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Effect of the addition of calcium chloride and different storage temperatures on the post-harvest of jabuticaba variety *Pingo de Mel*

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Abstract

The objective of this study was to analyze the effect of different calcium chloride concentrations on the post-harvest conservation of jabuticaba variety *Pingo de Mel* at different storage temperatures. The fruit were collected 30 days after the anthesis and subjected to immersions in calcium chloride solution at different concentrations (0%, 2%, 4%, and 6%) for 30 minutes at room temperature. Then, the fruit were dried and packed in polypropylene bags and incubated in a chamber at different temperatures (6 °C, 12 °C, and 25 °C). Samples were analyzed at time 0 and every two days, up to 12 days of storage. No effect of different calcium chloride concentrations was observed in the fruit characteristics at different storage temperatures over time. During storage, an increase of soluble and total pectin contents, antioxidant activity, CO_2, total sugars, acidity, and weight loss was observed. Higher storage temperatures affected both the increase in weight loss, pH, and O_2 production and the reduction of vitamin C content. Refrigeration was important for the post-harvest conservation of jabuticaba variety *Pingo de Mel*, once the fruit stored at 6 °C suffered minor variations with improvements or little changes during the 12 days.

Keywords: antioxidants; respiration rate; vitamin C; weight loss.

Practical Application: Studying the post-harvest shelf life of jabuticaba fruits to improve its commercialization.

1 Introduction

Jabuticaba tree is originally from Minas Gerais and widely cultivated in almost all Brazilian regions, from the State of Para to Rio Grande do Sul, in addition to other countries such as Bolivia, Argentina, Uruguay, and Peru. It produces fruit once or more rarely twice a year, usually between August and November. Its fruit have a dark peel, ranging from purple to black and whitish pulp, with a sweet and slightly sour taste. Jabuticaba fruit have a high commercial potential, being used to make sweets, juices, ice cream, yogurts, jams, vinegar, liquor, wine, among others (Ascheri et al., 2006; Wu et al., 2012).

Although Jabuticaba is a fruit appreciated worldwide, it has a limited market due to its high perishability, which affects the production and commercialization. After harvesting, the fruit lasts for up to three days, followed by changes in appearance, due to the intense water loss, deterioration, and fermentation of the pulp, thus affecting the commercialization of fruit *in natura* (Lima et al., 2008).

During the post-harvest of tropical fruit, several chemical and physical changes occur due to internal and external factors, thus special care is required at all stages of the production chain (from producer to consumer). Rapid maturation demands special handling technology and justifies the small export volume for most of these products.

Jabuticaba, as well as other native fruit, along with fruit from the same botanical family (Myrtaceae), such as gabiroba (*Campomanesia adamantium* Camb) (Melchior et al., 2006), cagaita (*Eugenia desynterica* DC.) (Carneiro et al., 2015), and araça (*Psidium* spp.) (Drehmer & Amarante, 2008) are considered regional food delicacies, with great potential for production and commercialization throughout the country. However, these fruit exhibit intense respiration rates when mature, leading to quality decline of fresh fruit.

Cold storage is one of the most widely used methods for conservation of fruit and vegetables. However, appropriate technologies that combine post-harvest with the refrigeration temperature are necessary to preserve fruit quality for longer periods (Martins et al., 2007).

Treatment with calcium along with low temperatures has a high commercial potential to improve the nutritional quality of fruit and vegetables. Calcium can increase postharvest shelf life by maintaining fruit firmness, reducing respiration rate, and ethylene production, delaying fruit ripening, increasing aroma synthesis (Chen et al., 2011).

Therefore, the aim of this study was to evaluate the effect of different calcium chloride concentrations, associated with

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different storage temperatures on the postharvest shelf life of jabuticabas variety 'Pingo de Mel'.

2 Materials and methods

2.1 Raw material

The experiment was performed in September 2015, during the peak season, at the Farm and Winery *Jabuticabal* in Nova Fatima, district of Hidrolandia-GO, located in the geographical coordinates 16°55'32.35" south latitude and 49°21'39.76" west longitude, 35.6 km from Goiânia-GO. Seventy trees were selected at random, homogeneous as to the size (± 2 m) and age (10 years), and branches were marked at the time of anthesis. Harvest began in the 30 days after anthesis, and the fruit were collected in the morning and selected for the presence of defects or pests.

2.2 Experimental design

In the laboratory, the jabuticabas were washed with running water and sanitized with sodium hypochlorite solution at 150 µL. L^{-1} for 15 minutes. Then, they were immersed in calcium chloride solution at different concentrations (0%, 2%, 4%, and 6%) for 30 minutes at room temperature. Subsequently, the fruit were dried using a centrifuge, and packed in 250 mL polypropylene (100 g fruit) bags and stored in the chamber at different temperatures (6 °C, 12 °C, and 25 °C). The samples were analyzed at time zero and every two days, up to twelve days (T0, T2, T4, T6, T8, T10, and T12), by means of analysis of color, firmness, respiration rate, weight loss, pH, titratable acidity, total and soluble pectin, vitamin, total sugars and antioxidante activity, carrying out four replicates with 3 readings each, totaling 12 readings for each time analyzed (T0, T2, T4, T6, T8, T10, and T12). However, not all treatments lasted the twelve days of storage, because in some treatments the fruits deteriorated before the 12 days.

2.3 Determinations

Color measurements

The color determination was performed by reading the color parameters defined by the CIEL* a* b* system. The parameters L*, a*, and b* were measured in the colorimeter (Hunterlab, ColorQuest II), in which L* defines brightness (L* = 0 black and L* = 100 white), and a * and b * define the chromaticity (+ a* = red and -a * = green; + b* = yellow and -b* = blue).

