Evaluation of 1-methylcyclopropene (1-MCP) and temperature in postharvest of banana passion fruit (*Passiflora tripartita* var. *mollissima*)

Evaluación de 1-metilciclopropeno (1-MCP) y temperatura en la poscosecha de curuba (*Passiflora tripartita* var. *mollissima*)

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ABSTRACT

Banana passion fruit or curuba (*Passiflora tripartita* var. *mollissima*) is an exotic fruit liana with fruits of high antioxidant capacity. Its fruits have medicinal, nutritional and industrial properties that make it a product with high nutraceutical potential. This fruit is perishable during postharvest, which is a limiting factor for its conservation. An alternative method for extending the shelf life of fruit postharvest is the use of 1-methylcyclopropene (1-MCP), which inhibits the action of ethylene, delaying the ripening process in fruits and, together with low temperatures, preserves curuba for a longer period without altering its nutritional composition. The effect of the application of 1-MCP and temperature on the quality of curuba fruits was determined. A completely randomized design with four treatments was used: control (14°C), temperature 4°C, 3 mg L^{-1} 1-MCP+14°C, and 3 mg L^{-1} 1-MCP+4°C. The variables evaluated in fruits were color, weight loss, respiration, firmness, total soluble solids, and total titratable acidity. The fruits exposed to the 4°C or 3 mg L^{-1} 1-MCP+4°C treatments had higher firmness and total soluble solids, lower weight loss, and lower color index and titratable acidity with a storage duration of 29 d. The fruits subjected to the 3 mg L^{-1} 1-MCP+4°C treatment showed lower weight loss than in the other treatments. The use of 1-MCP together with low temperatures prolongs the postharvest life of curuba.

Key words: antioxidant, ethylene, ripening, respiration, tropical fruits.

RESUMEN

La curuba (*Passiflora tripartita* var. *mollissima*) es una liana frutal exótica caracterizada por su alta capacidad antioxidante. Sus frutos poseen propiedades medicinales, nutricionales e industriales que hacen de ella un producto con alto potencial nutraceútico. Es un frutal perecedero durante la poscosecha, siendo esto una limitante para su conservación. Un método alternativo para prolongar la vida útil de la fruta después de la cosecha es el uso de 1-metilciclopropeno (1-MCP) que inhibe la acción del etileno, al retardar el proceso de madurez en los frutos, y junto con las bajas temperaturas, los conserva por más tiempo sin alterar su composición nutricional. Se determinó el efecto de la aplicación de 1-MCP y la temperatura sobre la calidad en frutos de curuba. Se utilizó un diseño completamente al azar con cuatro tratamientos: control (14°C), temperatura 4°C, 3 mg L^{-1} 1-MCP+14°C y 3 mg L^{-1} 1-MCP+4°C. Se evaluaron las variables de color, pérdida de peso, respiración, firmeza, sólidos solubles totales y acidez total titulable. Los frutos tratados con la temperatura 4°C o 3 mg L^{-1} 1-MCP+4°C presentaron mayor firmeza y sólidos solubles totales, menor pérdida de peso, índice de color y acidez titulable con una duración de 29 d de almacenamiento. Los frutos sometidos al tratamiento 3 mg L^{-1} 1-MCP+4°C presentaron menor pérdida de peso que los otros tratamientos. El uso de 1-MCP junto con temperaturas bajas prolonga la vida poscosecha de la curuba.

Palabras clave: antioxidante, etileno, maduración, respiración, frutos tropicales.

Introduction

Banana passion fruit or curuba (*Passiflora tripartita*) is a liana native to South America (García-Ruiz *et al*., 2017) known in international markets as an exotic fruit (Salazar & Ramírez, 2017) due to its antioxidant potential and sedative effects (Mayorga *et al*., 2020). It is cultivated in several departments of Colombia, including Antioquia, Boyacá, Huila, Norte de Santander, and Cundinamarca (Parra-Peñalosa & Cancino-Escalante, 2019). This fruit is a source of vitamins A, C, and riboflavin. Its content of phenols, carotenoids, and flavonoids gives it the ability to eliminate free radicals that cause oxidative stress (Chaparro-Rojas *et al*., 2015). It has a higher hypoglycemic and antioxidant capacity than many other fruits (Giambanelli *et al*., 2020). It is utilized as a preservative in lipid peroxidation (Botero *et al*., 2007). Additionally, it is used in the production of fermented beverages (Amorocho-Cruz *et al*., 2022), juices, and desserts. Its seeds are a source of vegetable oil that is processed in the pharmaceutical, food, and cosmetic industries (Hernández-Rivera *et al*., 2018).

