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Effects of calcium chloride dip and 1-methylcyclopropene on quality changes in arils from stored pomegranates

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Abstract. The objective of this study was to determine the effect of $CaCl_2$ dips, methylcyclopropene (1-MCP), and the combination of both on quality of extracted arils of 'Wonderful' cv. pomegranates. Arils were extracted from whole fruit stored 10 weeks at 7.5ºC in air. Treatments consisted of washing arils in chlorinate water (7 ºC, 100 ppm of NaOCl) (control), dipping arils into $CaCl_2$ (10 g l^{-1}) for 2 min, treating arils with 1-MCP (1μl l^{-1}) during 24 h at 5ºC, and the combination of $CaCl_2$ dip and 1-MCP. All treatments were packaged in jars and kept in humidified air flow for up to 12 days at 5ºC. The use of $CaCl_2$ or 1-MCP helped to keep a better overall quality and firmness at the end of storage (reduced C_2H_4 and respiration rates, respectively). All treatments scored above the limit of marketability, indicating the viability of long term storage of whole pomegranate for fresh-cut produce.

Keywords. Ethylene – Fresh-cut – Quality.

I – Introduction

The fresh-cut industry needs products which can be marketed during several months. Studies on pomegranate reported it is possible to market pomegranate from early October until March (Hess-Pierce and Kader, 2003) when stored at 7.5 ºC in 5 kPa O_2 + 15 kPa CO_2. However, the arils from these whole fruits usually lose firmness with long periods of storage. In addition, when fresh-cut fruits are mixed with climacteric fruit in the same tray, ethylene (C_2H_4) emission from the climacteric fruit may accelerate the ripening process and reduce the shelf-life of this tray. Treatments like calcium dips can help maintain firmness and visual quality resulting in a longer shelf life of the fresh-cut products as melon (Aguayo *et al.*, 2008) and apple slices (Aguayo *et al.*, 2010). Methylcyclopropene (1-MCP) can also retard flesh softening. Blankenship and Dole (2003) demonstrated 1-MCP can inhibit C_2H_4 action by blocking its receptor for extended periods. However, the effect of 1-MCP on fresh-cut fruits is variable. For example, the application of this compound in fresh-cut apples decreased the ethylene production, respiration, softening, color change and synthesis of aroma compounds (Jian and Joyce, 2002; Bai *et al.*, 2004; Calderón-López *et al.*, 2005). Vilas-Boas and Kader (2007) found different responses in firmness, color and CO_2 and C_2H_4 production, depending on the timing of 1-MCP application to kiwifruit, persimmon, and mango before (whole fruits) and after cutting (slices). In addition, exposure to 1-MCP has a synergistic effect when combined with $CaCl_2$ (1% for 2 min) plus controlled atmosphere (3 kPa O_2 + 10 kPa CO_2). This combined treatment slowed down softening, deterioration rate, and microbial growth of strawberries wedges (Aguayo *et al.*, 2006).

The aim of this study was to determine the potential of using calcium dips ($CaCl_2$) or 1-MCP (1 μl l^{-1} for 24h at 5 ºC) for extending the shelf life of arils pomegranate when whole fruit is stored with long periods. The combined effects of $CaCl_2$ dips with 1-MCP were also investigated.

II – Materials and methods

1. Material, fresh-cut preparation and treatments

'Wonderful' cv. pomegranates were stored for 10 weeks at 7.5 ºC in air until they were minimally processed. The whole fruit were sorted to eliminate any defects or decay. The arils were gently removed by hand, collected in a container and washed in cool (7ºC) chlorinated water (100 ppm NaOCl) (control). For calcium dip treatment, 10 g l^{-1} of $CaCl_2$ (99% purity, Merck) was added to the water and arils were dipped during 2 min. After the dip, arils were drained in a colander and dried with cheesecloth. For 1-MCP treatments, arils washed in chlorinated water was kept in glass jars inside a container with 1μl l^{-1} of 1-MCP during 24 h at 5ºC. The combination of $CaCl_2$ plus 1-MCP was also studied. Finally, 100 g of arils pomegranate from each treatment were packaged in glass jar (0.5 l) and kept in humidified air flow (725-900 ml h^{-1}) up to 12 days at 5ºC. For each treatment, three replicates were used.