Firmness

Firmness was determined using a texture analyzer (TA-XT Plus, Surrey, England) using a P/2 probe, with pre-test, test, and post-test speed of 2 $mm.s^{-1}$, 2 $mm.s^{-1}$ and 10 $mm.s^{-1}$, respectively, at a penetration distance of 6 mm. Firmness was expressed in Newton (N).

Respiration rate

The respiration rate was measured using the Dräger Simultan Test CO_2 equipment by injecting the needle into the closed bags. The measurement was performed rapidly inside the chamber to prevent changes in the storage temperature. After measurements, the "holes" were capped with silicone so that the gas transfer inside the bags was not affected.

Weight loss

The fresh weight loss was determined by the difference between the initial weight and the weight on the day of sampling and expressed as a percentage.

pH and titratable acidity

The pH was determined using a digital potentiometer (Tecnal, TEC 3P-MP). The apparatus was calibrated with pH 4.0 and 7.0 buffer, and direct readings were performed through the immersion of the electrode into the sample, according to the methodology of Association of Official Analytical Chemists (2010). Titratable acidity was determined by titration with 0.01 N sodium hydroxide (NaOH) using 1% phenolphthalein as indicator, according to Association of Official Analytical Chemists (2010).

Total and soluble pectin

Total and soluble pectins were extracted as described by McCready & McComb (1952), and determined colorimetrically by the reaction with carbazole, as reported by Bitter & Muir (1962). The total and soluble pectins were expressed as mg of galacturonic acid 100 g^{-1} fruit.

Vitamin C

The vitamin C content was determined by the colorimetric method as described by Strohecker & Henning (1967). Vitamin C was extracted with oxalic acid, filtered, and determined using 2,4-dinitrophenylhydrazine and ascorbic acid as standard. The reading was performed in a spectrophotometer (Biospectro SP-220) at 520nm, and the results were expressed as mg of ascorbic acid per 100 grams sample.

Total sugars

The total sugars content was determined in a spectrophotometer at 620 nm by the anthrone method and expressed as gram of glucose per 100 g sample (Dische, 1962).

Obtaining the extracts for determination of in vitro antioxidant activity

To obtain the extracts, the samples (pulp and peel) were homogenized with ethyl ether in the ratio 1:20 (w/v) under stirring and protected from light for one hour. Subsequently, the extracts were filtered through Whatman filter paper #1, and the volumes were adjusted. The extract was dried on filter paper for 2 hours at 35 °C to evaporate the ethyl ether residue. Then, the residue was weighed into a beaker and ethanol was added in the ratio of 1:20, and the extraction process (stirring+filtration) was repeated. After filtration, the residue was kept on filter paper for 30 minutes at 50 °C to evaporate the residual solvent. Finally, water in the ratio of 1:20 was added to the residue from the previous extracts to obtain the aqueous extract, which was kept

under stirring and protected from light for one hour. The extracts were stored in amber glass bottles at -18 °C until determination of the bioactive compounds.

Antioxidant activity in vitro

The antioxidant activity was determined in all extracts (ether, ethanol, and aqueous) by the iron reduction method (FRAP - Ferric Reducing Antioxidant Power), according to Pulido et al. (2000) with modifications by Rufino et al. (2006). Readings (tripyridyl triazine ferrous complex) were measured in a spectrophotometer at 595 nm (Biospectro SP-220), and the results were expressed as μmol $Fe_2SO_4.g^{-1}$of fresh weight.

The antioxidant activity by the $ABTS^{\bullet+}$radicals method was determined according to Rufino et al. (2007). The absorbance was measured in a spectrophotometer (BiospectroSP-220) at 734 nm after 6 minutes of the addition of $ABTS^{\bullet+}$. The results were expressed as μmol Trolox.g^{-1} fresh weight.

Statistical analysis

The calcium chloride solutions at different concentrations (0%, 2%, 4%, and 6%) and temperatures (6 °C, 12 °C, and 25 °C) were considered for principal component analysis (PCA). Over 12 days of storage, The parameters fruit weight, pH, titratable acidity, total and soluble pectins, vitamin C, total sugars, and antioxidant activity *in vitro* (ABTS •+ and FRAP) were compared within the treatments. Data were normalized and correlated to compare the parameters of different unit of measurement (Melo et al., 2015).

The same treatments and parameters used in PCA were subjected to multiple regression analysis with a significance level of 95%. To observe the relationship between the variables, the regression coefficient (R^2) of the model and the linear regression coefficient were determined. To analyze the relationship between the variables temperature and storage time and the fruit parameters, response surface graphs were constructed, considering the polynomial adjustment of the variables.

3 Results and discussion

In relation to the respiration rate (CO_2 and O_2) of jabuticaba variety 'Pingo de Mel', changes were observed with the increase in storage temperature (from 6 °C to 25 °C), with a reduction in CO_2 concentrations and an increase in O_2 levels (Figure 1 and Appendix A – Table 1A), which may favor fruit degradation. According to Chitarra & Chitarra (2005), respiration stands out as the main physiological phenomenon that most affects the conservation and quality of fruit and vegetables after harvest. The low temperature decreases the respiration rate, in addition to providing slower metabolism, increasing the shelf life and, consequently, maintaining post-harvest quality for longer periods. Velho et al. (2011) analyzed the effect of storage temperature on the postharvest quality of Highland guavas (*Accasellowiana* (O. Berg.) Burret), and also observed an increase in the respiration rate of fruit with increasing temperature, leading to a shorter shelf life, as also observed in the jabuticabas of the present study.

