

Full Length Research Paper

Postharvest quality of carrot cultivars, packaged and in bulk

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This study aimed at evaluating the postharvest durability of different carrot cultivars stored in bulk. The experimental design was completely randomized, with four repetitions. The treatments were arranged in a 3 x 2 factorial design comprising three cultivars (Brasília RL and AF-1620 from SAKATA, and Alvorada from EMBRAPA) and two forms of conservation (on polystyrene trays covered with PVC plastic film and in bulk). Mass loss was higher in carrots stored in bulk than in packaged carrots. 'Brasília RL' presented the highest number of sprouts when stored in bulk (48.5%) and the largest number of carrots with radicels (54.7%). The hybrid AF-1620 cv. presented the lowest number of sprouts when packaged (49%). The average number of carrots with radicels during this study was 14.7 and 75.5% with and without packaging, respectively. Packaged carrots showed a higher percentage of rot (5.4%) than carrots stored in bulk (0.7%). 'Brasília RL' showed the largest percentage of rotten carrots (10.8%). The Brasília RL, Alvorada and AF-1620 cultivars showed β -carotene concentrations of 351, 405 and 543 $\mu\text{g}\cdot 100\text{g}^{-1}$, respectively, without variations over time. Conservation in bulk extended to 14 days, while packaged product remained conserved for 8 days.

Key words: *Daucus carota* L., postharvest, weight loss.

INTRODUCTION

The carrot (*Daucus carota* L.), a plant of the family *Apiaceae*, produces an aromatic edible root and is considered one of the most important vegetables due to its widespread global consumption and large planted area. Carrots are the main sources of provitamin A carotenoids of vegetal origin, especially α and β -carotene (Britton, 1992).

After harvesting, garden vegetables lose their physicochemical and organoleptic properties in a few days, especially when they are stored in ambient conditions (Caron et al., 2003). In carrots, mass loss and the occurrence of disease in the root are the principal causes of postharvest loss during storage and commercialization (Oliveira et al., 2001). In most vegetables, mass losses of 5% or higher can produce wrinkling and a consequent decline in consumer acceptance (Pantastico et al., 1979). This is due to high rates of transpiration, which affects

the product's appearance by wrinkling and altering the texture of its skin, among other effects (Caron et al., 2003). The water content of carrot roots varies from 85 to 90%, a large part of which is lost through transpiration. Transpiration is a consequence of vapor pressure deficit (VPD), which results from the difference between the humidity at the surface of the product and the humidity of the surrounding air (Grierson and Wardowski, 1978; Chitarra and Chitarra, 2005). The higher the VPD the greater the loss of fresh material.

The product's useful life can be extended by using flexible plastic film that acts as modified atmosphere packaging, which is defined as the insertion of food products inside a gas barrier, where the initial composition of the gas medium was altered or will be modified over time. The objective is to reduce the respiration and microbial growth rates, as well as delay enzymatic deterioration, with the end effect of prolonging shelf life (Chitarra and Chitarra, 2005).

Sprouting and rooting are cited as possible losses in root and tuber vegetables resulting from the use of a modified atmosphere (Kader, 1992). In an experiment,

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Table 1 . Weight loss, percentage of carrots with sprouts and radicles as a function of cultivars and forms of storage for a period of 20 days. Ponta Grossa, PR. UEPG. 2007.

Cultivar	Weight loss (%)		Carrot with sprout (%)		Carrot with radicel (%)
	In bulk	Packaged	In bulk	Packaged	
Brasília	14.00* Aab	5.70 Ba	45.6 Ba	60.4 Aa	41.13 a
Alvorada	13.73 Ab	5.26 Ba	10.5 Bb	57.0 Aa	27.13 b
AF1620	15.20 Aa	5.32 Ba	18.1 Bb	46.3 Ab	33.38 b
CV (%)	21.3		28.5		30.3

* Mean values followed by the same letter for the same variable, lower case in the columns and upper case on the lines, did not differ according to Tukey's test $p > 0.05$.

Oliveira et al. (2001) found that PVC film packaging limited the useful life of carrot roots to 8 days to the occurrence of sprouting and radicles. Tessarioli Neto et al. (1998) suggest wrapping beetroots in perforated LDPE film or PVC film to prevent loss of quality of the roots due to adventitious sprouting.

The cultivar is one of the main factors that stand out in the characterization of the physicochemical composition of carrots (Chitarra and Carvalho, 1984). According to Shibairo et al. (1997), the postharvest conservation time is related to the differences in water loss that different cultivars present in relation to the surface volume of each cultivar.

