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Original article

Effects of 1-Methylcyclopropene on postharvest quality traits, antioxidant activity and ascorbic acid content of mature-ripe mango fruits

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Summary

Introduction – **Mango (*Mangifera indica* L.) is a climacteric fruit, very sensitive to prolonged storage with a relatively short postharvest life. The aim of this study was to investigate the effects of 1-MCP treatment on the pomological and sensory traits, antioxidant capacity and ascorbic acid content in late ripening mature-ripe mango fruits submitted to a simulated shelf life at 20 °C.** *Materials and methods* – **Mango late ripening fruits (cv. Keitt) were harvested from a commercial orchard, located at Furiano, province of Messina (Sicily, Italy; 38°3'N, 14°33'E; 5 m a.s.l.). Fruits were treated with 1-MCP (0.005 kg m^{-3}) for 20 h in 1 m^3 closed containers and then stored at 20 °C and 65% RH for 3, 6, 9 and 12 days. A total number of 120 fruits were used to measure firmness, total soluble solid content, titratable acidity, skin color, antioxidant activity, ascorbic acid content and weight loss. At the end of each storage period fruits were subjected to sensory evaluation.** *Results and discussion* – **The 1-MCP treatment delayed softening, weight loss, and changes in soluble solid content, titratable acidity, antioxidant activity and ascorbic acid in mature-ripe mango fruits stored at 20 °C.** *Conclusion* – **The response of the mango fruits grown in Mediterranean conditions to a 1-MCP postharvest treatment at 20 °C was positive in terms of organoleptic fruit quality, sensory profile, antioxidant capacity, and ascorbic acid content.**

Keywords
Mediterranean region, mango, *Mangifera indica*, 1-MCP, fruit quality, physicochemical characteristics, sensory analysis

Significance of this study

What is already known on this subject?

- 1-MCP, an efficient ethylene antagonist, is largely used on some climacteric fruits, slowing ripening and increasing their shelf life.

What are the new findings?

- Mature-ripe mango fruit grown in Mediterranean area can be stored at room temperature if treated with 1-MCP during postharvest.

What is the expected impact on horticulture?

- Treatments that extend postharvest life at room temperature should give new market opportunities to small scale production units where the cold chain infrastructure is often lacking.

Résumé

Effets du 1-méthylcyclopropène sur les attributs de qualité post-récolte, l'activité anti-oxydante et la teneur en acide ascorbique des mangues mûres.

Introduction – **La mangue (*Mangifera indica* L.) est un fruit climatérique, très sensible au stockage prolongé avec une durée de vie post-récolte relativement courte. L'objectif de cette étude était d'étudier les effets d'un traitement au 1-MCP sur les attributs pomologiques et sensoriels, la capacité anti-oxydante et la teneur en acide ascorbique des fruits arrivés à pleine maturité soumis à une conservation longue durée à 20 °C.** *Matériels et méthodes* – **Des mangues (cv. Keitt) à pleine maturité ont été récoltées dans un verger commercial situé à Furiano, province de Messine (Sicile, Italie ; 38°3'N, 14°33'E ; 5 m a.s.l.). Les fruits ont été traités au 1-MCP (0,005 kg m^{-3}) pendant 20 h dans des enceintes étanches de 1 m^3, puis stockés à 20 °C et 65% d'humidité relative pendant 3, 6, 9 et 12 jours. La fermeté, la teneur totale en matières solubles, l'acidité titrable, la couleur de la peau, l'activité anti-oxydante, la teneur en acide ascorbique et la perte de poids des fruits ont été mesurés sur un nombre total de 120 fruits. À l'issue de chaque période de stockage, les fruits ont été soumis à une évaluation sensorielle.** *Résultats et discussion* – **Le traitement au 1-MCP a retardé le ramollissement, la perte de poids et les changements de teneur en matières solubles, d'acidité titrable, d'activité anti-oxydante et de teneur en acide ascorbique des fruits mûrs stockés à 20 °C.** *Conclusion* – **La réponse des mangues cultivées sous climat méditerranéen au traitement post-récolte au 1-MCP à 20 °C a été positive en termes de qualité organoleptique des fruits, de profil sensoriel, de capacité anti-oxydante et de teneur en acide ascorbique.**

Mots-clés
bassin méditerranéen, manguier, *Mangifera indica*, 1-MCP, qualité du fruit, caractères physico-chimiques, analyse sensorielle

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Introduction

Mango (*Mangifera indica* L.) is the major fruit crop in tropical and subtropical regions. Its production is reported in more than 87 countries with an estimated production of 42.0 million t year^{-1} and it is expected to increase in the next future (FAOSTAT, 2013). In the last decades mango cultivation has been moving outside the traditional geographical regions and it is now largely cultivated in the Mediterranean area, particularly in Egypt, Israel, where it has been cultivated since a long time (Elsheshetawy *et al*., 2016; Tharanathan *et al*., 2006; Homsky, 1997), in Spain, along the coast of Granada and in the Canary Islands (Galán and Farré, 2005), and in Italy, along the coastal line of the island of Sicily (Calabrese *et al*., 2005).