No effect of the different calcium chloride concentrations (0%, 2%, 4%, and 6%) was observed in the maintenance of fruit characteristics at different storage temperatures (6 °C, 12 °C, and 25 °C), probably due to the thickness of the peel of Jabuticaba variety 'Pingo de Mel', which did not allow the permeabilization of calcium chloride. Calcium can penetrate fruit directly through the epidermis and/or by natural cuticle cracks (Conway et al., 1992), however the fruit of jabuticaba presents a very smooth and homogeneous epidermis, which may have made this penetration difficult. Longer immersion times result in greater absorption, but, Mota et al. (2002) investigated the immersion of jabuticaba variety 'Sabará' in $CaCl_2$ 40g.L^{-1} for 0, 5, 10, 20, 40, and 60 minutes, and found a reduction of firmness at all immersion periods studied, with an increase in both the weight loss of fresh fruit and acidity values, corroborating the present

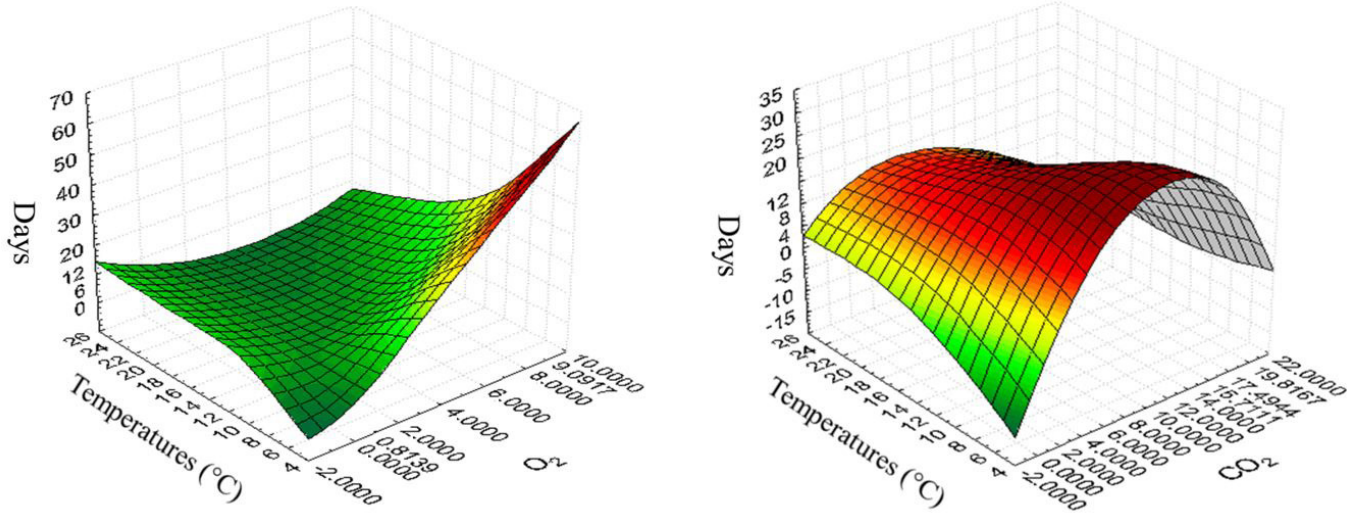

Figure 1. Mean values of the respiration rate (CO_2 and O_2) of jabuticaba fruit 'Pingo de Mel', stored at different temperatures (6 °C, 12 °C, and 25 °C), during storage (0 to 12 days).

data. Thus, studies on higher immersion times are required, as well as higher $CaCl_2$ concentrations, to evaluate the effectiveness of calcium chloride on the post-harvest shelf life of jabuticaba.

One of the major postharvest problems is moisture loss, followed by weight loss. However, in the present study, these two variables were in the same quadrant (Figure 2 and Appendix A – Table 1A), showing no effect of one over the other, which is a positive factor for the post-harvest of jabuticaba variety 'Pingo de Mel', once water loss results in wilting, causing consumers' rejection at the time of purchase.

Silva et al. (2015) analyzed the influence of the treatment with calcium chloride in papaya and observed that in all treatments the fruits showed progressive loss of fresh mass during the storage period, corroborating in this way with the results of this work that showed that the loss of mass was not significantly influenced by the application of calcium chloride solutions. Differently from the data found in the present study, Sanches et al. (2017), analyzing pitanga (*Eugenia uniflora* L.), observed that calcium chloride at concentrations of 1% and 2% resulted in lower mass loss over time. According to Azzolini et al. (2004), the excess of calcium salts in the solution applied on the fruit can cause dehydration, so the fact that calcium chloride did not influence the loss of mass in the present study can be justified by the fact that it was used more concentrated solutions of calcium chloride.

Kays (1997) reported that the weight loss in fruit may be largely associated with water loss through transpiration and, to a lesser extent, respiration, which increases when fruit are exposed to higher temperatures. This fact was observed in the present study, once the higher the storage temperature, the greater the weight loss. Thus, the storage temperature of 6 °C led to the lowest weight loss in jabuticaba variety 'Pingo de Mel' throughout the storage, as shown in Figure 3A and Appendix A – Table 1A. Brunini & Coelho (2004) studied the effect of packages associated with different temperatures in jabuticaba variety 'Sabará' and observed that the fruit stored at room temperature (21 °C to 26.5 °C) exhibited the highest fresh weight losses, as also observed in the present study.

