brasileira que é muito apreciada por seu sabor exótico, valor nutricional e atributos sensoriais. Este estudo teve como objetivo avaliar a qualidade do marolo fresco, verificando possíveis alterações nas características físicas, químicas, microbiológicas e sensoriais durante o armazenamento refrigerado (12 dias a 0°C, 5°C e 10°C). A firmeza variou ao longo do tempo de armazenamento; a fruta amoleceu no 8º dia e depois aumentou em dureza até o final do estudo. As temperaturas mais baixas de armazenamento reduziram a taxa de escurecimento deste produto. Não foram observadas variações nos níveis de sólidos solúveis (12,7 a 14,6 °B) ou fenólicos totais (741,06 a 1295,21 mg. GAE.100g<sup>-1</sup>). Os frutos armazenados a 10°C apresentaram aumento da acidez titulável após o 5º dia e aumento do pH no 10º e 12º dias. Foram observados aumentos na pectina solúvel (156 a 265,73 mg.100g<sup>-1</sup>) e nas pectinas totais (> 1.000 mg.100g<sup>-1</sup>). Não houve diferença significativa na contagem de coliformes totais e termotolerantes, e o crescimento de fungos filamentosos e leveduras diminuiu após o armazenamento a 0°C e 5°C após o 5º dia. O armazenamento a 5°C por 5 dias foi considerado o conjunto de condições mais eficiente para manter as características físicas, químicas, microbiológicas e sensoriais de marolo.

**Palavras-chave:** Frutas *Annona*. Frutos de savana. Antioxidante. Aceitabilidade. Qualidade.

**ABSTRACT:** Marolo is a fruit typical of the Brazilian Savanna that is highly appreciated for its exotic flavour, nutritional value and sensory attributes. This study aimed to assess the quality of fresh-cut marolo by checking for possible changes in physical, chemical, microbiological and sensorial characteristics during cold storage (12 days at 0°C, 5°C and 10°C). Firmness varied based on storage time; the fruit softened on the 8th day and then increased in hardness until the end of the study. The lowest storage temperatures reduced the darkening rate of this product. No variations in the levels of soluble solids (12.7 to 14.6°B) or total phenolics (741.06 to 1295.21 mg. GAE.100g<sup>-1</sup>) were observed. Fruits stored at 10 °C showed an increase in titratable acidity after the 5th day and an increase in pH on the 10th and 12th days. Increases in the soluble pectin (156 to 265.73 mg.100g<sup>-1</sup>) and total pectins (>1.000 mg.100g<sup>-1</sup>) were noted. No significant difference was observed in the count of the total and thermotolerant coliforms, and the growth of filamentous fungi and yeasts decreased after storage at 0°C and 5°C after the 5th day. Storage at 5 °C for 5 days was found to be the most efficient set of conditions for maintaining the physical, chemical, microbiological and sensory characteristics of marolo.

**Key words:** *Annona* fruits. Savanna fruits. Antioxidant. Acceptability. Quality.

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## INTRODUCTION

Marolo (*Annona crassiflora* Mart.) is a fruit typical of the Brazilian savanna biome. It has a peculiar and highly appreciated aroma and flavour, but it is at risk of extinction due to deforestation and wild extraction. It is considered a species of economic interest due to its utilization in the culinary industry and for its consumption *in natura*, which makes it an important part of the culture of local populations (Figure 1).

Although there have been relatively few studies on this fruit (REIS; SCHMIELE, 2019), it has a high nutritional value, such as significant levels of lipids, calories and fibres and rich in magnesium and phosphorus (DAMIANI et al., 2011; Silva et al., 2017). It is considered a functional food because it contains antioxidant substances including phenolic compounds (flavonoids and isoflavones), carotenoids and ascorbic acid (da SILVA et al., 2014) as well as prebiotic oligosaccharides (ARRUDA et al., 2017). This demonstrates the great potential of this fruit (CAVALCANTE et al., 2009).

Marolo has been developed into flours (CORRÊA et al., 2011), snack bars (DA SILVA et al., 2014) and bread formulations (VILLELA et al., 2013) and it can be used as an alternative for producing healthy foods with increased nutritional and sensory qualities.

Studies on this exotic fruit could further its potential technological applications because new industrial applications could increase consumer interest in new and exotic foods (JAMES; NGARMSAK, 2010; REIS; SCHMIELE, 2019).

In addition, the interest in native South American plant species has grown in recent years due to their health benefits (OLIVEIRA et al., 2012). One possible technique that could be used to process this fruit is fresh-cutting, which aims to maintain the freshness and quality of the food.

The rapid growth of the fresh-cut sector is due to an increase in the demand for natural, healthy and convenient produce and due to growth in the fast food service industry. Fresh-cut processing is a possible alternative for the commercialization of marolo. This process should be an integrated approach, where the handling, processing, packaging and distribution of raw material must be properly managed through the adoption of good practises to achieve an extended and practical postharvest shelf life of fruits and vegetables.

However, this procedure should only be done to extend shelf lives as far as the harvest permits (SIDDIQUI et al., 2011; PRUSKI, 2011). The injury process makes it possible that the functional compounds are present in different concentrations in the product and that some compounds that would not naturally be in the fruit can be present in higher concentrations (MORETTI, 2007), and this can jeopardize the sensorial and microbiological qualities of the fruit.

