EFFECT OF 1-METHYLCYCLOPROPENE (1-MCP) AND HOT WATER TREATMENT ON THE PHYSIOLOGY AND QUALITY OF ‘KEITT’ MANGOS

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ABSTRACT

The objective of this study was to evaluate the effect of 1-MCP (0 y 300 nl-liter-1) and different levels of hot water treatment (0, 52 °C for 5 min and 46 °C for 110 min) on the physiology and quality of ‘keitt’ cultivar mangos. The respiration rate, weight loss, firmness, pulp color, total soluble solids and diseased fruits were analyzed. The 1-MCP effect changed with the hot water treatment. In fruits without hot water treatment, 1-MCP decreased respiration rate; it did not affect weight loss; it maintained four folds the fruit firmness and delayed pulp color change and total soluble solids increase. However, in the 5 min hot water treatment, 1-MCP augmented the respiration rate; it did not affect weight loss and kept twice the fruit firmness while slowing down pulp color change and total soluble solids enhancing. The hot water treatment for 110 min significantly affected the effectiveness of 1-MCP to maintain firmness and avoid weight loss. The 1-MCP did not show any effect on controlling diseases, but the hot water treatment for 5 min reduced more than fifty percent the number of diseased fruits. Finally, it was observed that 1-MCP in combination with hot water treatment for 5 min extended the shelf life for five additional days and may be a good alternative for markets not requiring quarantine hot water treatment.

ADDITIONAL KEY WORDS: Mangifera indica L., respiration rate, weight loss, firmness, pulp color.

INTRODUCTION

The European Union and Japan require large amounts of Mexican mango, however, only exported 7.500 tonnes representing less than 1% of total exported (SAGARPA, 2006). Under current management, the export is by air (at a cost of 6 to $ 8 per box). By sea freight cost is reduced without However, past experiences have proved disappointing by high risks in the market, since it requires 20 to 24 days of shipment and the fruit arrives in advanced maturity, having only three to four days market, causing difficulties in marketing and high losses in terminal market.

The use of 1-methylcyclopropene (1-MCP) is a alternative to solve this problem and delaying maturation, maintains the quality of climacteric fruit and has the greatest effect on cultivars that produce high and medium concentrations of ethylene (Dong et al., 2002). The 1-MCP works by blocking the ethylene binding to its receptor the cell and prevents it from triggering the series of reactions that lead to the maturation process, such as
decrease in tissue firmness, decay cell wall, degradation of pigments, cleavage starch to soluble sugars, etc. (Sisler and Serek, 1997 and 1999, Blankenship 2001).

In Nayarit, the effect of 1-MCP has been studied in four varieties of mangoes for export. It has observed that 1-MCP delays ripening to reduce the loss of firmness and weight and delay increased total soluble solids and the development of flesh color, particularly in Kent and varieties Keitt (Osuna and Beltran, 2004, Osuna et al., 2005). However, interest still further in response of these varieties under different requirements hydrothermal treatment, as some countries like United States and Japan require quarantine treatment (46.1 °C for 75 to 110 min, depending on size of fruit) and others such as Europe and Canada are not required but if fruit treated with hot water at 52 °C for 5 to 15 min to prevent damage by anthracnose. As previously mentioned, the purpose of his study was to evaluate the effect of 1-MCP under different levels of hydrothermal treatment on the physiology and fruit quality of mango 'Keitt'.

Mango fruits were used 'Keitt' harvested physiological maturity with an initial value of soluble solids of 7.4 °Bx, from packaging and NATURAMEX Cruise, located in the city of Tepic, Nayarit. The fruits were subjected to hydrothermal treatment (0, 5 and 110 min) and 1-MCP application (0 and 300 nl / liter-1). The hydrothermal treatment was applied for 5 min at 52 °C to prevent damage by anthracnose (Spalding y Reeder, 1986); while the 110 min treatment with hot water 46.1 °C was recommended for the control of larvae fruit flies in fruits greater than 700 g (Báez et al. 1998). The application of 1-MCP after treatment Hydrothermal was performed for 12 h at 13 ± 2 °C and 85 ± 10% HR using specially designed to release tablets 300 nl L-1 of 1-MCP in a sealed plastic frame with dimensions of 135 X 163 X 183 cm for a volume 4 m3. The three tablets were dissolved in a vial with 18 ml of activator solution composed of citric acid (8 %), Sodium citrate (2%) and water (90%) and one tablet activator with sodium bicarbonate (95%), polyethylene glycol (3%) and hydroxypropyl cellulose ether (2%). After previous treatments, the fruits were stored in fourth refrigerated for 20 days at 13 ± 2 °C and 85 ± 10% RH for simulate maritime container transport, then transfer to simulate marketing conditions (22 ± 2 °C and 70 ± 10% RH) to reach ripeness.