The increase in temperature also influenced the reduction of firmness of the fruit (Figure 3B and Appendix A – Table 1A), since the weight loss contributes to the lower firmness. Regarding the storage period, jabuticaba presented greater firmness in the second day of storage, which decreased afterward. In addition, an increase in soluble and total pectin contents was observed throughout the storage, corroborating with the firmness data.

Higher titratable acidity values were observed during storage, with a reduction in pH (Figures 2 and 3C and Appendix A – Table 1A). According to Chitarra & Chitarra (2005), pH tends to decrease with increasing acidity only at acid concentrations ranging from 2.5% to 0.5%, as observed in the present study. In addition, the temperature affected the titratable acidity, once the higher acidity values were observed in the fruit stored at lower temperatures (6 °C). Typically, acidity tends to decrease in the course of storage, as the acids are converted to sugars, as observed in fruit such as passion fruit (*Passiflora edulis* Sims f. *flavicarpa* Deg.) variety 'Afruvec' (Arruda et al.,

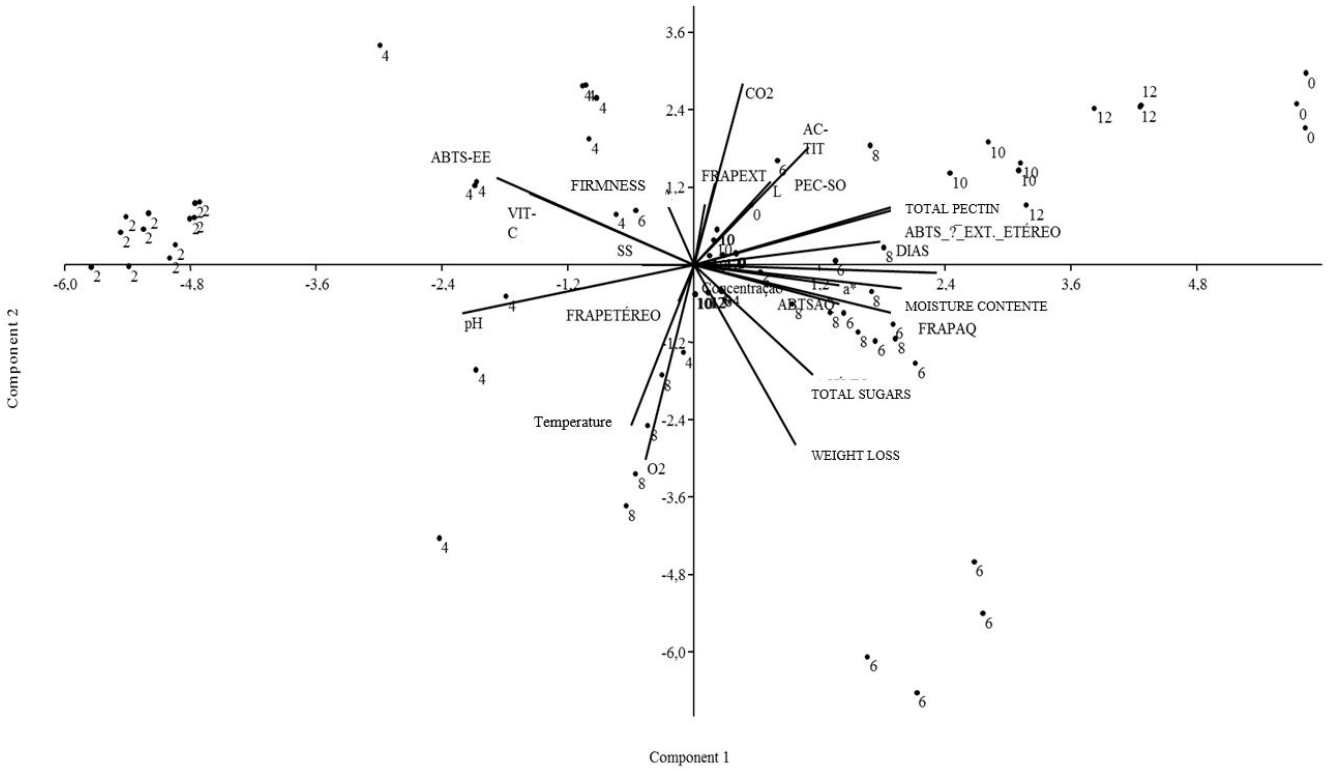

Figure 2. Principal component analysis for the storage time (0 to 12 days), calcium chloride concentrations (0%, 2%, 4%, and 6%), storage temperatures (6 °C, 12 °C, and 25 °C) and morphophysiological parameters of jabuticaba variety 'Pingo de Mel'.

2011), bilimbi (*Averrhoa bilimbi* L.) (Souza et al., 2009), peach (*Prunus persica* L.) cultivar 'Maciel' (Barreto et al., 2016), among others. However, acidity may increase in some fruit, as observed in the present study, and the study by Vilas Boas (2002) in banana and pineapple, with the highest acidity levels in the full ripening stage. Damiani et al. (2008) have also found an increase in acidity in minimally processed pequi and stated that this behavior is due to the low respiration metabolism, interrupted by the storage temperature, which generates accumulation of acids in the vacuoles.