Mango is a climacteric fruit and there are large differences in flavor quality (sweetness, sourness, aroma) and textural quality (fiber content) among cultivars. Eventually, fruit quality is associated with ripening stage at harvest and after storage (Kader and Mitcham, 2008). Changes in fruit shape (fullness of the cheeks) and in skin color from dark-green to light-green to yellow (in some cultivars) and in flesh color, from greenish-yellow to yellow or orange, are the most commonly fruit maturity indices (Kader and Mitcham, 2008). Fruits subjected to long transportation distances are usually harvested at the mature-green stage, whereas fruits sent to local markets or air-shipped are harvested at the mature-ripe stage (Lakshminarayana *et al*., 1970; Medlicott *et al*., 1988). The ripening process in mature-green fruit takes 9–14 days (Herianus *et al*., 2003) and includes starch to sugar conversion, decreased acidity and increased carotenoids and aroma volatiles; mature-ripe fruits shortly decline within 6 days under ambient conditions (Kalra *et al*., 1995). Temperature management is the most critical factor affecting postharvest life of mangoes. The optimum storage temperature is 12–13 °C (Medlicott *et al*., 1990). Lower temperatures (8–13 °C) were used to delay ripening of mature-green fruit (Galán, 2009; Ponce de León *et al*., 1997) though mango is very sensitive to prolonged storage below 10–13 °C (Mitra and Baldwin, 1997) because of the occurrence of chilling injury. Chilling susceptibility depends on the cultivar (Farooqui *et al*., 1985) and 'Keitt' is reported to be particularly susceptible (Brecht and Yahia, 2009). Mature-ripe fruits may be stored at a wider temperature range (10–25 °C) (Brecht and Yahia, 2009; Medlicott *et al*., 1990) but they may have a short postharvest life (Pantastico *et al*., 1984; Pesis *et al*., 2000). Ethylene production is, eventually, responsible for most of postharvest losses of mangoes (Reddy and Srivastava, 1999). Therefore, to minimize these effects, the hormone production should be inhibited. 1-Methylcyclopropene (1-MCP), an efficient ethylene antagonist (Blankenship and Dole, 2003), is largely used on some climacteric fruits, slowing ripening and increasing their shelf life. Its effects can persist for a long time; the time of receptor inactivation by cyclopropenes is from 3–36 days depending on the compound, then activity is restored (Sisler *et al*., 2003).

When mature-green mango fruits were treated with 1-MCP and stored at 25 °C for 12 days (Liu *et al*., 2010) and at 20 °C for up to 15 days (Penchaiya *et al*., 2006), or 16 days (Wang *et al*., 2009), their shelf life was prolonged (Hofman *et al*., 2001). Other researchers tested the effect of 1-MCP on the antioxidant levels (Singh and Dwivedi, 2008) during fruit ripening and on the changes of their activities (Wang *et al*., 2009). However, there is a lack of information about the effect of 1-MCP on the postharvest changes of mature-ripe mango fruits stored at room temperature; at mature-ripe stage mango develops its best organoleptic traits. Research showed that mango consumer acceptability increases with the fruit ripening (Palafox-Carlos *et al*., 2013; Dick *et al*., 2009).

The aim of this study was to investigate the effects of 1-MCP treatment on the pomological characteristics, sensory traits, antioxidant capacity and ascorbic acid content of mature-ripe fruit of the late ripening 'Keitt' cultivar grown in Sicily (Mediterranean area) and stored at 20 °C. In this growing area the average temperatures hover around 17–18 °C, while the average rainfalls are close to 690.8 mm with 77 rainy days (Duro *et al*., 1996; Drago, 2005; Gianguzzi *et al*., 2016). Under the bioclimatic aspect, the station is referred to the upper thermos-Mediterranean lower subhumid bioclimatic belt (Penchaiya *et al*., 2006). No data are available on the effect of 1-MCP treatment on the postharvest life of mango fruits grown in the Mediterranean area; furthermore, the application of 1-MCP at 20 °C could be useful to save energy and avoid fruit chilling injury symptoms.

Materials and methods

Fruit treatment

Late ripening mango (cv. Keitt) fruits were harvested from a commercial orchard, located at Furiano, province of Messina (Sicily, Italy; 38°3'N, 14°33'E; 5 m a.s.l.). Fruits were hand-picked at the mature-ripe stage, suitable for the fresh fruit market using skin color as maturity index (Galán and Farré, 2005). Immediately after harvest, firmness, total soluble solid content (TSS), titratable acidity (TA) and skin color were measured on 6 replicates of 5 fruits. Fruits were placed at 20 °C and 65% RH in 1 m^3 closed containers and treated with 0.005 kg m^{-3} 1-MCP for 20 h. The 1-MCP formulation (Smartfresh, Italy), a.i. of 0.14%, was weighed into a test tube and capped. Just before treatment, 5 mL of 40 °C water was added to the test tube. The tube was immediately closed, vortexed and placed in the jar with the fruits, and opened. The 1 m^3 plastic jar was immediately sealed. Untreated mango fruits (control) were placed in 1 m^3 closed container for 20 h to simulate similar conditions.

Three replicates of 6 fruits for each treatment (untreated control and 0.005 kg m^{-3} 1-MCP) were submitted to a simulated shelf life at 20 °C, 65% RH for 3, 6, 9 and 12 days and weight loss was measured during the storage period on 10 fruits per treatment. A total number of 120 fruits ($5_{\text{fruits}} \times 3_{\text{repl.}} \times 2_{\text{treatments}} \times 4_{\text{storage periods}}$) was used after storage to measure firmness, total soluble solids content, titratable acidity, skin color, flesh decay, antioxidant activity and ascorbic acid content. At the end of each storage period (3, 6, 9 and 12 days), 5 fruits per treatment were subjected to sensory evaluation.

