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Changes in the physicochemical properties of yellow pitahaya (*Hylocereus megalanthus*) during storage

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Abstract

Fresh fruits are essential for their flavor and nutritional value, and storage is one factor that decreases their shelf life. Low temperature or cold storage is a strategy to prolong the shelf life and maintain quality. Yellow pitahaya (*Hylocereus megalanthus*) was collected during the 2023 season, during May in the district of Magdalena (Chachapoyas, Amazonas, Peru). This study evaluated the physicochemical properties of yellow pitahaya stored at different conditions (room temperature, 2°C, and 4°C) every 15 days: Water activity, pH, total soluble solids (TSS), titratable acidity (TA), maturity index, antioxidant activity (by DPPH and ABTS) were also determined. The results showed significant changes in the physicochemical properties of pitahaya stored at different temperatures. The pitahaya stored at room temperature had higher water activity than samples stored at 2°C and 4°C, decreasing their solid content. The color of pitahaya also varied with the storage temperature, being 2°C ideal for maintaining the color. Therefore, storage at low temperatures slows down the degradation of the fruit, although precautions should be taken due to its susceptibility to physiological changes. Proper storage of pitahaya is essential to maintain its freshness and nutritional value.

1. Introduction

Fresh fruits possess physicochemical properties that maintain a balance concerning nutrient availability and preserve organoleptic characteristics such as flavor and aroma (Mesa *et al*., 2023; Pu *et al*., 2023). However, some of them are highly perishable, and their shelf life during storage is short (Jiang *et al*., 2020; Yu *et al*., 2023) due to microbial contamination and mechanical damage, among others, that occur during these postharvest processes (Ghosh and Singh, 2022; Liang *et al*., 2022). Due to this problem, the development of strategies to extend the shelf life and preserve the physicochemical properties of fruits has become a necessity (Liu *et al*., 2023) to reduce wastage, satisfy consumer needs, and maintain their quality (Fan, Rong, Li *et al*., 2022; Huang *et al*., 2023; Odeyemi *et al*., 2020; Zhang *et al*., 2022).

Different methods of fruit preservation have been studied, such as coating, modified atmosphere, and cold storage (Fang and Wakisaka, 2021; Jiang *et al*., 2022; Jurić *et al*., 2023; Khademi *et al*., 2019; Sun *et al*., 2023). Cold storage stands out as the safest method to extend the shelf life of fruits during storage (Fan, Lin, Lin *et al*., 2022; Silué *et al*., 2022; Sinha *et al*., 2022).

Pitahaya is a tropical fruit valued for its color, flavor, and high nutritional value due to its phenolic compounds with antioxidant properties (Jiang *et al*., 2021; Nur, Uddin, Meghla *et al.,* 2023; Nur, Uddin, Uddin *et al*., 2023; Xie *et al*., 2020). The yellow-shelled pitahaya (*Hylocereus megalanthus*) is characterized by its exceptional nutritional properties for the body, such as

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polyphenols, antioxidants, the presence of elements such as phosphorus, calcium, vitamin C, and fiber (Viñas and Jiménez, 2016). However, there is a lack of scientific data on preserving this fruit in a fresh state to preserve its bioactive properties effectively.

According to reported studies, low temperatures contribute to preserving the nutritional and physicochemical properties of fruits (Baena *et al*., 2023; Barikloo and Ahmadi, 2018; Hong *et al*., 2018). Therefore, this study aimed to analyze the changes in the physicochemical properties of pitahaya during storage at room temperatures (≈ 21°C), 2°C and 4°C.

2. Materials and methods

2.1 Plant material

Yellow pitahaya (*H. megalanthus*) fruits were harvested in May 2023 from a private orchard at Magdalena district (6° 22' 22" S, 77° 54' 6" W, 1892 mamsl), Chachapoyas province, Amazonas-Peru. The harvested fruits were transported to the Food and Postharvest Engineering Research Laboratory of the Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas in coolers with ice packs. They were divided into three parts and stored under three conditions (room temperature ≈ 21°C, 2°C, and 4°C). The evaluations were carried out daily for 15 days during May and June 2023.