The variables studied were: respiration rate, weight loss, firmness, pulp color, soluble solids total and percentage of diseased fruits. Speed breathing (VR) was measured using the technique reported by Tovar et al. (2001), for it led to three fruits per treatment which were placed in water resistant containers for two hours and then took 1 ml of headspace and analyzed using a gas Chromatograph HP brand 6890 model equipped with a thermal conductivity detector sensitive to CO2, an HP-Plot Q column 15 m X 0.53 i mm and 40 m in thickness, the injection temperature and the detector was 250 °C, nitrogen gas was used as carrier at a rate of 7 ml · min-1, plus hydrogen and air at a rate of 30 to 400 ml · min-1, respectively. The oven temperature was a ramp starting at 50 °C and reaching 80 °C at a rate 30 °C · min-1 expressing the results in · ml · kg-1 h-1. The weight loss was measured using a digital portable scale with a capacity of 2.000 g nearest 0.1 g (Ohaus Corp. Florham Park, NJ), for which 20 fruits were used were weighed periodically during the whole stage evaluation, the difference in weight and its relationship to initial weight was expressed as a percentage weight loss. Firmness was evaluated using a Chatillon penetrometer Model DFE-050 (Ametek Instruments, Largo, FL), adapted cylindrical punch 6 mm in diameter. In each fruit longitudinal cut was made at the equator of approximately 0.5 cm to remove the shell and was a measurement on each side of the fruit, the data were expressed in Newtons (N). The flesh color was measured with a colorimeter Minolta CR-300, and values are reported as hue. Total soluble solids (TSS) determined in 5 g of homogenized pulp by Atago digital refractometer PAL-1 (Atago USA INC.
Bellevue WA) with temperature correction (AOAC, 1984). Fruits patients were evaluated at the end of the same marketing fruits were used for weight loss and their values expressed as a percentage.

Data were analyzed with a factorial design 23 with twelve repetitions considering a result as the experimental unit. The weight loss variable was analyzed using nonparametric statistics while the firmness flesh color and total soluble solids velocity respiration were analyzed with general linear model (GLM) SAS (SAS, 1998).

RESULTS AND DISCUSSION

Respiration rate (VR)

The VR remained low during conditions of cooling in all treatments, and then increased when fruit were transferred to room environment (Figure 1). The capacity of succinate oxidation of mitochondria isolated from mango 'Amelie' stored at 12 º C for 25 days showed a maximum at 10 days and then decreased but was significantly lower than that seen at 10 days in mangoes stored at 20 º C (Kane et al., 1978). Thus, the VR was reduced and this could explain the lower VR observed in fruits stored for 20 days at 13 º C in this experiment. It is well established that low temperatures stimulate autocatalytic ethylene production (Lelievre et al., 1995) although in the laboratory could not detect ethylene, to transfer the fruit to room temperature VR significantly increased in all treatments, possibly induced autocatalytic ethylene. This behavior was also reported by Saucedo et al. (1977) in mango 'Kent' refrigerated at 13 º C and 85-90% RH for 23 days and then transferred to 25 º C. In the fruits treated with 1-MCP and without hydrothermal (300-0), the VR was lower than in the control (no hydrothermal and without 1-MCP, 0-0, Figure 1A), the same is observed in those fruits with 1-MCP and hydrothermal by 110 min (300-110, Figure 1C) compared with the control. However, the VR was equal to or slightly higher in fruits 1-MCP-treated and 5 min of hydrothermal treatment (Figure 1B). This increase in VR in these fruits could due to the temperature to prevent anthracnose is 52 º C and quarantine treatment is 46.1 º C enzyme activity was observed consistently upper respiratory metabolism but the fruits are treated with 1-MCP. This coincided with those reported by Mei-Jiao et al. (2005) and they found that the combination of hot water and 1-MCP extended the shelf life and reduced anthracnose in mango fruit but there were increases in breathing. These results agree with those reported by several authors for varieties Nahm-dawg-mai-sri-tong, and Nam Dokmai (Chaiprasart and Hansawasdi, 2006; Penchaiya et al., 2006). On the other hand, Nyanjage et al. (1999) found that mango peel 'Tommy Atkins' submerged in water heated to 46.5 º C 120 min had significantly greater leakage electrolytes compared with the control. If this happens in handle 'Keitt' hydrothermal treatment for 110 min internal CO2 could be more easily and this would explain because the fruit treated with this therapy but without 1 -MCP had a higher VR than those treated with 1-MCP, in which due to the effect of the latter is VR decreased (Mitcham and McDonald, 1993). This Thus, the increased VR in fruits treated hydrothermal depend on weather conditions and temperature and damage suffered by the rind of the fruit.

