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POST-HARVEST CONSERVATION OF ORANGE cv. FOLHA MURCHA TREATED WITH 1-MCP AND STORED UNDER REFRIGERATION

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Abstract: This study aimed to evaluate the postharvest quality of oranges cv. Folha Murcha, treated with 1-MCP and stored for 60 days at 7, 14 and 25 °C. The analysis performed every 15 days were: weight loss, percentage of juice, content of soluble solids (SS), titratable acidity (TA), ratio (SS/TA), and content of vitamin C, phenolic compounds and total carotenoids. Results showed: 1-MCP did not provide greater postharvest conservation for fruits analyzed; the application of 1-MCP did not changed the chemical characteristics as SS, TA, vitamin C, carotenoids and phenolic compounds; and the shorter the period between harvesting and cooling, the better was the preservation of fruits.

Keywords: *Citrus sinensis* L., ethylene, low temperature.

1. Introduction

Oranges are the main Citrus species cultivated in Brazil, where domestic production is focused on the export of their orange juice; because of the constant dissemination about its nutritional qualities, demand for this product is in full expansion. In Paraná State, the citrus industry is sustained mainly by the production of mandarin and orange (SCHÄFER and DORNELLES, 2000).

Oranges are classified as non-climacteric fruits, i.e., are not able to complete the ripening off the mother plant, given their low and constant rate of respiration and ethylene production. However, despite the low production, ethylene also interferes in the fruit ripening and can often affect the qualitative aspects of the product (CHITARRA and CHITARRA, 2005).

The effects of ethylene on the ripening of fruits in general make necessary to adopt some techniques, especially those of post-harvest, which can preserve them for longer time. One of the most recent examples is the use of 1-methylcyclopropene (1-MCP), a product in the form of gas that has characteristically the fact of linking to ethylene receptor, and therefore preventing its action (GIRARDI et al, 2007). The application of 1-MCP in horticultural products has obtained positive results for several fruits and vegetables, but studies on its effect on non-climacteric fruits, such as oranges, are scarce.

Given the importance of citrus in the State of Paraná and the scarcity of studies on the product 1-MCP on citrus fruits and more specifically oranges, studies addressing to this issue become relevant. In this context, the present study aimed to evaluate the conservation and post-harvest quality of oranges cv. Folha Murcha, through the use of 1-MCP and cooling for 60 days of storage.

2. Material and Methods

The fruits of cv. Folha Murcha were collected in 2008/2009 and 2009/2010 seasons in the experimental orchard of Cocamar Cooperativa Agroindustrial, located in Paranavaí County, Northwest Paraná (23 ° 4 '22 "S, 52 ° 27' 54" W); fruits were harvested in December in both seasons. In the first year (2008/2009), soon after harvesting, fruits were transported to the Laboratory of Food Biochemistry, State University at Maringá - UEM, and in the next harvesting (2009 / 2010), the fruits were transported to the Center for Post-harvest Research, Federal University at Santa Maria (UFSM-NPP), Santa Maria, State of Rio Grande do Sul.
After the reception in the laboratory, fruits were sanitized and divided into parcels. The 1-MCP applied is the commercial product SmartFresh™ fom Rohm and Hass Co., in the form of watered

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powder containing 0.14% of active ingredient. Four doses were used: T1: 0; T2: 0.1; T3: 0.5 and T4: 1.0 µL L^{-1}, and the amount of product required for each concentration was calculated according to the volume of boxes and the concentration of ingredient present in the commercial product. The product in the form of powder was placed in 20 mL flasks which were tightly sealed with rubber strips and later water Milli-Q was added at room temperature via syringe and then flasks were shaken vigorously until to completely dissolved product.

The sealed flasks were placed inside the boxes with the fruits previously packed and then the flasks were opened and the boxes immediately closed, remaining this way for 12 hours. The fruits from control treatment (no application of 1-MCP) also remained for 12 hours inside a box identical to those used for other treatments. After this period, the fruits harvested in 2008/2009 were stored at temperatures of 7 and 21 °C and those harvested in the 2009/2010 stored at temperatures of 7, 14 and 21 °C. Analyses were performed at 0, 15, 30, 45 and 60 days of storage.