Studies on the optimization of food processing and storage factors could provide essential information for reducing the degradation of phytochemicals for potential

health benefits (TIWARI; CUMMINS, 2013). This study aimed to evaluate the quality of fresh-cut marolo and check for possible changes in physical, chemical, microbiological and sensory characteristics during storage at different temperatures.

## MATERIAL AND METHODS

### Plant material and proximate composition

Mature marolo fruits (*Annona crassiflora* Mart.) were harvested from the savanna biome in Paraguaçu, Minas Gerais, Brazil (height 821m; 21°33'S, 45°48'W) approximately 140 days after anthesis. They were selected based on the parameters of uniformity of size (1.50kg), colouration of the rind (yellowish green and L\* 43.5 at 4.6 and b\* 12.21), distance between the carpels (approximately 2mm) and firmness (approximately 15 N).

Proximate analysis of the marolo pulp before processing was conducted in triplicate according to the Association of Official Analytical Chemists – AOAC, AOAC (2007).

The moisture content was determined by exposure to infrared radiation (120 °C/ 8 min). Fat was measured using a Soxhlet system by extraction with petroleum ether, the total nitrogen content was measured using the micro-Kjeldahl procedure (N x 6.25). Ash content was determined by incineration at 550 °C in a muffle furnace, and the mass of carbohydrates was considered to be any mass not included in the measured amounts of protein, fat, ash or moisture.

### Fresh-cut preparation and storage

The fruit was stored at room temperature and processed as soon as it achieved the sensory characteristics that denote maturation for consumption, namely, the segments were spread far apart, the pulp had softened, and it was giving off a strong characteristic aroma (Figure 1). The fruit underwent cleaning in a potable water solution and neutral detergent (0.5% v/v). The rind was sanitized in sodium dichloroisocyanurate solution (DCIS) (200 mg L-1/15 min.). The rind was peeled manually, and the granules present between the rind and the carpels were discarded. The carpels were detached from the central axis, sanitized in DCIS solution (20 mg. L-1/15 min./15-20 °C), centrifuged, packed (approximately 100 g) in polyethylene (PET) containers with lids (10.0 x 10.0 x 3.5 cm) and stored in BOD at 0, 5 and 10 °C ± 0.5 °C (UR=90±5%).

### Physical and chemical analysis

The following analyses were performed: mass loss (% m/m); colour by colorimeter (Minolta model CR 40) in the CIE L\*, a\* e b\* mode (Mcguire, 1992) and hue angle. Firmness by the value of the maximum force, expressed in Newtons (N) (Texturometer Stable Micro Systems, Model TA – XT2i, compression: 30%, velocity:

2 m/s, cylindrical stainless steel probe 6 mm in diameter). Soluble solids (SS), expressed in Brix; titratable acidity (TA), expressed as percentage of malic acid (NaOH 0.1 M, pH  $\geq$  8.1); pH determined by potentiometry (AOAC, 2007). Water activity by the methodology of IAL-INSTITUTE ADOLFO LUTZ (IAL, 2008); and total sugars by the Antrona method (DISCHE, 1962).



**Figure 1** – Marolo (*Annona crassiflora* Mart.), from the flower to the minimally processed fruit.

The total and soluble pectins were determined using a spectrophotometric method at 520  $\mu$ m according to Blumenkrantz and Asboe-Hansen (1973) (mg of galacturonic acid per 100 g of pulp). The antioxidant activity was determined by in vitro analysis using the free stable radical DPPH (2,2-diphenyl-1-picrylhydrazyl), which decreases the absorbance at 515  $\mu$ m (RUFINO et al., 2007). The results are expressed in free radical scavenging percentage (% DPPH). Determination of the phenolic compounds was achieved by the method proposed by Waterhouse (2002) using the Folin-Ciocalteu reagent (mg equivalents of gallic acid (EAG).100 g<sup>-1</sup>).

### Microbiological Analysis

The testing solution was prepared with 25 g samples of fruits from each packet in 225 mL of saline solution (dilution 1:10). Then, the solution was homogenized in a shaker at 300 rpm for five minutes. Serial dilutions were prepared in 0.85% saline solution (1:100 and 1:1000) according to ISO 6887-1 (ISO, 1999).

The total and thermotolerant coliforms were determined according to ISO 4831 (ISO, 2006; KORNACKI; JOHNSON, 2001), which is based on the most likely number per gram (NMP/g). The filamentous fungi and yeasts were counted using acidified dextrose potato agar broth (25 °C/5 days) (DOWNES; ITO, 2001; TOURNAS et al. 2001).

For the analysis of *Salmonella* sp., the samples were analysed by the FDA method (ANDREWS, 2011) in tetrathionate broth and Rappaport Vassiliadis R10 broth. The colonies that showed the desired characteristics were transferred to lysine iron agar (LIA) and triple sugar iron (TSI) agar and were incubated at 35 °C for 24 days (SILVA et al., 2007). The analyses were conducted in triplicate, and the counts of microorganisms are expressed in UFC/g.