Through the PCA, it was possible to observe an increase in total sugars during storage of jabuticaba variety 'Pingo de Mel' (Figure 2 and 3D and Appendix A – Table 1A). Brunini et al. (2004) studied the effect of packaging and storage temperature of

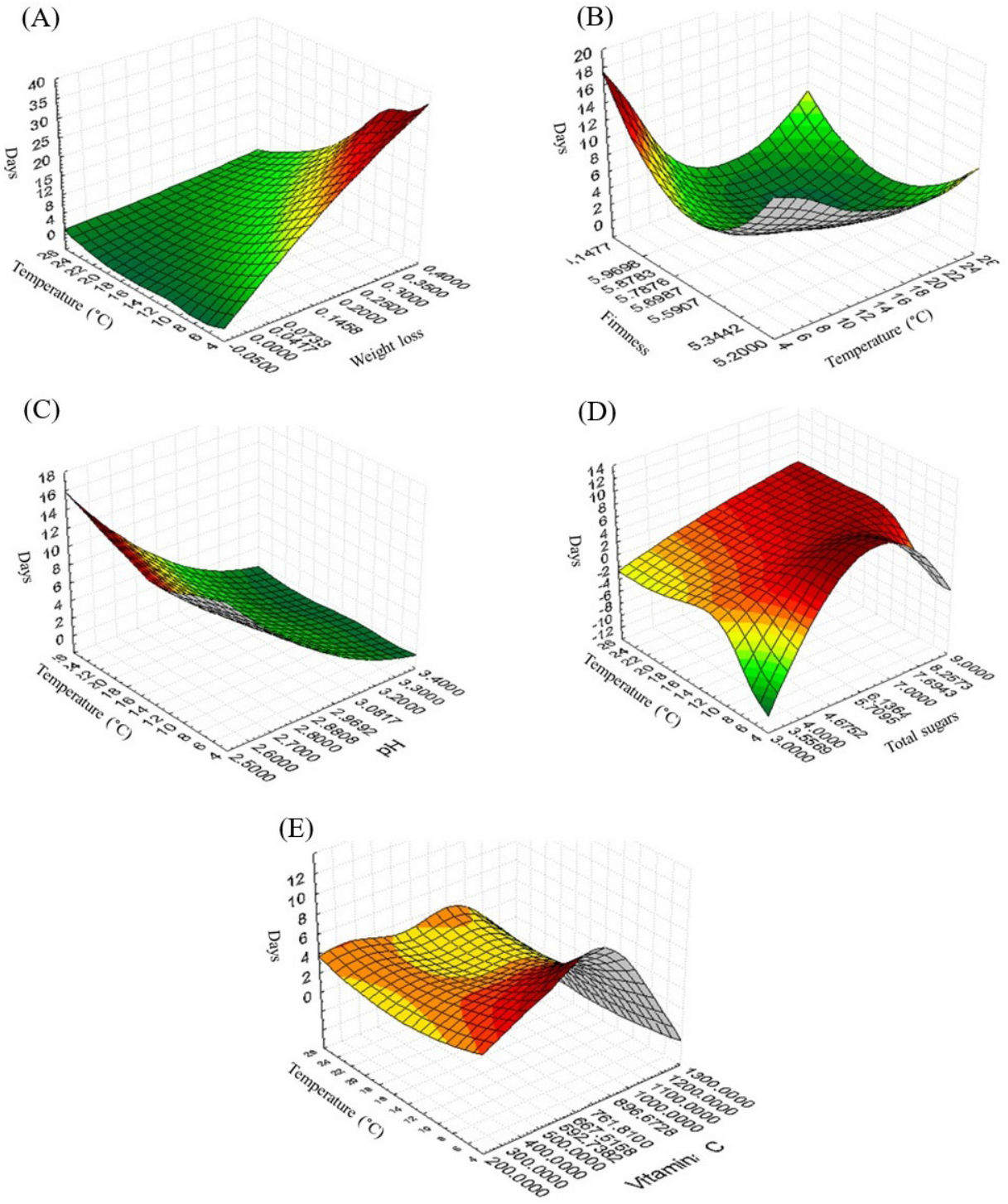

Figure 3. Weight loss (g 100 g-1) (A), firmness (N) (B), pH (C), total sugars (g 100 g-1) (D) and vitamin C (mg ascorbic acid 100 g-1) (E) of jabuticaba variety 'Pingo de Mel' stored at different temperatures (6 °C, 12 °C, and 25 °C) during storage (0 to 12 days).

jabuticaba variety 'Sabará', and also observed an increase in total carbohydrates during the storage period.

No changes in color were observed in jabuticaba fruit in the post-harvest, demonstrating that the treatments did not interfere in the color intensity of the peel, corroborating the studies of Brunini et al. (2004). According to Lima et al. (2013), color changes in the fruit epidermis is related to the degradation of chlorophyll and synthesis of other pigments, such as anthocyanins and carotenoids. Thus, the maintenance of color in jabuticaba may be due to the fruit were harvested at 30 days after anthesis (full ripening), representing the physiological development, with no degradation of chlorophyll and synthesis of anthocyanins.

A reduction of vitamin C content was also observed during storage, which was also affected by the storage temperature, as can be seen in Figure 3E and Appendix A – Table 1A. Similar behavior was observed by Agostini et al. (2009), who evaluated jabuticaba variety 'Paulista', and also found that the storage conditions led to a reduction of vitamin C, which was higher for the fruit stored at room temperature, probably because the refrigeration process inhibited the oxidative reactions, and delayed the physiological processes, which leads to a reduction of aroma, flavor, and texture, among other attributes.