After taking the weight of fruits, juice extraction was performed with subsequent filtering and mixing for evaluation, which showed:

- The content of total soluble solids (SS), obtained by refractometry, from the juice extracted from each sample and the results expressed in ° Brix.
- Titratable acidity (TA), determined by potentiometric titration with NaOH 0.1 M, from a solution containing 10 mL of orange juice diluted with 100 mL of distilled water until pH reaches 8.1. The pH was determined by a pHmeter Digimed ®. Values were expressed in meq 100 ml^{-1}.
- The ratio soluble solids/titratable acidity was calculated by the relation soluble solids and acidity, in which the factor is multiplied by 100, resulting in percentage.
- The content of vitamin C was obtained by titration of ascorbic acid in solution of 2,6-dichlorobenzeneindophenol, expressed in milligrams of ascorbic acid per 100 mL of juice; the extraction of the samples was performed with a solution of oxalic acid at 1%.
- Total carotenoids were obtained with a spectrophotometer at 663nm for chlorophyll, at 646 nm for chlorophyll b and at 470 nm for carotenoids. Phenolic compounds were obtained by the method of Follin-Ciocauteau according to Bucic-Kojic et al. (2007).
- The mass loss of fruits was determined by the difference between initial mass and mass after storage, using a semi-analytical balance.
- The juice yield was determined by the relation between the mass of orange juice and the total fruit mass.

The experimental design was completely randomized in a 2x4 factorial design (storage temperature x doses of 1-MCP) for fruits from 2008/2009 season with four replicates per treatment and five fruits per plot; and in a 3x4 factorial design (storage temperature x doses of 1 - MCP) for fruits from 2009/2010 season, with four replicates and eight fruits per plot. Data were subjected to analysis of variance (test F) and the means were studied by regression method (P≤0.05), utilizing the statistical program SISVAR (FERREIRA, 2008), and data in percentages were previously transformed in arc.sen $\sqrt{x/100}$.

3. Results and Discussion

In relation to SS, Table 1 shows there was significant interaction between treatment for 30 days of storage and temperatures at 7 and 21 °C, for 45 days of storage and temperature of 7 °C and for 60 days of storage and temperature of 21 °C. In other conditions of storage, there was no significant interaction between treatments.

Table 1. Content of total soluble solids (°Brix) in fruits of cv. Folha Murcha, stored for 60 days at temperatures of 7, 14 and 21 °C.

Stored time	Tratament 1-MCP (µL L^{-1})	TOTAL SOLUBLE SOLIDS (°Brix)				
		2008/2009		2009/2010		
		7 °C	21 °C	7 °C	14 °C	21 °C
INICIAL		9,28±0,29	9,28±0,29	8,73±0,21	8,73±0,21	8,73±0,21
15 DAYS	0,0	8,98±0,46 NS	9,25±0,39 NS	8,50±0,12 NS	8,43±0,30 NS	8,20±0,41 NS
	0,1	9,20±0,41 NS	9,40±0,47 NS	8,98±0,17 NS	8,65±0,06 NS	8,33±0,15 NS
	0,5	9,18±0,37 NS	9,20±0,27 NS	8,65±0,55 NS	8,48±0,09 NS	8,45±0,17 NS
	1,0	9,45±0,27 NS	9,65±0,42 NS	8,57±0,29 NS	8,43±0,30 NS	8,30±0,46 NS

30 DAYS	**0,0**	9,40±0,18*	9,65±0,52*	8,20±0,16*	9,00±0,29*	8,70±0,58*
	0,1	9,90±0,25*	9,83±0,32*	8,750±0,34*	9,20±0,59*	8,20±0,16*
	0,5	9,43±0,09*	9,26±0,51*	8,75±0,19*	8,80±0,29*	8,00±0,33*
	1,0	9,38±0,39*	8,25±0,58*	8,70±0,12*	8,47±0,25*	N/C
45 DAYS	**0,0**	9,40±0,18*	9,50±0,43 NS	8,63±0,05 NS	8,75±0,30 NS	N/C
	0,1	9,90±0,25*	9,88±0,21 NS	8,53±0,22 NS	8,85±0,41 NS	N/C
	0,5	9,43±0,09*	9,45±0,57 NS	8,58±0,35 NS	8,68±0,40 NS	N/C
	1,0	9,38±0,37*	9,30±0,25 NS	8,40±0,33 NS	N/C	N/C
60 DAYS	**0,0**	9,53±0,29 NS	9,65±0,52*	7,08±0,19*	8,93±0,25 NS	N/C
	0,1	10,03±0,61 NS	9,83±0,32*	7,80±0,52*	9,20±0,16 NS	N/C
	0,5	9,73±0,36 NS	9,23±0,51*	7,40±0,29*	9,07±0,34 NS	N/C
	1,0	9,40±0,48 NS	8,25±0,58*	7,85±0,19*	N/C	N/C