### Consumer acceptance test

The participants were subjects (over 18 years old) who enjoyed the fruit (Research Ethics Committee/approval protocol). Appearance, aroma and global impression were evaluated in individual cubicles according to a hedonic scale (1-“disliked very much”; 9-“liked very much”), throughout the storage period (on days 0, 3, 5, 8, 10 and 12), by approximately 50 potential consumers. Every panellist assessed one carpel sample (4 g) related to a given storage temperature (0 °C, 5 °C and 10 °C). The samples were placed in PET packets with lids, codified with random three-digit numbers, and presented only once in a random order.

### Statistical analysis

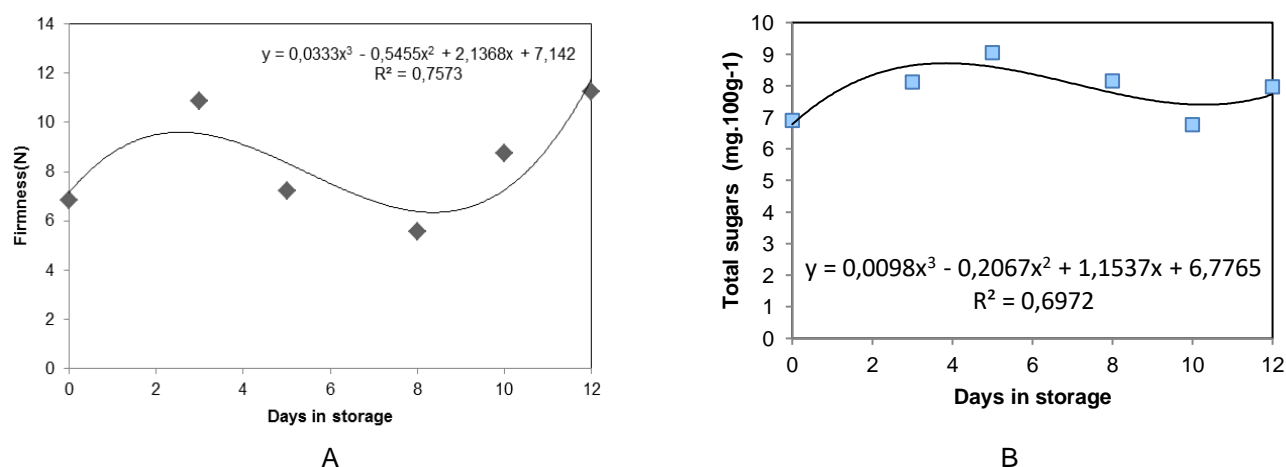
The experiment was conducted according to a completely randomized, double factorial scheme with an additional treatment (5x3+1): storage periods of 0 days

and 3, 5, 8, 10 or 12 days and 3 storage temperatures (0, 5 and 10 °C). For microbiological analysis, the experiment was conducted according to a completely randomized, triple factorial scheme (2x3x5) with 5 storage times (3, 5, 8, 10 and 12 days), 3 storage temperatures (0, 5 and 10 °C) and sanitization with DCIS 20 mg/mL solution or only water (control). The data obtained were subjected to an analysis of variance followed by an adjustment of the regression models or Tukey's test. The results were considered statistically significant when the P values obtained were 0.05 or less. Statistical analysis was performed via R software (R TEAM CORE, 2020) and ExpDes (FERREIRA et al., 2014) package.

## RESULTS AND DISCUSSION

Proximate Composition, physical and chemical evaluation of the fresh-cut marolo: Marolo pulp was found to have a proximate composition of carbohydrates (21.38 g.100 g<sup>-1</sup>), moisture (75.42 ± 0.68 g. 100 g<sup>-1</sup>), protein (1.44 ± 0.1 g. 100 g<sup>-1</sup>), and ash (0.50 ± 0.1 g.100 g<sup>-1</sup>) that was similar to that of other Annonaceas,

such as cherimoya, soursop and sweetsop; the exception to this was lipids (1.26 ± 0.22 g. 100 g<sup>-1</sup>), which was higher than those of other Annonaceas (0.3 ± 0.2; 0.6 ± 0.3 and 0.4 ± 0.3 g. 100 g<sup>-1</sup>, respectively) (DRAGANO et al.,2010; PAREEK et al., 2011). Fresh-cut marolo could be stored for 12 days at a temperature of 0 °C, 5 °C or 10 °C. The mass loss in fresh-cut fruits was noticeable starting from the 5th day of storage (10%), and then it stabilized regardless of the storage temperature. Firmness varied during storage. Initially, a slight hardening was observed, followed by a softening by the 8th day (p=0.008), at which point the samples began to harden again (Figure 2A). This softening followed by hardening can be explained by the loss of cellular turgor caused by the transpiration associated with the mass loss that occurred until the 6th day as well as the action of pectinases and hemicellulases. The hardening at the end of the storage period may be due to excessive water loss caused by exposure to cold. The total sugars varied significantly during the storage period (p=0.004) regardless of the storage temperature (p=0.671) (Figure 2B).



**Figure 2** - Means observed, adjusted regression model and coefficient of determination of firmness (A) and total sugar (B) in fresh-cut marolo during storage.