Quality parameters: firmness, total soluble solids, titratable acidity and weight loss

The fruits were analyzed at harvest, and every three days during the simulated shelf life period (0, 3, 6, 9, 12 days at 20 °C). Flesh firmness was measured on opposite cheeks of each fruit with a digital penetrometer (mod. 53205, Tr Turoni, Forlì, Italy) incorporating an 8 mm diameter probe, after removal of a small piece of peel. A wedge-shaped slice of flesh was taken longitudinally from each fruit and ten fruit wedges were peeled and juiced. Total soluble solids (TSS) were determined by digital refractometer (Palette PR-32, Atago Co., Ltd.) expressed in °Brix. Titratable acidity (TA) was measured by titration of 10 mL juice with 0.1 N NaOH to

pH 8.1 and expressed as % citric acid (mod. S compact titrator, Crison Instruments, Barcelona, Spain). Weight loss was measured on 10 fruits for each treatment by the difference between the initial and final weight. It was expressed as a percentage (%) using the following equation:

$$\%\text{Weight loss} = \frac{(\text{Harvest fruit weight} - \text{Final fruit weight}) \times 100}{\text{Harvest fruit weight}}$$

Antioxidant capacity

To prepare the fruit extracts, 5 g of flesh tissue from each sampling data (harvest, 3, 6, 9 and 12 days of storage) was homogenized with 5 mL of 950 mL L^{-1} cold ethanol and centrifuged at 10,000×*g* for 15 min, and a further 5 mL of 800 mL L^{-1} cold ethanol extracted the residua again. The supernatants were combined to make a final volume of 25 mL. The ethanol extract was used for analysis of the antioxidant capacity. The DPPH radical scavenging activity of the sample extract was estimated following the method of Larrauri *et al*. (1998). An aliquot (0.1 mL) of the ethanol extract was added to 2.9 mL of DPPH (120 µmol L^{-1}) in methanol. The absorbance at 517 nm was measured after the reaction mixtures were incubated for 30 min at 30 °C in the dark. A solvent containing 120 mol L^{-1} DPPH without mixing with sample solution was used as control. The result was calculated according to the following formula:

$$\%\text{DPPH radical scavenging activity} = 100 - \frac{\text{Absorbance of sample} \times 100}{\text{Absorbance of control}}$$

Ascorbic acid content

Ascorbic acid was determined by extracting 10 g of blended mango sample from each sampling data (harvest, 3, 6, 9 and 12 days of storage) in 100 mL metaphosphoric acid (HPO_3), then filtered through Whatman no. 1 filter paper. A volume of 10 mL from the filtered solution was determined volumetrically with the 2-6 dichlorophenol-indophenol reagent until a slightly pink coloration was observed and persisted for 15 s (Ranganna, 1977). The reading of ascorbic acid content was expressed in mg 100 g^{-1} fruit sample.

Skin color determination

Skin color was determined in each sampling data (harvest, 3, 6, 9 and 12 days of storage) by digital image analysis (Talluto *et al*., 2007) of five photographs per cultivar each containing six fruits**.** The digital images were analyzed using an algorithm developed with MATLAB software (The MathWorks Inc., Natick, MA, USA) that converts images from RGB to CIE 1976 L*a*b format (by lookup tables), extracts the fruit from the image (removing the image background) separates the total fruit area into two 2 sub-regions, cover color (closer to red) and ground color (closer to green) according to an adjustable green-red threshold, and quantifies color characteristics of each region as the weighed distance of each pixel in the image from pure green (ground color) or pure red (cover color). The output is a cover color index (CCI) ranging from 0 (no red) to 1 (red) and a ground color index (GCI), ranging from 0 (no green) to 1 (green). The percentage of cover color was calculated dividing the number of pixels of the red region by the number of pixels of the entire fruit area.

Ethylene determination

Three fruits (medium weight 515.0 ± 5.8 g) from each treatment were placed in individual 2,000-mL jars with a lid, which contained a septum for sampling. They were closed for 1 h at 20 °C each day during storage, then 1-mL samples were taken for ethylene determination. The samples were injected into a gas chromatograph (Agilent 7890B, CA, USA) with a flame ionization detector (FID) and a PoraPLOT Q column for ethylene determination.

Sensory analysis

At the end of the storage period 5 fruits for each treatment were subjected to sensory evaluation. The sensory profile was constructed by a semi-trained panel consisting of 10 judges that in a few preliminary meetings, by using commercial fruit, generated a list of descriptors. Sensory analysis was focused on flesh color, external appearance, flesh firmness, sweetness, juiciness, ripe aroma, off-flavor development and overall acceptance (Sivakumar *et al*., 2012). The different descriptors were quantified using a ten point intensity scale where the digit 1 indicates the descriptor absence while the digit 10 indicates the full intensity. The order of presentation was randomized between judges. Water was provided for rinsing between samples.

Statistical analysis

Data were submitted to one-way analysis of variance (ANOVA) and means were separated with Tukey's test at $P \leq 0.05$. The statistical analysis was carried out using Systat 10 (Systat, USA).

Results and discussion

Quality parameters: flesh firmness, total soluble solids, titratable acidity, weight loss

The application of 1-MCP (0.005 kg m^{-3}) significantly delayed softening of late ripening 'Keitt' mango fruit during simulated shelf life at room temperature. Mangoes treated with 1-MCP were significantly firmer than untreated ones during the whole storage period (Figure 1).

