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Postharvest behaviour of minimally processed watercress

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Abstract

Watercress (*Nasturtium officinale* R. Br.) is an aquatic plant of the Brassicaceae family and used as a leafy vegetable that grows in and around water. It is consumed raw or steamed and has a short shelf life of approximately seven days. The objective of this study was to evaluate the postharvest behaviour of watercress minimally processed and stored at optimal storage temperature vs. market temperature. Treatments were: shoots packed with plain film (PD961EZ, 31µm thickness) and stored in refrigerated chambers at 1 ± 0.5 ºC and 8 ± 2 ºC for 10 days. Overall visual quality, gas concentration inside the packages, chlorophyll, reducing sugar, ascorbic acid, oxalic acid and weight loss were evaluated. At the end of the storage period overall visual quality, gas concentration and reducing sugars were affected by storage time and temperature, whereas dehidro ascorbic, oxalic acid and weight loss were not.

Key words: *Nasturtium officinale*, quality, gas concentration, chlorophyll, weight loss, ascorbic acid, reducing sugar, oxalic acid

Introduction

Watercress (*Nasturtium officinale* R. Br.) is a leafy vegetable of the Brassicaceae family that grows in and around water. Raw watercress leaves are used as salad green or can be steamed and consumed as a normal processed vegetable. It is a good source of essential vitamins and minerals and beneficial phytonutrients and it has a short shelf life (approximately seven days) that can be extended through different techniques such as cold refrigeration and modified atmosphere packaging (Goncalves *et al*., 2009).

Minimally processed products are prepared and handled to maintain their fresh nature while providing convenience to the consumer as ready to eat (Francis *et al.,* 1999; Lanciotti *et al.*, 2004). The attractiveness and convenience of fresh-cut vegetables are helping to bring about increased consumption of fresh produce, but these benefits are offset by the rapid deterioration and short shelf life of the products in the marketplace (Allende *et al*., 2004).

The shelf life of a food can be defined as the time between the production and packaging of the product and the point at which it becomes unacceptable under defined environmental conditions. General appearance is the most important attribute that consumers use to evaluate the quality of fruits and vegetable, as people "buy with their eyes" (Piagentini *et al*., 2005). Exposure to higher temperatures and/or fluctuations of storage temperature produce cumulative adverse effects on the quality of stored foods, which is the primary cause of damage to food marketed through retail channels. Maintaining the shelf life of watercress represents a valuable advantage for distributors and retailers, and is also a convenient and healthy option to the final consumer (Piagentini *et al*., 2005).

The loss of quality is caused by physical and chemical changes taking place in the product. Colour is one of the most important attributes which affects the consumer perception, and it is also an indicator of the vegetable pigment concentration. During postharvest, the colour of green vegetables suffers modifications due to chlorophylls changes (Goncalves *et al.,* 2009).

Watercress is a major source of ascorbic acid that besides its vitamin action, is valuable for its antioxidant effect, stimulating the immune system and other health benefits. During processing, distribution and storage, the ascorbic acid oxidizes to dehydroascorbic acid which retains vitamin C activity (Cruz *et al.,* 2008).

The objective of this study was to evaluate the postharvest behaviour of watercress, minimally processed and stored at optimal storage temperature vs. market temperature (1 ºC and 8 ºC) for 10 days.

Material and methods

Watercress plants were grown in a floating system with a complete nutrient solution, in the greenhouse of the experimental field at the Horticultural Department of the Faculty of Agronomy, University of Buenos Aires, Argentina (35˚ 35' S, 58˚ 31' W).

After transplant, plants were grown for forty five days and finally were harvested, selected, washed and sealed in polyolefin bags: multilayered polyolefin PD-961EZ non perforated (oxygen permeability: 6000-8000 cm^3 m^2 24 h, 1 atm at 23 ºC, carbon dioxide permeability: 19000-22000 cm^3 m^2 24 h, 1 atm at 23 ºC, and water vapor transmission: 0,90 - 1,10 g 100 square inch, 24 h, 23 ºC, 100 % RH). About 35 ± 5 g of shoots cut were packed in bags, sealed and stored in refrigerated chambers at 1 ± 0.5 ºC and 8 ± 2 ºC (optimal storage temperature versus market temperature) for 10 days.

The samples were taken to evaluate overall visual quality, gas concentration (oxygen and carbon dioxide) inside the bags, total chlorophyll and weight loss at twenty four hours after sealed and every three days.