There was a slight difference until the 8th day (8.148 mg. 100 g<sup>-1</sup>) followed by a small oscillation with the lowest values being observed on the 10th and the 12th days (6.760 and 7.96 mg.100 g<sup>-1</sup>, respectively). This suggested the sugars were consumed through metabolism within the fruit. The luminosity (L\*) of the fresh-cut marolo varied significantly based on the storage time and temperature (p=0.02) (Figure 3A).

The L\* value decreased starting from the 3rd day of storage. In contrast, the L\* value of the fruits stored at 0°C and at 5°C remained relatively stable until the 10th day but decreased from the 10th to the 12th day. The samples stored at 0°C and 5°C showed higher L\* values than those at 10 °C starting from the 3rd and the 10th days of storage, respectively. Thus, the lowest temperatures reduced the darkening rate of marolo. The lightness of the fruits stored at 5°C did not change (p=0.08) until the 12th day of storage (75.52), which is similar to what was observed for the products stored at

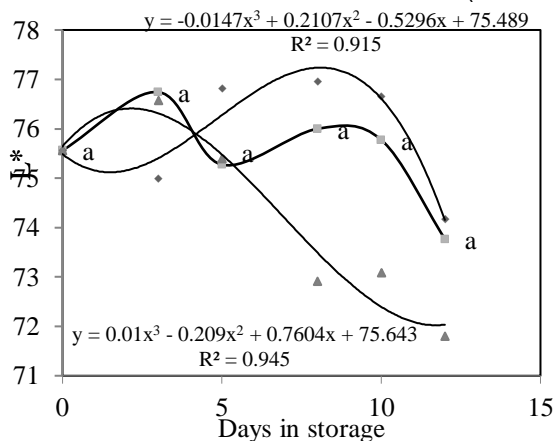
0°C. Starting from the 8th day, the samples stored at 0°C and 5°C were lighter than the ones at 10°C after the same storage periods (73 on the 8th day), and on the 12th day there was no difference (74.17, 71.80 and 73.77 at 0°C, 10°C and 5°C, respectively). The a\* and b\* values were not affected by the temperatures but did vary with storage time. Starting from the 5th day, regardless of the temperature, the fresh-cut marolo samples showed a significant increase in a\* (+6 to +8.5) and a decrease in b\* (+35.9 to +33), which meant there was more orange tonality to the pulp (Figure 3B, 3C).

This is typical behaviour for fruits with a high level of carotenoids such as marolo, which has a high carotenoid content (approximately 2822 µg. 100 g<sup>-1</sup>) (DRAGANO et al., 2010). The hue angle (h°) differed significantly based on the storage time and temperature (p=10<sup>-4</sup> and p=0.03, respectively). There was no significant difference between the initial averages and the hue angles measured throughout storage. There

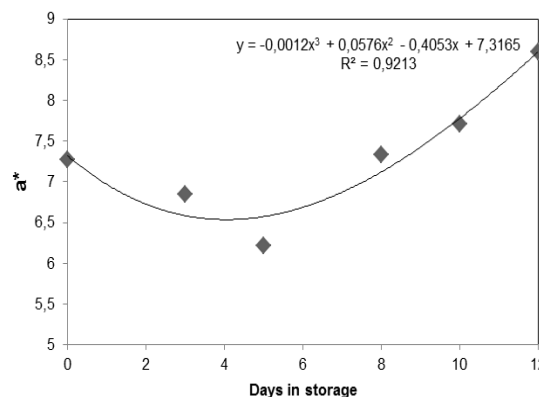
REFRIGERATED STORAGE OF FRESH-CUT MAROLO (*ANNONA CRASSIFLORA* MART.)

was a decrease in  $h^\circ$  starting from the 5th day, which indicated an increase in the yellow tonality. The fruits at 10 °C showed a slightly less yellowish colour (76.87) than the ones stored at 5°C and at 0°C (78.513 and

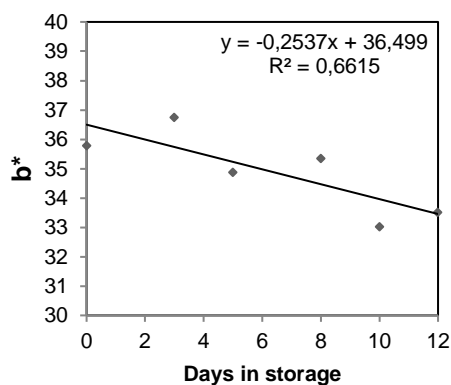
78.519, respectively). The amounts of yellow in samples stored at 5°C and at 0°C were not significantly different from each other (Figure 3D).