2.2 Physicochemical analysis

2.2.1 Water activity (aw)

Water activity values were determined by the indirect method (Mathlouthi, 2001) using a portable *aw* instrument (Rotronic AG, HygroPalm, Bassersdorf, Switzerland). The fruits were cut into small square pieces (approximately 3 cm on each side) until the tank of the device was filled, and after 4 mins, the data was recorded in triplicate.

2.2.2 pH measurement

The modified method described by (Song *et al*., 2018; Nur, Uddin, Uddin *et al*., 2023) was used. Before that, the multi-parameter (Hanna Instruments, HI2020, WoonsocketU, USA) was calibrated using pH reference solutions. Subsequently, 10 g of the pulp was mixed with 90 mL of ultrapure water in a beaker. Then, the electrode was immersed in each sample, waiting for the reading to stabilize. The pH values were recorded in triplicate.

2.2.3 Color measurement

Ten uniform fruits (without lesions or damage) were selected, then three zones around the equatorial plane of the fruit were selected as described by Castillo-Chuquizuta *et al*. (2023), and measurements were made with a trichromatic colorimeter (Chroma Meter, CR-400, Tokyo, Japan). It was recorded in the CIE coordinate system L* a* b*. The hue angle was calculated to represent the actual perceived color of the fruit (Zhang and Zhou, 2019) using the following equation 1:

$$h^{\circ} = tan^{-1}\left(\frac{b*}{a*}\right) \quad (1)$$

Color purity was determined using the chroma value (Zhang and Zhou, 2019) through the following equation 2:

$$C^{*} = (a^{*2} + b^{*2})^{\frac{1}{2}} \quad (2)$$

2.2.4 Total soluble solids

A mortar was used to extract the juice from the fruits to determine the TSS content. Subsequently, a few drops of the extracted juice were placed in a portable refractometer (WZ-103, TOP Instrument Co., Zhejiang, China) to measure its concentration. These measurements were expressed in °Bx.

2.2.5 Titratable acidity

It was determined by titrating the fruit samples employing the AOAC 942.15 method (Horwitz and Latimer, 2005) by spending NaOH (0.01 N) in the presence of a phenolphthalein indicator. Subsequently, the percentage acidity was calculated using the following equation 3:

$$\%\,TA = \frac{(\text{ml NaOH}) * (\text{N}) * (\text{weight}_{mq}\ \text{predominant acid})}{\text{sample weight(g)}} \times 100 \quad (3)$$

Where: N is normality of titrant (NaOH) (it is 0.01 N), 0.064 g is the milliequivalent weight of citric acid (Arivalagan *et al*., 2021), the predominant acid in pitahaya.

2.2.6 Maturity index

The fruit maturity index was estimated according to Kalt *et al*. (1995) using the following equation 4:

$$\text{Maturity index} = \frac{TSS}{TA} \quad (4)$$

2.2.7 Determination of antioxidant activity

2.2.7.1 DPPH assay

The assay described in Medina-Mendoza *et al*. (2023) was used with minor modifications. The DPPH solution was dissolved with ethanol to obtain an absorbance of 0.7±0.02 units at 517 nm. The fruit extracts (0.1 mL) were allowed to react with 3.9 mL of the DPPH solution for 30 mins in the dark, and the decrease in the absorbance of the resulting solution was examined. The absorbance of the reaction mixture was

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measured at 517 nm. The results were expressed as µmol Trolox equivalent/g sample (µmol (TE)/g), and a light purple color was observed. Analyses were performed in triplicate in a spectrophotometer (GENESYS™, Thermo Scientific, USA).

2.2.7.2 ABTS assay

It was determined as described by De Souza *et al.* (2014), with some modifications. The radical cation ABTS was generated by reacting 5 mL of an aqueous solution of ABTS with 88 µm potassium persulfate (final concentration of 2.45 mM). The mixture was kept in the dark for 16 hrs before use and then diluted with ethanol to an absorbance of 0.7±0.02 units at 734 nm using a spectrophotometer. The extracts (30 µm) were reacted with 3 mL of the resulting product from the ABTS radical solution, which presented a blue-green color under dark conditions. After 6 mins, the absorbance was measured at 734 nm. The analyses were performed in triplicate in a spectrophotometer (GENESYS™, Thermo Scientific, USA), and the results were expressed in µmol Trolox equivalent/g sample (µmol (TE)/g).