Flesh firmness of untreated mango fruits dropped drastically three days after storage, probably due to the ethylene action; untreated fruits continued to soften until they reached the over-ripe stage (< 2 N) by 9 days of storage, due to senescence (Figure 1). Fruit firmness after 3, 6, 9, 12 days of storage was 27%–22%, 51%–29%, 79%–46% and 84%–72% lower than at harvest, respectively for untreated and 1-MCP treated fruits (Figure 1). After 9 days of storage, the fruits treated with 1-MCP were more than two-folds firmer than untreated ones and still marketable, indicating the fruit ripening process was delayed by 1-MCP action as other authors reported on 'Kensington Pride' (Hofman *et al*., 2001).

Our data demonstrated that 1-MCP could be useful in terms of firmness retention on late ripening 'Keitt' mango fruits. The treatment was effective in terms of delaying ripening and senescence of mature-ripe 'Keitt' mango fruits; indeed, 1-MCP delayed softening of mango fruit due to the 1-MCP inhibition action on ethylene (Mattheis *et al*., 2003). Our data confirm the effectiveness of 1-MCP treatment on delaying softening and increasing the shelf life of mature-ripe mango fruits grown in a Mediterranean area in similar ways as mangoes from different growing areas (Sisler *et al*., 2003).

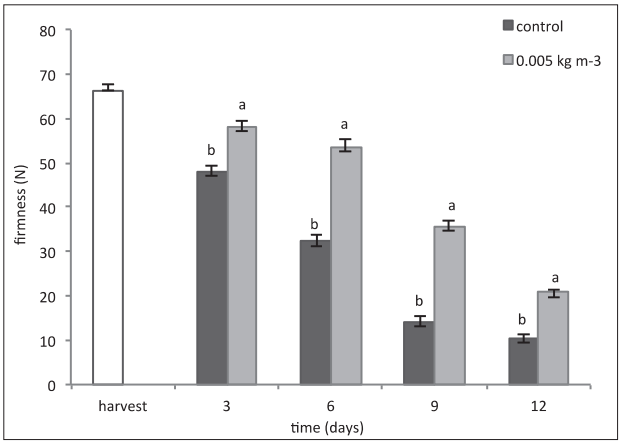

Figure 1. Effect of 1-MCP treatment (0.005 kg m^{-3}) on the firmness of mango fruits (*Mangifera indica* L. cv. Keitt) during storage at 20 °C (65% RH) for 12 days. Data are means ± S.E. (n = 15). Column values marked with different letters are significantly different (Tukey's test at $P \leq 0.05$).

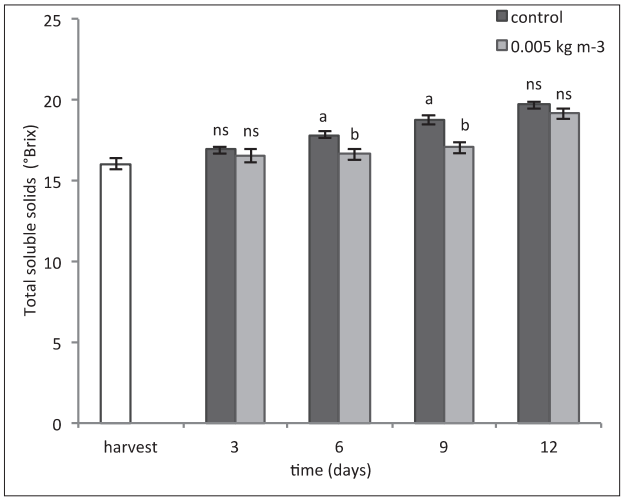

Figure 2. Effect of 1-MCP treatment (0.005 kg m^{-3}) on the total soluble solid content of mango (cv. Keitt) fruits during storage at 20 °C (65% RH) for 12 days. Data are means ± S.E. (n = 15). Column values marked with different letters are significantly different (Tukey's test at $P \leq 0.05$).

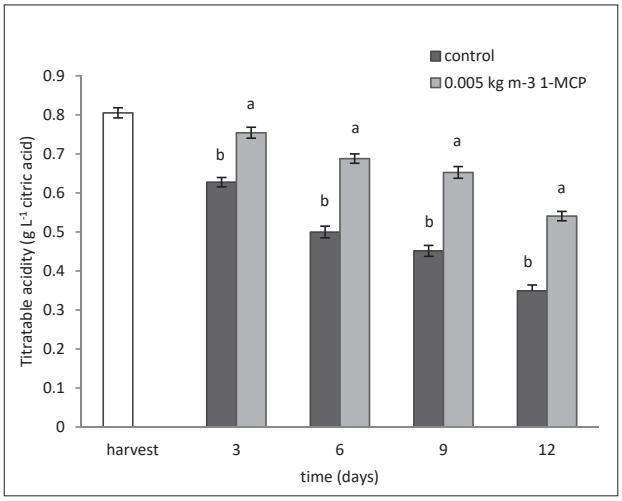

Figure 3. Effect of 1-MCP treatment (0.005 kg m^{-3}) on the titratable acidity of mango (cv. Keitt) fruits during storage at 20 °C (65% RH) for 12 days. Data are means ± S.E. (n = 15). Column values marked with different letters are significantly different (Tukey's test at $P \leq 0.05$).

