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Effect of Postharvest Preservation Methods on the Storage Stability and Quality of Prickly Pear *Opuntia ficus-indica*

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Abstract

Prickly pear (*Opuntia ficus-indica* (L.) Miller) is a highly valued fruit due to its nutritional and functional properties. However, its postharvest shelf life is limited by rapid weight loss, decay, and chilling injury during storage. This study evaluated the effects of different postharvest preservation methods (room temperature storage, sodium bicarbonate treatment, wax coating, and refrigeration at 5°C), storage duration (1–4 weeks), and variety ("Cristalina" and "Roja Paulina") on fruit quality attributes. Results showed that wax coating and sodium bicarbonate treatment significantly preserved fruit length, diameter, and weight compared to room temperature storage and refrigeration. The highest fruit quality was recorded for wax-coated and sodium bicarbonate-treated fruits, particularly in the first two weeks of storage. Refrigeration maintained peel integrity but led to weight loss and pulp shrinkage over time. "Cristalina" exhibited superior storage stability compared to "Roja Paulina." The findings indicate that a combination of wax coating or sodium bicarbonate treatment with appropriate storage conditions effectively extends prickly pear shelf life while maintaining quality attributes.

Keywords: prickly pear, postharvest preservation, sodium bicarbonate, wax coating, refrigeration, fruit quality, storage duration.

INTRODUCTION

Cactus pear (*Opuntia ficus-indica* (L.) Miller) is a valuable food source appreciated for its unique flavor, juiciness, and nutritional benefits (Piga et al., 2000; Cefola et al., 2014). Beyond its importance as a fresh fruit, the plant is widely used as livestock forage due to its high drought tolerance and substantial biomass production per unit of water (Márquez-Berber et al., 2012). The increasing global demand for cactus pear fruit is primarily attributed to its reported nutritional and functional properties, including high antioxidant content and potential health benefits (Tesoriere et al., 2004; Butera et al., 2002). The chemical composition of cactus pear fruit is comparable to that of papaya, nectarine, and oranges, with approximately 85% water content and 10–15% carbohydrates. It is also a rich source of bioactive compounds such as ascorbic acid (25–30 mg 100 g^{-1}), betalains, polyphenols, and dietary fiber, which contribute to its health-promoting properties (Cantwell, 1995; Stintzing & Carle, 2005; Rashwan et al., 2021). Cactus pears are non-climacteric fruits with a very low ethylene production rate after harvest, which limits their ability to regulate postharvest ripening through ethylene-mediated processes (Amaya-Cruz et al., 2019 a). However, these fruits are highly sensitive to marketing conditions, particularly at 20 °C and 60–70% relative humidity (RH), where they experience rapid weight loss and decay, significantly reducing their shelf life (Juhaimi et al., 2020;). Additionally, harvest timing significantly influences the chemical composition and postharvest behavior of prickly pear fruits. Cold storage is one of the most effective methods for preserving postharvest quality in fresh fruits, but cactus pear fruits are highly susceptible to chilling injury when stored at temperatures below 9–10 °C (Granata & Sidoti, 2002). To mitigate chilling injury and enhance storage life, several treatments such as waxing, edible coatings, and the application of natural antimicrobials have been investigated (Rodríguez-Félix & Villegas-Ochoa, 2010). Waxing forms a protective barrier on the fruit surface, reducing moisture loss and respiration rate while enhancing appearance and microbial resistance (Abbasi et al., 2015 a; Abbasi et al., 2015 b). The use of sodium bicarbonate ($NaHCO_3$) as a postharvest treatment has gained attention due to its antifungal properties and ability to maintain fruit quality during storage. Sodium bicarbonate helps suppress fungal decay, particularly *Penicillium* spp. and *Alternaria* spp., which are common pathogens affecting postharvest prickly pear fruit (Palou et al., 2001). When combined with cold storage, sodium bicarbonate treatments have been shown to reduce weight loss, maintain firmness, and preserve antioxidant compounds, thereby extending shelf life (Cefola et al., 2022). In addition to conventional cold storage, controlled atmosphere (CA) and modified atmosphere packaging (MAP) techniques have been explored to delay ripening and reduce microbial spoilage. CA conditions with low O_2 (2%) and moderate CO_2 (2–5%) help to slow metabolic processes and preserve sensory attributes of the fruit (Ochoa-Velasco & Guerrero-Beltrán, 2016; Hahn-Schlam et al., 2019). Minimally processed cactus pears, including ready-to-eat products, require washing, peeling, cutting, disinfecting, draining, drying, packaging, and refrigerated storage (Baldwin et al., 1995; Aguayo et al., 2004). However, these treatments often induce mechanical stress on fruit tissues, leading to increased respiration rates, enzymatic browning, ethylene production, softening, loss of vitamins and phenolic compounds, microbial growth, and changes in sensory attributes (Gontard et al., 1996; Rojas-Graü et al., 2009). Ethylene production in minimally processed fruits can also activate enzymes such as phenylalanine ammonia-lyase (PAL), which is associated with senescence and deterioration (Martinez et al., 2005). One of the primary challenges in maintaining the quality of minimally processed fruits and vegetables is their short shelf life (Wang et al., 2007). To mitigate deterioration, the application of edible coatings has gained attention as a promising strategy to extend shelf life and preserve quality attributes. Certain edible coatings, such as chitosan-based and aloe vera-based coatings, not only act as physical barriers to moisture loss and microbial contamination but also possess antimicrobial and antioxidant properties that can enhance fruit preservation (Petersen et al., 1999; Ali et al., 2011). The integration of multiple postharvest preservation techniques, including cold storage, CA/MAP packaging, waxing, edible coatings, and natural antimicrobial treatments like sodium bicarbonate, is a promising approach to extending the shelf life and maintaining the quality of prickly pear fruit. Future research should focus on optimizing these treatments and exploring novel bio-based preservation methods to enhance sustainability and reduce postharvest losses. The objective of this study is to evaluate three preservation methods on the storability and quality of prickly pear fruit.

MATERIALS AND METHODS

The fruits used in this study were hand-harvested using traditional methods. The trees where the fruit harvested are grown in the experimental farm, Faculty of Agriculture, Sohag University, Elkawthar suburb, Sohag, Egypt. Four postharvest treatments were applied:

1. **Control (Room Temperature Storage)** – Fruits were stored under ambient room conditions.
2. **Sodium Bicarbonate Treatment** – Fruits were dipped in a sodium bicarbonate solution.
3. **Wax Coating** – Fruits were covered with a film of edible wax.
4. **Refrigeration** – Fruits were stored at 5°C.

For each treatment, three fruits per replicate were used, with three replications per treatment per week, for two different varieties. Fruit quality parameters were analyzed at 7-day intervals over a period of four weeks. The soil of the study is calcareous, with calcium carbonate content ranging from 8% to 17%. The soil texture varies from sandy to loamy sand, with a slightly alkaline pH (7.7 to 8.6) and electrical conductivity (EC) values between 0.23 and 2.95 dS/m, indicating slight salinity. The availability of macro- and micronutrients is generally low, and organic matter content does not exceed 0.2%. A detailed soil characterization is presented in Table 1.