Therefore, the objective of this work was to compare different cultivars and forms of postharvest storage of carrots.

MATERIALS AND METHODS

The experiment was conducted at the Ponta Grossa State University – UEPG located in Ponta Grossa, state of Paraná, Brazil. The experimental design was completely randomized, with four repetitions. The treatments were arranged in a 3 x 2 factorial design comprising three cultivars: Brasília RL and AF – 1620, SAKATA and Alvorada, from Embrapa, and two forms of conservation: on polystyrene trays covered with polyvinyl chloride (PVC) film and in bulk. The carrots were washed under running water, rubbing them lightly with a sponge to remove remnants of soil, after which they were left to dry at room temperature. The roots used here were standardized to a length of approximately 14 cm. After drying, the carrots were placed on polystyrene trays (21 x 14 cm) covered with PVC plastic film, two carrots per tray; and in bulk in plastic boxes. These were stored at room temperature for a period of 20 days.

The following parameters were evaluated: percent mass loss – determined by the ratio of the carrots' initial mass to their mass on the date of evaluation; percentage of carrots with rotten areas – determined by the ratio of the number of carrots with visible symptoms of rot to the total number of carrots; percentage of carrots with radicles – determined by the ratio of the number of carrots with at least one radicel 5 mm long or longer to the total number of carrots; concentration of β -carotene – determined by petroleum ether extraction and determination by spectrophotometry (absorbance at 450 nm), following the analytical standards of the Adolfo Lutz Institute (1985).

The data thus obtained were subjected to an analysis of variance and the mean values were compared by Tukey's test with a 5% level of probability.

RESULTS

The parameters of weight loss and percent of carrots with sprouts and rotten areas showed a significant correlation with the types of storage (Tables 1 and 2). The percentage of carrots with radicles showed a significant isolated effect (Table 1). Mass loss is one of the main causes of postharvest loss in carrot roots, and it is strongly influenced by storage conditions. In this study, the carrots stored in bulk showed a higher percentage of weight loss than the packaged carrots, regardless of the cultivar. The cultivar Alvorada presented a lower mass loss than AF1620 when stored in bulk.

In addition to reducing mass loss, PVC film packaging gave the carrots greater firmness up to the end of the storage period. In contrast, the carrots stored in bulk showed high levels of shrinkage, thus compromising their sale.

Another factor that was strongly influenced by both the form of storage and the cultivars was the percentage of carrots with sprouts (Table 1). All the cultivars showed a higher occurrence of sprouting when packaged than in bulk, probably as a result of the higher level of humidity inside the PVC film-wrapped packaging, which favored the development of sprouts. Among the cultivars, AF1620 sprouted the least, both packaged and in bulk, although, in the latter form of storage it did not differ from the Alvorada cultivar. In general, sprouting followed an upward curve until the 19th day, at which point it gradually declined as a function of the product's perishability (Figure 2). At the end of the storage period, the packaged carrots presented approximately 70% of sprouting, while the carrots stored in bulk showed 50%. A similar result was reported by Oliveira et al. (2001).

The percentage of roots with radicles (Table 1) was influenced only by the cultivars, with Brasília presenting the highest percentage. Packaged carrots developed more rootlets over time than those stored in bulk. At 8 days, approximately 40% of the packaged carrots presented radicles, while the carrots stored in bulk showed 8%.

Another factor that was affected by the forms of storage was the percentage of carrots with rotten spots (Table 2), with the packaged carrots showing higher values than those stored in bulk (Figure 3). This is due to the