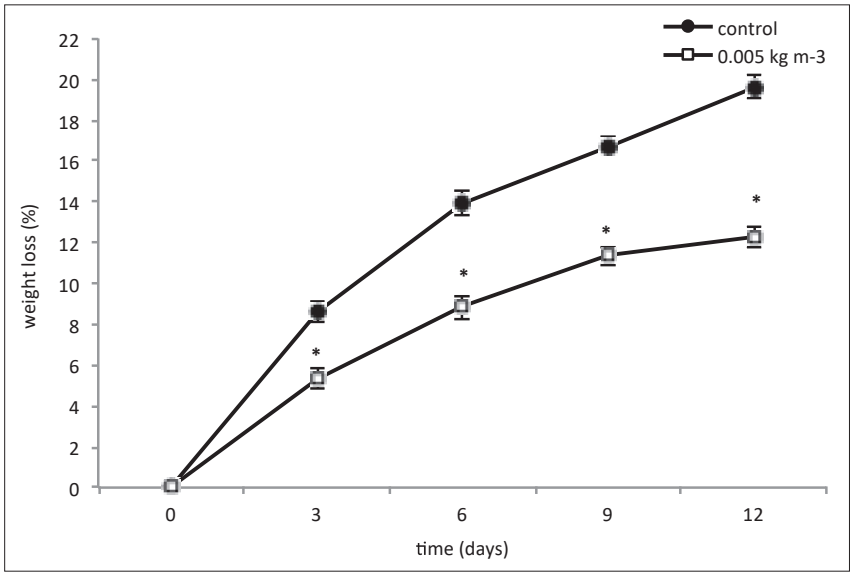

Figure 4. Effect of the 1-MCP treatment (0.005 kg m^{-3}) on the weight loss of mango (cv. Keitt) fruits during storage at 20 °C (65% RH) for 12 days. Data are means ± S.E (n = 15). * indicates significant differences for values ($P < 0.05$).

The total soluble solid (TSS) content in the fruits treated with 1-MCP changed only after 12 days of storage, when it was 10% higher than at harvest time. The TSS content was significantly lower in the fruits treated with 1-MCP than in the untreated ones, 6 and 9 days after storage. At the end of the shelf life, TSS content in untreated fruits was almost 20% higher than at harvest time (Figure 2), indicating that the fruit ripening process was delayed by 1-MCP. Otherwise, Alves *et al.* (2004) found that there were no significant delays of TSS accumulation in 'Tommy Atkins' mangoes harvested at two maturity stages and treated with 1-MCP. This different behavior was probably due to the different response or sensitivity to 1-MCP treatment (Blankenship and Dole, 2003). The TA decreased during the storage period and mango fruits treated with 1-MCP had the highest TA during the whole storage period. TA after 3, 6, 9, 12 days of storage was 6%–22%, 15%–38%, 20%–44% and 30%–57% lower than at harvest, respectively for 1-MCP treated and untreated fruits (Figure 3). Previous studies reported that TTS and TA of mango did not change significantly after 1-MCP treatment (Sisler *et al*., 2003; Wang *et al*., 2006), probably because fruits in these studies were harvested at a green-ripe ripening stage.

Both 1-MCP treated and untreated fruits showed a continuous and large weight loss during shelf life at 20 °C and 75% RH. However, the application of 1-MCP significantly reduced weight loss during the whole storage period (Figure 4).

Antioxidant capacity

The antioxidant capacity decreased during the shelf life at 20 °C. However, the application of 1-MCP significantly improved the retention of antioxidant capacity in treated mango fruits (Figure 5) as reported in previous research (Sivakumar *et al*., 2012). At the end of the storage period, the antioxidant capacity was 30% lower than at harvest time in untreated fruits and 15% lower in fruits treated with 1-MCP (Figure 5).

Antioxidant capacity or scavenging activity is a desirable attribute for marketing the potential health benefits of fresh fruit and vegetables (Sivakumar *et al*., 2012). Cocozza *et al.* (2004) reported that higher ascorbic acid was recorded in 1-MCP-treated 'Tommy Atkins' mangoes compared to the control, what was probably due to a larger accumulation of glucose through the reduction of respiration rate by 1-MCP, thus favoring vitamin C synthesis (Cocozza *et al*., 2004).

Ascorbic acid content

Ascorbic acid content halved in untreated fruits during the simulated shelf life at 20 °C, while 1-MCP application showed an inhibitory effect on the decline (limited to 20%) of ascorbic content during storage (Figure 6). Ascorbic acid content was significantly higher in mangos treated with 1-MCP than in untreated ones, during the whole storage period (Figure 6).

Skin color determination

Skin color is a major determinant of consumer appeal for mangos. As observed by Jacobi *et al.* (1995), when mangoes were kept at 20 °C, the fruits changed their color very quickly from green to green-yellow and to yellow-red during a few days after harvest. Green-mature fruits reached their best color characteristics after 4–8 days of storage at 20 °C (Talluto *et al*., 2007; Sivakumar *et al*., 2012) and after 2–6 days at 22 °C (Jacobi *et al*., 1995). Our data showed that in both treated and untreated fruits GCI increased during fruit simulated shelf life due to the color change resulting from the gradual degradation of chlorophyll and the carotenoids synthesis (Medlicott *et al*., 1986). Hence, the 1-MCP treatment did not influence the color evolution and the fruit reached the definitive values of GCI after 9 days of storage (Figure 7). Also the CCI values increased during storage with a rapid intensification of red color during the first six days (Figure 8) as observed by Nunes *et al.* (2007). At the same time, we observed an increase of CC percentage during the simulated shelf life in treated and untreated fruits. This enlargement of colored skin surface was faster from the 6th to 9th day after storage (Figure 9). Treated and control fruits did not differ significantly. After 12 days at 20 °C, the skin of 'Keitt' mango fruit was almost full yellow-reddish colored, while it took approximately 9 days to reach the best quality to be sold more easily (Saks *et al*., 1999). Overall, the 1-MCP treatment did not influence the color changes during fruit storage.