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Its importance lies in its health-promoting compounds (Ballesteros-Vivas *et al*., 2019). In Colombia, *arepa* (a traditional flatbread made with corn flour) with curuba pectin could reduce blood glucose levels (Ortiz & Anzola, 2018). Fonseca-Benítez *et al.* (2022) found that curuba seed extract can inhibit the proliferation and growth of oral tumor cells by positively regulating cell death genes, suggesting that it could be a potential treatment for oral cancer.

However, there is a lack of studies on Passifloraceae like the curuba regarding the improvement of their postharvest quality (Fischer *et al*., 2018). Fruits have high water content, which makes them perishable (Zapata *et al*., 2015) and susceptible to damage after harvest (Márquez *et al*., 2017). Therefore, it is important to use alternatives that help maintain fruit quality during the postharvest. One such alternative is 1-methylcyclopropene (1-MCP), which irreversibly binds to ethylene (C_2H_4) receptors (Brasil & Siddiqui, 2018). Some transcriptional regulators of 1-MCP can repress the ethylene response (Gwanpua *et al*., 2017). This blocks fruit maturation; however, the expression of new ethylene receptors would continue with the maturation process. Therefore, it is necessary to develop strategies for each crop based on its ethylene gene expression (Diaz *et al*., 2021). Several studies have been conducted on passion fruit plants, including one on common passion fruit that evaluated the effect of 1-MCP on prolonging shelf life (Dussán-Sarria *et al*., 2011). Another study applied 1-MCP and chitosan at various concentrations to passion fruits stored at 4°C (You *et al*., 2022). Curuba's postharvest life can be extended by storing it at 7°C or 4°C, as reported by Botía-Niño *et al.* (2008). Additionally, Díaz *et al.* (2021) suggest that combining 1-MCP with cold storage is a commonly used method to prolong the shelf life of fruits. The aim of this study was to assess the effect of the application of 1-MCP and the temperature on the postharvest quality of the curuba (*P. tripartita*) fruits.

Materials and methods

Plant material and experimental conditions

Eighty homogeneous curuba (*Passiflora tripartita*) fruits, with approximately 25% yellow color and 75% green color, were collected from a commercial farm in the municipality of Umbita, Boyacá (Colombia). The fruits were free from physical and mechanical damage and had good sanitary conditions. The farm is located at an altitude of 2500 m a.s.l., with an average air temperature of 14°C and monthly precipitation of 100-150 mm (IDEAM, 2022). In October 2022, the selected fruits were transported to the Plant Physiology Laboratory at the University Juan de Castellanos in Soracá, Boyacá.

Sample preparation

The fruits were disinfected with a solution of 0.1 N NaOH in 5 L of water for 5 min. In addition, a commercially available EthylBlocTM (Oasis Grower Solutions, OH, USA) sachet containing 1-MCP 0.014% was applied in two treatments. A dose of 1-MCP was weighed using a precision digital balance (analytical model USS-DB58, Cleveland, OH, USA), then added to 5 L of water. The fruits were immersed in the solution for 10 min and left to dry in the open air. The fruits were subsequently stored at two temperatures: 4ºC in a climatic chamber ref C240 (ISAK.S.AS) and 14ºC room temperature, monitored with an ambient thermometer (Tab. 1).

TABLE 1. Postharvest treatments of curuba (*Passiflora tripartita*) fruits.