Table (1) soil characterization of the study area.

Soil characteristics	Range
pH	7.7 – 8.6
EC (dS/m)	0.23 – 2.95
Texture class	Sandy – loamy sand
O.M (%)	0.09 – 0.19
CaCO3 (%)	8 - 17
N (%)	0.01 – 0.017
P (mg/kg)	1.4 – 4.5
K (mg/kg)	56 - 118
Fe (mg/kg)	0.3 – 1.1
Mn (mg/kg)	0.1 – 1.6
Cu (mg/kg)	0.02 – 0.1
Zn (mg/kg)	0.01 – 0.06

Fruit Quality Assessment

Fruit quality parameters were evaluated based on fruit size (weight and dimensions), peel weight, pulp weight, TSS, juice volume and total acidity. Fruit length and diameter were measured using a digital caliper, while fruit and pulp weight were determined using an electronic balance with an accuracy of 0.01 g. Soluble solids content (°Brix) was measured using a digital refractometer. Titratable acidity was assessed by titrating the juice with 0.1 N NaOH using phenolphthalein as a color indicator. Titratable acidity (QAC) was calculated according to IFU (2017) using the following equation:

QAC=0.67×VNaOH QAC = 0.67 \times V (NaOH)

Where **QAC** is the titratable acidity expressed in grams of malic acid per liter of juice, and **VNaOH** is the volume of NaOH used in titration (in mL).

Statistical analysis:

This experiment was arranged in Randomized Complete Block Design (RCBD) with three replications (one three pear each replicate), in split split blot layout. Factorial experiment data were subjected to analysis of variance according to Snedecor and Cochran (1980). Treatments were compared by Duncan's multiple range tests at 5% level of probability in the average of two seasons of study (mean with a different letter(s) are significantly different) (Steel and Torrie, 1980).

RESULTS

Fruit Length (cm):

The effects of post-harvest treatments on fruit length in "Cristalina" and "Roja Paulina" varieties during 2022 and 2023 are shown in Table 2. Significant differences were observed among treatments. The highest fruit length was recorded for wax and sodium bicarbonate treatments in "Cristalina" (8.45 cm and 8.64 cm) in the first and second seasons, respectively. The lowest values were recorded for sodium bicarbonate in "Roja Paulina" (7.37 cm and 7.24 cm) in the first and second seasons, respectively. Weekly averages showed significant variations. "Cristalina" had the highest fruit length in the first week (8.26 cm and 8.47 cm), while "Roja Paulina" had the lowest in the fourth week (7.42 cm and 6.91 cm) in both seasons. The interaction between variety (A), treatment (B), and week (C) was significant. The highest values were for wax and sodium bicarbonate in "Cristalina" (8.80 cm and 8.73 cm) during the first week. The lowest were for sodium bicarbonate and room atmosphere in "Roja Paulina" (7.05 cm and 6.53 cm) in the fourth week. Across treatments, wax recorded the highest overall fruit length (8.07 cm and 8.05 cm). The lowest values were in the fourth week (7.48 cm and 7.41 cm) in both seasons. The highest treatment-week interaction was recorded for wax and sodium bicarbonate in the first week (8.33 cm and 8.41 cm).

Fruit Diameter (cm):

Table (3) presents the effect of post-harvest treatments on fruit diameter for *Cristalina* and *Roja Paulina* varieties during the 2022 and 2023 seasons. Significant differences were observed among treatments. The highest fruit diameters were recorded for *Cristalina* under wax and sodium bicarbonate treatments (5.23 cm, 5.59 cm) in the first and second seasons, respectively. The lowest values were found in *Roja Paulina* stored at 5°C (4.24 cm, 4.68 cm). Over the weeks, *Cristalina* showed the highest diameter in the first week (5.35 cm, 5.56 cm), while the lowest values were recorded for *Roja Paulina* in the fourth week (4.26 cm, 4.77 cm). The interaction between variety, treatment, and storage duration was significant. The highest values were recorded in *Cristalina* under wax and sodium bicarbonate treatments in the first week (5.53 cm, 5.87 cm). The lowest values were found in *Roja Paulina* under cooling at 5°C in the fourth week (4.00 cm, 4.47 cm). Regardless of variety, wax and sodium bicarbonate showed the highest mean values (4.87 cm, 5.54 cm), while the lowest mean diameter was recorded in the fourth week (4.48 cm, 4.88 cm). The highest interaction between treatments and weeks was found in wax and sodium bicarbonate treatments in the first week (5.12 cm, 5.82 cm).

Fruit Weight (g):

Table (4) shows significant differences in fruit weight among post-harvest treatments for *Cristalina* and *Roja Paulina* during the 2022 and 2023 seasons. The highest fruit weights were recorded in *Cristalina* under wax and sodium bicarbonate treatments (124.7 g, 142.9 g) in the first and second seasons, respectively. The lowest weights were observed in *Roja Paulina* stored at 5°C (82.88 g, 87.98 g). Across weeks, *Cristalina* had the highest fruit weight in the first week (114.0 g, 127.5 g), while *Roja Paulina* had the lowest in the fourth week (81.09 g, 90.08 g). The interaction between variety, treatment, and storage duration was significant. The highest fruit weights were recorded in *Cristalina* under wax and sodium bicarbonate treatments in the first week (133.6 g, 152.2 g), while the lowest were in *Roja Paulina* stored at 5°C in the fourth week (72.98 g, 79.18 g). Regardless of variety, wax and sodium bicarbonate treatments had the highest average fruit weight (106.2 g, 126.1 g), while the lowest was recorded in the fourth week (89.57 g, 97.98 g). The highest interaction between treatment and week was observed in wax and sodium bicarbonate treatments in the first week (111.4 g, 133.5 g).

Peel Weight (g):

Table (5) indicates significant differences in peel weight among post-harvest treatments for *Cristalina* and *Roja Paulina* during the 2022 and 2023 seasons. The highest peel weights were recorded in *Cristalina* under cooling at 5°C and sodium bicarbonate treatments (40.79 g, 43.22 g) in the first and second seasons, respectively. The lowest values were observed in *Roja Paulina* stored in room atmosphere and cooling at 5°C (31.38 g, 36.64 g). Across weeks, *Cristalina* had the highest peel weight in the first week (35.09 g, 44.71 g), while the lowest values were recorded in the fourth week for both varieties (31.78 g, 33.07 g). The interaction between variety, treatment, and storage duration was significant. The highest peel weights were observed in *Cristalina* and *Roja Paulina* under wax treatment in the first week (43.44 g, 49.88 g), while the lowest were in *Cristalina* under room atmosphere and cooling at 5°C in the fourth week (27.93 g, 28.20 g). Regardless of variety, cooling at 5°C and sodium bicarbonate treatments resulted in the highest peel weights (37.59 g, 43.98 g), while the lowest values were recorded in the fourth week (31.80 g, 34.66 g). The highest interaction between treatment and week was observed in wax and sodium bicarbonate treatments in the first week (39.54 g, 45.55 g).