NS – Averages not presenting significant differences, in the same row, according to variance analysis (test F, p≤0,05).
* - Averages presenting significant difference, in the same row, according to variance analysis (teste F; p≤0,05).
N/C – No fruits for analysis.

In periods when there was interaction, the concentration of 0.1 µL of 1-MCP per liter (T2) showed the highest content of soluble solids, and in doses of 0.5 and 1.0 µL of 1-MCP per liter (T3 and T4, respectively), values were lower than the control (T1). The results from T3 and T4 differ from those found in pineapple by Selvarajah et al. (2001), who observed an increase in the levels of SS in fruits treated with 1-MCP. The findings in this study confirm those reported by Porat et al. (1999) who described no change in SS of oranges cv. Shamouti treated with 1-MCP.

The average values observed in this study were lower than those reported by Stenzel et al. (2005) who found levels from 11.3 to 13.1 °Brix in fruits of the same cultivar. However, one emphasizes that fruits in this experiment were harvested before complete ripeness, given that it was necessary to anticipate the harvest to accomplish the application of 1-MCP.

The content of SS is an important attribute in determining the fruit flavor, since it is indicative of the amount of existing sugars, along with compounds that occur in smaller amounts, such as acids, vitamins, amino acids, etc. (KLUGE et al., 2002) . Pereira et al. (2006) describe that minimum levels of SS in oranges and tangerines should stand around 9.0 to 10.0 °Brix. Thus, the average content of SS found for cv. Folha Murcha in this work is close to the standard value, with or no application of 1-MCP.

In relation to titratable acidity (TA), Table 2 shows there was significant interaction in the temperature of 7 °C only for fruits evaluated at 30 days of storage. At 21 °C, there was significant interaction at 15, 30 and 45 days, with a decrease in the values. According to Volpe et al. (2002), citric acid begins to accumulate in the fruit soon after its formation and quickly reaches the maximum, after which the content of this acid decreases. The decrease in concentration during maturation is partly due to increasing size of fruit by absorption of water and consequent dilution of the acid content and due to respiratory rate, which is temperature dependent.

Table 2. Titratable acidity (mg 100 mL^{-1}) in fruits of cv. Folha Murcha stored for 60 days at temperatures of 7, 14 and 21 °C.

Stored time	Tratament 1-MCP (µL L^{-1})	TITRATABLE ACIDITY (mg 100mL^{-1})				
		2008/2009		2009/2010		
		7 °C	21 °C	7 °C	14 °C	21 °C
INICIAL		0,62±0,09	0,62±0,09	0,56±0,01	0,56±0,01	0,56±0,01
15 DAYS	0,0	0,61±0,04 NS	0,59±0,04*	0,59±0,04 NS	0,66±0,02*	0,59±0,03 NS
	0,1	0,58±0,04 NS	0,51±0,03*	0,58±0,05 NS	0,59±0,04*	0,60±0,04 NS
	0,5	0,57±0,06 NS	0,61±0,03*	0,55±0,04 NS	0,61±0,02*	0,60±0,05 NS
	1,0	0,57±0,03 NS	0,61±0,04*	0,56±0,01 NS	0,59±0,01*	0,61±0,09 NS
30 DAYS	0,0	0,54±0,08*	0,61±0,06*	0,53±0,01*	0,58±0,02 NS	0,56±0,04 NS
	0,1	0,66±0,02*	0,53±0,03*	0,56±0,02*	0,59±0,04 NS	0,53±0,01 NS
	0,5	0,66±0,05*	0,57±0,02*	0,56±0,01*	0,56±0,02 NS	0,51±0,02 NS
	1,0	0,62±0,02*	0,57±0,02*	0,55±0,01*	0,54±0,02 NS	N/C
45 DAYS	0,0	0,61±0,03 NS	0,72±0,03*	0,55±0,003 NS	0,56±0,02 NS	N/C
	0,1	0,64±0,08 NS	0,61±0,03*	0,55±0,01 NS	0,57±0,03 NS	N/C
	0,5	0,63±0,04 NS	0,61±0,11*	0,55±0,02 NS	0,56±0,03 NS	N/C
	1,0	0,62±0,05 NS	0,57±0,04*	0,54±0,02 NS	N/C	N/C
60 DAYS	0,0	0,67±0,09 NS	0,58±0,06 NS	0,65±0,03 NS	0,51±0,05 NS	N/C
	0,1	0,58±0,04 NS	0,54±0,01 NS	0,64±0,04 NS	0,57±0,04 NS	N/C
	0,5	0,61±0,02 NS	0,53±0,06 NS	0,64±0,02 NS	0,57±0,01 NS	N/C
	1,0	0,59±0,03 NS	0,49±0,04 NS	0,62±0,02 NS	N/C	N/C