The antioxidant activity of all extracts (ether, ethanol, and aqueous) determined by both methods was analyzed through PCA, with an increase during the storage period. Taiz & Zeiger (2006) reported an increase in the phenolic compounds and antioxidants during fruit development and storage, which can often be related to the biotic and abiotic stresses that induce the secondary metabolism of fruit. The increase in these levels has great importance from the nutritional point of view, since several authors have reported a possible role in the prevention of many diseases associated with oxidative stress, such as cancer, cardiovascular and other chronic diseases (Cavalcanti et al., 2011; Lima et al., 2011).

The present study highlighted the cold storage as an important preservation method for post-harvest storage of jabuticaba variety 'Pingo de Mel', once little or no changes were observed in fruit stored for 12 days at 6 °C. Despite the absence of statistical significance, it is believed that the application of calcium chloride along with the reduction of temperature has influenced the increase in the useful life of jabuticaba, since according to Pinheiro et al. (2005), the application of calcium salts in the fruits can increase the levels of this element in the tissues, providing greater resistance in the cell wall and increase the useful life of the fruits. The increase in cell wall resistance hinders the action of pectic enzymes, promoting greater cell integrity and, consequently, lower physiological disorders, as observed in the fruits of jabuticaba var. *Pingo de mel*.

4 Conclusion

The use of the different calcium chloride concentrations did not contribute to the increase in the storage period of jabuticabas variety 'Pingo de Mel'. However, the refrigeration temperature at 6 °C was a viable alternative for storage for 12 days, maintaining the fruit quality.

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Appendix A. Main results of the different applications of calcium chloride in fruits of jabuticaba.

Table 1A. Main results of the different applications of calcium chloride in fruits of jabuticaba variety. *Pingo de mel*. stored at different temperatures and evaluated every 2 days for 12 days.

Treatments*	Days	CO_2	O_2	Firmness	TS	TA	WL	SP	TP	Frap Ether	Frap Ethanol	Frap Aqueous	ABTS Ether	ABTS Ethanol	ABTS Aqueous	Vit. C
6 °C/$CaCl_2$ 0%	0	-	-	5.65	4.68	0.92	0.00	48.70	48.70	2.21	31.64	25.42	5.18	29.48	46.79	1168.37
6 °C/$CaCl_2$ 0%	2	20.63	0.48	6.20	4.65	1.22	0.02	57.98	129.08	3.37	49.27	25.42	5.98	35.44	30.04	918.38
6 °C/$CaCl_2$ 0%	4	20.46	0.93	5.76	8.33	1.07	0.04	40.85	83.36	2.11	32.19	62.69	8.65	26.65	52.94	559.63
6 °C/$CaCl_2$ 0%	6	20.41	0.82	5.13	6.98	1.03	0.04	56.59	149.01	2.06	30.05	78.99	8.65	11.19	47.54	434.57
6 °C/$CaCl_2$ 0%	8	20.67	0.61	5.48	6.12	0.99	0.05	73.74	166.05	2.02	29.84	61.18	11.42	9.81	69.06	807.86
6 °C/$CaCl_2$ 0%	10	20.58	0.67	5.39	5.71	1.18	0.04	71.67	195.79	1.78	23.76	60.72	11.35	12.40	62.44	617.08
6 °C/$CaCl_2$ 0%	12	20.53	0.64	4.57	7.81	1.33	0.10	56.51	274.06	2.33	37.63	71.94	13.12	17.90	64.56	748.65
6 °C/CaCl2 2%	0	-	-	5.65	4.68	0.92	0.00	48.70	48.70	2.21	31.64	25.42	5.18	29.48	46.79	1168.37
6 °C/CaCl2 2%	2	20.4	0.8	6.05	5.09	1.25	0.02	70.51	111.25	3.06	34.32	59.53	5.18	31.23	35.29	457.88
6 °C/CaCl2 2%	4	20.6	0.7	6.08	6.29	1.18	0.08	34.27	76.07	2.58	52.98	48.35	8.12	35.81	69.31	322.79
6 °C/CaCl2 2%	6	20.5	0.6	5.93	5.51	1.18	0.05	40.30	128.23	2.41	48.73	48.24	10.48	17.60	49.38	366.90
6 °C/CaCl2 2%	8	20.6	0.6	5.48	6.70	1.22	0.08	45.42	124.47	1.97	20.08	68.82	12.85	6.94	85.31	1117.06
6 °C/CaCl2 2%	10	20.4	0.7	6.33	6.02	1.03	0.05	73.15	157.30	2.09	31.66	73.65	11.88	14.60	63.69	755.23
6 °C/CaCl2 2%	12	20.4	0.7	5.50	4.23	1.07	0.05	53.84	336.04	2.06	39.65	86.02	11.18	21.10	59.56	564.45
6 °C/CaCl2 4%	0	-	-	5.65	4.68	0.92	0.00	48.70	48.70	2.21	31.64	25.42	5.18	29.48	46.79	1168.37
6 °C/CaCl2 4%	2	20.5	0.8	5.61	4.85	1.13	0.02	51.84	131.05	2.90	31.84	25.46	12.32	27.06	24.63	497.35
6 °C/CaCl2 4%	4	20.6	0.7	4.97	7.80	1.03	0.10	34.70	109.41	2.43	28.26	91.47	8.58	26.65	66.19	331.56
6 °C/CaCl2 4%	6	20.4	0.6	5.76	5.13	1.07	0.07	51.68	148.46	2.55	42.40	66.06	10.18	16.52	52.71	216.53
6 °C/CaCl2 4%	8	20.7	0.6	5.64	4.25	1.22	0.10	48.82	153.35	2.12	36.50	63.00	8.18	15.15	39.94	840.75
6 °C/CaCl2 4%	10	20.4	0.7	5.73	6.57	1.03	0.04	77.13	213.09	2.37	35.31	73.65	12.65	18.60	70.31	755.23
6 °C/CaCl2 4%	12	20.3	0.8	5.71	6.37	1.22	0.08	57.31	296.88	2.34	42.63	86.02	13.45	17.90	63.94	689.44
6 °C/CaCl2 6%	0	-	-	5.65	4.68	0.92	0.00	48.70	48.70	2.21	31.64	25.42	5.18	29.48	46.79	1168.37
6 °C/CaCl2 6%	2	20.4	0.9	5.65	4.12	1.11	0.00	59.68	139.15	2.56	34.21	38.31	10.85	26.77	29.96	655.24
6 °C/CaCl2 6%	4	20.5	0.9	6.13	8.35	1.11	0.07	33.09	115.45	2.25	24.30	96.98	8.48	26.19	64.31	261.39
6 °C/CaCl2 6%	6	20.2	0.9	6.33	10.40	0.92	0.06	40.98	117.22	2.40	39.23	77.71	10.85	13.85	41.04	389.46
6 °C/CaCl2 6%	8	20.4	0.7	6.19	5.77	1.14	0.07	53.51	144.29	2.36	32.47	63.42	12.05	13.65	62.69	821.02
6 °C/CaCl2 6%	10	20.4	0.8	6.42	5.97	0.92	0.03	51.29	180.64	2.14	24.22	86.02	10.42	15.23	59.56	919.70
12 °C/CaCl2 0%	0	-	-	5.65	4.68	0.93	0.00	48.70	48.70	2.21	31.64	25.42	5.18	29.48	46.79	1168.37
12 °C/CaCl2 0%	2	19.8	1.9	6.08	2.87	0.87	0.11	61.44	120.93	2.48	29.91	35.31	8.78	28.94	33.54	615.76
12 °C/CaCl2 0%	4	19.6	2.3	5.47	9.70	0.93	0.09	52.72	70.73	2.82	44.28	79.73	7.65	10.56	76.31	419.28
12 °C/CaCl2 0%	6	19.4	2.1	4.85	5.09	0.87	0.15	54.14	157.87	2.64	41.53	38.03	10.95	13.27	41.29	547.35
12 °C/CaCl2 2%	0	-	-	5.65	4.68	0.93	0.00	48.70	48.70	2.21	31.64	25.42	5.18	29.48	46.79	1168.37
12 °C/CaCl2 2%	2	20.0	1.7	5.50	3.93	0.87	0.07	49.30	116.55	2.58	40.62	45.99	10.15	26.98	45.46	339.46