Treatments	Description	1-MCP	Temperature
T1	Control	0	14°C
T2	4°C	0	4°C
T3	1-MCP+14°C	3 mg L^{-1}	14°C
T4	1-MCP+4°C	3 mg L^{-1}	4°C

Variable evaluation

The following variables were evaluated in curuba fruits every 7 d in 4 fruits for each treatment. The epidermal color was measured with a digital colorimeter brand FRU WR-18 (Shenzhen MileSeey Technology Co., Ltd., Shanghai, China), and the parameters of the CIELab system were measured. This color spacing, widely used by researchers to evaluate color attributes, is expressed in numerical values. Colors are classified in terms of luminosity (brightness), hue (color), and saturation (vividity). Three measurements were taken in the equatorial area of the fruits during postharvest storage. The values of "a" <0 indicate the direction towards green and values >0 towards the red, while the values of "b" <0 indicate the direction towards blue and values >0 towards yellow. "L" indicates the luminosity, where zero (0) is black and one hundred (100) is white.

The color index (CI) was established according to Thompson (1998) (Eq. 1).

$$CI = \frac{(1000\times a)}{(L\times b)} \qquad \text{(Eq. 1)}$$

Total soluble solids (TSS), expressed in °Brix, were measured every 7 d using a Hanna HI 9681 digital refractometer (Hanna Instruments®, Woonsocket, RI, USA) with an accuracy of 0.01%, covering a range from 0 to 85%.

The total titratable acidity (TTA) was calculated using Equation 2 with the volume of NaOH until pH 8.2 was reached. To measure, 1 g of curuba juice, 3 drops of phenolphthalein were added to a beaker (AOAC, 2023).

$$\text{TTA\%} = \frac{(A \times B \times C)}{D} \times 100 \qquad \text{(Eq. 2)}$$

where A represents the volume of NaOH used, B represents the normality of NaOH (0.1 N), C represents the equivalent weight in grams of acid in the fruit (citric acid 0.064 g meq^{-1}) (Chaparro-Rojas *et al*., 2015), and D represents the fresh weight in grams of the sample. The maturity ratio was determined as the TSS/TTA ratio.

The respiration rate (mg CO_2 kg^{-1} h^{-1}) was measured according to Garavito *et al*. (2021) using a CO_2 analyzer, AtmoCheck® Double (Hi Tech Systems, Inc., Knoxville, TN, USA). To determine the respiration rate, 100 g of fruit were placed in airtight chambers for 30 min. The weights of the fruit were taken into account and the data was then converted to mg CO_2 kg^{-1} h^{-1}. The firmness of the fruit was measured using a GY-4 digital penetrometer with a 0.05 N approximation (Zhejiang Top Cloud-agri Technology Co., Ltd., Hangzhou, China).

Weight loss % (WL) was calculated according to Equation 3. The fresh weight of the fruits was measured using the analytical balance model USS-DB58, Cleveland, OH, USA, with a precision of 0.0001 g.

$$\%\,WL = \frac{(wi\text{-}wf)}{wi} \times 100 \qquad \text{(Eq. 3)}$$

where wi represents the initial weight of a fruit, and wf represents the weight obtained on the sampling date (measurements were taken weekly starting on day 0 of storage, with four fruits being evaluated per treatment).

Experimental design and statistical analysis

A completely randomized design with four treatments and four replicates was used, with five measurements over time for a total of 80 experimental units (4 fruits per experimental unit). The data was analyzed using R statistical software (R Studio interface, version 1.4). The assumptions of homogeneity (Barlett's test) and the normality of variance (Shapiro-Wilk test) were validated, followed by a one-way ANOVA analysis and Tukey's multiple comparison test ($P \leq 0.05$).

Results and discussion

Color

According to the three dimensions of color (Tab. 2), at 8 d of storage the L parameter increased for the control (59.64) and for 1-MCP (61.66). This shows that an increase in luminosity is correlated with a reduction in fruit chromaticity during the ripening process. This was also significantly different from the 4°C (37.66) treatment and 1-MCP+4°C (38.99). The two treatments with the longest

TABLE 2. Color of curuba fruits (*Passiflora tripartita*) in the three dimensions *L*, *a*, *b* during postharvest storage.