NS – Averages not presenting significant differences, in the same row, according to variance analysis (test F, p≤0,05).

* - Averages presenting significant difference, in the same row, according to variance analysis (teste F; p≤0,05).

N/C – No fruits for analysis.

The average values of acidity in this work (Table 2) are low when compared to those of Nascimento et al. (2005) who found value of 1.10 mg of citric acid per 100 mL for cultivar Folha Murcha, in the County of Brotas, São Paulo State. According to Volpe et al. (2002), nutritional conditions and mainly temperature are the factors influencing the levels of citric acid, which may explain partly the difference among results found in different regions.

As occurred in SS, the TA content observed in this study was indifferent in relation to doses of 1-MCP, which confirms Porat et al. (1999) who found no significant differences between the control fruits and the different doses of 1-MCP applied in oranges cv. Shamouti.

The ratio is calculated by the relation between SS and TA contents. It is one of the main indicators used to determine the maturity stage, which regulates the balance of sweetness/acidity (COUTO and CANNIATTI-BRAZACA, 2010). According to Viégas (1991), the ratio range can vary between 6 and 20, and the interval from 15 to 18 is preferred by consumers. But Sartori et al. (2002) regard as suitable for consumption fruits having a SS/TA ratio between 8.8 and 15.4. In Brazil, the preference is for juices with a ratio above 14. The evolution of this content can be partly explained by the relationship graft bearer/canopy, age of plants, flowering and productivity, besides climate changing from year to year (VOLPE et al., 2002). For fruits of cv. Folha Murcha harvested in the 2008/2009 and stored at 7 °C there was no significant interaction for any period analyzed. However, under 21 °C there was interaction at 15, 30 and 45 days. For fruits stored at 7 °C, the ratio was between 14.4 and 17.8, while for fruits stored at 21 °C it was between 13.2 and 18.6. In the following season (2009/2010), the mean ratios were between 10.9 and 15.9 at temperature of 7 °C, between 14.9 and 17.8 at 14 °C and between 13.2 and 15,0 at 21 °C. Significant variation between treatments was observed only for 60 days at 7 °C and 14 °C. In other periods and temperatures, there was no significant difference between treatments.

The average ratios in the present study are high when compared to that of Nascimento et al. (2005), who found value of 7.6 for the same cultivar. Some authors consider the SS/TA as the main feature to indicate the point of commercial maturation for citrus (COUTO and CANNIATTI-BRAZACA, 2010). However, Santos et al. (2010) claim that the use of this parameter solely can lead to misinterpretations, since in their work with seedless citrus fruits, the ratio found was considered high; however, this happened due to low TA, although SS content was considered inadequate. The authors state that the impression is a fruit that pleases fully the consumer, due to the high ratio, but in reality the result is tasteless because of the imbalance in the relation SS/TA. Similar fact was observed in this study, with high values of ratio, however with soluble solids content close to the recommended.