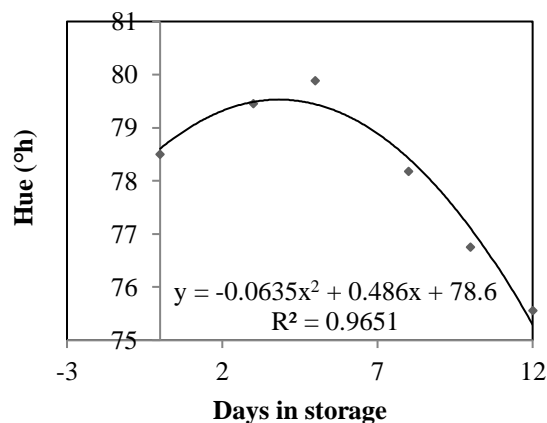
A



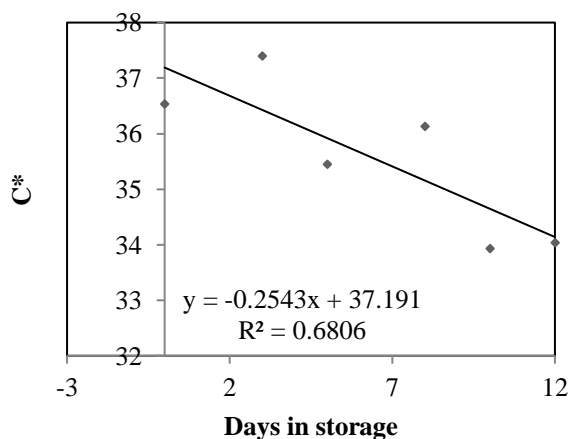
B



C



D



E

**Figure 3** - Mean values of the parameters coloring for fresh-cut marolos during storage A)Lightness ( $L^*$ ) at different temperatures , B)  $a^*$  and C)  $b^*$  , D) Hue angle ( $^\circ h$ ), E) Cromaticity ( $C^*$ ).

The colour intensity ( $C^*$ ) only differed in relation to storage time ( $p=0.03$ ), and decreased starting mainly from the 8th day (Figure 3E).

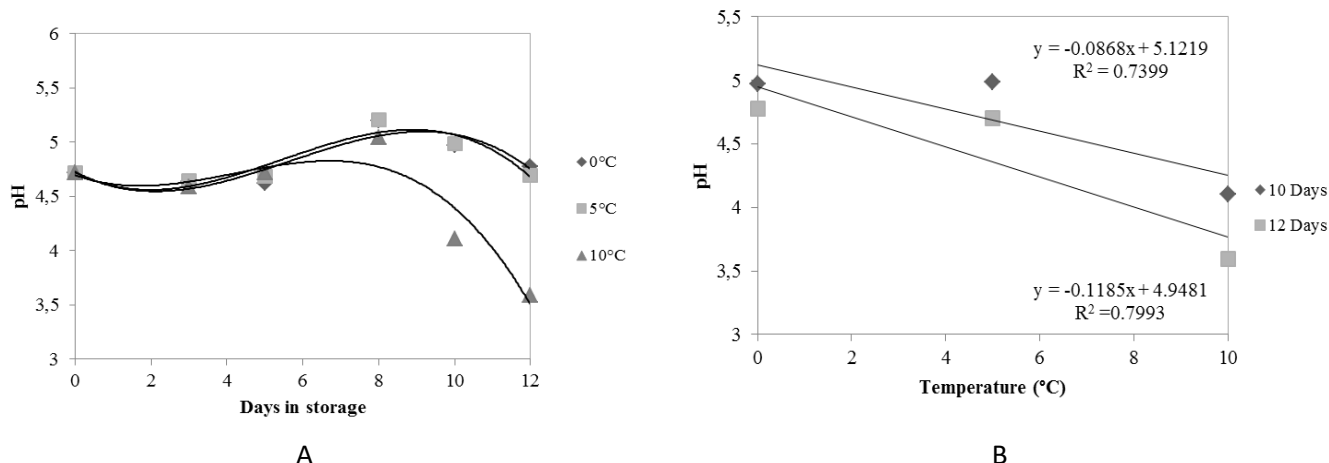
No variations in the level of soluble solids (SS) in relation to the time ( $p=0.141$ ) or the tested temperatures ( $p=0.286$ ) were reported. The averages varied from 12.7 to 14.6 °Brix, which is less than those measured by

Dragano et al (2010) ( $20.26 \pm 1.99$  °Brix). The increase in respiration caused by injury can deplete the reserves; however, there was no change in the SS profile, which is probably because of the conversion of starch into sugars during the storage and because respiration regenerates the SS content, which keeps the level stable (BRECHT, 2007).



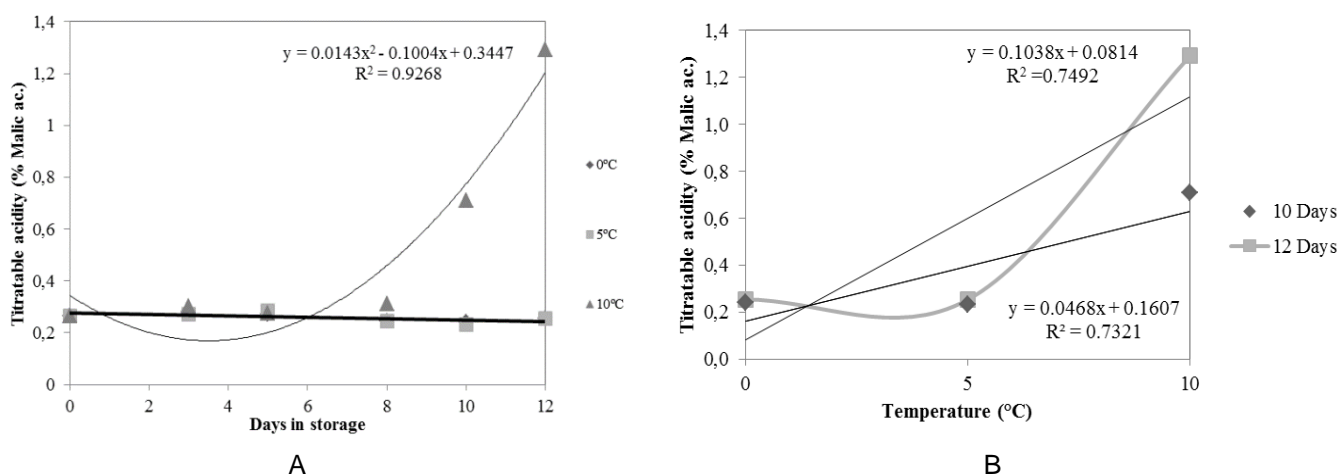
The titratable acidity varied significantly with storage time and temperature ( $p < 0.005$ ). No significant difference was detected in the titratable acidity for the fruits at 0 °C and at 5 °C; however, those stored at 10