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Table (2): Effect of Post-harvest treatments on fruit length (cm) of prickly pear cv. "*cristalina*" and "*Roja Paulina*" during 2022 and 2023 growing seasons.

Seasons		2022					2023				
Var. (A)		Weeks (C)					Weeks (C)				
	Treat (B)	1st week	2nd week	3rd week	4th week	Mean (AB)	1st week	2nd week	3rd week	4th week	Mean (AB)
Cristalina	Room atmosphere	7.70^{b-g}	7.51^{c-g}	7.23^{fg}	7.05^{g}	7.37^{D}	8.65^{ab}	8.57^{abc}	8.27^{a-d}	7.89^{a-g}	8.35^{A}
	Sodium bicarbonate	8.12^{a-f}	7.93^{a-g}	7.70^{b-g}	7.30^{efg}	7.76^{CD}	8.73^{a}	8.69^{ab}	8.65^{ab}	8.49^{abc}	8.64^{A}
	Wax	8.80^{a}	8.60^{ab}	8.40^{abc}	8.00^{a-f}	8.45^{A}	8.43^{abc}	8.43^{abc}	8.33^{abc}	8.03^{a-g}	8.31^{A}
	Cooling at 5°C	8.40^{abc}	8.40^{abc}	8.33^{a-d}	7.77^{b-g}	8.23^{AB}	8.07^{a-f}	7.93^{a-g}	7.87^{a-h}	7.20^{g-k}	7.77^{AB}
	Mean (AC)	8.26^{A}	8.11^{AB}	7.92^{ABC}	7.53^{CD}		8.47^{A}	8.41^{A}	8.28^{AB}	7.90^{CD}	
Roja Paulina	Room atmosphere	8.17^{a-e}	7.80^{b-g}	7.73^{b-g}	7.67^{c-g}	7.84^{BC}	8.17^{a-e}	7.27^{f-k}	7.20^{g-k}	6.53^{k}	7.29^{B}
	Sodium bicarbonate	7.59^{c-g}	7.42^{d-g}	7.39^{efg}	7.05^{g}	7.37^{D}	7.73^{c-j}	7.35^{e-k}	6.99^{ijk}	6.89^{jk}	7.24^{B}
	Wax	7.87^{b-g}	7.83^{b-g}	7.60^{c-g}	7.47^{d-g}	7.69^{CD}	8.30^{abc}	8.17^{a-e}	7.37^{e-k}	7.33^{e-k}	7.79^{AB}
	Cooling at 5°C	8.03^{a-f}	7.97^{a-g}	7.93^{a-g}	7.50^{c-g}	7.86^{BC}	7.83^{b-i}	7.43^{d-j}	7.03^{h-k}	6.90^{jk}	7.30^{B}
	Mean (AC)	7.92^{ABC}	7.76^{BCD}	7.67^{CD}	7.42^{D}		8.01^{BC}	7.56^{D}	7.15^{E}	6.91^{E}	
Treat (B)	Room atmosphere	7.93^{a-e}	7.65^{b-f}	7.48^{def}	7.36^{ef}	7.61^{B}	8.41^{a}	7.92^{a-e}	7.73^{c-f}	7.21^{fg}	7.82^{A}
	Sodium bicarbonate	7.86^{a-e}	7.68^{b-f}	7.55^{c-f}	7.18^{f}	7.56^{B}	8.23^{a-d}	8.02^{a-e}	7.82^{b-e}	7.69^{def}	7.94^{A}
	Wax	8.33^{a}	8.22^{ab}	8.00^{a-d}	7.73^{a-f}	8.07^{A}	8.37^{ab}	8.30^{abc}	7.85^{a-d}	7.68^{def}	8.05^{A}
	Cooling at 5°C	8.22^{ab}	8.18^{ab}	8.13^{abc}	7.63^{b-f}	8.04^{A}	7.95^{a-e}	7.68^{def}	7.45^{efg}	7.05g	7.53^{A}
	Mean (C)	8.09^{A}	7.93^{AB}	7.79^{B}	7.48^{C}		8.24A	7.98B	7.71C	7.41D	

Means followed by the same letters are not significantly different at 5%.

Table (3): Effect of Post-harvest treatments on fruit diameter (cm) of prickly pear cv. "*cristalina*" and "*Roja Paulina*" during 2022 and 2023 growing seasons.

Seasons		2022					2023				
Var. (A)		Weeks (C)					Weeks (C)				
	Treat (B)	1st week	2nd week	3rd week	4th week	Mean (AB)	1st week	2nd week	3rd week	4th week	Mean (AB)
Cristalina	Room atmosphere	5.27^{abc}	5.03^{a-g}	4.88^{a-i}	4.40^{g-k}	4.90^{AB}	5.51^{a-e}	5.08^{b-g}	4.90^{c-g}	4.70^{fg}	5.05^{CDE}
	Sodium bicarbonate	5.27^{abc}	5.14^{a-f}	4.97^{a-h}	4.67^{b-k}	5.01^{A}	5.87^{a}	5.70^{ab}	5.55^{a-d}	5.25^{a-f}	5.59^{A}
	Wax	5.53^{a}	5.20^{a-d}	5.13^{a-f}	5.07^{a-g}	5.23^{A}	5.53^{a-e}	5.40^{a-f}	5.37^{a-f}	5.17^{a-g}	5.37^{ABC}
	Cooling at 5°C	5.33^{ab}	5.17^{a-e}	4.47^{f-k}	4.67^{b-k}	4.91^{AB}	5.33^{a-f}	5.23^{a-g}	5.20^{a-g}	4.80^{d-g}	5.14^{BCD}
	Mean (AC)	5.35^{A}	5.13^{AB}	4.86^{BC}	4.70^{CD}		5.56^{A}	5.35^{A}	5.25^{A}	4.98^{A}	
Roja Paulina	Room atmosphere	4.73^{b-j}	4.53^{d-k}	4.50^{e-k}	4.47^{f-k}	4.56^{BC}	5.13^{a-g}	5.03^{b-g}	4.87^{c-g}	4.67^{fg}	4.93^{DE}
	Sodium bicarbonate	4.67^{b-k}	4.65^{c-k}	4.49^{f-k}	4.29^{ijk}	4.52^{BC}	5.77^{ab}	5.58^{abc}	5.49^{a-e}	5.15^{a-g}	5.50^{AB}
	Wax	4.70^{b-j}	4.60^{c-k}	4.47^{f-k}	4.27^{ijk}	4.51^{BC}	5.30^{a-f}	5.00^{b-g}	4.90^{c-g}	4.80^{d-g}	5.00^{CDE}
	Cooling at 5°C	4.50^{e-k}	4.30^{h-k}	4.17^{jk}	4.00^{k}	4.24^{C}	4.77^{efg}	4.77^{efg}	4.70^{fg}	4.47^{g}	4.68^{E}
	Mean (AC)	4.65^{CD}	4.52^{DE}	4.40^{DE}	4.26^{E}		5.24^{A}	5.10^{A}	4.99^{A}	4.77^{A}	
Treat (B)	Room atmosphere	5.00^{a}	4.78^{a-d}	4.69^{a-e}	4.43^{cde}	4.73^{AB}	5.32^{b-e}	5.06^{c-g}	4.88^{efg}	4.68fg	4.99^{B}
	Sodium bicarbonate	4.97^{a}	4.89^{ab}	4.73^{a-e}	4.48^{b-e}	4.77^{AB}	5.82^{a}	5.64^{ab}	5.52^{abc}	5.20^{b-f}	5.54^{A}
	Wax	5.12^{a}	4.90^{ab}	4.80^{abc}	4.67^{a-e}	4.87^{A}	5.42^{a-d}	5.20^{b-f}	5.13^{b-g}	4.98^{d-g}	5.18^{B}
	Cooling at 5°C	4.92^{ab}	4.73^{a-e}	4.32^{e}	4.33^{de}	4.58^{B}	5.05^{c-g}	5.00^{c-g}	4.95^{d-g}	4.63^{g}	4.91^{B}
	Mean (C)	5.00^{A}	4.83^{AB}	4.63^{BC}	4.48^{C}		5.40^{A}	5.22^{AB}	5.12^{B}	4.88^{C}	