2.3 Experiment arrangement

The evaluation was carried out daily for 15 days, where the response variables were: water activity (*aw*), pH, color index, total soluble solids (TSS), titratable acidity (TA), determination of antioxidant activity (DPPH, ABTS); taking into account three storage conditions: room temperature (≈ 21°C), 4°C and 2°C and three replicates for each evaluation, as detailed in Table 1.

2.4 Statistical analysis

The measurements were conducted in triplicates, and the means ± standard deviation (SD) were reported. Assumptions of variance analysis (ANOVA) were checked before analysis and were fulfilled, concomitant with a Tukey multiple comparisons test (95%). Unsupervised pattern recognition theory was used to form clusters (K-means); the clusters were based on two dimensions and explained 59.4% of the point variability. Data processing was performed with the RMarkdown free software (RStudio, version 2022.07.2+576, USA).

3. Results and discussion

The day of storage significantly affected *aw* in Pitahaya. At room temperature, water activity (0.910 to 0.967) was higher than in the samples stored at 2°C (0.815 to 0.939) and 4°C (0.815 to 0.939) (Figure 1). A slower evaporation rate causes this observed phenomenon due to the lower temperature, which resulted in a slower decrease in the water content (Bosquez *et al*., 2008), the enzymatic and microbial activity, and the crystal formation (Raypah *et al*., 2022) during storage. The results suggest that storing pitahaya at lower temperatures may be beneficial to reduce the risks caused by room temperature and its chemical degradation Murmu and Mishra, 2018; Angonese *et al*., 2021; Jiang *et al*., 2021). However, at low temperatures, due to pitahaya's climatic nature, it may suffer physiological disorders and changes caused by cold (Vargas *et al*., 2005; Bosquez *et al*., 2008), manifested as skin splitting and bract wilting, as observed in our study; negatively affecting its commercial value and quality. Therefore, an appropriate storage temperature for pitahaya depends on several factors and should be established according to the characteristic storage conditions of each food (Raypah *et al*., 2022).

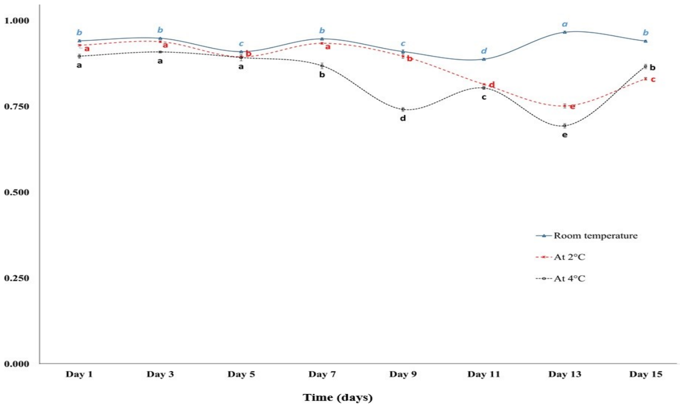

Figure 1. Water activity of pitahaya *(Hylocereus megalanthus)* during three storage conditions. n = 3 for the *aw* (three replications × day for each replication). Different notations above the data points are statistically significantly different within the same time (days) (Tukey's test, $p \leq 0.05$).

It was found that storage days significantly influenced the pH and TSS, as shown in Table 2, the pH of the pitahaya increased during the postharvest storage; these results are consistent with the studies reported by Jiménez-Esparza *et al*. (2017), Rodríguez *et al*. (2005) and Vera *et al*. (2021), where at an room temperature

Table 1. Experiment arrangement

Temperature	Postharvest storage							
	Day 1	Day 3	Day 5	Day 7	Day 9	Day 11	Day 13	Day 15
Environment (21°C)	3R	3R	3R	3R	3R	3R	3R	3R
2°C	3R	3R	3R	3R	3R	3R	3R	3R
4°C	3R	3R	3R	3R	3R	3R	3R	3R

R: repetitions.

