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Handling and postharvest shelf life of ora-pro-nobis leaves

Camila Karen Reis Barbosa[*], Fernando Luiz Finger and Vicente Wagner Dias Casali

Departamento de Fitotecnia, Universidade Federal de Viçosa, Av. Peter Henry Rolfs, s/n, 36570-900, Viçosa, Minas Gerais, Brazil.
**Author for correspondence. E-mail: camila.barbosa@ufv.br*

ABSTRACT. The goal of this study was to assess the effects of hydrocooling and plastic bag use on the postharvest quality ora-pro-nobis (*Pereskia aculeata* Mill.) leaves stored at 5 and 25ºC. The experiments were conducted in a split plot scheme, with treatments in plots and subplots storage time in a randomized block design. The leaf chlorophyll content, mass loss (ML), relative water content (RWC), soluble sugars levels, reducings (RED), non-reducings and starch were determined. In leaves stored at 25ºC, the ML was higher when leaves were hydrocooled. The highest RWC resulted from the use of plastic bag, which prevented the leaves from wilting for a longer period of time. The soluble sugars levels varied according to the increase or decrease in RWC. The contents of RED decreased with the time of storage at 25°C. The cold storage increased the shelf life of ora-pro-nobis by 168 hours. The hydrocooling increased the RWC of leaves, although it did not influence the shelf life. The perforated plastic bag was effective in increasing the shelf life, and when associated with hydrocooling, the plastic bags provide a lower rate of loss of fresh mass.

Keywords: *Pereskia aculeata* Mill., hydrocooling, packing, cold storage.

Manejo e conservação pós-colheita de ora-pro-nobis

RESUMO. O objetivo do trabalho foi avaliar os efeitos do hidroresfriamento e da embalagem plástica na qualidade pós-colheita das folhas de ora-pro-nobis (*Pereskia aculeata* Mill.) armazenadas a 5 e 25ºC. Os experimentos foram instalados segundo o esquema de parcelas subdivididas, tendo os tratamentos nas parcelas e o tempo de armazenamento nas subparcelas no delineamento em blocos casualizados. Avaliou-se a quantidade de clorofila, a perda de massa fresca (ML), o teor relativo de água (RWC), os teores de açúcares solúveis totais, redutores (RED), não redutores e amido. Houve maior ML em folhas hidroresfriadas quando armazenadas a 25ºC. Maior RWC foi proporcionado pela embalagem plástica, a qual evitou por maior período de tempo o murchamento das folhas. Os teores de carboidratos oscilaram em resposta ao efeito de concentração ou diluição atrelado ao RWC. Os teores de RED decresceram com o tempo de armazenamento à 25ºC. O armazenamento refrigerado aumenta em 168 horas a vida de prateleira. O hidroresfriamento aumenta o teor relativo de água das folhas, embora não influencie a vida de prateleira. O saco de plástico perfurado foi eficaz no aumento da vida de prateleira e, quando associado ao hidroresfriamento, a embalagem plástica fornece a menor taxa de perda de massa fresca.

Palavras-chave: *Pereskia aculeata* Mill., hidroresfriamento, embalagem, armazenamento refrigerado.

Introduction

The cultivation and consumption of fresh vegetables has decreased in several regions of Brazil, as a result of the increasing use of processed foods. However, vegetables are extremely important for a well-balanced diet. This fact has led some world-recognized agencies for hunger prevention to organize programs to promote the construction of residential gardens as a way of fighting diseases related to vitamin deficiency and obesity. Ora-pro-nobis (*Pereskia aculeata* Mill.) is an unconventional rustic vegetable found in many Brazilian backyards and is used in folk medicine. The vegetables begin an accelerated deterioration process once harvested, and the shelf life is determined by a combination of internal and external factors. Some simple postharvest management techniques can extend the vegetable's shelf life without resulting in higher costs to the farmers. Plastic packages work as physical protection and reduce deterioration by diminishing water loss. Hydrocooling, which is an essential technique for removing field heat from freshly harvested products, may be beneficial in the postharvest of many perishable products (WILLS et al., 2004). The objective of this study was to evaluate the effects of hydrocooling, plastic bag use and cold storage on the postharvest quality of ora-pro-nobis leaves.