2. Evaluations

Respiration rate and C_2H_4 emission. The respiration rate and C_2H_4 emission of arils were measured daily by taking 10 ml gas samples from the headspace of each jar through a pipe silicone using a plastic syringe. The CO_2 concentrations were determined in an infrared gas chromatograph (CG) (Model PIR-2000 R, Horiba Instruments, Irvine, CA) equipped with a thermal conductivity detector, and C_2H_4 emission was measured with a CG (model 211 Carle Instruments, Anaheim, CA) equipped with a flame ionization detector.

Firmness. A deformation test was used based on the resistance of each piece to a pressure applied by a Texture analyzer instrument (Texture Technologies Corp., Stable Micro System, NY). A 25 mm diameter steel cylindrical plate deformed each aril (1 mm depth) at a speed of 2 mm s^{-1}. The firmness of 54 pieces from each treatment was measured.

Sensorial quality. Five panelists were given approximately 5 g of fresh arils. After eating, they were asked about overall quality. This parameter was rated on a scale of 1 (very poor) to 9 (excellent), with the limit of marketability being at 5 and the limit of usability at 3.

Soluble solids content (SSC). Soluble solids content (SSC) of the juice was measured with an Abbé Refractometer, model 10450 (American Optical, Buffalo, NY) and expressed as %.

3. Statistical analysis

The experiment followed a completely randomized design (n = 3). To evaluate firmness, overall quality and SSC, the mean and standard error was calculated and analysis of variance (ANOVA) and least significant difference test ($P \leq 0.05$) to compare means within each sampling date.

III – Results and discussion

In all treatments, a uniformly low respiration rate (1-2 ml CO_2 kg^{-1} h^{-1}) was found (Fig. 1). This low respiration rate could be to a long period under cool storage of the whole fruits (10 weeks). A wound response was detected in the control treatment arils, as indicated by the increase in CO_2 (5 ml CO_2 kg^{-1} h^{-1}) and C_2H_4 (350-150 nl C_2H_4 kg^{-1} h^{-1}, Fig. 2). This stress was observed during the first days, probably due to the peeling operation. At the end of storage, arils treated with 1-MCP had a slightly reduced respiration rate. In all treatments, C_2H_4 emissions were decreasing as time storage increased (Fig. 2).

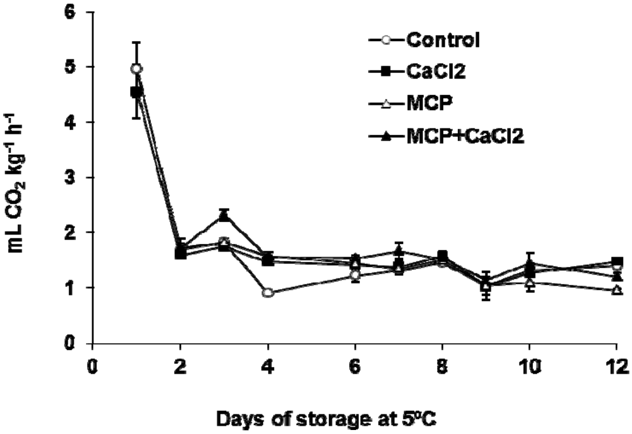

Fig. 1. **Respiration rate of arils pomegranate 'Wonderful' in air up to 12 days at 5ºC. Mean (n = 3) ± S.E.**