The non-effectiveness of 1-MCP treatment on mango color change is positive, because to be successfully marketed, the mango fruit needs to be predominantly yellow-red when taken from storage. Commercial buyers of mango, indeed, use skin color as an indicator of the remaining postharvest life of stored fruit whereas consumers use skin color as an indicator of the ready-to-eat ripeness stage.

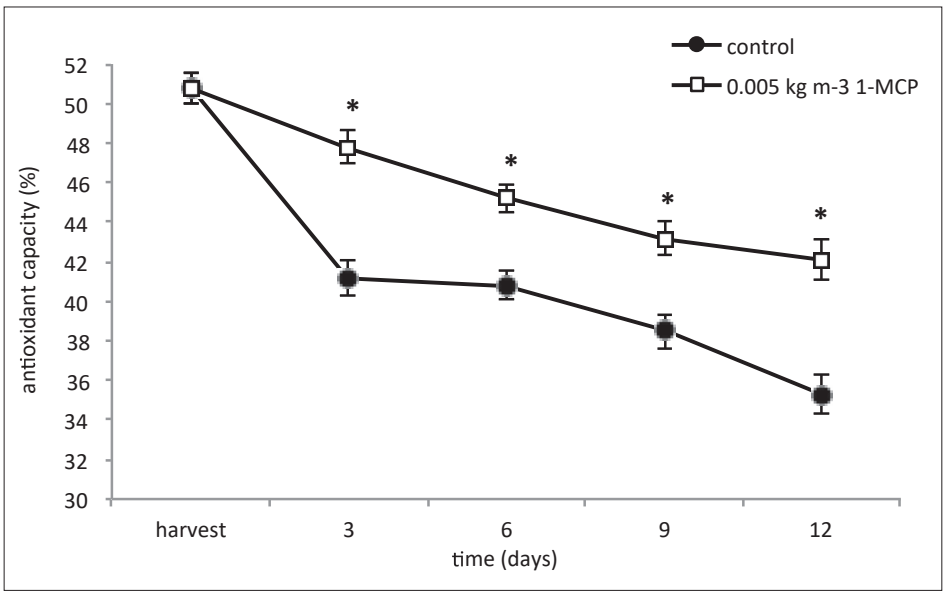

Figure 5. Changes in antioxidant capacity of untreated and 1-MCP (0.005 kg m^{-3}) treated mango (cv. Keitt) fruits during 12 days of storage at 20 °C (65% RH). Data are means ± S.E (n = 15). * indicates significant differences for values (P < 0.05).

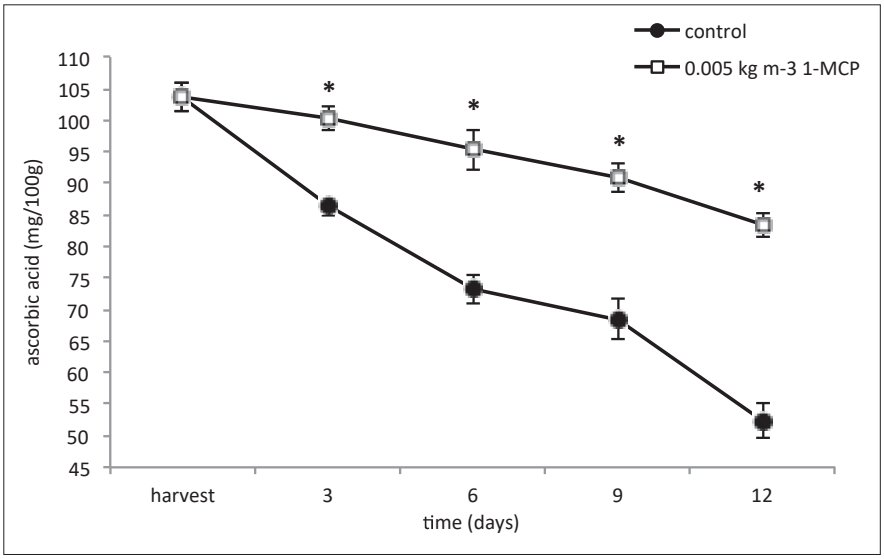

Figure 6. Changes in ascorbic acid content of untreated and 1-MCP (0.005 kg m^{-3}) treated mango (cv. Keitt) fruits during 12 days of storage at 20 °C (65% RH). Data are means ± S.E (n = 15). * indicates significant differences for values (P < 0.05).