Means followed by the same letters are not significantly different at 5%

Table (4): Effect of Post-harvest treatments on fruit weight (gm) of prickly pear cv. "*cristalina*" and "*Roja Paulina*" during 2022 and 2023 growing seasons.

Seasons	2022						2023				
Var. (A)		Weeks (C)					Weeks (C)				
	Treat (B)	1st week	2nd week	3rd week	4th week	Mean (AB)	1st week	2nd week	3rd week	4th week	Mean (AB)
Cristalina	Room atmosphere	101.6^{c-g}	97.24^{c-h}	96.36^{c-h}	93.52^{d-i}	97.17^{BC}	117.6^{b-g}	115.4^{b-i}	110.8^{c-j}	102.4^{e-l}	111.60^{BC}
	Sodium bicarbonate	113.1^{bcd}	107.3^{b-e}	96.51^{c-h}	95.55^{c-h}	103.1^{B}	152.2^{a}	150.4^{a}	137.4^{ab}	131.7^{abc}	142.90^{A}
	Wax	133.6^{a}	125.2^{ab}	123.7^{ab}	116.3^{abc}	124.7^{A}	130.2^{abc}	122.2^{b-f}	116.2^{b-h}	103.7^{d-l}	118.10^{B}
	Cooling at 5°C	107.5^{b-e}	105.9^{b-f}	104.7^{b-f}	86.79^{e-i}	101.2^{B}	109.8^{c-j}	102.0^{e-l}	101.8^{e-l}	85.79^{jkl}	99.84^{CD}
	Mean (AC)	114.0^{A}	108.9^{A}	105.3^{AB}	98.05^{BC}		127.50^{A}	122.50^{A}	116.60^{AB}	105.90^{BC}	
Roja Paulina	Room atmosphere	93.23^{d-i}	90.70^{e-i}	90.46^{e-i}	88.99^{e-i}	90.85^{BCD}	125.4^{b-e}	109.6^{c-j}	97.83^{f-l}	89.24^{i-l}	105.50^{BC}
	Sodium bicarbonate	88.40^{e-i}	86.65^{e-i}	82.57^{ghi}	75.92^{hi}	83.39^{D}	114.7^{b-i}	114.3^{b-i}	106.7^{c-k}	101.3^{e-l}	109.20^{BC}
	Wax	89.20^{e-i}	88.91^{e-i}	86.57^{e-i}	86.48^{e-i}	87.79^{CD}	128.8^{a-d}	112.4^{b-i}	95.99^{f-l}	90.56^{h-l}	106.90^{BC}
	Cooling at 5°C	88.17^{e-i}	85.93^{e-i}	84.46^{f-i}	72.98^{i}	82.88^{D}	96.55^{f-l}	94.96^{g-l}	81.22^{kl}	79.18^{l}	87.98^{D}
	Mean (AC)	89.75^{CD}	88.04^{D}	86.02^{D}	81.09^{D}		116.40^{AB}	107.80^{B}	95.43^{CD}	90.08^{D}	
Treat (B)	Room atmosphere	97.39^{a-e}	93.97^{b-f}	93.41^{b-f}	91.25^{c-f}	94.01^{B}	121.5^{a-d}	112.5^{b-f}	104.3^{d-g}	95.83^{fgh}	108.5^{B}
	Sodium bicarbonate	100.8^{a-d}	96.99^{a-e}	89.54^{def}	85.74^{ef}	93.25^{B}	133.5^{a}	132.3^{a}	122.0^{abc}	116.5^{a-e}	126.1^{A}
	Wax	111.4^{a}	107.0^{ab}	105.1^{abc}	101.4^{a-d}	106.2^{A}	129.5^{ab}	117.3^{a-e}	106.1^{c-g}	97.11^{fgh}	112.5^{B}
	Cooling at 5°C	97.84^{a-e}	95.92^{b-e}	94.56^{b-e}	79.89^{f}	92.05^{B}	103.2^{efg}	98.50^{fgh}	91.49^{gh}	82.49^{h}	93.91^{C}
	Mean (C)	101.9A	98.48A	95.66^{AB}	89.57^{B}		121.9^{A}	115.1^{A}	106.0^{B}	97.98^{C}	

Means followed by the same letters are not significantly different at 5%.

Table (5): Effect of Post-harvest treatments on peel weight (gm) of prickly pear cv. "*cristalina*" and "*Roja Paulina*" during 2022 and 2023 growing seasons.

