The inhibition of mango (Mangifera indica L.) fruit ripening by 1-Methylcyclopropen

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1. Introduction

The inhibitor of ethylene action 1-Methylcyclopropen (1-MCP) can be effectively applied to many climacteric and non-climacteric fruit. 1-MCP improves fruit firmness and extends fruit shelf life by blocking ethylene receptors (Johnson et al., 2009). 1-MCP delayed ripening in some climacteric fruit such as avocado by 4.4 days, custard apple by 3.4 days, papaya by 15.6 days, and mango by 5.1 days compared to ethrel treatments (Hofman et al., 2001). After ethephon treatment, post-harvest exposure of mango fruit (Zihua) at 20°C to increasing concentrations of 1-MCP for 12 h decreased flesh firmness following 7 day shelf-life. Concentration of between 1 and 100 µL.L\textsuperscript{-1} 1-MCP reduced softening of produce, however, 200 µL.L\textsuperscript{-1} 1-MCP had no continued positive effect on fruit firmness. Exposure duration of fruit from 1 to 12 h with 50 or 100 µL.L\textsuperscript{-1} 1-MCP increased impact of reducing softening, though more than 12 h had no additional benefit (Jiang and Joyce, 2000).

Exposure time and concentration of 1-MCP depends on fruit species and cultivar. The most effective treatment duration of 1-MCP ranged from 12 to 24 h (Sylvia and John, 2003). In case of unripe bananas, there was no effect at concentrations of 5 and 50 nL.L\textsuperscript{-1} 1-MCP, but ripening was delayed at 500 nL.L\textsuperscript{-1} (Lurie et al., 2002). ‘Golden’ papaya harvested at maturity stage 1 (up to 15% yellow skin), treated with 100 nL.L\textsuperscript{-1} of 1-MCP and stored at 23°C had a reduction in respiratory activity, ethylene production, skin color development and pectinmethylesterase activity (Bron and Jacomino, 2009). Sapodilla fruit exposed to 1-MCP for 24 h at 20°C and 85–95 % relative humidity had decreased rates of respiration and ethylene production for 6 days (Quiping et al., 2006).

However some fruit may not achieve the fully ripe stage following 1-MCP treatment; for example nectarines did not ripen normally after cold storage and 1-MCP treatment (Dong et al., 2001). Application of 1.0 µL.L\textsuperscript{-1} 1-MCP to ‘Bartlett’ pear inhibited scald, but failed to soften (Ekman et al., 2004). Attempt to induce ripening of 1-MCP-treated avocado by ethylene exposure was not successful (Jeong and Huber, 2004).

Climacteric fruit such as mango ripen rapidly at higher temperature (Nguyen et al., 2002) quickly soften after harvest. Therefore, suitable post-harvest storage conditions need to be identified, including the effectiveness of 1-MCP for improving storage duration, fruit quality and market returns.

The aim of this work was to evaluate the effects of 1-MCP and cold storage on the ripening pattern of two local mango cultivars in the Son La province of northern Vietnam.

2. Material and Methods

2.1. Plant materials and 1-MCP treatments

In 2009 ten fruit of five ‘Tron’ and ‘Hoi’ trees from each of four orchards, respectively, were collected at commercial harvest and 10 days prior. The later maturing mango cultivar ‘Hoi’ was harvested 10 days after ‘Tron’. After harvest fruit was either exposed for 12 hours to 250, 500 and 1000 nL.L\textsuperscript{-1} 1-MCP in 0.5 m\textsuperscript{3} glass chambers at ambient condition (about 30°C and 75% relative humidity) or used as untreated controls. Fruit was then sealed plastic bags and stored at 12°C and a relative humidity of approximately 70%. Following 5, 10, 15, 20 and 25 days of storage, 10 fruit/ cultivar/ pick/ treatment were removed, kept for 24h at 20°C and then analysed for various quality parameter.

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2.2. Fruit quality assessment

At each assessment date, fruit weight, flesh weight and fruit height and thickness were recorded by conventional methods. Skin disorders were evaluated based on a score from 1 (no disorder) to 5 (severe disorder). Total soluble solids (TSS) were measured by a portable refractometer and flesh firmness was determined using a standard penetrometer. The colour in terms of L*, a*, b* values (CIE 2000) was determined by colorimeter (CR-410, Konica Minolta).