Material and methods

The experiment was conducted in Viçosa, Minas Gerais State, Brazil (20º45' S, 651 m a.s.l.), from

July to September 2011. Entire branches of ora-pro-nobis were randomly collected in the morning between 7:00 and 8:00 a.m., and they were immediately taken to the laboratory where the leaves were separated using pruning shears. The leaves with yellowing color, those showing symptoms of disease and those that were wilted were discarded. Two independent experiments were conducted simultaneously by storing the leaves at 25ºC and 50% RH or at 5°C and 90% UR. Approximately 40 g of leaves was subjected to the following treatments: 1) Control without hydrocooling and packing; 2) Hydrocooling + perforated plastic bag; 3) Hydrocooling; and 4) Perforated plastic packaging without hydrocooling. Initially, tests were performed to determine the length of time for hydrocooling by submersing the leaves in a mixture of ice and water at 5°C. The leaves temperature was measured using a digital infrared thermometer. Polyethylene plastic bags with a capacity of 1 liter, containing 40 holes that were 1.0 cm in diameter were used to wrap the leaves. Shelf life of the leaves as well as their, loss of fresh weight, chlorophyll content, relative water content, total soluble sugars, reducing sugars, non-reducing sugars and starch were determined. The chlorophyll content and loss of fresh weight were measured successively in the same experimental unit from the beginning to the end of the evaluations. Destructive analyses were performed using different samples, so the experimental unit, which initially established 40 g of leaves, would not be compromised. The end of the shelf life of the ora-pro-nobis was characterized by a loss of water and wilting or blackening of the leaves. The amount of leaf chlorophyll was estimated using the portable meter SPAD-502 [Soil-Plant Analysis Development (SPAD) Section, Minolta] and readings were taken at 0, 6, 12, 18, 24, 30, 36, 42, 48, 72, 96 and 120 hours after harvesting.These readings were taken at six points that had been marked on each of two leaves prior to the procedure. The loss of fresh weight in the experimental unit (40 g) and the content of carbohydrate content present in the leaves were determined at the same frequency. The relative water content was evaluated before and every 24 hours after treatment, according to Álvares et al. (2010). In this case, eight sections (for each repetition) of leaf blade were cut and were approximately 1 cm^2 in size. To quantify the total soluble sugars, the phenol-sulfuric method described by Dubois et al. (1956) was used. The quantification of reducing sugars was determined using the Somogyi-Nelson method (NELSON, 1944). The non-reducing sugars content was obtained by subtracting the values of reducing sugar values from the total soluble sugars. The experiment was conducted with four replication in a split-plot scheme design, with treatments in plots and subplots storage time in a randomized block design. Data were submitted to variance analysis, and the means were separated using Tukey's test at 5% probability. Quantitative data were analyzed by regression analysis, with the model chosen according to the coefficient of determination and biological phenomenon. The statistical program was the Software Analysis and Experimentation Group (SAEG / UFV).

Results and discussion

Length of hydrocooling – To determine the ideal hydrocooling time, the leaves were immersed in water at 5 ± 0.5ºC. A sharp decrease in temperature happened in the first 5 minutes, but the then atabilized at 5ºC, which lasted more than 20 minutes (Figure 1).

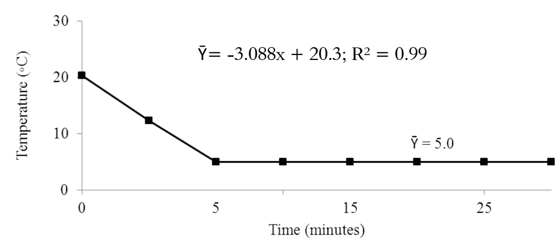

Figure 1. Temperature of ora-pro-nobis during hydrocooling.

During the cooling period, there was a reduction of 15.3°C, which occurred at a rate of 3.6°C per minute, thus amounting to a 75.4% removal of the initial heat. Such behavior was also observed by Álvares et al. (2007), who observed that parsley branches required 15 minutes for temperature stabilization.