Overall visual quality (OVQ) was evaluated using a scale of 9 to 1, where 9 = excellent and 1 = unusable, a score of 6 was considered as the limit of commercial acceptability (López-Gálvez *et al*., 1996).

Oxygen (%) and carbon dioxide (%) concentration inside the packages were analyzed with a PBI-Dansensor Gas Analyzer Checkmate 9000 (Denmark).

Total chlorophyll content (mg 100 g^{-1} fresh tissue) was estimated with a Minolta SPAD 502 according to León *et al.* (2010).

Reducing sugars (mg g^{-1} fresh tissue) were measured according an adaptation of the technique developed by Somogyi-Nelson (Nelson, 1944).

Dehidroascorbic acid (mg g^{-1} fresh tissue) was measured with a spectrophometric method according to Vicente *et al.* (2006).

Weight of bags was recorded initially and after storage; the difference was used to calculate weight loss percentage (León *et al*., 2009).

Oxalic acid (mg g^{-1} fresh tissue) was analyzed according to the procedure descripted by Conesa *et al*. (2009).

An experimental design completely randomized was used; the experimental unit was each bag. The data obtained were subjected to an analysis of variance using SAS statistical program 8.5 and later for media comparisons of each treatment the Tukey test (P= 0.05) was used. For the analysis of the overall visual quality non parametric methods according to Friedman was used.

Results and discussion

Overall visual quality (OVQ**):** Overall visual quality was significantly affected by storage time and temperature. OVQ declined during storage period and quality losses were mainly attributed to wilting and yellowing (Table 1).

Table 1. OVQ for watercress minimally processed packed in non perforated film (PD-961EZ) and stored in refrigerated chambers at 1 ± 0.5 ºC and 8 ± 2 ºC for 10 days

Storage temperature	Days after packaging				
	0	1	4	7	10
1 ± 0.5 ºC	9 a	9 a	8 a	8 a	6 b
8 ± 2.0 ºC	9 a	9 a	8 a	7 ab	3 c

Different letters means significant difference (P<0.05)

At the end of postharvest, the best quality was obtained for watercress minimally processed and stored at 1 ± 0.5 ºC. Overall visual quality was below the commercial limit of acceptability when watercress plants were stored at 8 ± 2 ºC for 10 days.

Gas concentration inside the bags: Gas concentration inside the non perforated bags was affected by storage time and temperature (Table 2 and 3).

During storage period oxygen concentration decreased while carbon dioxide concentration increased as a consequence of the respiratory process. Gas concentration inside the bags is a consequence of a dynamic and interactive process among external environment, the permeability of the packaging material, the internal atmosphere inside the bags and the product itself (León *et al*., 2009).

Chlorophyll content: Total chlorophyll content was affected by storage time and temperature (Table 4). At the end of the storage period, total chlorophyll was higher when watercress minimally processed was stored at 1 ± 0.5 ºC. This parameter is very important because these pigments are responsible for the green color and it is one of the major attributes which affects the consumer perception of quality (Francis, 1999).

Table 2. Oxygen concentration (%) evolution inside the bags for watercress minimally processed packed in non perforated film (PD-961EZ) and stored in refrigerated chambers at 1 ± 0.5 ºC and 8 ± 2 ºC for 10 days

Storage temperature	Days after packaging				
	0	1	4	7	10
1 ± 0.5 ºC	21 f	20.4 ef	19.2 cd	18.9 bc	19.2 cd
8 ± 2.0 ºC	21 f	19.9 de	18.7 bc	18 ab	17.2 a

Different letters means significant difference (P<0.05)

Table 3. Carbon dioxide concentration (%) evolution inside the bags for watercress minimally processed packed in non perforated film (PD-961EZ) and stored in refrigerated chambers at 1 ± 0.5 ºC and 8 ± 2 ºC for 10 days

Storage temperature	Days after packaging				
	0	1	4	7	10
1 ± 0.5 ºC	0.03 a	4.1 f	3.9 ef	2.9 bc	2.8 b
8 ± 2.0 ºC	0.03 a	4.1 f	3.5 de	3.2 bcd	3.2 cd

Different letters means significant difference (P<0.05)

Table 4. Total chlorophyll content (mg 100 g^{-1} fresh tissue) for watercress minimally processed packed in non perforated film (PD-961EZ) and stored in refrigerated chambers at 1 ± 0.5 ºC and 8 ± 2 ºC for 10 days

Storage temperature	Days after packaging				
	0	1	4	7	10
1 ± 0.5 ºC	36.4 b	38.6 b	41.7 b	40.2 b	37 b
8 ± 2.0 ºC	36.4 b	38.7 b	38.5 b	35.9 b	24.3 a

The loss of chlorophyll is responsible for the yellowing of fresh cut products and is the result of disruption of compartmentalization that occurs when cells are broken, allowing substrates and oxidases to come in contact (Tavarini *et al*., 2007).