Color	Storage days	Treatments							
		Control		Temperature 4°C		1-MCP		1-MCP + Temp (4°C)	
		mean	SE	Mean	SE	mean	SE	mean	SE
L	0	44.98^{a}	1.59	38.24^{a}	1.44	41.74^{a}	1.78	39.15^{a}	0.77
	4	53.22^{a}	3.50	36.90^{b}	2.51	51.40^{a}	2.31	40.92^{ab}	0.65
	8	59.64^{a}	1.72	37.67^{b}	1.39	61.67^{a}	0.85	38.99^{b}	0.62
	15	61.39^{a}	2.08	37.67^{b}	1.81	56.99^{a}	0.48	39.37^{b}	1.37
	22			35.67^{b}	1.69			42.44^{a}	1.31
	29			29.91^{b}	1.60			40.34^{a}	1.24
a	0	-6.76^{a}	0.42	-7.73^{a}	0.46	-7.57^{a}	0.18	-8.38^{a}	0.36
	4	-4.42^{a}	0.64	-7.98b^{c}	0.24	-4.78^{ab}	0.84	-8.66^{c}	0.13
	8	2.35^{a}	0.29	-6.44^{b}	0.60	3.35^{a}	0.28	-8.51^{b}	0.16
	15	7.56^{b}	0.21	-4.54^{c}	0.54	12.61^{a}	0.43	-6.54^{c}	0.34
	22			-1.28^{a}	0.91			-5.56^{a}	0.25
	29			2.82^{a}	0.75			-3.06^{b}	0.50
b	0	28.35^{a}	0.75	28.57^{a}	1.39	32.74^{a}	2.25	31.16^{a}	0.54
	4	33.03^{a}	0.77	34.36^{a}	2.02	39.84^{a}	1.27	33.28^{a}	0.25
	8	34.97^{b}	1.38	43.86^{ab}	1.26	48.41^{ab}	1.08	40.04^{ab}	0.65
	15	47.68^{ab}	0.22	42.92^{ab}	1.65	56.18^{a}	1.75	41.71^{b}	1.01
	22			54.20^{a}	2.49			45.87^{a}	2.24
	29			44.85^{a}	2.39			44.44^{a}	0.70

The color parameters are of the CIELab system using the coordinates: L*(luminosity), a*(red/green), b* (yellow/blue). SE corresponds to the standard error of the data. Different letters in the row indicate significant differences according to the Tukey test ($P \leq 0.05$).

shelf life have a storage life of 29 d. This is related to weight loss and loss of fruit quality. Significant differences were observed in coordinate *a* between the control (2.35) and 1-MCP (3.34) treatment compared to the 4°C (-6.44) and 1-MCP+4°C (-8.50) treatments at 8 d; at 15 d significant differences were found for the control (7.56) and 1-MCP (12.61) compared to 1-MCP+4°C (-6.54) and 4°C (-4.54). The 4°C treatment (29.91) also showed significant differences from the 1-MCP+4°C treatment (40.33) at 29 d. A gradual increase in red color of fruit skin was observed in both control (7.56) and 1-MCP (12.61) treatments after 15 d of storage, while the fruits in treatments 4°C (2.82) and 1-MCP+4°C (-3.0) remained green until 29 d of storage. This indicates better color preservation at the temperature 4°C and 1-MCP+4°C treatments.

After 8 and 15 d of storage, significant differences were observed in parameter *b* between control (34.96) and 1-MCP+4°C treatment (40.03). The highest values were observed in control (54.14) and 1-MCP (58.92), approaching the yellow color, while the lowest value was observed in 1-MCP+4°C treatment (45.87). According to Téllez *et al.* (1999), a change from green to yellow color in a shorter time at a temperature of 20°C causes fruit wrinkling due to dehydration and the presence of fungi. According to Franco *et al.* (2013), carotenoid content increases as the fruit ripens, which can be related to a decrease in luminosity, with higher a-coordinates and lower b-coordinates, which was evidenced in the temperature 4°C and 1-MCP+4°C treatments.

Color index

At 8 d of storage, both control (1400) and 1-MCP (2631) had a rapid increase in color changes, significantly different from the treatments of 4°C (-7754) and 1-MCP+4°C (-8733). The same trend was observed at 15 and 22 d of storage, with significant differences in the same treatments. In addition, the fruits of the control and 1-MCP treatments lost their postharvest quality after 15 d of storage (Fig. 1). As observed by Fischer *et al.* (2018), the tonality in Passiflora fruit epidermis increases the maturity index. At 29 d of storage, the treatment of temperature 4°C (5092) showed significant differences with the treatment 1-MCP+4°C (-3362), highlighting the color stability with the 1-MCP+4°C treatment. This is consistent with Cheng *et al.* (2012), who found that pear fruits treated with 1-MCP had high chlorophyll content, intact chloroplasts with organized grana thylakoids, and low ethylene production for up to 30 d and 15 d of storage, respectively, compared to untreated fruits.