Seasons	2022						2023				
Var. (A)		Weeks (C)					Weeks (C)				
	Treat (B)	1st week	2nd week	3rd week	4th week	Mean (AB)	1st week	2nd week	3rd week	4th week	Mean (AB)
Cristalina	Room atmosphere	34.26^{b-g}	30.90^{efg}	30.14^{fg}	27.93^{g}	30.81^{A}	36.25^{e-j}	35.35^{f-k}	34.28^{g-k}	33.80^{h-k}	34.92^{DE}
	Sodium bicarbonate	37.72^{a-f}	33.89^{c-g}	30.61^{efg}	30.54^{efg}	33.19^{A}	45.72^{ab}	45.22^{ab}	41.90^{b-e}	40.04^{b-g}	43.22^{AB}
	Wax	43.44^{a}	39.84^{a-d}	38.98^{a-e}	32.57^{d-g}	38.71^{A}	35.99^{f-k}	35.51^{f-k}	31.55^{jkl}	30.23^{kl}	33.32^{E}
	Cooling at 5°C	42.38^{ab}	42.31^{ab}	42.23^{abc}	36.23^{a-g}	40.79^{A}	36.79^{e-j}	34.44^{g-k}	34.33^{g-k}	28.20^{l}	33.44^{E}
	Mean (AC)	39.45^{A}	36.74^{AB}	35.49^{BC}	31.82^{C}		38.69^{C}	37.63^{CD}	35.52^{D}	33.07^{E}	
Roja Paulina	Room atmosphere	32.38^{d-g}	31.32^{efg}	31.41^{d-g}	30.42^{fg}	31.38^{A}	44.14bc	40.42^{b-f}	36.87^{e-j}	34.73^{f-k}	39.04^{BCD}
	Sodium bicarbonate	35.98^{a-g}	34.49^{b-g}	32.16^{d-g}	30.40^{fg}	33.26^{A}	45.39^{ab}	45.22^{ab}	44.86^{abc}	43.45^{bcd}	44.73^{A}
	Wax	35.64^{a-g}	35.54^{a-g}	34.36^{b-g}	34.31^{b-g}	34.96^{A}	49.88^{a}	40.50^{b-f}	35.34^{f-k}	33.10^{i-l}	39.70^{BC}
	Cooling at 5°C	36.36^{a-g}	34.73^{b-g}	34.53^{b-g}	31.99^{d-g}	34.40^{A}	39.42^{c-h}	38.31^{d-i}	35.07^{f-k}	33.76^{h-k}	36.64^{CDE}
	Mean (AC)	35.09^{BC}	34.02^{BC}	33.12^{BC}	31.78^{C}		44.71^{A}	41.11^{B}	38.04^{CD}	36.26^{CD}	
Treat (B)	Room atmosphere	33.32^{b-e}	31.11^{de}	30.78^{e}	29.18^{e}	31.10^{C}	40.20^{cd}	37.88^{de}	35.58^{ef}	34.27^{efg}	36.98^{B}
	Sodium bicarbonate	36.85^{abc}	34.19^{a-e}	31.39^{cde}	30.47^{e}	33.23^{BC}	45.55^{a}	45.22^{ab}	43.38^{abc}	41.75^{bc}	43.98^{A}
	Wax	39.54^{a}	37.69^{ab}	36.67^{a-d}	33.44^{b-e}	36.83^{AB}	42.93^{abc}	38.01^{de}	33.45^{fg}	31.66^{g}	36.51^{B}
	Cooling at 5°C	39.37^{a}	38.52^{ab}	38.38^{ab}	34.11^{a-e}	37.59^{A}	38.10^{de}	36.38^{ef}	34.70^{efg}	30.98^{g}	35.04^{B}
	Mean (C)	37.27^{A}	35.38^{AB}	34.30^{B}	31.80^{C}		41.70^{A}	39.37^{B}	36.78^{C}	34.66^{D}	

Means followed by the same letters are not significantly different at 5%

Pulp Weight (g):

Table (6) shows significant differences in pulp weight among post-harvest treatments for *Cristalina* and *Roja Paulina* during the 2022 and 2023 seasons. The highest pulp weights were recorded in *Cristalina* under wax and sodium bicarbonate treatments (85.99 g, 99.71 g) in the first and second seasons, respectively, while the lowest were observed in *Roja Paulina* under cooling at 5°C (48.48 g, 51.33 g). Across weeks, *Cristalina* had the highest pulp weight in the first week (74.50 g, 88.76 g), while *Roja Paulina* had the lowest in the fourth week (49.31 g, 53.81 g). A significant interaction was observed between variety, treatment, and storage duration. The highest pulp weight was recorded in *Cristalina* under wax and sodium bicarbonate treatments in the first week (90.20 g, 106.5 g), while the lowest was in *Roja Paulina* under cooling at 5°C in the fourth week (41.00 g, 45.42 g). Regardless of variety, wax and sodium bicarbonate treatments resulted in the highest pulp weights (69.41 g, 82.11 g), while the lowest were recorded in the fourth week (57.77 g, 63.32 g). The highest interaction between treatment and week was observed in wax and sodium bicarbonate treatments in the first week (71.88 g, 87.91 g).

Juice Volume per Fruit (ml):

Table (7) shows significant differences in juice volume among post-harvest treatments for *Cristalina* and *Roja Paulina* during the 2022 and 2023 seasons. The highest juice volume was recorded in *Cristalina* under cooling at 5°C and sodium bicarbonate treatments (47.50 ml, 44.42 ml) in the first and second seasons, respectively. The lowest was observed in *Roja Paulina* under room atmosphere and wax treatments (29.58 ml, 33.08 ml). Across weeks, *Cristalina* had the highest juice volume in the first week (51.58 ml, 53.17 ml), while *Roja Paulina* had the lowest in the fourth week (27.92 ml, 28.83 ml). A significant interaction was found between variety, treatment, and storage duration. The highest juice volume was recorded in *Cristalina* under sodium bicarbonate treatment in the first week (55.67 ml, 59.67 ml), while the lowest was in *Roja Paulina* under room atmosphere and wax treatments in the fourth week (22.00 ml, 22.33 ml). Regardless of variety, sodium bicarbonate treatment resulted in the highest juice volume (45.29 ml, 42.58 ml), while the lowest was recorded in the fourth week (29.75 ml, 26.58 ml). The highest interaction between treatment and week was observed in sodium bicarbonate treatment in the first week (55.33 ml, 53.00 ml).

Total Soluble Solids (TSS):

Table (8) indicates significant differences in TSS among post-harvest treatments for *Cristalina* and *Roja Paulina* during the 2022 and 2023 seasons. The highest TSS was recorded for *Roja Paulina* under wax and room atmosphere treatments (13.88, 13.52) in the first and second seasons, respectively, while the lowest was found under sodium bicarbonate and wax treatments (13.32, 13.00). Across weeks, the highest TSS was observed in the fourth week for *Roja Paulina* (13.93) and *Cristalina* (13.82), while the lowest was in the second and first weeks for *Cristalina* (13.17, 12.27). A significant interaction occurred between variety, treatment, and week. The highest TSS was recorded under cooling at 5°C and sodium bicarbonate treatments in the fourth week (14.13, 14.07), while the lowest was in *Roja Paulina* under sodium bicarbonate and wax treatments in the first week (12.73, 11.87). Regardless of variety, the highest TSS was found in room atmosphere and sodium bicarbonate treatments (13.77, 13.43), while the lowest occurred in the first week (13.26, 12.31). The strongest interaction between treatment and week was observed under room atmosphere and sodium bicarbonate treatments in the fourth week (13.97, 14.03).