Weight loss

The cumulative weight loss in fruits without Hydrothermal was 10.8% (Figure 2A), and it was statistically different from that found in fruits hydrothermal treatment for 5 min (Figure 2B) which was 12.3% and fruit by treatment hot water for 110 min and with 1-MCP (Figure 2C) with 12.8 %, Which is the greater loss. This behavior could be due to the negative effect treatment hot water in the fruit as it can cause an increase in transpiration due to rupture of cells and destruction of the mesocarp (Jacobi and Gowanlock, 1995; Nyanjage et al., 1999). On
the other hand, we observed that 1-MCP did not influence the behavior of this variable the fruits without hydrothermal treatment (Figure 2A) and treated for 5 min (Figure 2B), but increased the loss weight of fruit with 110 min (Figure 2C), which could mostly due to the effect of treatment itself hydrothermal since several authors report that 1-MCP decreases or remains unchanged weight loss of fruits mango (Osuna et al., 2005, Silva et al., 2004).

**Firmness**

The 1-MCP significantly influenced maintenance of fruit firmness in untreated hydrothermal and in those treated for 5 min but had no significant effect on fruit treated by 110 min (Figure 3). In fruits with 1-MCP and untreated hydrothermal (300-0) noted the greater efficiency of 1-MCP maintain firmness, especially during the 20 days of refrigeration since the end of this fruit Witness (0-0) lost 89.3% of their initial firmness while those treated with 1-MCP lost only 23.8% (Figure 3A). For the conditions of 5 min of treatment hydrothermal (Figure 3B), the efficiency of 1-MCP decreased but was considered significant in relation to control fruits (0-5) as they lost 88.3% of Firmness and treated with 1-MCP (300-5) 44.2%. These results are consistent with those reported by several authors who state that one of the key attributes of 1-MCP is to maintain the firmness of fruits mango (Chaiprasart and Hansawasdi, 2006; Penchaiya et al. 2006, Osuna et al., 2005). On the other hand, Qiuping and Wenshui (2007) reported that 1-MCP markedly reduced polygalacturonase activity (PG) in Jujube fruit India stored at 21 °C and remained firmly high for seven days. These authors confirm that the decrease firmness is one of the processes most sensitive to ethylene and that the accumulation of PG mRNA is regulated by the ethylene and 1-MCP delayed the production rate of ethylene, inhibited the expression of PG and therefore also the loss of firmness. With regard to little or no response 1-MCP on fruit with hot water treatment for 110 min (Figure 3C), this could be due to the effect of the prolonged hydrothermal treatment, which can cause a decrease in the activity of pectinesterase and significant increase in beta-galactosidase as report Kets et al. (1998) in mango 'Nam Dokmai' treaty 38 °C for three days in a chamber with temperature controlled and then stored at 25 °C with respect to untreated mango. Also this is coupled with the breakdown of mesocarp cells and caused destruction of tissue by prolonged hydrothermal treatment (Jacobi and Gowanlock, 1995). These data suggest that 1-MCP is a viable technology to extend the shelf life of fruits handle that could be marketed in national (and that does not require hot water treatment) and for those exported to Canada or the European Union where hydrothermal treatment does not require quarantine.

**Flesh color (h)**

The 1-MCP significantly affect the evolution of flesh color in fruits without hydrothermal treatment and those treated for 5 min but not in those treated by 110 min (Figure 4). In fruit without hydrothermal treatment (300-0) and those treated for 5 min (300-5), 1-MCP delayed color change from yellow-green pulp to amarillonaranja compared with the control (0-0) (Figures 4A and 4B), without But at the end of storage were not detected differences between different treatments with 1-MCP and witnesses, indicating that synthesis was affected carotenoids effect of 1-MCP. Chaiprasart and Hansawasdi, (2006) in mango Nahm-dawg-mai-sri-tong and Penchaiya et al. (2006) in mango mention Dokmai Nam that 1-MCP delayed the development of flesh color. With on the fruits without 1-MCP and hydrothermal for 110 min and fruit with 1-MCP and hydrothermal (0-110 and 300-110, respectively) there were no significant differences in hue angle (h) during the first five days after being
transferred to room temperature, possibly was caused by hydrothermal treatment accelerates of maturation as the day the firm is 20 0 significantly decreased (Figure 3C) and therefore accelerates the synthesis of carotenoids.

**Total Soluble Solids (TSS)**

With regard to the development of SST, 1-MCP only alter its content in fruits without hot water treatment (300-0) as lower mean values were observed with compared with the control (0-0), but at the end of storage There were no significant differences in this parameter (Figure 5A). In this regard, Blankenship and Dole (2003) note that 1-MCP may increase, reduce or leave unchanged the development of SST based on the species. Osuna et al. (2005) reported that mango 'Kent' treated for 15 min with hot water, 1-MCP delayed the development of TSS while Silva et al. (2004) mention that 1-MCP unchanged development of TSS in Rosa varieties and Sword. With respect to fruit treated with hot water for 5 or 110 min with and without 1-MCP (Figures 5B and 5C), the evolution of the SST was statistically unchanged during storage, this meant that the increase in soluble solids in these fruit was mainly the effect of treatment hydrothermal and not the 1-MCP.