Table 2. Physicochemical properties of pitahaya *(Hylocereus megalanthus)* during three storage conditions

Days	pH			TSS			TA			MI		
	RT	4°C	2°C	RT	4°C	2°C	RT	4°C	2°C	RT	4°C	2°C
Day 1	5.4±0.030^{e}	5.4 ±0.015^{e}	5.5±0.040^{f}	20±0.00^{b}	18±0.00^{c}	17±0.00^{c}	0.16±0.00^{a}	0.19±0.00^{a}	0.13±0.00^{b}	126±0.00^{f}	93.9±0.283^{e}	133±0.604^{d}
Day 3	5.8±0.02^{c}	5.7±0.015^{c}	5.8±0.005^{c}	16±0.00^{e}	14±0.00^{f}	15±0.00^{e}	0.13±0.00^{b}	0.19±0.00^{a}	0.13±0.00^{b}	125±0.00^{f}	73.6±0.223^{g}	118±0.00^{e}
Day 5	5.8±0.043^{bc}	5.6±0.015^{d}	5.8±0.005^{b}	16±0.00^{e}	16±0.00^{e}	16±0.00^{d}	0.13±0.00^{bc}	0.16±0.00^{b}	0.19±0.00^{a}	125±0.00^{f}	100±0.363^{d}	83.3±0.00^{f}
Day 7	5.9±0.045^{bc}	5.9±0.011^{a}	5.9±0.011^{a}	17±0.00^{d}	17±0.00^{d}	15±0.00^{e}	0.13±0.00^{c}	0.19±0.00^{a}	0.19±0.00^{a}	134±0.00^{e}	89.2±0.270^{f}	78.3±0.236^{g}
Day 9	5.7±0.011^{d}	5.7±0.015^{cd}	5.8±0.010^{a}	18±0.00^{c}	16±0.00^{e}	17±0.00^{c}	0.1±0.00^{d}	0.16±0.00^{b}	0.13±0.00^{b}	189±0.00^{d}	100±0.363^{d}	134 ±0.00^{c}
Day 11	5.9±0.025^{a}	5.8±0.020^{b}	5.7±0.005^{d}	16±0.00^{e}	20±0.00^{a}	18±0.00^{b}	0.06±0.00^{f}	0.14±0.00^{c}	0.1 ±0.00^{c}	250±0.00^{b}	144±0.593^{c}	188±0.00^{b}
Day 13	5.8±0.030^{c}	5.8±0.015^{b}	5.7±0.015^{e}	21±0.00^{a}	20±0.00^{a}	18±0.00^{b}	0.06±0.00^{f}	0.13±0.00^{d}	0.1±0.00^{c}	328±0.00^{a}	157±0.710^{b}	188±0.00^{b}
Day 15	5.9±0.015^{ab}	5.7±0.020^{cd}	5.8±0.010^{c}	18±0.00^{c}	19±0.00^{b}	20±0.00^{a}	0.08±0.00^{e}	0.1±0.00^{e}	0.06±0.00^{d}	235±1.78^{c}	198±0.00^{a}	312±0.00^{a}

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different (Tukey's test, $p \leq 0.05$). n = XX for the pH, TSS, TA and MI (three replications x day for each replication). RT: Room temperature, pH: degree of acidity or basicity of a solution, TSS: total soluble solids content, TA: titratable acidity, MI: maturity index.

Table 3. L*, chroma and hue angle of pitahaya (*Hylocereus megalanthus*) during three storage conditions

