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Watercress (*Nasturtium officinale* R. Br.) Minimally Processed: Effect of Storage Temperature and Different Films of Packaging

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Abstract

Watercress is a leafy vegetable of the family Brassicaceae that grows in and around water, it has a short shelf life (approximately seven days) and it is consumed raw or steamed.The objective of this work was to study the effect of packaging film and different storage temperature on the postharvest quality of watercress minimally processed. Treatments were: packed with plain film (PD961EZ, 31µm thickness), non perforated and perforated (perforated area percentage 0.3%, hole diameter 1.1mm) and stored in refrigerated chambers at 1 ± 0.5 ºC and 8 ± 2 ºC (optimal storage temperature vs market temperature) for 10 days. Overall visual quality, gas concentration inside the packages, color Hunter lab parameters and weight loss were evaluated. Overall visual quality, gas concentration and weight loss were significantly affected by treatment, storage time and temperature. Color parameters did not show a clear tendency. In conclusion, non perforated PDZ 961 film was suitable for preserving watercress quality at the tested storage temperatures and in both temperatures, the overall visual quality was maintained above the limit values of commercial acceptability. The perforated film was no suitable for the packaging of watercress at any of the tested temperatures, mainly due to significant weight loss that reduce the overall visual quality of the product less than limit of acceptability by the consumers.

Keywords: Color, Gas concentration, *Nasturtium officinale*, Postharvest, Quality, Weight loss.

INTRODUCTION

Watercress is a leafy vegetable of the family Brassicaceae 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 (Higdon *et al.*, 2007; Cruz *et al.*, 2009) and it has a short shelf life (approximately seven days) that can be extended throughout different techniques such as cold refrigeration and modified atmosphere packaging (Goncalvez *et al.*, 2009).

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. Exposure to high temperatures and/or fluctuations of storage temperature produce cumulative adverse effects on the quality of stored food, which is the primary cause of damage to food marketed through retails. Maintaining shelf life of watercress represents a valuable advantage for distributors and retailers and is also a convenient and healthy option to the final consumer (Allende *et al*., 2004).

Colour is one of the most important attributes which affects the consumer perception, and is also an indicator of the vegetable pigment concentration (Francis, 1995). The loss of quality is caused by physical and chemical changes taking place in the product. During postharvest, the colour of green vegetables suffers due to chlorophyll changes (Goncalves *et al.*, 2009).

The objective of present work was to study the effect of packaging film and different storage temperature on the postharvest quality of watercress minimally processed.

MATERIALS AND METHODS

Watercress plants were grown in a floating system with a complete nutrient solution in the greenhouse of the experimental field in Horticultural Department of the Faculty of Agronomy, University of Buenos Aires, 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.) and perforated (perforated area percentage 0.3%, hole diameter 1.1mm). About 25 ± 1 g of stems cut were packed in bags, sealed and stored in refrigerated chambers at 1 ± 0.5 ºC and 8 ± 2 ºC (optimal storage temperature vs market temperature) for 10 days.

Every three days samples were taken to evaluate the following parameters:
Overall visual quality (OVQ) was evaluated using a scale of 9 to 1, where 9 = excellent and 1 = unusable, a score of 6 will be considered as the limit of commercial acceptability (López-Gálvez *et al.,* 1996).

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

Color parameters were measured by the Hunter Lab co-ordinates by a tristimulurs colorimeter (model CR 300, Minolta Corporation, Japan) and a CIE standard illuminant D65. The colorimeter was calibrated with a standard white tile (Y = 95.3, x = 0.3133, y = 0.3197). Color was expressed using L*, a* and b* parameters. For the evaluation samples were placed in a petridish and 9 measurements were taken in triplicates with nine readings (Goncalvez *et al*., 2009).

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

In chambers, experimental design was completely randomized and the experimental unit was each bag. The data obtained were subjected to an analysis of variance using SAS statistical program in its version 8.5 and later for media comparisons of each treatment was used Tukey test ($p \leq 0.05$). For the analysis of the overall visual quality non parametric methods according to Friedman was used.

RESULTS AND DISCUSSION

Overall visual quality

Overall visual quality was significantly affected by treatment, storage time and temperature. General appearance is the most important quality attribute that consumers use to evaluate the quality of fruits and vegetable, as people "buy with their eyes" (Piagentini *et al*., 2005).

OVQ declined during storage period and quality losses were mainly attributed to wilting and yellowing. The best quality was obtained with non-perforated film until the end of experiment. With perforated film commercial limit of acceptability was reached at sixth day of storage period at both temperatures. These results agreed with several authors who reported that modified atmosphere packaging increase the shelf life of products (Kader *et al*., 1989; Ahvenainen, 1996).

Gas concentration inside the bags

Gas concentration evolution inside the non perforated bags was affected by type of film, storage time and temperature (Table 2). Changes in gas concentration within the bags were natural consequences of the progress of respiratory activity and gas diffusion across the film. As a consequence, oxygen is consumed and carbon dioxide is accumulating inside the bags. This is a dynamic and interactive process among external environment, the permeability of the packaging material, the packaging atmosphere and the product itself (León *et al.*, 2009).

Under decrease of oxygen and increase of carbon dioxide concentration inside the bags, the respiration rate of the product is decreased and the postharvest life of perishable products is extended. (Allende *et al.*, 2004).