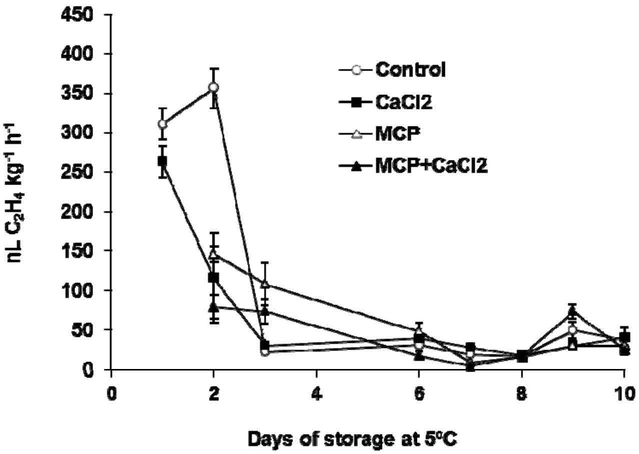

Fig. 2. **C_2H_4 emission of arils pomegranate 'Wonderful' in air up to 10 days at 5ºC. Mean (n = 3) ± S.E.**

During the peeled stress, arils dipped in $CaCl_2$ showed a lower C_2H_4 emission than control (350 nl C_2H_4 kg^{-1} h^{-1} *vs* 125 nl C_2H_4 kg^{-1} h^{-1}). Arils from 1-MCP, $CaCl_2$ and 1-MCP + $CaCl_2$ treatments kept a better firmness than control arils (Fig. 3).

However, this behavior was found only at the end of storage. Overall quality decreased at the end of storage. At day 12, arils treated with $CaCl_2$ or 1-MCP kept the best overall quality (Table 1) although all treatments were qualified above the limit of marketability. In SSC, no differences were found in any treatment (data not shown), with levels ranging from 16.6 to 17.2 °Brix. It is well known that firmness and resistance to softening can be increased by the addition of Ca, due to stabilization of the membrane systems and formation of Ca-pectates increasing the rigidity of middle lamella and cell wall and retarding the polygalacturonase activity (Poovaiah, 1986). The use of $CaCl_2$ (1%) dips reduced the initial stress from peeled arils (as indicated by C_2H_4 results).The delay of senescence often depends on the state of calcium in the tissue and when this level is increased various senescence parameters are altered (Poovaiah, 1986). Arils treated with 1-MCP (1μλ l^{-1} 24 h at 5ºC) reduced lightly the respiration rate during the last days. In this study, arils treated with $CaCl_2$ or 1-MCP kept the best overall quality and the firmness at the end of storage. These results are in agreement to other researchers who (treating with 1-MCP) found a lightly reduced respiration rate, retarded softening and provided a better overall quality in fresh-cut apples (Jian and Joyce, 2002; Bai *et al.*, 2004; Calderón-López *et al.*, 2005).

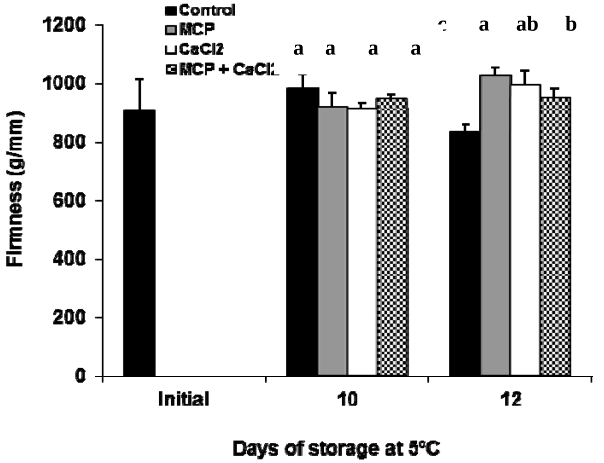

Fig. 3. Firmness of arils pomegranate 'Wonderful' in air up to 12 days at 5ºC. Mean (n = 3) ± S.E.

Table 1. Effect of 1-MCP and calcium treatment on overall quality of arils pomegranate 'Wonderful' in air up to 12 days at 5ºC

Treatment	LSD mean
Control	6.7 b
$CaCl_2$	7.6 a
1-MCP	7.2 a
$CaCl_2$ + 1-MCP	6.7 b

IV – Conclusions

$CaCl_2$ dips and 1-MCP treatments improved the firmness and market acceptability of pomegranate arils at the end of the storage life. The use of $CaCl_2$ dips is recommended rather than 1-MCP, as a lower cost-effective method of extending storage life in arils pomegranate.

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