Days	L*			a*			b*			C*			°h		
	Ambient	4°C	2°C	Ambient	4°C	2°C	Ambient	4°C	2°C	Ambient	4°C	2°C	Ambient	4°C	2°C
Day 1	59.9 ±4.27^{a}	56.2 ±2.89^{a}	57.0 ±3.22^{a}	7.03 ±2.36^{c}	7.76 ±1.14^{a}	7.27 ±1.19^{a}	30.8 ±4.60^{c}	34.9 ±2.37^{a}	33.4 ±2.40^{a}	31.7 ±4.48^{d}	35.8 ±2.23^{a}	34.2 ±2.24^{a}	1.34 ±0.0823^{a}	1.35 ±0.0386^{a}	1.350 ±.043^{a}
Day 3	60.3 ±3.34^{a}	56.9 ±5.08^{a}	57.4 ±1.88^{a}	7.81 ±3.64^{bc}	7.68 ±2.19^{a}	7.79 ±1.09^{a}	31.4 ±5.33^{c}	35.8 ±4.07^{a}	33.9 ±1.96^{a}	32.6 ±5.16^{cd}	36.7 ±3.97^{a}	34.8 ±1.74^{a}	1.32 ±0.117^{a}	1.36 ±0.0662^{a}	1.34 ±0.041^{a}
Day 5	60.6 ±1.90^{a}	57.1 ±2.69^{a}	58.0 ±3.43^{a}	8.29 ±2.74^{bc}	8.47 ±2.04^{a}	7.93 ±1.69^{a}	32.1 ±3.22^{c}	36.0 ±4.35^{a}	34.1 ±2.71^{a}	33.2 ±3.23^{cd}	37.1 ±4.13^{a}	35.0 ±2.80^{a}	1.32 ±0.0819^{a}	1.34 ±0.0671^{a}	1.34 ±0.043^{a}
Day 7	61.0 ±4.40^{a}	57.6 ±3.45^{a}	58.1 ±3.43^{a}	8.31 ±1.95^{bc}	8.96 ±2.85^{a}	8.00 ±1.79^{a}	32.5 ±4.99^{c}	36.5 ±3.22^{a}	34.5 ±2.30^{a}	33.6 ±4.74^{cd}	37.5 ±3.11^{a}	35.4 ±2.23^{a}	1.37 ±0.0818^{a}	1.33 ±0.0850^{a}	1.34 ±0.053^{a}
Day 9	61.4 ±3.53^{a}	57.9 ±6.22^{a}	58.3 ±5.57^{a}	9.62 ±2.64^{abc}	7.08 ±3.30^{a}	8.24 ±2.49^{a}	33.8 ±3.87^{bc}	36.6 ±3.16^{a}	34.8 ±3.12^{a}	35.2 ±4.10^{cd}	37.7 ±2.91^{a}	35.9 ±2.95^{a}	1.29 ±0.0642^{a}	1.38 ±0.0891^{a}	1.34 ±0.077^{a}
Day 11	62.7 ±1.79^{a}	59.0 ±4.99^{a}	58.7 ±2.97^{a}	10.0 ±2.55^{abc}	9.46 ±2.23^{a}	8.67 ±1.98^{a}	35.7 ±2.87^{bc}	37.1 ±3.49^{a}	35.0 ±2.20^{a}	37.2 ±3.02^{bc}	38.3 ±3.67^{a}	36.1 ±2.04^{a}	1.30 ±0.0633^{a}	1.32 ±0.0487^{a}	1.33 ±0.060^{a}
Day 13	62.9 ±2.05^{a}	59.4 ±5.96^{a}	59.4 ±3.82^{a}	11.1 ±1.11^{ab}	10.3 ±3.09^{a}	8.95 ±1.41^{a}	39.2 ±2.79^{ab}	37.5 ±4.33^{a}	35.1 ±4.86^{a}	40.8 ±2.67^{ab}	39.0 ±4.27^{a}	36.2 ±4.97^{a}	1.29 ±0.0336^{a}	1.30 ±0.0839^{a}	1.32 ±0.027^{a}
Day 15	63.1 ±2.23^{a}	59.6 ±3.93^{a}	59.8 ±1.62^{a}	12.1 ±1.83^{a}	8.72 ±3.75^{a}	9.25 ±1.91^{a}	41.3 ±3.33^{a}	37.9 ±1.54^{a}	35.2 ±5.05^{a}	43.1 ±3.48^{a}	39.1 ±1.24^{a}	36.4 ±5.05^{a}	1.29 ±0.0356^{a}	1.34 ±0.0988^{a}	1.31 ±0.054^{a}