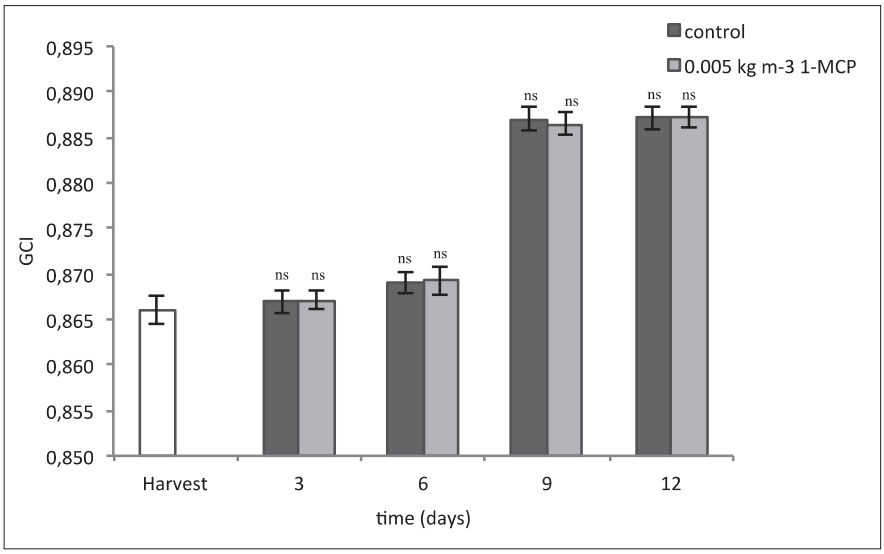

Figure 7. Ground color index (GCI) evolution of untreated and 1-MCP (0.005 kg m^{-3}) treated mango (cv. Keitt) fruits stored at 20 °C (65% RH) for 12 days. Data are means ± S.E. (n = 15). ns = not significant differences (Tukey's test).

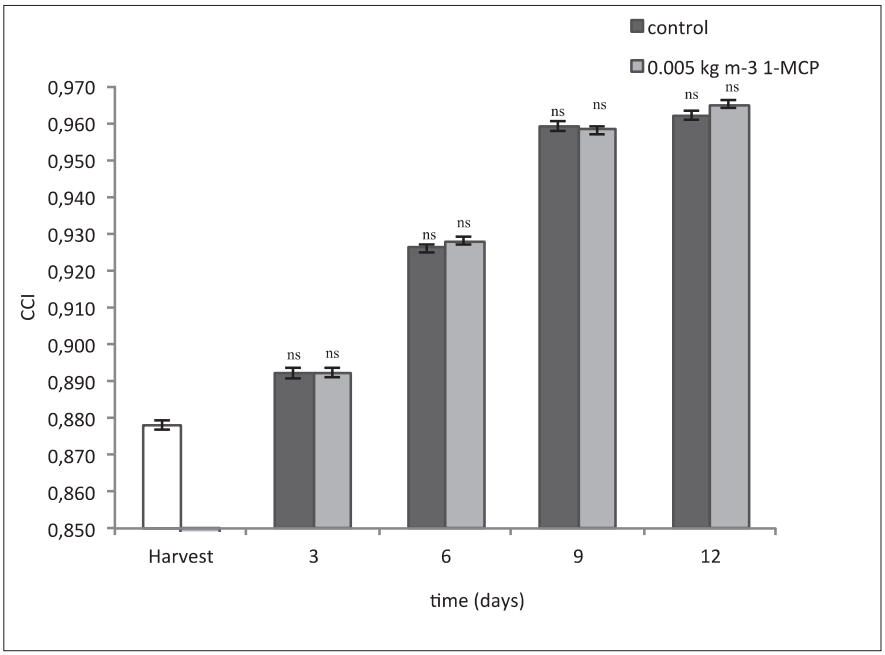

Figure 8. Cover color index (CCI) evolution of untreated and 1-MCP (0.005 kg m^{-3}) treated mango (cv. Keitt) fruits stored at 20 °C (65% RH) for 12 days. Data are means ± S.E (n = 15). ns = not significant differences (Tukey's test).

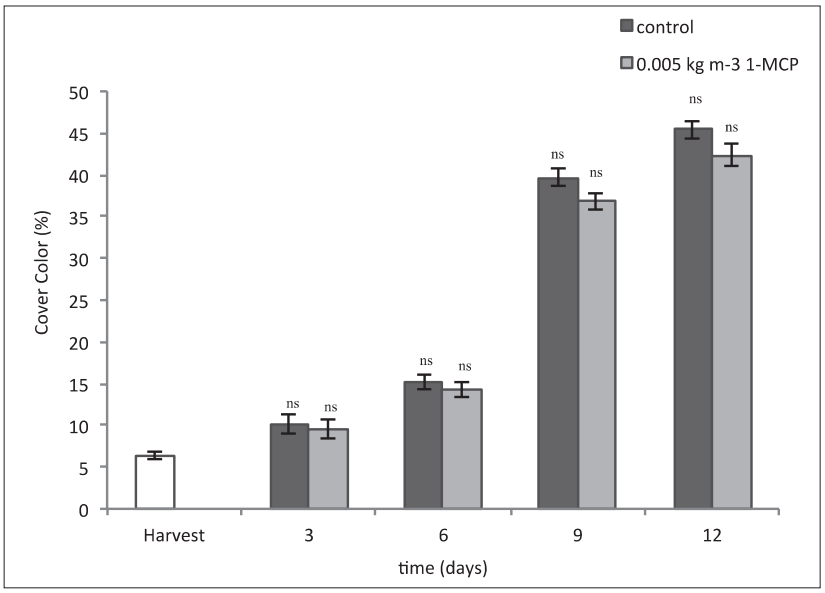

Figure 9. Cover color percentage (%) evolution of untreated and 1-MCP (0.005 kg m^{-3}) treated mango (cv. Keitt) fruits stored at 20 °C (65% RH) for 12 days. Data are means ± S.E. (n=15). ns=not significant differences (Tukey's test).