°C showed no significant difference in the titratable acidity until the 5th day, but the titratable acidity increased thereafter (Figure 4A, 4B).

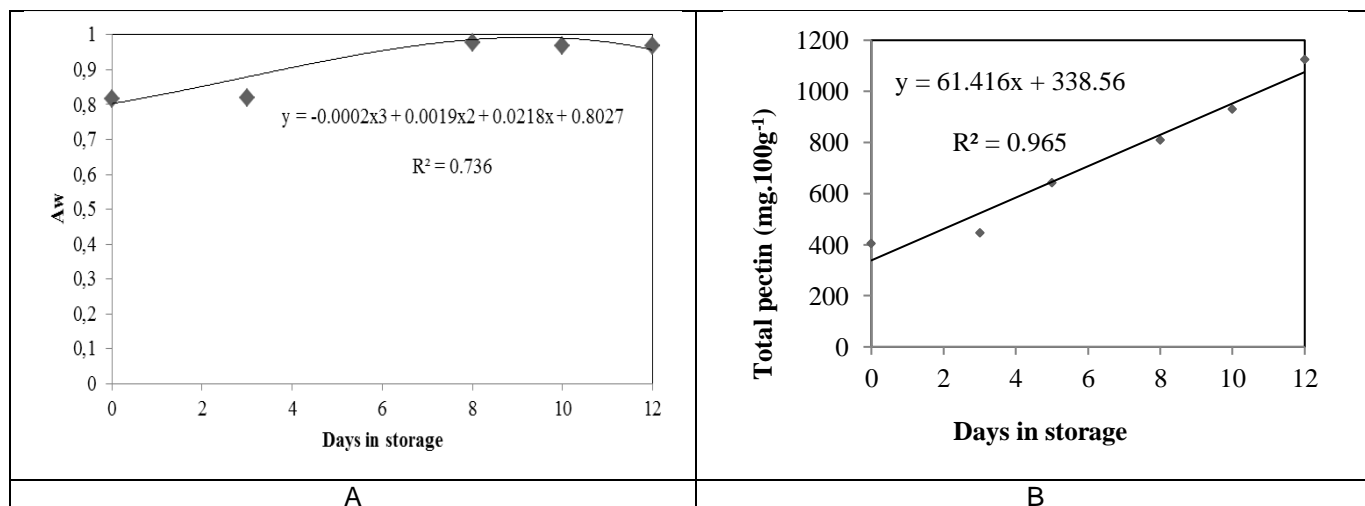


**Figure 4 - Means values, adjusted regression model and coefficient of determination for pH in fresh-cut marolo during storage\* (A) and on days 10 and 12 of storage at different temperatures (B).**

\*0°C:  $y = 4.72 - 0.18x + 0.05x^2 - 0.003x^3$   $R^2 = 0.798\%$  5°C:  $y = 4.72 - 0.17x + 0.05x^2 - 0.003x^3$   $R^2 = 0.8652\%$  10°C:  $y = 4.69 - 0.12x + 0.046x^2 - 0.003x^3$   $R^2 = 0.875\%$



**Figure 5 - Means values, adjusted regression model and coefficient of determination for titratable acidity in fresh-cut marolo at 10°C during storage (A) and on days 10 and 12 along temperature (B).**



**Figure 6 - Means values, adjusted regression model and coefficient of determination for water activity (Aw) and total pectin in fresh-cut marolo along storage.**

The pH increased on the 10th and 12th days mainly for the samples stored at 10°C (Figure 5A). The pH varied significantly with storage time and temperature ( $p < 0.005$ ). At 0°C and 5°C, the pH showed a slight decrease followed by an increase on the 8th day but decreased thereafter (Figure 5B). However, when the samples were stored at 10°C, the pH tended to increase slightly followed by a sudden and continuous decline starting from the 8th day (5.0 to 3.5, at the 12th day).

There was a difference between the water activity ( $A_w$ ) average of the additional treatment (day average 0 – 0.815) and the factorial treatment (0.947) ( $p < 0.005$ ).  $A_w$  varied with storage time ( $p < 0.005$ ). The  $A_w$  means increased until the 5th day but were then constant until the end of the storage period ( $A_w = 0.96$ ) (Figure 6A).