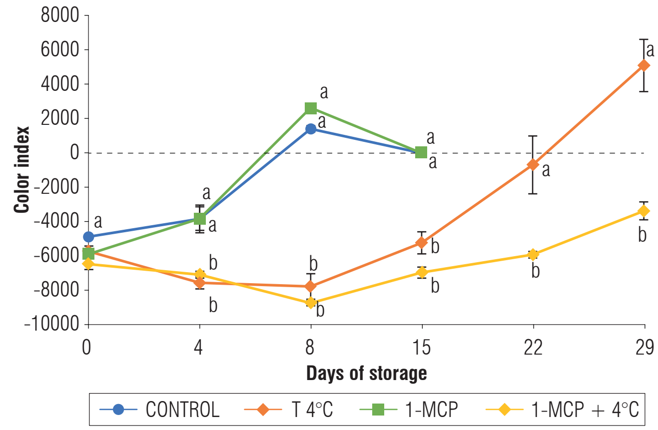

FIGURE 1. Color index of curuba fruits (*Passiflora tripartita*) subjected to preservation treatments during postharvest storage. 1-MCP – 1-methylcyclopropene. Different letters indicate significant differences according to Tukey's test ($P \leq 0.05$); vertical bars indicate standard error (n=4). No data are presented for the control and 1-MCP treatments because they lost their postharvest quality after 15 d of storage.

Total titratable solid contents (TSS)

The TSS in fruits at 15 d of storage presents significant differences between the control (9.2 °Brix) and 1-MCP (9.5 °Brix) compared to the treatment of temperature 4°C (11.2 °Brix) and 1-MCP+4°C (9.8 °Brix). Thereafter, the TSS began to decrease in the fruits subjected to the temperature 4°C and 1-MCP+4°C treatments without significant differences between them until 29 d of storage (Fig. 2A). The decrease occurs because, as respiration increases during storage, some sugars are used as substrate in metabolic processes such as glycolysis and conversion to sucrose (Saltveit, 2019). This statement agrees with Téllez *et al.* (1999) regarding curuba fruits, where a decrease in TSS was found after 19 and 22 d of storage. Additionally, Botía-Niño *et al.* (2008) found no significant differences in temperature treatments for curuba fruits at week six of postharvest storage, indicating that continuous refrigeration can preserve the fruits for a longer period.

Total titratable acidity (TTA)

The results indicate that there were significant statistical differences in the TTA of the fruits after 8 d of storage. The fruits treated with 1-MCP+4°C had an increase in TTA (2.92%), while the TTA decreased in the control (1.65%), 1-MCP (1.46%) and temperature 4°C (1.81%) treatments. This decrease may be associated with increased respiratory metabolism in fruits, consuming acids in the tricarboxylic acid cycle (Vallarino & Osorio, 2018). These findings are consistent with a previous study conducted by Mayorga *et al.* (2020), who found higher total titratable acidity in