In relation to ascorbic acid or vitamin C for fruits harvested in the 2008/2009 season, there was no significant interaction between treatments for any temperature and period analyzed. For fruits stored at 7 °C, the levels of vitamin C ranged between 47.9 and 70.8 mg 100 mL^{-1}, whereas for fruits stored at 21 °C, this levels were between 43.7 and 77.1 mg 100 mL^{-1}. The mean values of vitamin C for fruits of 2009/2010 season were between 31.9 and 48.9 mg 100 mL^{-1} at temperature of 7 °C, between 32.0 and 65.6 mg 100 mL^{-1} at 14 °C and between 31.9 to 72.1 mg 100 mL^{-1} at 21 °C. It was also noted that for the fruits from this season, there was no significant difference between treatments of 15 days at 21 ° C and 45 days at 14 ° C, and no statistical difference in the other periods analyzed.

In this study, there was great variation in vitamin C content during storage at the three temperatures. The same oscillation was observed by Andrade et al. (2002), who analyzed orange fruits at different maturation stages with a approximate range from 50 to 75 mg of ascorbic acid 100 mL^{-1}. The authors also noted that greener fruits presented lower content of vitamin C when compared to more mature fruits.

The determination of vitamin C is an important attribute of quality for citrus in general. It is a natural antioxidant involved in reactions taking place during the senescence of fruits as a way to repair oxidative damage in cells.

It should be noted that applications of 1-MCP showed no increase or decrease in the levels of vitamin C and data were adjusted into cubic equations, with oscillation between the values without, however, be possible to say that higher dose of 1-MCP increases or reduces the amount of ascorbic acid in the fruits. As observed in this work, Jomori et al. (2003) did not obtain significant differences in the levels of vitamin C in acid lime cv. Tahiti, when comparing treatments of 1-MCP; the authors explained this result to the fact that the action of products applied was restricted to the albedo and flavedo of fruits, not happening possibly a more internal dissemination of these products. This fact should also justify the insignificant results between treatments found in this study.

Another important compound in citrus is the carotenoids that make up one of the most important groups of natural pigments due to wide distribution, structural diversity and number of functions (RIBEIRO and SERAVALLI, 2004). These compounds are unique in the nature; they are present in various structures of plants, in a variety of animals, algae, fungi and bacteria and are responsible for the colors yellow, orange and red (MELÉNDEZ-MARTÍNEZ et al., 2007).

For fruits harvested in 2008/2009 and kept at 7 °C, the carotenoids content was between 0.386 and 0.601 mg 100 mL^{-1}, whereas for fruits stored at 21 °C, the total carotenoids stayed between 0.390 and 0.728 mg 100 mL^{-1}. Fruits stored at 7 °C and 21 °C showed significant differences among treatments in the periods of 30 and 60 days and no difference in the periods of 15 and 45 days. In the season 2009/2010, the values observed were between 0.309 and 0.870 mg 100 mL^{-1} at the temperature of 7 °C, between 0.108 and 0.607 mg 100 mL^{-1} at 14 °C and between 0.132 and 0.446 mg 100 mL^{-1} at 21 °C. Significant variation between treatments was observed only for 15 days at temperature of 7 °C and for 30 days at 21 °C, and no statistical difference in the other periods analyzed.

Table 3. Content of total carotenoids (mg 100 mL^{-1}) in fruits of cv. Folha Murcha, stored for 60 days at temperatures of 7, 14 and 21 °C.