This can be explained by the differences in the relative humidity inside the storage container. During the testing period, the humidity increased due to

humidity exchange with the environment of the cold chamber, which could have favoured contamination by fungi.

There was an increase in the level of soluble pectin during the storage (156.01 mg.100 g<sup>-1</sup> at time 0 and 265.73 mg.100 g<sup>-1</sup> - average of the factorial points) ( $p = 0.004$ ). The effect of time and temperature on the soluble pectin content was significant ( $p = 10^{-4}$ ) because it increased in the majority of the treatments during the storage period and the values remained high (Table 1). The level of soluble pectin did not change for the fruits stored at 5°C ( $p = 0.05$ ).

There was an increase in the level of total pectins during the storage, and it reached values higher than 1.000 mg.100 g<sup>-1</sup> by the 12th day ( $p < 0.005$ ). The average of the initial total pectin (406.33 mg.100 g<sup>-1</sup>) was significantly smaller than that of treated samples (791.77 mg.100 g<sup>-1</sup>) ( $p = 0.003$ ) (Figure 6B).

**Table 1** - Mean values for soluble pectin (mg 100g<sup>-1</sup>) in fresh-cut marolo at different temperatures and during the storage time.

Temperature (°C)	Days in storage					
	0	3	5	8	10	12
0	156,01 BC	60,87 bC	302,32 a A	375,64 a A	300,32 a BA	335,49 a A
5	156,01 A	297,88 aA	322,42 a A	220,81 b A	237,15 ab A	187,35 b A
10	156,01 B	212,22 aAB	337,05 a A	314,64 ab A	168,05 b B	313,71 a A

\* Means followed by the same capital letter (inside columns) and lowercase letters (inside rows) are statistically equal ( $p > 0.05$ ).

The fruits stored at 0°C showed lower levels of total pectin (675.56 mg.100 g<sup>-1</sup>), and those maintained at 5°C showed higher levels (896.90 mg.100 g<sup>-1</sup>) ( $p = 0.018$ ). The fruits stored at 10°C showed intermediate levels that were not different from the other samples (802.84 mg. 100 g<sup>-1</sup>). Despite this increase, this is not the typical trend for fruits; the increasing pectin levels may imply that these fruits are still metabolically active. There was no difference in total antioxidant activity between the initial values and different times ( $p = 0.707$ ) or among different temperatures ( $p = 0.489$ ).

The antioxidant activity varied significantly between samples at different points during storage and between samples stored at different temperatures ( $p = 0.0031$ ). A significant difference was observed between the 3rd day of storage (83.52%) and the 5th day (63.96%), but then there was a slight increase followed by a stabilization in the following days (72.84, 79.09 and 73.24% on days 8, 10 and 12 of storage, respectively). The averages of the 8th, 10th and 12th days did not differ among each other, and they were not different from the values found on other storage days; they were intermediate values.

No difference was found in the level of total phenolics based on any of the variables studied ( $p \geq 0.05$ ). The means varied from 741.06 to 1295.21 mg. GAE.100 g<sup>-1</sup>. Considering that different trends were observed for the antioxidant activity and the level of total phenolics, it is not possible to establish a relationship between them. The trend in antioxidant activity was most likely due to an association with other antioxidant

compounds such as carotenoids, which are present in notable quantities in this fruit.

#### Acceptability of fresh-cut Marolo during the storage

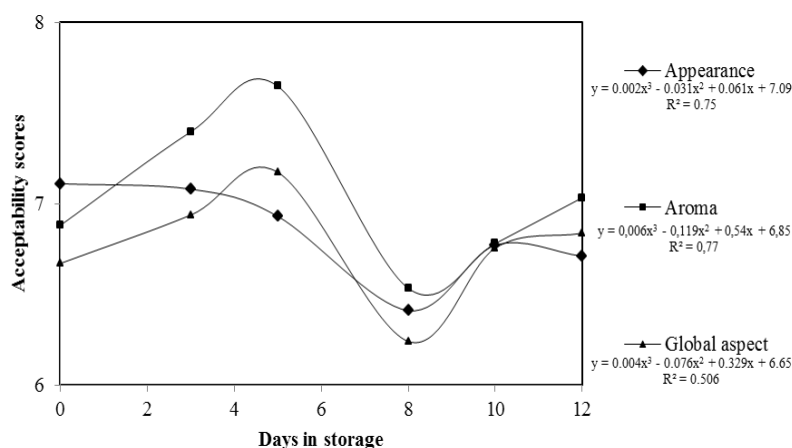
In general, the averages of all the sensorial attributes tested were above 6 (like slightly), which indicates a good acceptance. However, the averages of acceptability tended to slightly decrease from the 5th to the 8th days of storage ( $p \leq 0.05$ ). Thus, a temperature of 5 °C is preferable for the maintenance of the sensorial qualities for a maximum of 5 days. Regarding the appearance, there was a slight decrease in the acceptability values during storage (starting from the 5th day), probably due to the colour change that occurs. This is supported by a reduction in the L\* and C\* values (reduction of lightness), which suggests a darkening and a loss of colour intensity, respectively, especially at the end of the storage. The acceptability of the appearance attribute varied significantly between 5°C (6.91) and 10°C (6.57) (Figure 7).