Shelf life - Leaves stored at 25°C, regardless of the treatment applied developed darkening areas after 48 hours of harvest. Hydrocooling without the subsequent cold storage did not increase the shelf life of leaves because, despite showing the effect of relative water content, the leaves darkened, similar to leaves that were not hydrocooled. Blackening was not observed in leaves that were stored at 5°C for the entire storage period. The end of the shelf life of the ora-pro-nobis under refrigeration was characterized by loss of water and subsequent wilting of the leaves, which occurred after 120 hours in control and hydrocooled only leaves and after 216 hours for the leaves wrapped in plastic bags, with or without hydrocooling. Hydrocooling with subsequent cold storage without plastic packaging did not increase the shelf life of the leaves because, although the initial water content in the leaves increased, that water was rapidly lost to the surrounding atmosphere. At the end of 120 hours, the hydrocooled leaves that were packaged had the same water content and appearance as the leaves that were hydrocooled and not packaged. There was an increase of 168 hours (7 days) in the shelf life of the leaves that were packed and were stored under refrigeration compared to the shelf life of that were not packed and were stored at room temperature. As in present study, a previous studied noted that the longevity of parsley leaves was extended by refrigeration and hydrocooling under the same conditions of temperature (ÁLVARES et al., 2010).

Weight loss of fresh leaves - A significant correlation was found between time and the treatments for the leave's accumulated weight loss. In storage at 25°C for 12 hours, the leaves stored in perforated plastic bags presented lower accumulated weight loss, thus differing from the other treatments. At the end of the shelf life, greater accumulated weight loss was present in all treatments that had been submitted to hydrocooling, with or without perforated packaging, compared to the other treatments. Nevertheless, greater weight loss was present in the control compared to the plastic packed leaves (Table 1).

Table 1. Average accumulated weight loss values for ora-pro-nobis leaves stored at room temperature (25ºC) for 48 hours over the storage time; control (C), hydrocooling (HC), packaging (P).

Time (hours)	Control (%)		HC + P (%)		P (%)		HC (%)	
0	0.00 ± 0.00	a	0.00 ± 0.00	a	0.00 ± 0.00	a	0.00 ± 0.00	a
6	1.91 ± 0.19	a	1.75 ± 0.17	a	0.71 ± 0.01	a	1.92 ± 0.19	a
12	2.96 ± 0.56	a	2.84 ± 0.56	a	1.27 ± 0.56	b	3.04 ± 1.17	a
18	5.14 ± 0.90	a	5.49 ± 0.76	a	2.78 ± 0.25	b	6.03 ± 0.35	a
24	6.37 ± 0.97	a	7.00 ± 0.95	a	3.62 ± 0.42	b	7.52 ± 0.37	a
30	7.50 ± 1.14	a	8.46 ± 1.11	a	4.45 ± 0.52	b	8.82 ± 0.42	a
36	8.81 ± 1.48	b	10.06 ± 1.18	ab	5.49 ± 0.67	c	10.40 ± 0.45	a
42	10.07 ± 1.48	b	11.56 ± 1.31	a	6.59 ± 0.82	c	12.03 ± 0.42	a
48	11.07 ± 1.45	b	12.73 ± 1.41	a	7.38 ± 0.99	c	13.10 ± 0.50	a

Means (n=4) followed by the same lowercase letter in the row do not differ according to Tukey's test at 5% probability.

The highest weight loss in the leaves subjected to hydrocooling is due to the evaporation of water adhered to the leaf surface and/or absorbed during the treatment. This behavior was also observed by Gillies and Toivonen (1995), in whose study hydrocooling added 5% to the weight of broccoli. After 36 hours of storage at 5°C, the leaves packed in perforated plastic don't hydrocooled had the lowest weight loss values and the leaves hydrocooled without plastic bags had the highest accumulated weight loss. This behavior continued until the end of the shelf life (Table 2).