Total Acidity (%):

Table (9) shows significant differences in total acidity among post-harvest treatments for *Cristalina* and *Roja Paulina* during the 2022 and 2023 seasons. The highest acidity was recorded for *Roja Paulina* under room atmosphere treatment (0.361, 0.369), while the lowest was found in *Cristalina* under sodium bicarbonate treatment (0.243, 0.267). Across weeks, the highest acidity was observed in the first week for *Roja Paulina* (0.372, 0.443), while the lowest was recorded in the fourth week for *Cristalina*

(0.218, 0.252). A significant interaction occurred between variety, treatment, and week. The highest acidity was recorded in *Roja Paulina* under room atmosphere treatment in the first week (0.423, 0.463), while the lowest was in *Cristalina* under wax and sodium bicarbonate treatments in the fourth week (0.200, 0.207). Regardless of variety, no significant differences were found among treatments, but room atmosphere had the highest average acidity (0.315, 0.341). The lowest acidity occurred in the fourth week (0.238, 0.266). The strongest interaction between treatment and week was observed in the first week under cooling at 5°C and room atmosphere treatments (0.382, 0.435).

Table (6): Effect of Post-harvest treatments on pulp weight (gm) of prickly pear cv. "*cristalina*" and "*Roja Paulina*" during 2022 and 2023 growing seasons.

Seasons		2022					2023				
Var. (A)		Weeks (C)					Weeks (C)				
	Treat (B)	1st week	2nd week	3rd week	4th week	Mean (AB)	1st week	2nd week	3rd week	4th week	Mean (AB)
Cristalina	Room atmosphere	67.30^{cd}	66.34^{cd}	66.22^{cd}	65.58^{cd}	66.36^{BC}	81.32^{c-g}	80.09^{c-h}	76.57^{c-j}	68.63^{f-j}	76.65^{BC}
	Sodium bicarbonate	75.38^{abc}	73.44^{bc}	65.90^{cd}	65.01^{cd}	69.93^{B}	106.5^{a}	105.2^{ab}	95.50^{abc}	91.62^{a-e}	99.71^{A}
	Wax	90.20a	85.31^{ab}	84.69^{ab}	83.76^{ab}	85.99^{A}	94.21^{a-d}	86.64^{a-f}	84.66^{b-f}	73.43^{c-j}	84.73^{B}
	Cooling at 5°C	65.13^{cd}	65.59^{cd}	62.43^{cde}	50.56^{def}	60.43^{CD}	72.98^{d-j}	67.59^{f-k}	67.43^{f-k}	57.60^{h-k}	66.40^{CD}
	Mean (AC)	74.50^{A}	72.17^{AB}	69.81^{AB}	66.23^{B}		88.76^{A}	84.87^{A}	81.04^{AB}	72.82^{BC}	
Roja Paulina	Room atmosphere	60.85^{cde}	59.38^{cde}	59.05^{cde}	58.57^{cde}	59.46^{CD}	81.24^{c-g}	69.14^{f-j}	60.95^{g-k}	54.50^{jk}	66.46^{CD}
	Sodium bicarbonate	52.42^{def}	52.16^{def}	50.41^{def}	45.52^{ef}	50.13^{E}	69.29^{f-j}	69.06^{f-j}	61.81^{g-k}	57.88^{h-k}	64.51^{D}
	Wax	53.56^{def}	53.37^{def}	52.21^{def}	52.17^{def}	52.83^{DE}	78.97^{c-i}	71.88^{e-j}	60.65^{g-k}	57.46^{h-k}	67.24^{CD}
	Cooling at 5°C	51.81^{def}	51.20^{def}	49.93^{def}	41.00^{f}	48.48^{E}	57.13^{ijk}	56.65^{ijk}	46.14^{k}	45.42^{k}	51.33^{E}
	Mean (AC)	54.66^{C}	54.03^{C}	52.90^{C}	49.31^{C}		71.66^{BC}	66.68^{CD}	57.39^{DE}	53.81^{E}	
Treat (B)	Room atmosphere	64.07^{a-d}	62.86^{a-d}	62.63^{a-d}	62.08^{a-d}	62.91^{B}	81.28^{ab}	74.61^{a-d}	68.76^{b-e}	61.56^{def}	71.55^{B}
	Sodium bicarbonate	63.90^{a-d}	62.80^{a-d}	58.15^{bcd}	55.26^{de}	60.03^{BC}	87.91a	87.12a	78.66^{abc}	74.75^{a-d}	82.11^{A}
	Wax	71.88a	69.34^{ab}	68.45^{ab}	67.96^{abc}	69.41^{A}	86.59a	79.26^{abc}	72.65^{a-d}	65.45^{c-f}	75.99^{AB}
	Cooling at 5°C	58.47^{bcd}	57.40^{bcd}	56.18^{cde}	45.78^{e}	54.46^{C}	65.06^{c-f}	62.12^{def}	56.79^{ef}	51.51^{f}	58.87^{C}
	Mean (C)	64.58^{A}	63.10^{AB}	61.36^{AB}	57.77^{B}		80.21^{A}	75.78^{AB}	69.21^{BC}	63.32^{C}	

Means followed by the same letters are not significantly different at 5%.

Table (7): Effect of Post-harvest treatments on juice volume per fruit of prickly pear cv. "*cristalina*" and "*Roja Paulina*" during 2022 and 2023 growing seasons.