There was an increase in the acceptability value of the aroma attribute on the 3rd day followed by a decline on the 8th day, and then a return to the initial value at the end of the storage period. The highest score was for the sample stored at 5°C (7.27), which differed significantly from the sample stored at 10°C (6.92). The acceptability of the global impression attribute oscillated during the storage period. This is because there was an increase in the average value on the 5th day, a

decrease on the 8th day, and another increase on the 10th day.

Aroma is an important sensorial characteristic, and it is appreciated by marolo consumers and seems to be relatively preserved in the fresh-cut process based on the fact that the averages were satisfactory throughout the storage period ( $\geq 6.9$ ). The highest average of

acceptability for the global impression attribute was for the sample stored at 5°C and was significantly different from that of the sample stored at 10°C. In all attributes analysed, the averages for the samples stored at 0°C were intermediate and did not differ from the other averages



**Figure 7** - Means values, adjusted regression model and coefficient of determination \* for acceptability of appearance, aroma and global aspect of fresh-cut marolo along time.

**Table 2** - Means\* of logarithmic count of yeasts and molds in fresh-cut marolo after water sanitization (control) or sodium dichloroisocyanurate, 20 mg / L (DCIS) stored at different temperatures during storage time

Temperature		Days in storage*					
		0	3	5	8	10	12
0°C	Control	4,99 <sup>a</sup>	9,94 <sup>a</sup>	9,82 <sup>a</sup>	7,14 <sup>a</sup>	8,99 <sup>a</sup>	5,95 <sup>a</sup>
	DCIS	4,51 <sup>a</sup>	9,41 <sup>a</sup>	10,38 <sup>a</sup>	6,04 <sup>b</sup>	5,56 <sup>b</sup>	4,61 <sup>b</sup>
5°C	Control	4,99 <sup>a</sup>	7,61 <sup>a</sup>	13,08 <sup>a</sup>	9,69 <sup>a</sup>	8,91 <sup>a</sup>	6,40 <sup>a</sup>
	DCIS	4,51 <sup>a</sup>	5,62 <sup>b</sup>	10,18 <sup>b</sup>	7,50 <sup>b</sup>	7,67 <sup>b</sup>	6,26 <sup>a</sup>
10°C	Control	4,99 <sup>a</sup>	8,92 <sup>a</sup>	13,29 <sup>a</sup>	15,69 <sup>a</sup>	15,68 <sup>a</sup>	15,69 <sup>a</sup>
	DCIS	4,51 <sup>a</sup>	5,51 <sup>b</sup>	12,94 <sup>a</sup>	15,69 <sup>a</sup>	15,68 <sup>a</sup>	15,69 <sup>a</sup>

\* Means followed by the same letters in the same column are statistically equal ( $p > 0.005$ )

### Microbiological Stability

The absence of *Salmonella* sp. was verified for 25 g of sample at all the storage temperatures. No significant difference in the count of thermotolerant coliforms was observed. The count of the total coliforms was  $\leq 4$  NMP/g in the fruit in natura at different analysis times and storage temperatures. The count of thermotolerant coliforms was  $\leq 3$  NMP/g; NMP/g values less than  $5 \times 10^{-2}$  are considered acceptable. All the results were within the limits established by Brazilian Legislation (BRASIL, 2001). The use of sanitizer, different storage temperatures and different storage times had significant impacts on the growth of filamentous fungi and yeasts (Table 2).

Regarding storage at 0°C, there was a difference ( $p < 0.05$ ) between the control group and the treatment group starting from the 8th day of storage. A significant difference was observed between the control and treatment groups that were stored at 5°C at four storage times (3, 5, 8 and 10 days), and this result was highlighted by the fact that on the 5th day, the treatment

group had a value 2.9 log lower than that of the control. There was no significant difference between the two groups stored at 10°C except for the 3rd day. The growth of filamentous fungi and yeasts decreased for the storage temperatures of 0°C and 5°C after 5 days of storage, and this evidence suggests that the metabolism and the reproduction of fungi may be compromised. The growth of filamentous fungi and yeasts on the plates maintained at 10°C was different from the growths observed on other plates. At this temperature, fresh-cut marolo deteriorated rapidly; it darkened on the 4th day, and a crescent curve was observed for the development of filamentous fungi and yeasts.

The pH values observed in the samples stored at 10°C, which were substantially different from the other samples, may be due to the fungal growth. This could be because these fruits showed higher concentrations of sugars and more acidic pH levels ( $< 4.5$ ), and they were stored at a temperature higher than 3°C; these conditions favour the growth of lactic acid bacteria and fungi (BARTH et al., 2009).



It should be noted that the storage temperature may be more important than the sanitization itself in controlling microbiological growth considering that no sanitizing substance is truly effective for this product. The best combination of sanitizing, storage temperature and storage time for the filamentous fungi and yeasts was the conditions related to storage at 5°C because that combination was more efficient, was cheaper than storage at 0°C and caused less damage than storage at 10°C.

## CONCLUSIONS

To guarantee the physical, chemical, microbiological and sensorial qualities of fresh-cut marolo, this fruit should be stored at 0 or 5°C for 5 days. It was possible to obtain an alternative to commercial processing of this fruit *in natura* and thus contribute to nutritive and diversified food alternatives.

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