*Mean values of the main analisys of jabuticaba fruit 'Pingo de Mel', stored at different temperatures, during storage. 6 °C/$CaCl_2$ 0% = Storage at 6 °C and without addition of calcium chloride; 6 °C/$CaCl_2$ 2% = Storage at 6 °C and immersed in 2% calcium chloride solution; 6 °C/$CaCl_2$ 4% = Storage at 6 °C and immersed in 4% calcium chloride solution; 6 °C/$CaCl_2$ 6% = Storage at 6 °C and immersed in 6% calcium chloride solution; 12 °C/$CaCl_2$ 0% = Storage at 12 °C and without addition of calcium chloride; 12 °C/$CaCl_2$ 2% = Storage at 12 °C and immersed in 2% calcium chloride solution; 12 °C/$CaCl_2$ 4% = Storage at 12 °C and immersed in 4% calcium chloride solution; 12 °C/$CaCl_2$ 6% = Storage at 12 °C and immersed in 6% calcium chloride solution; 25 °C/$CaCl_2$ 0% = Storage at 25 °C and without addition of calcium chloride; 25 °C/$CaCl_2$ 2% = Storage at 25 °C and immersed in 2% calcium chloride solution; 25 °C/$CaCl_2$ 4% = Storage at 25 °C and immersed in 4% calcium chloride solution; 25 °C/$CaCl_2$ 6% = Storage at 25 °C and immersed in 6% calcium chloride solution. TS = Total sugars; TA = Titrabable acidity; WL = Weight loss; SP = Soluble pectins; TP = Total pectins; Frap ether/ethanol/aqueous = antioxidant activity by the FRAP method in the ether/ethanol/aqueous extract; ABTS ether/ethanol/aqueous = antioxidant activity by the ABTS method in the ether/ethanol/aqueous extract; Vit C = vitamin C. Some fruits (treatments) deteriorate, becoming unfit for consumption, before the 12 days of storage, so they were not analyzed.

Appendix A. Continued...