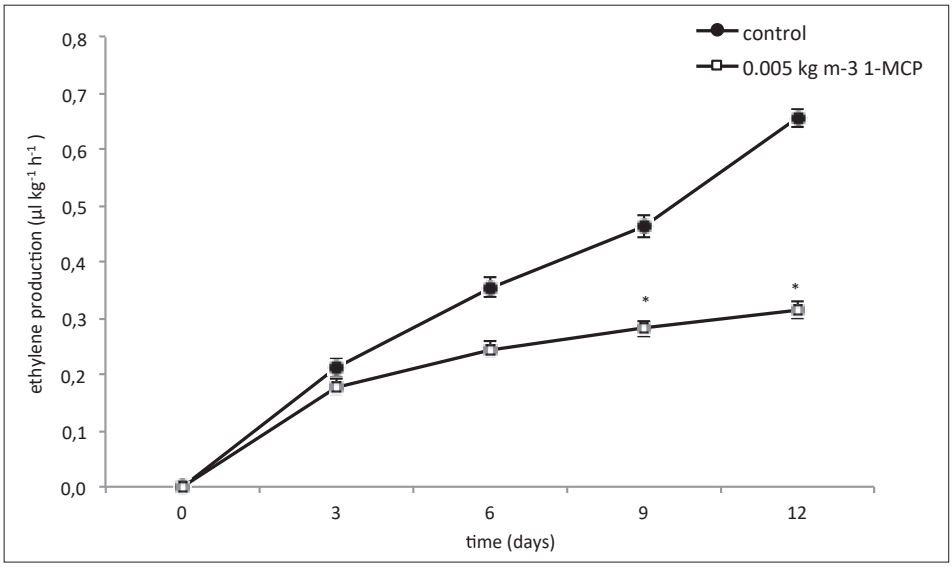

Figure 10. Ethylene production of untreated and 1-MCP (0.005 kg m^{-3}) treated mango (cv. Keitt) fruits stored at 20 °C (65% RH) for 12 days. Data are means ± S.E. (n = 3). * indicates significant differences for values (P < 0.05).

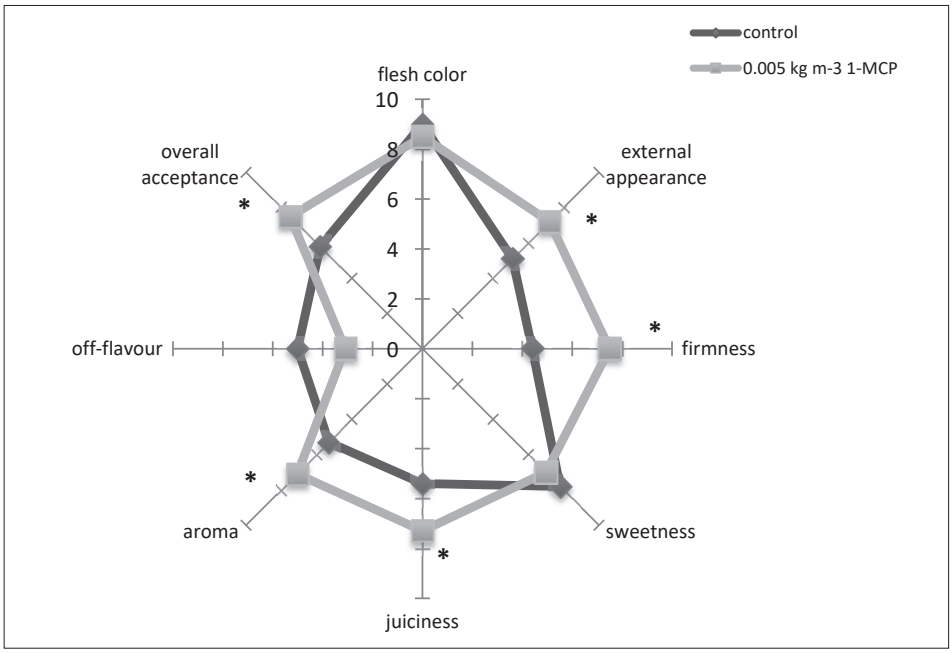

Figure 11. Sensory analysis of mango (*Mangifera indica* L. cv. Keitt) untreated and 0.005 kg m^{-3} 1-MCP treated fruits stored at 20 °C (65% RH) for 12 days. Data are mean values (n = 5) for each treatment. * indicates significant differences for values (P < 0.05).

Ethylene determinations

Untreated mango fruits showed a steady ethylene increase during the 12 days at 20 °C. Untreated mango fruits produced a high amount of ethylene after 9 days, while 1-MCP mango treated fruits produced less ethylene until the end of storage (Figure 10).

Sensory analysis

The panelists indicated highest values of firmness, juiciness, aroma and external appearance of mangoes treated with in 1-MCP, tested 12 days after storage (Figure 11). The overall acceptance was higher for 1-MCP treated mangoes and indicated that the panelists preferred firmer but juicy fruit, with less off-flavor and acceptable sweetness.

Conclusion

The positive response of the fruit to the ethylene action inhibitor at room temperature (20 °C) allowed the fruit to be treated during postharvest storage, maintaining organoleptic fruit quality, sensory profile, antioxidant capacity, ascorbic acid content and avoiding chilling injuries due to cold storage temperature. Thus, the application of 1-MCP (0.005 kg m^{-3}) during storage can extend the shelf life of mango fruit at ambient temperature. Treatments that extend postharvest life at ambient temperature are configurable as low-cost and low-energy storage system, hence are interesting in view of the current energy crisis, for small scale (family) farming or in some developing countries where the cold chain infrastructure is often lacking. Further research is needed to understand the possibility to extend the treatment with 1-MCP at 20 °C to other cultivars of mango grown in Mediterranean conditions.

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