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different (Tukey's test, $p \leq 0.05$). n = xx for the L*, chroma and hue angle (three replications × day × three different storage condition). L*: Luminosity, a*: redness, b*: yellowness, C*: Chroma index, H: hue index.

similar to ours, pH also increased. The TSS of the pitahaya preserved at room temperature decreased between 16 - 21°Bx (Table 2), similar ranges to those reported by Nerd and Mizrahi (1999), and Obenland *et al*. (2016). The variations observed in the TSS values are due to the conversion of starch into glucose and fructose, which are indicators of the pitahaya ripening degree (Vilaplana *et al*., 2020). On the other hand, the behavior of the TSS could be because the fruits used in this study were wild and were collected at different levels of maturity; however, it can be observed that the TSS average values of storage at room temperature were higher, followed by 4°C and 2°C, deducting that better preservation of the fruit occurred at 4°C and 2°C compared to room temperature.

The maturity of the fruit is conditioned by the content of pigments, sugars, and organic acids, so the color is related to the state of maturity (Kalt *et al*., 1995; Samaniego *et al*., 2020), which depends on the storage parameters. Table 3 shows the variation of pitahaya color at different temperatures (room temperature, 4°C, and 2°C). Pitahaya shows a significant effect ($p<0.05$) only in reddening and yellowing at room temperature, which shows that the ripening process is faster at this temperature. On the other hand, it is observed that there is more reddening at room temperature, followed by 4°C and then 2°C, which suggests that the optimal temperature for this fruit is 2°C because the respiration rate of pitahaya is lower at low temperatures (Ho *et al*., 2020), contrary to what was reported by Balendres and Bengoa (2019), where it is mentioned that storing pitahaya at 6°C reduces the variation of the fruit color.

The TA behavior of yellow pitahaya shows significant differences ($p<0.05$) (Table 2); in our study, a decreasing trend is observed during the three storage conditions, resulting consistent with what was described by Domínguez-Guadarrama *et al*. (2018) and Sotomayor *et al*. (2019). Likewise, Jiménez-Esparza *et al*. (2017) mentioned that the fruit ripens, as the room temperature decreases, which causes a gradual decrease in TA due to the decomposition of organic acids; however, at lower temperatures, the deterioration may be slower compared to fruit stored at room temperature (Jiang *et al*., 2021). Regarding the maturity index of pitahaya, the results show an upward trend during storage of the 3 conditions, similar to those obtained by Rodríguez *et al*. (2005). When stored at different temperatures, the fruit's chemical composition and organoleptic properties change (Jiang *et al*., 2021). Using remarkably ripe pitahaya as a sample for the study allowed a more accurate representation of the changes and characteristics related to fruit maturity. This deliberate choice contributed to an increase in the maturity index of yellow pitahaya, where the fruit exhibited characteristics with more pronounced sweetness, aroma, and flavor (Angonese *et al*., 2021).

Antioxidant activity by DPPH and ABTS methods indicates an antioxidant compound's ability to prevent its substrate's oxidation (Pérez-Nájera *et al*., 2013). According to Figures 2 and 3, variations in the antioxidant activity of the pitahaya were observed as a function of the storage temperature, highlighting that temperatures of 2°C and 4°C allowed a better preservation of the fruit's chemical properties.