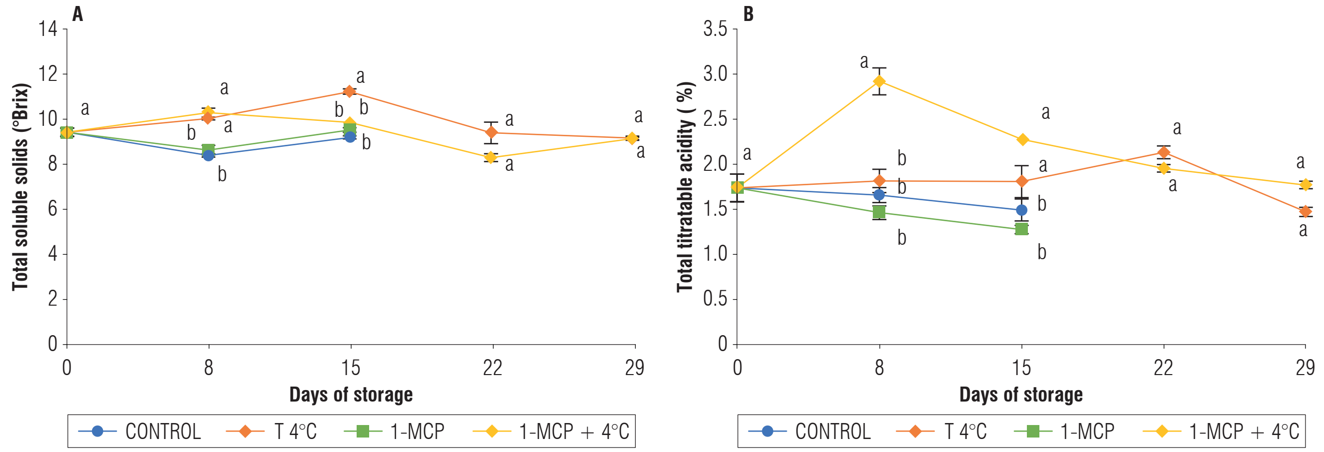

FIGURE 2. A) Total soluble solids and B) Total titratable acidity in fruits of curuba (*Passiflora tripartita*) subjected to preservation treatments during of postharvest storage. 1-MCP – 1-methylcyclopropene. Different letters indicate significant differences according to Tukey's test ($P\leq0.05$); vertical bars indicate standard error (n=4).

curuba fruits. After 22 d of storage, the treatments of temperature 4°C and 1-MCP+4°C showed significant differences in TTA compared with the control and 1-MCP, with a decrease in TTA observed (Fig. 2B). Similarly, Téllez *et al.* (1999) observed a gradual reduction in the TTA of curuba fruits during postharvest. Botía-Niño *et al.* (2008) reported that as fruits ripen, TTA decreases and new components such as organic acids and dehydrogenases are formed.

Maturity ratio

The maturity ratio calculated as TSS/TTA presented significant differences at 29 d of storage for the 4°C (6.56) treatment compared to the 1-MCP+4°C (5.09) (Fig. 3).

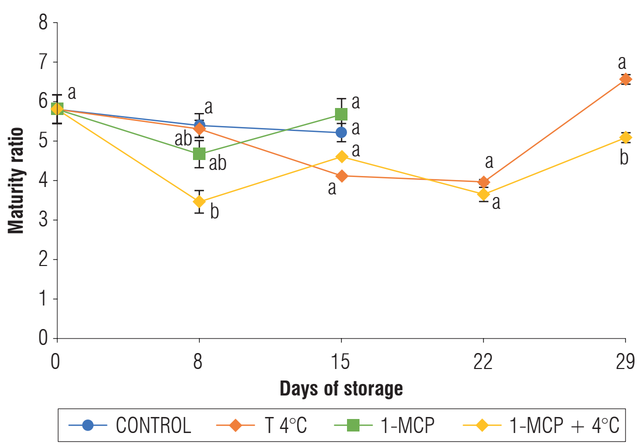

FIGURE 3. Maturity ratio in curuba fruits (*Passiflora tripartita*) subjected to preservation treatments during postharvest storage. 1-MCP – 1-methylcyclopropene. Different letters indicate significant differences according to Tukey's test ($P\leq0.05$); vertical bars indicate standard error (n=4).

According to Fischer *et al.* (2018), in fruits, as the maturity index increases, the TTA decreases and TSS increases. Similarly, Téllez *et al.* (2011) found that curuba fruits presented a higher maturity ratio during storage at room temperature. Likewise, Téllez *et al.* (1999) observed low values of maturity ratio in curuba fruits stored at 8°C. In addition, Botía-Niño *et al.* (2008) found lower maturity ratio values in curuba fruits in treatments with continuous refrigeration, which preserved them for a longer period.