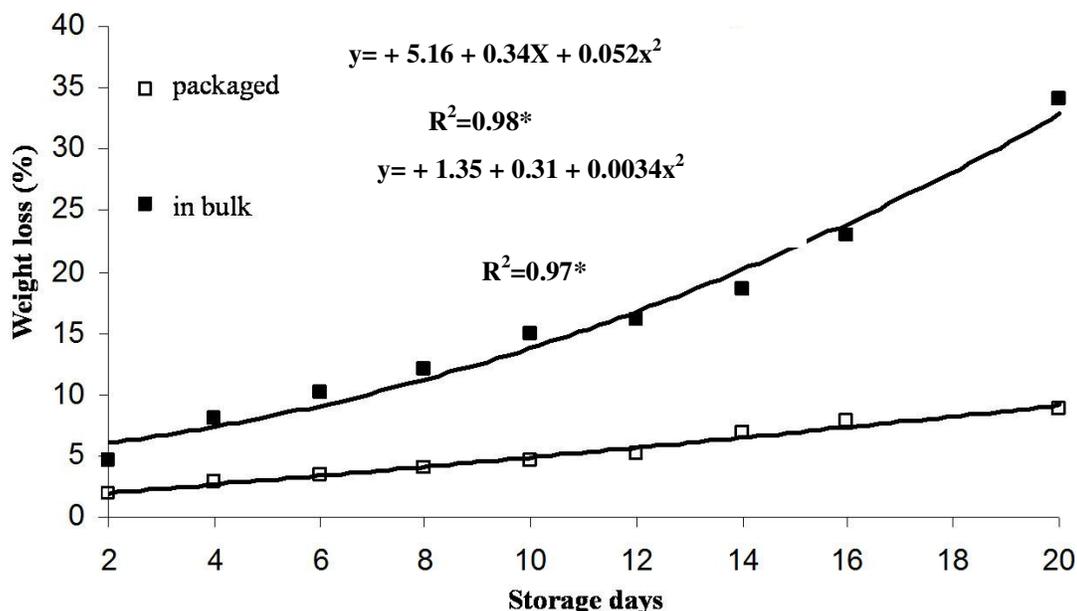


Figure 1. Loss of fresh mass of the three carrot cultivars, packaged and in bulk, as a function of time over a storage period of 20 days. Ponta Grossa, PR. UEPG. 2007.

Table 2. Percentage of carrots with rotten areas as a function of cultivars and forms of storage, over a period of 20 days. Ponta Grossa – PR. UEPG. 2007.

Cultivar	% Rotten carrot	
	In Bulk	Packaged
Brasília	0.00 Ba	8.50* Aa
Alvorada	3.50 Aa	4.25 Aab
AF1620	0.00 Aa	0.00 Ab
CV (%)	280.3	

* Mean values followed by the same letter for the same variable, lower case in the columns and upper case on the lines, did not differ according to Tukey's test $p > 0.05$.

favorable micro-climate for the development of diseases inside the packaging. Among the packaged cultivars, Brasília showed the highest number of carrots with rotten areas, differing very little from Alvorada.

DISCUSSION

Mass loss was constant as a function of time (Figure 1), with a higher loss in carrots stored in bulk that is about 15% at 10 days, which is lower than the 35% mass loss reported by Caron et al. (2003) for the cultivar Brasília after 4 days of storage. In contrast, the mass loss of the packaged carrots was limited to 4% at 10 days, which is very satisfactory for carrots, and is a better result than the 10% reported by Oliveira et al. (2001), who also used PVC film. This difference between the forms of storage is due to the barrier imposed by plastic films, which are little permeable to water vapor, creating a saturated environ-

ment inside the packaging and reducing the pressure gradient of water vapor between the internal tissues of the roots and the inside of the packaging, thus preventing the roots from dehydrating (Grierson and Wardowski, 1978; Hardenburg et al., 1986).

Ayub et al. (2010) observed a higher percentage of carrot roots sprouting when stored wrapped in PVC film. The muffling of tubers potato sprouting stimulates due to increased temperature and CO₂ concentration and the decrease of O₂ concentration (Bisognin et al., 1996). An alternative to reducing sprouting in the packed storage would be with the use of film with perforations to reduce the increased temperature and CO₂ concentration (Tessarioli Neto et al., 1998).

The concentration of β -carotene remained constant over time, showing an average of 3.73, 4.67 and 5.41 mg. 100g⁻¹, respectively, for the cv. Brasília, Alvorada and AF1620. Because they are localized in lipid droplets or in chromoplasmic membranes by lipoproteins, carotenoids

