Effect of Preharvest Calcium Chloride Sprayed on Growth and Development and Quality of Mulberry Fruit

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Effect of preharvest calcium chloride sprayed on growth and development and quality of mulberry fruit were studied. The thirty two of mulberry trees were hard pruned and divided into 2 groups of 16 each non-sprayed and sprayed with 2% CaCl₂. After mulberry tree developed new branches for about 50 cm length, new flower started blossom. After fruits developed to about 0.5-1 cm fruits diameter, fruits were spray with 2% CaCl₂ every week for 4 week (set A), while another set B were non-sprayed. Fruit were harvested at ripe stage (purple red color), selected with uniform shape and size. All samples were packed in PE bag, then stored at 5°C for 24 days. The experimental design was Completely Randomized Design (CRD), fruit growth, development and fruits quality included weight loss, firmness, total soluble solids (TSS), titratable acidity (TA), color change and anthocyanin content were recorded every 6 days. The results showed that, mulberry fruit sprayed with 2% CaCl₂ resulted in significantly different in number of fruit and number of branch, non-significantly different in number of leaf, branch length and fruit size. Fruit sprayed with 2% CaCl₂ had lower in percentage of weight loss (0.28%) when compared to non-sprayed fruit (1.61%). Significantly differences between non-sprayed and sprayed with 2% CaCl₂ were found in fruit firmness and TSS/TA ratio, sprayed fruits had higher in fruit firmness and lower in TSS/TA ratio than non-sprayed fruits. L* and a* values decreased throughout the shelf life, rapidly decreased in non-sprayed fruits. Development of anthocyanin content in fruit was reduced by CaCl₂, 2 time lower content than non-sprayed at the accumulation peak (days 12 in storage). Thus, CaCl₂ could enhanced number of fruits and delayed the ripening of mulberry fruits during storage.

Keywords: anthocyanin, firmness, total soluble solids, quality, ripening

Introduction

Mulberry (Morus alba Lin.) is a plant in the same family as jackfruit, paper mulberry and banyan tree (Moraceae). Mulberry is widely grown in Europe and West Asia as edible fruits (Ercisli, 2004) and the growing area is more than 95% in the Northeast of Thailand. Mulberry fruit is a collactive fruit, the ripe mulberry will look succulent. The proportion of sour and sweet balance
is commonly eaten as a fresh or processed product. Lou et al. (2012) reported the assessment of total phenols, total flavonoids, sugars and antioxidant activity in mulberry fruits vary with different skin color intensities, which correspond to different development levels of the fruits. For fresh consumption, fruit is purple-red or purple-black color must be harvested. If left until fruit turns black will decreased shelf life during storage.

Mulberry fruit has high in were water content, easily damaged and short shelf life. Storage at low temperatures can only be kept for 1-2 days. Calcium chloride solution is especially used in ready-to-eat fruit, helps to maintain the firmness of the strawberry by interfere with the pectin in the cell wall, the pectin structure adheres more closely (Chen et al., 2011; Suutarinen et al., 2000). Use of calcium chloride solution can reduce the severity of chilling injury and browning (Manganaris, 2007). Extend the shelf life of fresh mulberry fruit for consumption, slow down the effects of postharvest and preserve the ingredients contained within the fruit. Moreover, calcium is considered to be an important mineral element that regulates fruit quality, maintenance of fruit firmness (Lruie et al., 2009; Machado et al., 2008). The objective of this research was to study the effect of preharvest calcium chloride sprayed on growth and quality of fresh mulberry fruits.

**Materials and methods**

**Plant materials**

Two years of 32 mulberry tree were used for this study. All tree were pruned then divided into 2 groups of 16 each. After mulberry tree developed new branches for about 50 cm length, new flower started blossom. After fruits developed to about 0.5-1 cm fruits diameter (Figure 1E), fruits were spray with 2% CaCl₂ every week for 4 week (set A), while another set B were non-sprayed. Mulberry were harvest at ripe stage (purple red color), selected with uniform shape and size. All samples were packed in polyethylene (PE) bag, then stored at 5°C for 24 days (Figure 1A-F).

**Data recorded**

Fruit growth and development included number of fruit, number of branch, number of leaf, leaf area, branch diameter and branch length were recorded. Fruits quality included, weight loss, firmness, total soluble solids (TSS), titratable acidity (TA), TSS/TA ratio, color change (L*, a* and b* values), anthocyanin content were also determined. The experimental design was Completly Randomized Design (CRD). Data were analyzed using analysis
of variance (ANOVA). Differences among treatments means were separated according to LSD (P≤0.05).

**Results and Discussion**

The growth rate of mulberry tree after pruned and sprayed with 2% calcium chloride, showed non significantly different in number of leaf, leaf area, branch diameter and branch length (Table 1). Fruits sprayed with 2% calcium chloride had significantly different in number of branches and number of fruits when compared to non sprayed (Figure 2).