Table 2. Average accumulated weight loss values for ora-pro-nobis leaves stored under refrigeration (5ºC) for 120 hours over the storage time; control (C), hydrocooling (HC), packaging (P).

Time (hours)	Control (%)		HC + P (%)		P (%)		HC (%)	
0	0.00 ± 0.00	a	0.00 ± 0.00	a	0.00 ± 0.00	a	0.00 ± 0.00	a
6	1.05 ± 0.31	a	1.22± 0.32	a	0.98± 0.27	a	1.58± 0.22	a
12	1.66 ± 0.70	a	2.02± 0.71	a	1.40± 0.28	a	2.57± 0.84	a
18	3.01 ± 1.08	a	2.75± 0.76	a	2.37± 0.27	a	4.45± 0.74	a
24	3.87 ± 0.92	a	3.16± 0.84	a	2.94± 0.32	a	5.71± 0.90	a
30	4.81 ± 1.02	a	3.77± 0.93	a	3.47± 0.20	a	7.09± 1.28	a
36	5.98 ± 1.15	ab	4.62± 1.38	b	4.08± 0.21	b	8.64± 1.50	a
42	6.98 ± 1.33	ab	4.94± 1.20	b	4.61± 0.20	b	9.84± 2.09	a
48	7.80 ± 1.52	ab	5.55± 1.34	b	5.11± 0.28	b	10.98± 2.49	a
72	11.52 ± 2.39	b	7.56± 1.88	c	7.73± 0.42	c	15.67± 3.59	a
96	14.53 ± 2.35	b	9.12± 2.83	c	10.02± 0.71	c	19.71± 5.27	a
120	17.37 ± 2.47	b	11.40± 2.47	c	12.23± 0.94	c	22.82± 6.12	a

Means (n=4) followed by the same lowercase letter in the row do not differ according to Tukey's test at 5% probability.

The highest weight loss of the hydrocooled leaves, compared to that observed in the control, was due to the evaporative loss of water adhered to the surface and/or absorbed during hydrocooling. However, the appearance of the leaves was the same: both types of leaves were very wilted after 120 hours. A perforated plastic bag was used to reduce the rate of weight loss in both hydrocooling and non-hydrocooling treatments. The use of a plastic package was also effective in reducing the cumulative weight loss of broccoli (TOIVONEN, 1997). It is believed that the perforated plastic, in addition to reducing the vapor pressure deficit between air and the produce, also maintained the temperature inside the container lower than the temperature of the cooling room, thus reducing the effect of random variations in temperature in the room (GILLIES; TOIVONEN, 1995). The weight loss of leaves accumulated over time during storage at 25°C (Figure 2) and 5°C (Figure 3) increased linearly.

During storage at 25ºC, the rate of mass loss varied among treatments. The rate of mass loss observed was 5.85% per day in the control, 3.65% per day in packaged leaves, 6.89% per day in hydrocooled leaves and 6.61% per day in hydrocooled and packaged leaves. During storage at 5°C, the rates of mass loss per hour also varied among treatments. The rate of mass loss observed was 3.66% per day in the control, 2.53% per day in packaged leaves, 4.96% per day in hydrocooled leaves and 2.45% per day in hydrocooled and packaged leaves.

Chlorophyll – There was no significant effect of the treatments or storage on the chlorophyll content of leaves stored at 25 or 5ºC (data not show).

Relative water content – Only the treatment affected the relative water content for the leaves stored at 25°C. Higher relative water content was observed in hydrocooled and packed leaves compared to leaves that were hydrocooled without plastic bag. This effect demonstrates the importance of using perforated plastic packaging to maintain the water content. The unpacked hydrocooled leaves did not differ from the control in their relative water content. In ora-pro-nobis leaves stored at 5°C, the effect of the interaction between treatment and storage time was observed. In this case, the use of a perforated plastic package resulted in a higher relative water content in leaves with or without prior hydrocooling (Table 3).