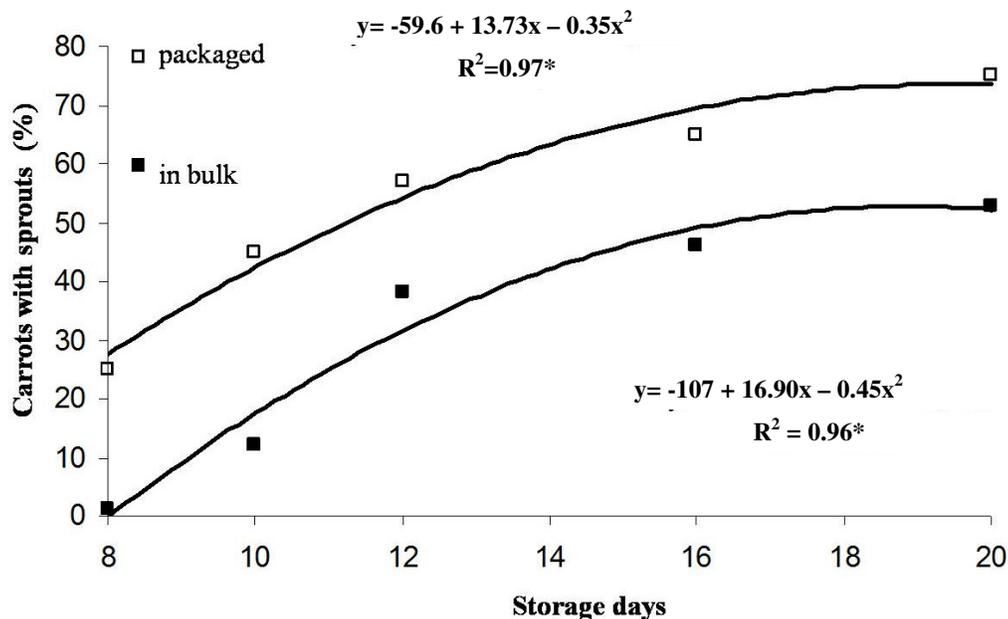


Figure 2. Percentage of carrots with sprouts of the three cultivars, packaged and bulk, as a function of time over a storage period of 20 days. Ponta Grossa – PR. UEPG. 2007.

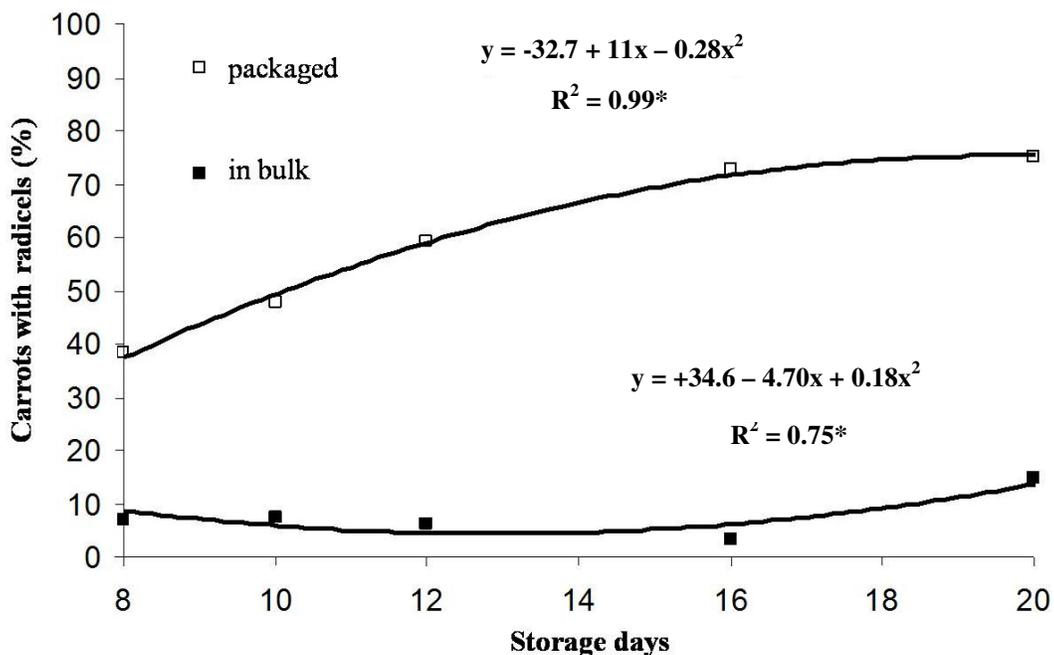


Figure 3. Percentage of carrots with radicles of the three cultivars, packaged and bulk, as a function of time over a storage period of 20 days. Ponta Grossa – PR. UEPG. 2007.

present high stability (Lima et al., 2004).

Conclusions

The use of storage on trays covered with PVC plastic film

was efficient in reducing mass loss over time. However, it favors the development of sprouting and radicles, limiting the storage time to 8 days. Mass loss was the main loss factor in bulk conservation, extending the storage time to 14 days, considering the quality of the product for commercialization.

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