Seasons	2022						2023				
Var. (A)		Weeks (C)					Weeks (C)				
	Treat (B)	1st week	2nd week	3rd week	4th week	Mean (AB)	1st week	2nd week	3rd week	4th week	Mean (AB)
Cristalina	Room atmosphere	49.33^{abc}	47.00^{a-e}	37.67^{e-j}	31.00^{i-l}	41.25^{ABC}	48.00^{bcd}	36.67^{d-h}	31.67^{e-k}	23.33^{ijk}	34.92^{B}
	Sodium bicarbonate	55.67^{a}	51.00^{abc}	47.67^{a-d}	34.67^{g-k}	47.25^{A}	59.67^{a}	55.00^{ab}	42.33^{c-f}	20.67^{k}	44.42^{A}
	Wax	46.33^{a-d}	44.33^{b-g}	38.33^{d-i}	29.00^{i-l}	39.50^{BC}	56.00^{ab}	46.00^{bcd}	25.00^{ijk}	21.00^{jk}	37.00^{AB}
	Cooling at 5°C	55.00^{a}	53.33^{ab}	50.00^{abc}	31.67^{ijk}	47.50^{A}	49.00^{bc}	47.00^{bcd}	46.67^{bcd}	32.33^{e-j}	43.75^{A}
	Mean (AC)	51.58^{A}	48.92^{AB}	43.42^{C}	31.58^{DE}		53.17^{A}	46.17^{B}	36.42^{C}	24.33^{D}	
Roja Paulina	Room atmosphere	36.33^{f-k}	31.67^{ijk}	28.33^{jkl}	22.00^{l}	29.58D	42.00^{c-f}	40.33^{c-g}	40.00^{c-g}	29.67^{g-k}	38.00^{AB}
	Sodium bicarbonate	55.00^{a}	45.00^{b-f}	38.33^{d-i}	35.00^{g-k}	43.33^{AB}	46.33^{bcd}	43.00^{cde}	40.33^{c-g}	33.33^{e-i}	40.75^{AB}
	Wax	43.67^{b-g}	42.33^{c-h}	32.67^{h-k}	26.67^{kl}	36.33^{C}	43.00^{cde}	41.00^{c-g}	26.00^{h-k}	22.33^{ijk}	33.08^{B}
	Cooling at 5°C	53.33^{ab}	52.00^{abc}	38.67^{d-i}	28.00^{jkl}	43.00^{AB}	46.00^{bcd}	41.00^{c-g}	31.00^{f-k}	30.00^{g-k}	37.00^{AB}
	Mean (AC)	47.08^{BC}	42.75^{C}	34.50^{D}	27.92^{E}		44.33^{B}	41.33^{B}	34.33^{C}	28.83^{D}	
Treat (B)	Room atmosphere	42.83^{cd}	39.33^{de}	33.00^{efg}	26.50^{h}	35.42^{B}	45.00^{bcd}	38.50^{de}	35.83^{ef}	26.50^{gh}	36.46^{BC}
	Sodium bicarbonate	55.33^{a}	48.00^{bc}	43.00^{cd}	34.83^{ef}	45.29^{A}	53.00^{a}	49.00^{abc}	41.33^{cde}	27.00^{gh}	42.58^{A}
	Wax	45.00^{cd}	43.33^{cd}	35.50^{ef}	27.83^{gh}	37.92^{B}	49.50^{ab}	43.50^{bcd}	25.50^{gh}	21.67^{h}	35.04^{C}
	Cooling at 5°C	54.17^{ab}	52.67^{ab}	44.33^{cd}	29.83^{fgh}	45.25^{A}	47.50^{abc}	44.00^{bcd}	38.83^{de}	31.17^{fg}	40.38^{AB}
	Mean (C)	49.33^{A}	45.83^{B}	38.96^{C}	29.75^{D}		48.75^{A}	43.75^{B}	35.38^{C}	26.58^{D}	

Means followed by the same letters are not significantly different at 5%.

Table (8): Effect of Post-harvest treatments on total soluble solids of prickly pear cv. "*cristalina*" and "*Roja Paulina*" during 2022 and 2023 growing seasons.

Seasons		2022					2023				
Var. (A)		Weeks (C)					Weeks (C)				
	Treat (B)	1st week	2nd week	3rd week	4th week	Mean (AB)	1st week	2nd week	3rd week	4th week	Mean (AB)
Cristalina	Room atmosphere	13.40^{a-d}	13.67^{abc}	13.80^{abc}	13.80^{abc}	13.67^{AB}	12.40^{d-g}	12.67^{c-g}	13.47^{abc}	13.67^{ab}	13.05^{A}
	Sodium bicarbonate	13.40^{a-d}	12.53^{d}	14.00^{ab}	14.00^{ab}	13.48^{AB}	12.33^{efg}	13.60^{ab}	13.87^{ab}	14.07^{a}	13.47^{A}
	Wax	12.93^{bcd}	13.07^{a-d}	13.53^{a-d}	13.73^{abc}	13.32^{B}	12.07^{g}	13.13^{a-f}	13.60^{ab}	13.93^{ab}	13.18^{A}
	Cooling at 5°C	13.33^{a-d}	13.40^{a-d}	13.60^{a-d}	13.73^{abc}	13.52^{AB}	12.27^{fg}	12.50^{d-g}	13.20^{a-e}	13.60^{ab}	12.89^{A}
	Mean (AC)	13.27^{BC}	13.17^{C}	13.73^{AB}	13.82^{A}		12.27^{D}	12.98^{C}	13.53^{AB}	13.82^{A}	
Roja Paulina	Room atmosphere	13.60^{a-d}	13.73^{abc}	14.00^{ab}	14.13^{a}	13.87^{A}	13.20^{a-e}	13.47^{abc}	13.67^{ab}	13.77^{ab}	13.52^{A}
	Sodium bicarbonate	12.73^{cd}	13.40^{a-d}	13.47^{a-d}	13.67^{abc}	13.32^{B}	12.27^{fg}	13.40^{abc}	13.87^{ab}	14.00a	13.38^{A}
	Wax	13.73^{abc}	13.93^{ab}	14.07^{a}	13.80^{abc}	13.88^{A}	11.87^{g}	13.00^{b-f}	13.47^{abc}	13.67^{ab}	13.00^{A}
	Cooling at 5°C	12.93^{bcd}	13.40^{a-d}	13.93^{ab}	14.13^{a}	13.60^{AB}	12.10^{g}	13.27^{a-d}	13.53^{abc}	13.67^{ab}	13.14^{A}
	Mean (AC)	13.25^{BC}	13.62^{ABC}	13.87^{A}	13.93^{A}		12.36^{D}	13.28^{BC}	13.63^{AB}	13.77^{A}	
Treat (B)	Room atmosphere	13.50^{a-d}	13.70^{abc}	13.90a	13.97a	13.77^{A}	12.80^{de}	13.07^{cd}	13.57^{abc}	13.72^{ab}	13.29^{AB}
	Sodium bicarbonate	13.07^{cd}	12.97^{d}	13.73^{abc}	13.83^{ab}	13.40^{B}	12.30^{ef}	13.50^{abc}	13.87^{ab}	14.03^{a}	13.43^{A}
	Wax	13.33^{a-d}	13.50^{a-d}	13.80^{abc}	13.77^{abc}	13.60^{AB}	11.97^{f}	13.07^{cd}	13.53^{abc}	13.80^{ab}	13.09^{AB}
	Cooling at 5°C	13.13^{bcd}	13.40^{a-d}	13.77^{abc}	13.93^{a}	13.56^{AB}	12.18^{f}	12.88d	13.37^{bcd}	13.63^{abc}	13.02^{B}
	Mean (C)	13.26^{B}	13.39^{B}	13.80^{A}	13.88^{A}		12.31^{C}	13.13^{B}	13.58^{A}	13.80^{A}	

Means followed by the same letters are not significantly different at 5%.

Table (9): Effect of Post-harvest treatments on total acidity of prickly pear cv. "*cristalina*" and "*Roja Paulina*" during 2022 and 2023 growing seasons.