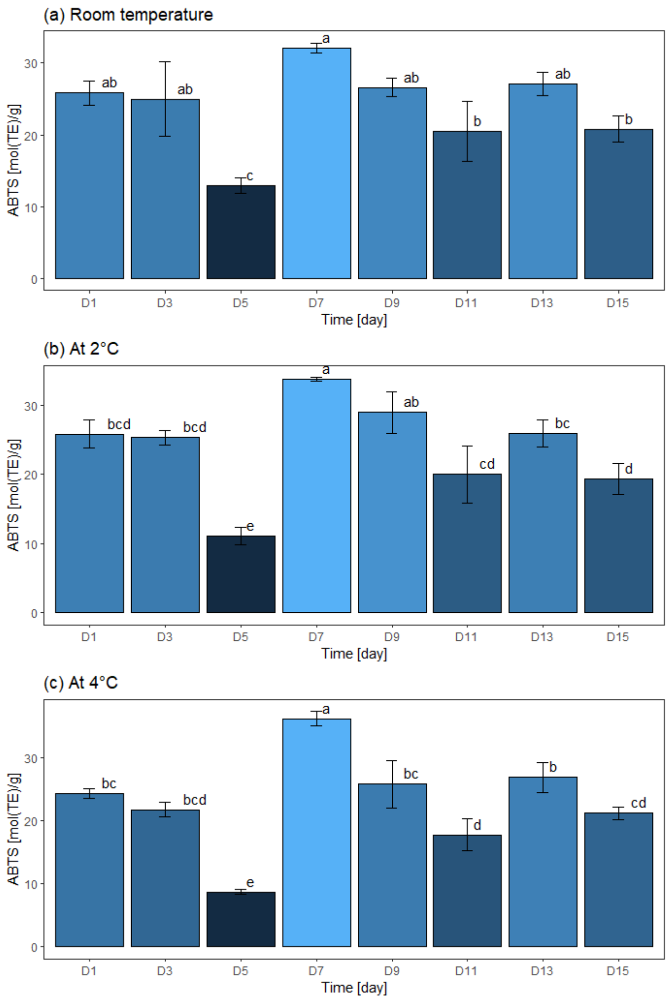

Figure 2. Antioxidant activity (ABTS) of pitahaya during three storage conditions: (a) room temperature, (b) stored at 2°C, (c) stored at 4°C. n = 3 for the ABTS assay (three replications × day for each replication). Bars with different notations are statistically significantly different within the same time (days) among the different storage conditions (Tukey's test, $p \leq 0.05$).

In addition, during the storage period between days 3 and 13 at 4°C, the antioxidant activity remained constant according to the Tukey test method, suggesting that storage at 4°C during this specific period (days 3-13) is recommended; however, storage applications under field conditions require monitoring.

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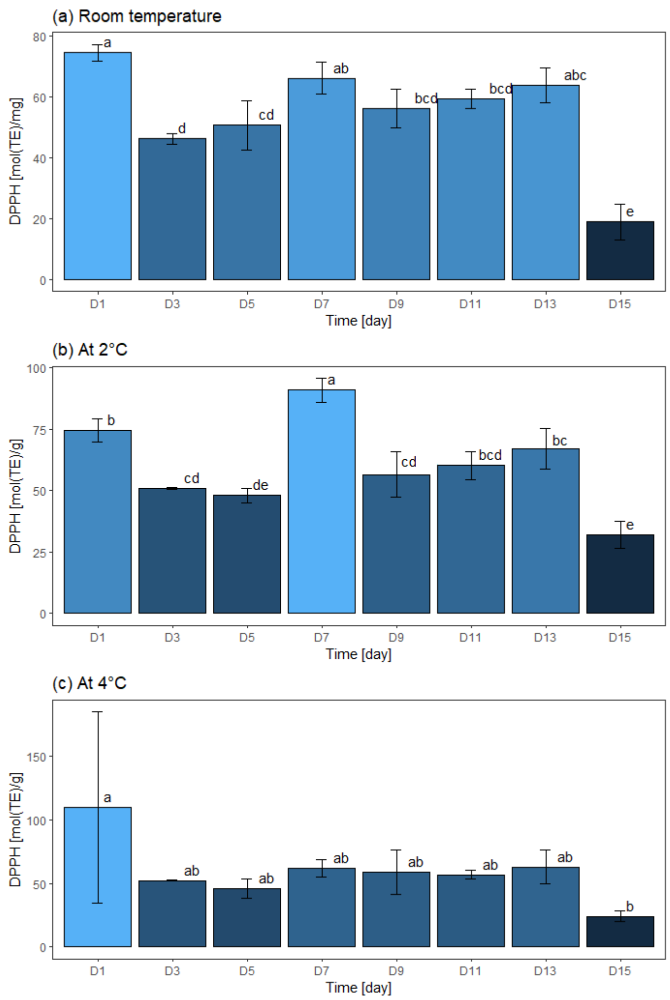

Figure 3. Antioxidant activity (DPPH) of pitahaya during three storage conditions: (a) room temperature, (b) stored at 2°C, (c) stored at 4°C. n = 3 for the DPPH assay (three replications × day for each replication). Bars with different notations are statistically significantly different within the same time (days) among the different storage conditions (Tukey's test, $p \leq 0.05$).