Treatments*	Days	CO_2	O_2	Firmness	TS	TA	WL	SP	TP	Frap Ether	Frap Ethanol	Frap Aqueous	ABTS Ether	ABTS Ethanol	ABTS Aqueous	Vit. C
12 °C/CaCl2 2%	4	20.0	1.7	5.51	5.83	0.93	0.10	46.30	93.17	2.67	34.14	88.92	7.88	5.69	64.19	208.76
12 °C/CaCl2 2%	6	19.8	1.5	5.77	5.69	0.87	0.13	38.76	127.49	2.72	47.70	42.78	11.92	13.56	49.46	182.45
12 °C/CaCl2 4%	0	-	-	5.65	4.68	0.93	0.00	48.70	48.70	2.21	31.64	25.42	5.18	29.48	46.79	1168.37
12 °C/CaCl2 4%	2	20.2	1.3	6.96	3.73	0.87	0.08	47.07	158.21	2.58	40.48	37.67	11.68	27.52	42.54	681.55
12 °C/CaCl2 4%	4	20.4	1.2	5.81	5.00	0.93	0.04	31.58	73.32	3.08	57.94	67.47	7.32	16.94	61.56	410.51
12 °C/CaCl2 4%	6	20.1	1.1	5.36	7.03	0.87	0.15	37.41	166.41	2.26	31.70	48.53	9.32	12.23	43.21	406.56
12 °C/CaCl2 6%	0	-	-	5.65	4.68	0.93	0.00	48.70	48.70	2.21	31.64	25.42	5.18	29.48	46.79	1168.37
12 °C/CaCl2 6%	2	20.2	1.3	6.05	3.69	0.87	0.09	47.92	124.70	2.50	43.89	43.39	5.55	29.60	42.21	734.18
12 °C/CaCl2 6%	4	20.4	1.2	6.21	5.35	0.93	0.13	32.71	107.03	2.31	30.44	83.26	9.78	14.06	62.06	375.42
12 °C/CaCl2 6%	6	20.1	1.1	5.41	10.81	0.87	0.15	53.21	184.74	2.53	27.23	38.85	11.08	10.98	42.46	1024.96
25 °C/CaCl2 0%	0	-	-	5.65	4.68	0.93	0.00	48.70	48.70	2.21	31.64	25.42	5.18	29.48	46.79	1168.37
25 °C/CaCl2 0%	2	17.3	6.8	5.64	2.55	0.87	0.20	74.89	132.16	2.67	40.30	59.21	6.32	29.48	54.71	668.39
25 °C/CaCl2 0%	4	16.3	9.0	4.55	6.75	0.93	0.35	41.12	101.10	2.32	25.10	62.64	6.98	5.23	61.94	629.80
25 °C/CaCl2 2%	0	-	-	5.78	4.68	0.93	0.00	48.70	48.70	2.21	31.64	25.42	5.18	29.48	46.79	1168.37
25 °C/CaCl2 2%	2	19.4	3.0	5.57	9.72	0.87	0.23	75.66	181.50	2.21	23.69	46.85	11.72	22.98	46.79	549.98
25 °C/CaCl2 2%	4	17.8	6.8	4.93	7.93	0.93	0.35	38.70	129.85	2.44	22.93	81.65	8.68	6.94	52.94	207.89
25 °C/CaCl2 4%	0	-	-	5.27	4.68	0.93	0.00	48.70	48.70	2.21	31.64	25.42	5.18	29.48	46.79	1168.37
25 °C/CaCl2 4%	2	17.0	12.2	5.65	8.99	0.87	0.21	52.76	131.85	2.90	31.64	40.51	7.62	26.85	47.63	615.76
25 °C/CaCl2 4%	4	16.9	12.2	5.72	9.79	0.93	0.36	44.63	74.56	2.79	28.14	86.90	6.65	7.48	56.69	198.27
25 °C/CaCl2 6%	0	-	-	5.67	4.68	0.93	0.00	48.70	48.70	2.21	31.64	25.42	5.18	29.48	46.79	1168.37
25 °C/CaCl2 6%	2	19.0	4.3	5.95	4.68	0.87	0.21	55.22	236.00	2.89	40.23	41.35	8.75	37.35	51.04	694.71
25 °C/CaCl2 6%	4	18.9	4.6	6.44	8.56	0.93	0.38	30.71	96.25	2.54	32.55	93.55	6.25	10.60	66.44	213.58

*Mean values of the main analisys of jabuticaba fruit 'Pingo de Mel', stored at different temperatures, during storage. 6 °C/$CaCl_2$ 0% = Storage at 6 °C and without addition of calcium chloride; 6 °C/$CaCl_2$ 2% = Storage at 6 °C and immersed in 2% calcium chloride solution; 6 °C/$CaCl_2$ 4% = Storage at 6 °C and immersed in 4% calcium chloride solution; 6 °C/$CaCl_2$ 6% = Storage at 6 °C and immersed in 6% calcium chloride solution; 12 °C/$CaCl_2$ 0% = Storage at 12 °C and without addition of calcium chloride; 12 °C/$CaCl_2$ 2% = Storage at 12 °C and immersed in 2% calcium chloride solution; 12 °C/$CaCl_2$ 4% = Storage at 12 °C and immersed in 4% calcium chloride solution; 12 °C/$CaCl_2$ 6% = Storage at 12 °C and immersed in 6% calcium chloride solution; 25 °C/$CaCl_2$ 0% = Storage at 25 °C and without addition of calcium chloride; 25 °C/$CaCl_2$ 2% = Storage at 25 °C and immersed in 2% calcium chloride solution; 25 °C/$CaCl_2$ 4% = Storage at 25 °C and immersed in 4% calcium chloride solution; 25 °C/$CaCl_2$ 6% = Storage at 25 °C and immersed in 6% calcium chloride solution. TS = Total sugars; TA = Titrabable acidity; WL = Weight loss; SP = Soluble pectins; TP = Total pectins; Frap ether/ethanol/aqueous = antioxidant activity by the FRAP method in the ether/ethanol/aqueous extract; ABTS ether/ethanol/aqueous = antioxidant activity by the ABTS method in the ether/ethanol/aqueous extract; Vit C = vitamin C. Some fruits (treatments) deteriorate, becoming unfit for consumption, before the 12 days of storage, so they were not analyzed.