Seasons		2022					2023				
Var. (A)		Weeks (C)					Weeks (C)				
	Treat (B)	1st week	2nd week	3rd week	4th week	Mean (AB)	1st week	2nd week	3rd week	4th week	Mean (AB)
Cristalina	Room atmosphere	0.317^{b-f}	0.287^{b-i}	0.240^{e-i}	0.230^{f-i}	0.268^{BC}	0.407^{a-d}	0.320^{d-k}	0.287^{g-l}	0.240^{jkl}	0.313^{AB}
	Sodium bicarbonate	0.263^{c-i}	0.260^{d-i}	0.240^{e-i}	0.210^{hi}	0.243^{C}	0.330^{d-j}	0.270^{i-l}	0.260^{i-l}	0.207^{l}	0.267^{B}
	Wax	0.340^{a-d}	0.323^{b-e}	0.237^{e-i}	0.200^{i}	0.275^{BC}	0.363^{b-h}	0.323^{d-k}	0.290^{f-l}	0.290^{f-l}	0.317 ^{AB}
	Cooling at 5°C	0.350^{abc}	0.320^{b-e}	0.270^{c-i}	0.230^{f-i}	0.293^{ABC}	0.380^{a-f}	0.347^{c-i}	0.273^{h-l}	0.270^{i-l}	0.318 ^{AB}
	Mean (AC)	0.318^{BC}	0.298^{C}	0.247^{DE}	0.218^{E}		0.370^{B}	0.315^{C}	0.278^{CD}	0.252^{D}	
Roja Paulina	Room atmosphere	0.423^{a}	0.360^{ab}	0.347^{a-d}	0.313^{b-f}	0.361^{A}	0.463^{a}	0.377^{a-g}	0.317^{d-k}	0.320^{d-k}	0.369^{A}
	Sodium bicarbonate	0.310^{b-f}	0.300^{b-g}	0.293^{b-h}	0.270^{c-i}	0.293^{ABC}	0.433^{abc}	0.333^{d-i}	0.300^{f-k}	0.277^{h-l}	0.336^{AB}
	Wax	0.340^{a-d}	0.317^{b-f}	0.293^{b-h}	0.240^{e-i}	0.298^{ABC}	0.450^{ab}	0.393^{a-e}	0.313^{e-k}	0.290^{f-l}	0.362^{A}
	Cooling at 5°C	0.413^{a}	0.373^{ab}	0.263^{c-i}	0.213^{ghi}	0.316^{AB}	0.423^{abc}	0.327^{d-k}	0.290^{f-l}	0.237^{kl}	0.319^{AB}
	Mean (AC)	0.372^{A}	0.338^{AB}	0.299^{BC}	0.259^{D}		0.443^{A}	0.358^{B}	0.305^{C}	0.281^{CD}	
Treat (B)	Room atmosphere	0.370^{ab}	0.323^{b-e}	0.293^{c-f}	0.278^{efg}	0.315^{A}	0.435^{a}	0.348^{b-e}	0.302^{d-g}	0.280^{fg}	0.341^{A}
	Sodium bicarbonate	0.287^{def}	0.280^{efg}	0.267^{efg}	0.240^{fg}	0.268^{A}	0.382^{abc}	0.302^{d-g}	0.280^{fg}	0.242^{g}	0.301^{A}
	Wax	0.340^{a-d}	0.320^{b-e}	0.265^{efg}	0.220^{g}	0.286^{A}	0.407^{ab}	0.358^{bcd}	0.302^{d-g}	0.290^{efg}	0.339^{A}
	Cooling at 5°C	0.382^{a}	0.347^{abc}	0.267^{efg}	0.222^{g}	0.304^{A}	0.402^{ab}	0.337^{c-f}	0.282^{fg}	0.253^{g}	0.318^{A}
	Mean (C)	0.345 ^{A}	0.318^{B}	0.273^{C}	0.238^{D}		0.406^{A}	0.336^{B}	0.291^{C}	0.266^{C}	

Means followed by the same letters are not significantly different at 5%

DISCUSSION

The present study evaluated the impact of postharvest preservation methods, storage period, and variety on the fruit quality of prickly pear. The results revealed significant variations in fruit length, diameter, weight, peel weight, pulp weight, and total soluble solids (TSS) across different treatments, highlighting the effectiveness of sodium bicarbonate and wax coating in maintaining fruit quality over an extended storage period. The findings demonstrated that wax and sodium bicarbonate treatments resulted in the highest fruit length, diameter, and weight, particularly in the "Cristalina" variety. This aligns with previous research indicating that wax coatings reduce moisture loss, maintain fruit firmness, and extend shelf life by creating a protective barrier against microbial contamination and dehydration (Abbasi et al., 2015). Similarly, sodium bicarbonate treatment has been reported to possess antifungal properties and preserve fruit quality by limiting microbial decay (Palou et al., 2001). The effectiveness of these treatments in maintaining fruit integrity during storage highlights their potential for commercial postharvest management of prickly pear. Storage duration had a significant impact on fruit quality attributes, with a general decline observed over four weeks. The reduction in fruit length, diameter, and weight during prolonged storage is consistent with previous studies showing that prolonged storage leads to moisture loss, metabolic changes, and degradation of cell structure in fresh fruits (Juhaimi et al., 2020). The highest fruit quality attributes were recorded in the first week, particularly for wax and sodium bicarbonate-treated fruits, while the lowest values were observed in the fourth week, especially in room-stored fruits. This suggests that controlled postharvest treatments are necessary to mitigate deterioration and extend the marketability of prickly pear. Peel and pulp weights followed a similar trend, with wax and sodium bicarbonate treatments maintaining higher values than other treatments. Peel weight was highest under refrigeration and sodium bicarbonate treatment, supporting findings that low temperatures can reduce respiration rates and maintain firmness (Granata & Sidoti, 2002). However, refrigeration alone was less effective in preserving overall fruit quality, particularly in terms of pulp weight, which showed the most significant decline in refrigerated and room-stored fruits. The high pulp weight observed in wax and sodium bicarbonate treatments further supports their role in reducing water loss and enzymatic degradation (Cefola et al., 2022). Total soluble solids (TSS) were significantly influenced by both variety and treatment. The highest TSS values were recorded in "Roja Paulina," especially under room storage and wax treatment. This increase in TSS over storage time is consistent with previous findings that starch hydrolysis and concentration of sugars contribute to higher sweetness in stored fruits (Wang et al., 2007). However, the decline in TSS in sodium bicarbonate-treated fruits in later storage weeks suggests that this treatment may influence sugar metabolism differently, possibly by reducing enzymatic activities that contribute to sugar accumulation (Ochoa-Velasco & Guerrero-Beltrán, 2016). The significant interaction between storage period, variety, and treatment underscores the complexity of postharvest quality retention in prickly pear. While wax and sodium bicarbonate treatments were most effective in maintaining fruit quality across multiple parameters, refrigeration alone was less effective in preventing deterioration. These results are in agreement with studies demonstrating the benefits of combining postharvest treatments to optimize fruit preservation (Rodríguez-Félix & Villegas-Ochoa, 2010).

CONCLUSION

This study highlights the critical role of postharvest preservation methods in maintaining the quality of prickly pear fruits. Wax and sodium bicarbonate treatments proved to be the most effective in preserving fruit size, weight, and quality properties over four weeks, particularly in the "Cristalina" variety. Refrigeration alone, although helpful in slowing metabolic processes, was less effective in maintaining fruit integrity and pulp weight. The findings emphasize the need for integrated postharvest management strategies to prolong the shelf life and marketability of prickly pear.

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