Respiration rate

The respiration rate in fruits presented significant differences at 15 d of postharvest storage, with the control (329.80 mg CO_2 kg^{-1} h^{-1}) and 1-MCP (469.76 mg CO_2 kg^{-1} h^{-1}) differing from the 4°C (267.83 mg CO_2 kg^{-1} h^{-1}) and 1-MCP+4°C (230.41 mg CO_2 kg^{-1} h^{-1}) treatments. At 29 d of storage the 4°C (116.99 mg CO_2 kg^{-1} h^{-1}) and 1-MCP+4°C (146.92 mg CO_2 kg^{-1} h^{-1}) treatments did not present significant differences (Fig. 4). Similar to Téllez *et al.* (1999), curuba fruits presented a climacteric behavior in the respiration rate. On the other hand, Téllez *et al.* (2011) observed a respiration peak in curuba fruits without wax application at 20°C after 11 and 12 d storage and at 8°C after 12 d and 14 d storage. In this study, the respiration peak occurred at 22 d in the 1-MCP+4°C treatment. However, the 4°C and 1-MCP+4°C treatments presented lower respiration rates during the first 15 d compared to the control. This is consistent with Baraza *et al.* (2013), who reported that purple passion fruit (P*assiflora edulis* Sims) fruits treated with 1-MCP had a decrease in respiration rate.

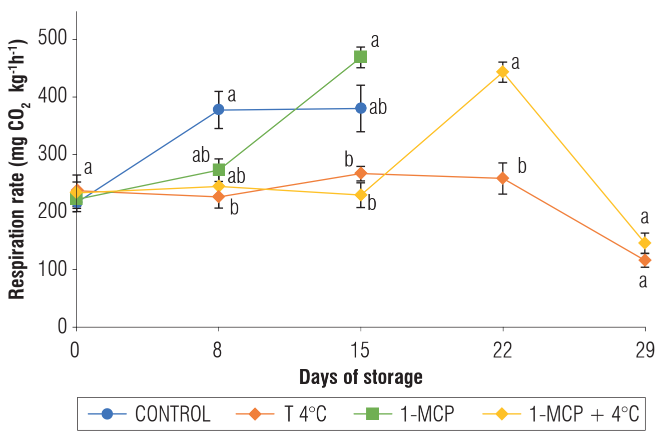

FIGURE 4. Respiration rate in curuba fruits (*Passiflora tripartita*) subjected to preservation treatments during postharvest storage. 1-MCP – 1-methylcyclopropene. Different letters indicate significant differences according to Tukey's test ($P\leq0.05$); vertical bars indicate standard error (n=4).

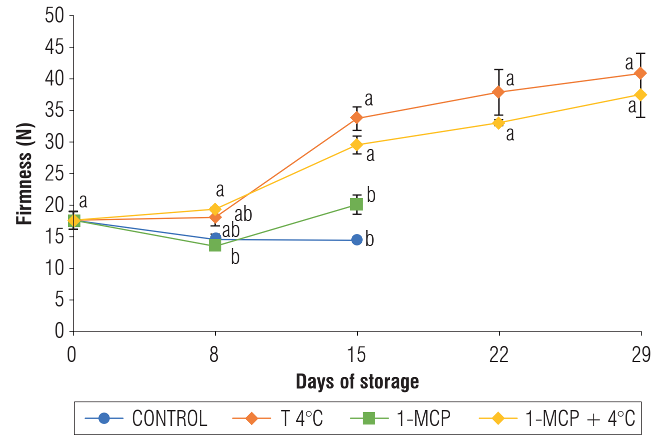

FIGURE 5. Firmness of curuba fruits (*Passiflora tripartita*) subjected to preservation treatments during postharvest storage. 1-MCP – 1-methylcyclopropene. Different letters indicate significant differences according to Tukey's test ($P\leq0.05$); vertical bars indicate standard error (n=4).

Firmness

After 15 d of storage, fruit firmness differed significantly among the treatments. The 4°C (33.69 N) and 1-MCP+4°C (29.53 N) treatments had higher firmness compared to the control (14.42 N) and 1-MCP (20.08 N), which had lower firmness (Fig. 5). This is consistent with Téllez *et al.* (1999), who found that curuba fruits lose firmness as temperature increases. After 29 d of storage, firmness increased in 4°C (40.8 N) and 1-MCP+4°C (37.5 N) treatments, without significant differences among them. According to Maftoonazad *et al.* (2008), hydrolyzing enzymes of the cell wall ensure the firmness of the fruits during postharvest.