It is important to note that pitahaya has phytochemical potential, as it contains various secondary metabolites with antioxidant activity (Vázquez and García-Vieyra, 2016). These compounds include polyphenols and carotenoids, known for their ability to neutralize free radicals and protect against oxidative stress. In our study, the storage at temperatures of 2°C and 4°C favors the preservation of these metabolites, enhancing the antioxidant activity of the pitahaya during days 3 to 13, suggesting a better conservation of these metabolites, but further research is needed.

The first cluster (Figure 4), composed of days 13 and 15, presented a higher index of color coordinates (L, a, b), which is associated with a higher chroma index and H index, which explains the saturation and the color hue as they are stored longer. The second cluster was composed of day 9 to day 15 and presented antioxidant values and ripening indexes higher than the other days. Meanwhile, the third cluster included all the days of storage with higher antioxidant activity, *aw*, pH, and total soluble solids.

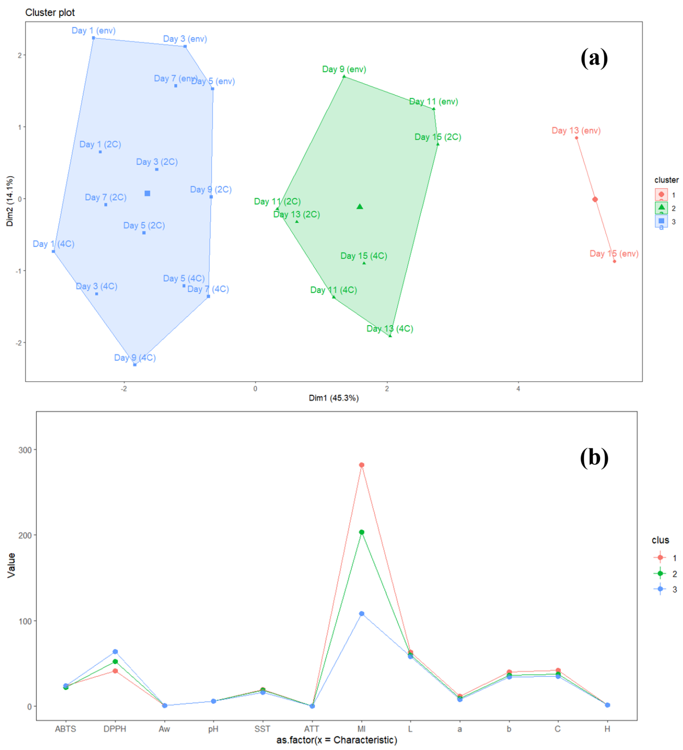

Figure 4. Cluster of evaluated parameters of pitahaya at three moments during postharvest storage. (a) division of the parameters in three stages (cluster), (b) measured values of ABTS, DPPH, *aw*, pH, TSS, TA, MI, L, a, b, C, H parameters in each cluster. ABTS and DPPH: methods to know the antioxidant activity, *aw*: water activity, pH: degree of acidity or basicity of a solution, TSS: total soluble solids content, TA: titratable acidity, MI: maturity index, L: brightness, a: redness, b: yellowness, C: chroma index, H: hue index.

4. Conclusion

Determining pitahaya's quality and shelf life and studying its physicochemical properties during postharvest storage is crucial. This research found significant changes in the properties analyzed when the fruits were stored at room temperature, 2°C, and 4°C. According to the results, the optimum temperatures for preserving pitahaya during a postharvest storage period between days 3 and 13 were 2°C and 4°C due to the analyzed behavior of TSS, TA, *aw*, color, and antioxidant activity. However, when very ripe samples are stored, the temperature does not inhibit the ripening process. In conclusion, the analyses provided a better understanding of the pitahayas' physicochemical changes during storage at different temperatures.

Conflict of interest

The authors declare no conflicts of interest.

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