Reducing sugars: Significant differences were obtained for reducing sugars at the end of the storage period. Lower values obtained when plants were stored at 8 ± 2 ºC could be due to an increase in the respiration rate estimated through high oxygen depletion inside the bags.

Table 5. Reducing sugar concentration (mg g^{-1} fresh tissue) for watercress minimally processed packed in non perforated film (PD-961EZ) and stored in refrigerated chambers at 1 ± 0.5 ºC and 8 ± 2 ºC for 10 days

Storage temperature	Days after packaging				
	0	1	4	7	10
1 ± 0.5 ºC	10.6 cd	11.5 cd	9.6 bc	9.5 bc	12.9 d
8 ± 2.0 ºC	10.6 cd	11.3 cd	7.0 ab	8.4 abc	5.5 a

Different letters means significant difference (P<0.05)

Dehidro ascorbic acid: At the end of postharvest, dehidro ascorbic acid content of watercress minimally processed and stored at 1 ± 0.5 ºC and 8 ± 2 ºC for 10 days did not differ significantly.

Watercress minimally processed presents higher contents of dehidro ascorbic than most commonly consumed vegetables (peas 31-26 mg 100 g^{-1}; green beans 25-100 mg 100 g^{-1}; carrots 4 mg 100 g^{-1}; spinach 31-22 mg 100 g^{-1}) (Cruz *et al*., 2009). This result demonstrates that watercress is a good vitamin C source

Table 6. Dehidro ascorbic acid concentration (mg g^{-1} fresh tissue) for watercress minimally processed packed in non perforated film (PD-961EZ) and stored in refrigerated chambers at 1 ± 0.5 ºC and 8 ± 2 ºC for 10 days

Storage temperature	Days after packaging				
	0	1	4	7	10
1 ± 0.5 ºC	3.9 a	5.6 ab	8.5 b	6.4 ab	6.4 ab
8 ± 2.0 ºC	3.9 a	6.8 ab	6.2 ab	5.9 ab	6.4 ab

Different letters means significant difference (P<0.05)

and an important vegetable for the human diet.

Weight loss: This parameter was significantly affected by storage time (Table 7). At the end of the storage period weight loss were lower than 1 % and these results could be due to the very high relative humidity inside the bags. These results agree with Hong and Kim (2004) for green onion who reported that non-perforated film acts like a water vapor barrier reducing weight loss of products.

Table 7. Weight loss (%) for watercress minimally processed packed in non perforated film (PD-961EZ) and stored in refrigerated chambers at 1 ± 0.5 ºC and 8 ± 2 ºC for 10 days

Storage temperature	Days after packaging				
	0	1	4	7	10
1 ± 0.5 ºC	0 a	0 a	0 a	0.3 ab	0.3 ab
8 ± 2.0 ºC	0 a	0 a	0.2 ab	0.2 ab	0.7 b

Different letters means significant difference (P<0.05)

Oxalic acid: At the end of the storage period oxalic acid content remained constant (Table 8) although at 1 ± 0.5 ºC it has a tendency to increase and this response is similar with those reported by Merry Evelyn *et al.* (2003) for spinach stored at dark who found increases of oxalic acid content after 24 days of storage.

Table 8. Oxalic acid content (mg g^{-1} fresh tissue) for watercress minimally processed packed in non perforated film (PD-961EZ) and stored in refrigerated chambers at 1 ± 0.5 ºC and 8 ± 2 ºC for 10 days.

Storage temperature	Days after packaging				
	0	1	4	7	10
1 ± 0.5 ºC	171 a	203 a	188 a	221 a	231 a
8 ± 2.0 ºC	171 a	203 a	193 a	221 a	170 a

Different letters means significant difference (P<0.05)

PD 961EZ film was suitable for preserving watercress quality at 1 ± 0.5 ºC for ten days. The overall visual quality was maintained above the limit values of commercial acceptability. If the product was stored at higher temperature, the overall visual quality was below the limit of acceptability by the consumers, mainly due to significant yellowing that could be explained by the lower values of total chlorophyll recorded at the end of storage. Gas concentrations inside the bags were significantly affected by storage time and temperature. At the end of the storage, reducing sugar and total chlorophyll content were affected by temperature, while, oxalic, dehidro ascorbic acid and weight loss were not.

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