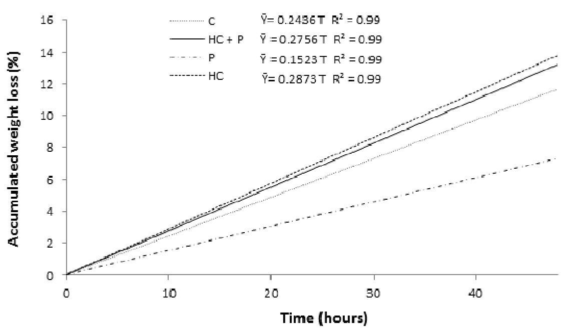

Figure 2. Estimated accumulated weight loss in ora-pro-nobis leaves during storage at room temperature (25ºC) for 48 hours per treatment; control (C), hydrocooling (HC), packaging (P).

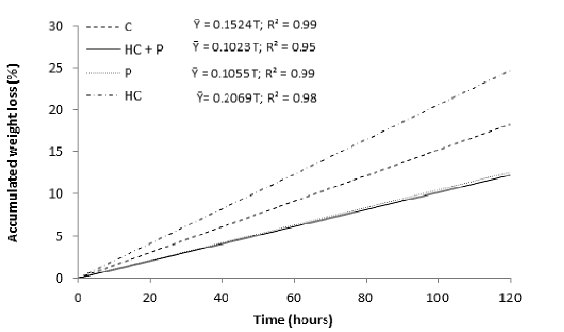

Figure 3. Estimated accumulated weight loss in ora-pro-nobis leaves during storage under refrigeration (5ºC) for 120 hours per treatment; control (C), hydrocooling (HC), packaging (P).

Table 3. Average values of relative water content in ora-pro-nobis leaves stored under refrigeration (5°C) for 120 hours at room temperature (25ºC).

Temp.	Time (hours)	Control (%)		HC + P (%)		P (%)		HC (%)	
	0	83.74	a AB	83.74	a B	83.74	a AB	83.74	a AB
	24	77.34	b ABC	94.03	a AB	83.00	ab AB	85.69	ab AB
5ºC	48	70.77	b BCD	90.03	a AB	81.13	a AB	84.43	a AB
	72	69.33	c BCD	89.37	a AB	82.14	ab AB	76.18	bc B
	96	64.14	b CD	85.90	a AB	80.67	a AB	65.25	bc C
	120	60.22	c D	84.86	a B	73.44	b B	61.85	c C
25ºC		80.00	a	86.60	a	82.95	ab	82.30	b

Means (n = 4 at 5ºC and n = 12 at 25ºC) followed by the same lowercase letter in the row and the same uppercase letter in the column do not differ according to Tukey's test at 5% probability.

The relative water content at 24 hours was increased in hydrocooled leaves due to the absorption of water during hydrocooling process. Higher relative water content was observed in mustard leaves (*Brassica juncea*) when they were hydrocooled and subsequently packaged, regardless of the storage temperature (LAZAN et al.,1987) and in parsley leaves that were hydrocooled and stored at 5°C, compared to the control without hydrocooling (ÁLVARES et al., 2010).

Levels of carbohydrates - The treatments and length of storage affected the levels of reducing sugars, non-reducing sugars and starch leaves that were stored at 25 and 5ºC. An effect on concentration was observed in all cases, except that of the reducing sugars in leaves that were stored at 25°C. With a lower relative water content, there was concentration of carbohydrate per gram of fresh leaf that lost more water, as detected in the control. In the hydrocooled and packaged leaves, there was lower content of soluble sugars due to the higher relative water content. The reducing sugar content over time in leaves that were stored at 25ºC for 48 hours exhibited a linear decreasing behavior in the hydrocooled and packed leaves and a quadratic polynomial behavior in the other treatments and control. There were no changes in the levels of reducing sugars as a function of the applied treatments in parsley leaves (ÁLVARES et al., 2010).

Conclusion

The cold storage increased the shelf life of ora-pro-nobis by 168 hours (seven days). The hydrocooling increased the relative water content of leaves, although it did not influence the shelf life. The perforated plastic bag was effective in increasing the shelf life by reducing the rate of weight loss accumulated regardless the storage temperature. When associated with hydrocooling, the plastic bags provided a lower rate of loss of fresh mass.

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