Colour parameters

Colour is one of the major attributes which affect the consumer perception of quality and also can be used as an estimate of chemical components as index of quality (Francis, 1995). The loss of chlorophyll is responsible of the yellowing of fresh cut products and it is the result of disruption of component that occurs when cell are broken, allowing substrates contact with oxidases (Tavarini *et al*., 2007).

At the end of storage period, colour values did not show differences between storage temperatures, however, lowest values of a* were observed in perforated film that correspond with the yellowing of the tissues.

Weight loss

This parameter was significantly affected by type of film, storage time and temperature (Table 4).

Plant tissues are in equilibrium with an atmosphere at the same temperature and a relative humidity of 99 to 99.5 %. Every reduction of water vapor pressure in the atmosphere cause to water loss in plant tissue as accord in perforated films. On the side, non perforated films maintained the relative humidity in high amount, so dehydration is not a common problem. Our results agree with Hong and Kim (2004) reports for green onion who stated that non-perforated film acts like a water vapor barrier reducing weight loss of products.

CONCLUSION

In conclusion, non perforated film (PDZ 961) was suitable for preserving watercress quality at the tested storage temperature and in both cases the overall visual quality was maintained above the commercial acceptability limit.

The perforated film was no suitable for the packaging of watercress, at any of the tested temperatures, mainly due to significant weight loss and yellowing that reduce the overall visual quality of the product less than limit of acceptability by the consumers.

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Tables

Table 1. Overall visual quality (OVQ) for watercress minimally processed packed in perforated and non perforated film and stored in refrigerated chambers at 1 ± 0.5 ºC and 8 ± 2 ºC for 10 days (Different letters mean significant difference).

		Overall Visual Quality Days after packaging			
Treatments	**Storage temp.**	**Harvest**	**3**	**6**	**10**
Non perforated	1 ± 1 ºC	9.00 g	9.00 g	8.00 f	7.00 e
	8 ± 2 ºC	9.00 g	9.00 g	7.00 e	7.00 e
perforated	1 ± 1 ºC	9.00 g	6.30 d	3.00 b	2.00 a
	8 ± 2 ºC	9.00 g	8.00 f	4.00 c	2.00 a

Table 2. Gas concentration (oxygen and carbon dioxide) inside the bags for watercress minimally processed packed in non perforated film and stored in refrigerated chambers at 1 ± 0.5 ºC and 8 ± 2 ºC for 10 days (Different letters mean significant difference).

		Gas concentration (%) Days after packaging			
Treatments	**Storage temp.**	**0**	**3**	**6**	**10**
			Oxygen		
Non perforated	1 ± 1 ºC	21.00 e	20.17 d	19.43 bc	18.93 b
	8 ± 2 ºC	21.00 e	19.87 cd	17.53 a	17.67 a
			Carbon dioxid		
Non perforated	1 ± 1 ºC	0.03 a	3.67 d	3.23 b	3.17 b
	8 ± 2 ºC	0.03 a	4.17 d	3.67 d	3.37 b

Table 3. Colours parameters (L*, a* and b*) for watercress minimally processed packed in perforated and non perforated film and stored in refrigerated chambers at 1 ± 0.5 ºC and 8 ± 2 ºC for 10 days (Different letters mean significant difference).

		L* Parameter Days after packaging			
Treatments	**Storage temp.**	**Harvest**	**3**	**6**	**10**
Non perforated	1 ± 1 ºC	41.37 a	42.29 ab	48.01 ab	44.94 ab
	8 ± 2 ºC	41.37 a	49.64 ab	50.66 ab	50.18 ab
perforated	1 ± 1 ºC	41.37 a	48.25 ab	47.43 ab	41.83 ab
	8 ± 2 ºC	41.37 a	42.66 ab	48.83 ab	47.23 ab

		a* Parameter Days after packaging			
Treatments	**Storage temp.**	**Harvest**	**3**	**6**	**10**
Non perforated	1 ± 1 ºC	-17.68 abc	-17.61 abcd	-18.64 ab	-19.18 ab
	8 ± 2 ºC	-17.68 abc	-18.30 abc	-19.72 ab	-20.59 a
perforated	1 ± 1 ºC	-17.68 abc	-15.33 cdef	-14.54 ef	-13.47 f
	8 ± 2 ºC	-17.68 abc	-17.47 bcde	-19.01ab	-14.55 def

		b* Parameter Days after packaging			
Treatments	**Storage temp.**	**Harvest**	**3**	**6**	**10**
Non perforated	1 ± 1 ºC	30.79 abc	35.35 abc	36.69 abc	34.48 abc
	8 ± 2 ºC	30.79 abc	38.55 bc	38.70 bc	41.06 c
perforated	1 ± 1 ºC	30.79 abc	32.59 abc	29.03 a	28.04 a
	8 ± 2 ºC	30.79 abc	34.02 abc	38.79 bc	34.50 abc

Table 4. Weight loss (%) for watercress minimally processed packed in perforated and non perforated film and stored in refrigerated chambers at 1 ± 0.5 ºC and 8 ± 2 ºC for 10 days (Different letters mean significant difference).

		Weight Loss (%) Days after packaging			
Treatments	**Storage temp.**	**Harvest**	**3**	**6**	**10**
Non perforated	1 ± 1 ºC	0.00 a	0.00 a	0.00 a	0.17 a
	8 ± 2 ºC	0.00 a	0.73 a	0.03 a	0.70 a
perforated	1 ± 1 ºC	0.00 a	11.37 d	9.80 d	10.97 d
	8 ± 2 ºC	0.00 a	9.77 d	4.37 b	7.17 c