Stored time	Tratament 1-MCP (μL L^{-1})	TOTAL CAROTENOIDS TOTAIS (mg 100mL^{-1})				
		2008/2009		2009/2010		
		7 °C	21 °C	7 °C	14 °C	21 °C
INICIAL		0,58±0,05	0,58±0,05	0,29±0,04	0,29±0,04	0,29±0,04
15 DAYS	0,0	0,43±0,05^{NS}	0,51±0,11^{NS}	0,57±0,08*	0,12±0,03^{NS}	0,21±0,22^{NS}
	0,1	0,50±0,21^{NS}	0,49±0,16^{NS}	0,44±0,09*	0,14±0,08^{NS}	0,13±0,05^{NS}
	0,5	0,46±0,10^{NS}	0,56±0,09^{NS}	0,31±0,03*	0,12±0,04^{NS}	0,15±0,02^{NS}
	1,0	0,45±0,04^{NS}	0,59±0,08^{NS}	0,39±0,06*	0,11±0,07^{NS}	0,15±0,05^{NS}
30 DAYS	0,0	0,48±0,06*	0,73±0,08*	0,41±0,09^{NS}	0,49±0,04^{NS}	0,29±0,08*
	0,1	0,39±0,04*	0,59±0,06*	0,44±0,04^{NS}	0,47±0,07^{NS}	0,37±0,02*
	0,5	0,49±0,13*	0,57±0,04*	0,42±0,04^{NS}	0,45±0,06^{NS}	0,45±0,04*
	1,0	0,59±0,03*	0,51±0,04*	0,44±0,04^{NS}	0,42±0,07*	N/C
45 DAYS	0,0	0,39±0,05^{NS}	0,73±0,08^{NS}	0,81±0,09^{NS}	0,51±0,08^{NS}	N/C
	0,1	0,42±0,12^{NS}	0,59±0,06^{NS}	0,87±0,07^{NS}	0,45±0,06^{NS}	N/C
	0,5	0,43±0,03^{NS}	0,57±0,04^{NS}	0,81±0,11^{NS}	0,48±0,06^{NS}	N/C
	1,0	0,44±0,02^{NS}	0,51±0,04^{NS}	0,79±0,09^{NS}	N/C	N/C
60 DAYS	0,0	0,39±0,06*	0,57±0,03*	0,45±0,03^{NS}	0,59±0,12^{NS}	N/C
	0,1	0,48±0,06*	0,58±0,04*	0,48±0,07^{NS}	0,61±0,15^{NS}	N/C
	0,5	0,60±0,04*	0,53±0,06*	0,49±0,11^{NS}	0,44±0,02^{NS}	N/C
	1,0	0,58±0,05*	0,39±0,11*	0,45±0,06^{NS}	N/C	N/C

^{NS} – Averages not presenting significant differences, in the same row, according to variance analysis (test F, p≤0,05).
* - Averages presenting significant difference, in the same row, according to variance analysis (test F; p≤0,05).
$^{N/C}$ – No fruits for analysis.

In relation to phenolic compounds, fruits of 2008/2009 season stored at 7 °C presented average values between 0.071 and 5.303 mg 100 mL^{-1}, whereas for fruits stored at 21 °C, phenolic compounds ranged from 0.075 to 11.579 mg 100 mL^{-1}. There was a significant influence of treatments only at 21 °C for all storage periods, whereas for fruits stored at 7 °C the significant influence of treatments was observed only in 45 days of storage.

Mean values of phenolic compounds in fruits of cv. Folha Murcha from 2009/2010 season were between 3.675 and 13.650 mg 100 mL^{-1} at temperature of 7 °C, between 6.093 and 15.129 mg 100 mL^{-1} at 14 °C and between 8.329 and 10.332 mg 100 mL^{-1} at 21 °C. It was noted that there was significant difference between treatments of 15 days at temperature of 7 °C and 45 days at temperature of 14 °C, and no statistical difference in the remaining periods analyzed.

Results in this study differ from those found in the literature. Duzioni et al. (2010) observed values of phenolic compounds in the range of 648.6 for orange cv. 'Valencia' and 551.9 mg 100 mL^{-1} for tangerine cv. Murcott. Melo (2008) obtained results of total phenolic of 208.10 for orange cv. Pera and 146.30 g mL^{-1} for orange cv. Cravo. Couto and Canniatti-Brazaca (2010) obtained results of 78.47 mg 100 mL^{-1} for orange cv. Valencia and 21.47 mg 100 mL^{-1} for tangerine cv. Murcott.

Morais et al. (2007), in a study with sapodilla, found variation in the content of phenolic compounds in fruits treated with 1-MCP. These authors observed that content of phenolic compounds remained higher in fruits that received the application of 1-MCP when compared to the control throughout the storage period. Sales (2002) reported similar results for bananas treated with 1-MCP, with a delay in the reduction of phenolic compounds in fruits treated when compared with the control treatment.

In relation to weight loss for fruits of the 2008/2009 season, the average values were between 5.5 and 21.8% for fruits kept at temperature of 7 °C and 5.2 to 38.1% for fruit stored at 21 °C. There was difference between treatments 15 and 60 days at temperature of 7 °C and 45 and 60 days at 21 °C, trending to increase mass loss with increasing levels of 1-MCP applied. Analyzing data over storage period, the weight loss had a tendency to increase gradually, as Figure 1 shows.