Li *et al.* (2020) found that treatment with 1-MCP in purple passion fruit (*Passiflora edulis* Sims) can regulate cell wall metabolism pathways, increase enzymatic activities, accelerate lignin accumulation, and reduce cell wall degradation during fruit ripening by inhibiting ethylene synthesis. The application of 1-MCP in *Passiflora* fruits helps to improve postharvest life and prevent diseases, as evidenced by a lower incidence of anthracnose, according to Dutra *et al.* (2018). In this sense, Botía-Niño *et al.* (2008) found that continuous refrigeration increased the firmness of curuba fruits, in contrast to the control fruits which experienced reduced firmness.

Weight loss

At 8 and 15 d of storage, weight loss in fruits significantly differed between the treatments 1-MCP (29.6%) and 1-MCP+4°C (18.8%) (Fig. 6). This is consistent with Téllez *et al.* (2011), who found that curuba fruits waxed and stored at low temperatures had lower weight loss and longer preservation. Similarly, Téllez *et al.* (1999) observed less weight loss in curuba fruits stored for 12 d and 14 d at 8°C compared to those stored at 20°C, which accelerated transpiration and oxidative metabolism of the fruits.

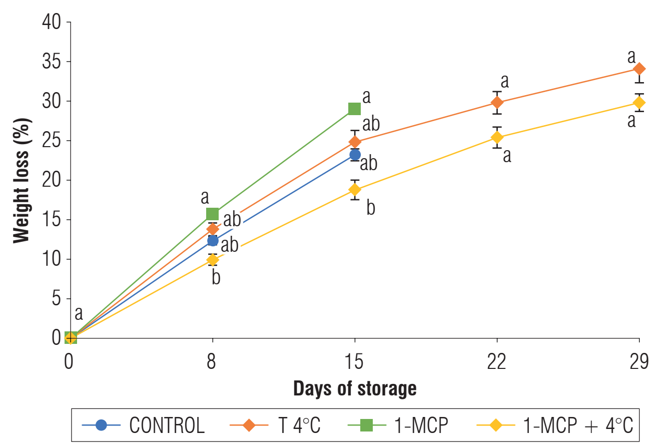

FIGURE 6. Weight loss in curuba fruits (*Passiflora tripartita*) subjected to preservation treatments during postharvest storage. 1-MCP – 1-methylcyclopropene. Different letters indicate significant differences according to Tukey's test ($P\leq0.05$); vertical bars indicate standard error (n=4).

After 29 d of storage, the fruit weight loss was lower in the 1-MCP+4°C treatment (29.8%) compared to the 4°C treatment (34.1%). This is consistent with Franco-Mora *et al.* (2022), who reported decreased weight loss in *Passiflora biflora* fruits stored at temperatures below 4°C. Additionally, Botía-Niño *et al.* (2008) found that curuba fruits can be stored for a longer time at temperatures between 4°C and 7°C, which reduces weight losses due to respiration and transpiration, making them more suitable for consumption.

Conclusions

Curuba fruits in the 4°C and 1-MCP+4°C treatments exhibited lower values in color index, TSS (8 and 15 d of storage), maturity ratio, respiration rate, and weight loss, and higher values in TTA and firmness. This resulted in a postharvest storage life of 29 d compared to the control and 1-MCP treatments, which had a storage life of 15 d.

The 1-MCP+4°C treatment resulted in lower fruit weight loss, higher TTA and a progressive increase in TSS. It also provided high fruit firmness, lower values in color index and maturity fruit ratio compared to the other three treatments. Thus, this treatment can be considered as an alternative to improve the postharvest life of curuba fruits.

The use of 1-MCP delays the ripening process, and when accompanied by a temperature of 4ºC, is the most effective treatment, with a lower maturity index and weight loss. This slows oxidative metabolism, making it an alternative to improve the postharvest quality of the fruits.

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Conflict of interest statement

The authors declare that there is no conflict of interests regarding the publication of this article.

Author's contributions

DNSS and YADO designed the experiments, developed the methodology, and carried out the laboratory experiments; YADO contributed to the data analysis; and DNSS and YADO wrote the article. All authors reviewed the final version of the manuscript.

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