**Presence of disease**

Figure 6 shows the percentage of fruit patients in response to application of 1-MCP and hydrothermal. It was evident that 1-MCP had no effect on the percentage of infected fruit being equal or superior to the untreated control, confirming that 1-MCP no fungicide and in some cases increases damage, as indicated by Hofman et al., (2001) in mango 'Kensington Pride'. However, Osuna and Beltran (2004) state that the 1-MCP slowed damage anthracnose in mango 'Kent', which is possibly due to a decrease in respiration rate and ethylene production and not strictly an action fungal 1-MCP. However, it was obvious the effect benefit from treatment with hot water at 52 °C for 5 min that declined over 50% the presence of fruits patients (Spalding and Reeder, 1986). In addition, these results coincide with those expressed by Mei-Jiao et al. (2005), who indicate that 1-MCP alone did not control anthracnose but that the combination of 1-MCP with water Hot resulted in good control of the disease and more shelf life.

**CONCLUSIONS**

In nuts, the effect of hydrothermal treatment 1-MCP was evident by delaying the ripening process. Under conditions of hydrothermal treatment for 5 min, 1-MCP reduced its effectiveness, but still managed to delay the ripening of fruits and effectiveness of 1-MCP was significantly affected by hydrothermal treatment 110 min, especially for variable firmness pulp and weight loss. The 1-MCP had no effect on the presence disease, however, water treatment heated for 5 min decreased by more than 50% the presence of diseased fruits. The 1-MCP in combination with treatment 5 min hydrothermal lengthened to five days in the life of mango shelf 'Keitt' and could be a viable alternative for markets that do not require treatment hydrothermal quarantine to control fly fruit.
LITERATURE CITED


MITCHAM, E. J.; McDONALD, R. E. 1993. Respiration rate, internal atmosphere, and ethanol and acetaldehyde accumulation in heat-treated mango fruit. Postharvest Biology and Technology 3: 77-86.


QIUPING, Z.; WENSHUI, X. 2007. Effect of 1-methylcyclopropene and/or chitosan coating treatments on storage life and quality maintenance of Indian jujube fruit. LWT-Food Science and Technology. 40: 404-411.


FIGURE 1. Respiration rate of mango fruits 'Keitt' in response to the application of 1-MCP and hydrothermal simulation for maritime transport (20 days 13 ± 2 °C and 85 10% RH) and then stored at temperature (22 ± 2 °C and 70 ± 10% RH) until maturity consumption. Each point represents the mean of three observations ± standard error.
FIGURE 2. Weight loss mango 'Keitt' in response to the application of 1-MCP and hydrothermal simulation for maritime transport (20 days $13 \pm 2 \, ^\circ\text{C}$ and $85 \pm 10\% \text{RH}$) and then stored at temperature ($22 \pm 2 \, ^\circ\text{C}$ and $70 \pm 10\% \text{RH}$) until maturity consumption. Each point represents the mean of twelve observations ± standard error.
FIGURE 3. Mango fruit firmness 'Keitt' in response to 1-MCP application and hydrothermal during maritime transport simulation (20 days at 13 ± 2 ºC and 85 ± 10% RH) and then stored at ambient (22 ± 2 ºC and 70 ± 10% RH) until ripe. Each point represents the mean of twelve observations ± standard error.
FIGURE 4. Colour mango pulp 'Keitt' in response the application of 1-MCP and hydrothermal during maritime transport simulation (20 days at 13 ± 2 °C and 85 ± 10% RH) and then stored at ambient (22 ± 2 °C and 70 ± 10% RH) until ripe. Each point represents the mean of twelve observations ± standard error.
FIGURE 5. Evolution of total soluble solids of fruits Mango 'Keitt' in response to the application of 1-MCP and hydrothermal during transfer simulation Maritime (20 days at 13 ± 2 °C and 85 10% RH) and then stored at temperature (22 ± 2 °C and 70 ± 10% RH) until ripe. Each point represents the mean of twelve observations ± standard error.
Diseased fruits (%) Nesquen to the end of storage (20 days at 13 ± 2 °C and 85 ± 10% RH) and then stored at ambient (22 ± 2 °C and 70 ± 10% RH).

FIGURE 6. Presence of diseased fruits Mango 'Keitt' at the end of storage in response to 1-MCP application and hydrothermal during maritime transport simulation (20 days at 13 ± 2 °C and 85 ± 10% RH) and then stored at ambient (22 ± 2 °C and 70 ± 10% RH).