Carotenoids were analyzed by spectrometry and both of vitamin C and carbohydrate were used by enzymatic methods.

2.3. Statistics

Data were analysed by ANOVA using the statistical package SAS 9.2. Mean treatment comparison was made by the least significant difference (LSD) at the 0.05 significance level.

3. Results and Discussion

Both cultivars had less skin disorder in the first pick than in second pick (data not shown), but ‘Hoi’ had more skin disorders than ‘Tron’ at higher 1-MCP concentration (Fig. 1A) and. Although fruit weight was considerably greater for ‘Hoi’, it was not significantly affected by 1-MCP treatments in both cultivars (Fig. 1B).

Fig. 1 – Skin disorder (A) and fruit weight (B) of ‘Tron’ and ‘Hoi’ mango (averaged over two picks) at removal date 5, 10, 15, 20 and 25. * means significant differently at P < 0.05 between two cultivars.

Flesh firmness of ‘Hoi’ and ‘Tron’ declined considerably over the first 15 days of storage in all 1-MCP treatments, (Fig. 2A). It was reported that 1-MCP could bind to receptors to inhibit ethylene responses about 5-10 days and re-application may be needed for enhancing 1-MCP effectiveness depending on produces (Sylvia and John, 2003).

Fig. 2 – Flesh firmness (A) and TSS (D) of ‘Tron’ and ‘Hoi’ mango (averaged over two picks) at removal date 5, 10, 15, 20 and 25. Different letters are significantly different at P < 0.05 between treatments of one cultivar. ns = non significant
Fig. 2 – Flesh firmness of ‘Tron’ (B) and ‘Hoi’ (C) mango varieties at each picks at removal date 5, 10, 15, 20 and 25. Different letters are significantly different at P < 0.05 between treatments of one cultivar. ns = non significant

Furthermore, irrespective of 1-MCP treatments, flesh firmness of both cultivars was significantly reduced within 15 days of storage for the first pick and within 10 days of storage for the second pick. As expected, flesh firmness of first pick was much greater than that of second pick; however, following 10 days of storage no differences in fruit firmness were observed (Fig. 2B, C). This suggests that fruit maturity contributed to 1-MCP application efficacy as was seen in ‘Pink Lady’ apple where greater effects of 1-MCP were found in less mature fruit (Wilkinson et al., 2008).

First pick fruit of both cultivars had lower TSS than second pick fruit; however, TSS declined in both cases with storage time (data not shown). ‘Tron’ tended to have greater amounts of TSS than ‘Hoi’, indicating sweeter fruit. Irrespective of 1-MCP treatment, TSS increased over the first 15-20 days of storage before it reached a plateau or declined toward the end of storage period. Treated sapodilla fruits by 40 and 80 nL.L⁻¹ 1-MCP for 24 h had a higher TSS concentration during first 15-18 days after storage (Quiping et al., 2006).

Fig. 3 – Skin (A) and flesh (B) hue angle of ‘Tron’ and ‘Hoi’ mango (averaged over two picks) at removal date 5, 10, 15, 20 and 25. Different letters are significantly different at P < 0.05 between treatments of one cultivar. ns = non significant

In control treatment ‘Tron’ fruit was more mature than ‘Hoi’ at each removal date, indicated by a lower hue angle and therefore more yellow fruit. 1-MCP treatment, even at the lowest concentration, seems to delay the colour change of the skin but not of the flesh in ‘Tron’. However, fruit of both cultivars and irrespective of 1-MCP concentration were more yellow with storage time (Fig. 3A, B).
Indeed ‘Tommy Atkins’ mango treated with 1-MCP and kept in cold storage (at 10.6°C ± 3.6 and 84% RH ± 7) had a increased chroma and a reduced hue angle of skin (Lima et al., 2007).

4. Conclusions and Outlook

Application of 500 and 1000 nL.L⁻¹ 1-MCP to ‘Hoi’ and ‘Tron’ showed potential for delaying the reduction of flesh firmness, skin and flesh hue angle and the increase of TSS for at least 10 days of storage. 1-MCP applications were more effective on early harvested fruit of both cultivars and ‘Hoi’ showed greater responsiveness than ‘Tron’.

References