For fruits from the season 2009/2010, the average values were between 3.5 and 20.9% for fruits kept at temperature of 7 °C, between 5.4 to 59.5% for fruits stored at 14 °C and 2.8 to 19.6% at 21 °C. There were significant differences between treatments for 15 days, at temperatures of 14 and 21 °C and for 30 days at 21 °C; there was no statistical difference in the remaining periods analyzed. Most of the results found in this study showed that application of 1-MCP did not significantly affect fruit weight loss, and the mass loss observed was due to storage time (Figure 1).

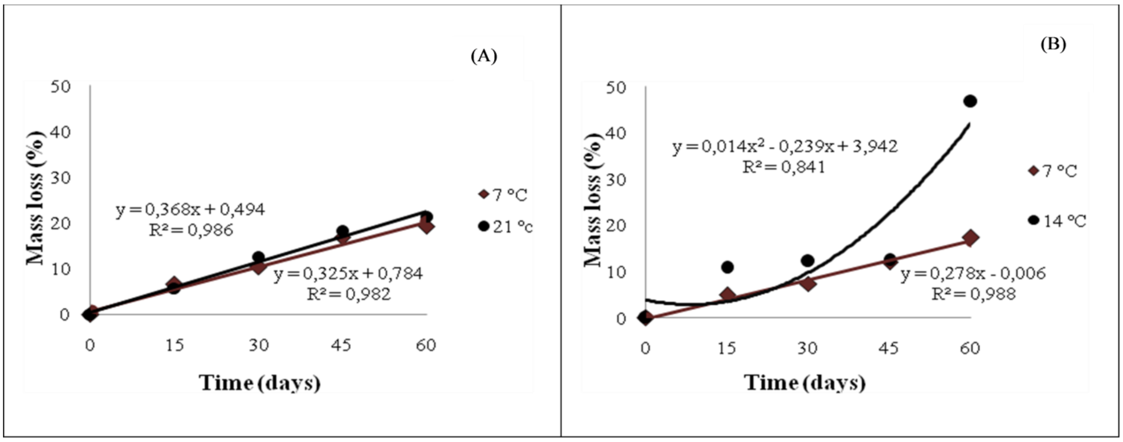

Figure 1. Weight loss along 60 days of storage for fruits of cv. Folha Murcha: (2008/2009) and (2009/2010).

Results in this study confirm those reported by Mendonça et al. (2003) who observed an increase of mass loss in lemon cv. Siciliano throughout the storage time. The authors reported the fact to transpiration as the main process involved in post-harvest losses of fresh matter. Malgarim et al (2007) found similar results in oranges cv. Navelina, with increasing mass loss during the storage period.

As to the influence of 1-MCP on the mass loss, some authors reported lower mass loss in fruits treated with 1-MCP, such as tangerines (LAAMIN et al., 2005), plums (VALERO et al. 2005), mango (LIMA et al., 2006, SILVA et al., 2004) and avocado (JEONG et al., 2002). These results differ from this present study, in which the application of 1-MCP showed no significant difference for most of the periods and temperatures analyzed.

As previously reported, in general, the application of 1-MCP did not significantly affect fruit weight loss, and the mass loss observed was due to storage time. Porat et al. (1999) also reported that mass loss in oranges treated with 1-MCP was not significant.

In relation to juice yield, fruits of the 2008/2009 season stored at 7 °C presented mean values from 49.3 to 60.6% and 53.4 to 65.4% for fruits stored at temperature of 21 °C. For fruits from this season, there was no significant difference between treatments. In the 2009/2010 season, the juice yield was between 35.4 and 48.6% for fruit kept at temperature of 7 °C, between 41.9 and 48.9% at temperature of 14 °C and between 46.1 and 48.5% at 21 °C. As occurred in the 2008/2009 season, there was no significant variation between treatments for any temperature or period studied.

4. Conclusions

- The product 1-MCP does not provide longer post-harvest conservation of fruits.
- The application of 1-MCP did not cause a change in the chemical characteristics of fruits, such as SS, TA, vitamin C, carotenoids and phenolic compounds.
- The shorter the period between harvesting and cooling, the better was the conservation of fruits.

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