During storage, mulberry fruits had weight loss about 0.2-0.6% throughout the shelf life, mulberry sprayed with 2% CaCl\(_2\) had lower in weight loss 0.28% than non-sprayed 0.61% (Figure 3A). Karemera and Habimana (2014) reported that maximum weight loss of fruits occurred in control treatment while lower weight loss was recorded in 1.50% CaCl\(_2\) sprayed trees. In addition, Turmanidze et al. (2016) found that maximum lost was observed for untreated fruits and minimum lost was observed for fruits treated with 2% CaCl\(_2\). Bender (1998) have also reported that treatment with 0.6-2.0% calcium nitrate and CaCl\(_2\) delayed ripening after harvest, lower weight loss and reduced respiration rates. Fruits storability was also improved by CaCl\(_2\) under cold storage (Wahdan et al., 2011). The pre and postharvest application of CaCl\(_2\) and Ca(NO\(_3\))\(_2\) are known to influence the quality and shelf life of fruits during storage (Gill et al., 2005). The loss in fruit weight is mainly due to water loss as a result of evaporation and transpiration. (El-Badawy, 2012). CaCl\(_2\) reduced the percentage of weight loss during storage of sapotas (Choudhury et al., 2003), nectarines (Serrano et al., 2004), apples and peaches (Hafez and Haggag, 2007; Mahmoud, 2008). This problem was greatly reduced due to preharvest sprays of calcium in the form of calcium chloride at 0.3-7.5%.

Fruit firmness tended to increase in all treatments during storage. Mulberry sprayed with 2% CaCl\(_2\) solution had higher in firmness (10.90 N), but non significantly different from non-sprayed (Figure 3B). Calcium solution could delayed loss of firmness in strawberry fruit grown in Spain (Hernandez-Munoz et al., 2006). Calcium contributes to improving the rigidity of cell wall; retard tissue softening also reduces the accessibility of cell wall degrading enzymes to their substrates (Vicente et al., 2009). Application of calcium sprays during the growing season reduction in fruit softening of stored raspberries (Eaves et al., 1972). Postharvest treatment of Japanese plums with calcium chloride solution reduced the physiological response to mechanical damage (Serrano et al., 2004). Postharvest application of calcium chloride increased the flesh calcium concentration of cherries and improved the texture and the incidence of pitting resulting from impact damage (Lidster et al., 1979)
Fruits sprayed with 2% CaCl$_2$ solution and non-sprayed had significantly difference in TSS/TA ratio, higher in non-sprayed 11.46% than in sprayed treatment 8.41% (Figure 3C).

L* and a* values decreased during storage with significantly different, on the last day of storage and lower in non-sprayed fruits (Figure 3D,E). During ripening progressed, the L* and b* values decreased, while a* values increased until the middle stage and decreased at the last stage (Lee et al., 2017).

Development of anthocyanin content in fruit was reduced by CaCl$_2$. Non-sprayed mulberry had 2 time lower content at the accumulation peak on days 12 in storage (Figure 3F). Bae and Suh (2007), reported that mulberry and other deep-coloured fruits have higher contents of polyphenols including flavonoids, anthocyanins, and carotenoids. Liang et al. (2012) reported that the content of total anthocyanins and total flavonoids varied widely across different species.

**Table 1.** The growth rate of mulberry plants after pruned on number of leaf, leaf area, branch diameter, branch length.

<table>
<thead>
<tr>
<th>Growth parameters</th>
<th>Treatments</th>
<th>Day after pruning</th>
<th>Growth rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>30</td>
<td>45</td>
</tr>
<tr>
<td>Number of leaf</td>
<td>Non-sprayed</td>
<td>335.89b</td>
<td>392.69b</td>
</tr>
<tr>
<td></td>
<td>2% calcium chloride</td>
<td>412.29a</td>
<td>475.25a</td>
</tr>
<tr>
<td>Leaf area (cm$^2$)</td>
<td>Non-sprayed</td>
<td>63.60a</td>
<td>66.48a</td>
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<tr>
<td></td>
<td>2% calcium chloride</td>
<td>60.99a</td>
<td>67.12a</td>
</tr>
<tr>
<td>Branch diameter (mm)</td>
<td>Non-sprayed</td>
<td>4.61a</td>
<td>5.20a</td>
</tr>
<tr>
<td></td>
<td>2% calcium chloride</td>
<td>4.80a</td>
<td>5.12a</td>
</tr>
<tr>
<td>Branch length (cm)</td>
<td>Non-sprayed</td>
<td>40.16a</td>
<td>45.27a</td>
</tr>
<tr>
<td></td>
<td>2% calcium chloride</td>
<td>39.32a</td>
<td>42.62a</td>
</tr>
</tbody>
</table>

**Figure 2.** Number of branch (A) and Number of fruit (B) of mulberry fruits with and without 2% CaCl$_2$ sprayed before harvest
Figure 1. Mulberry tree were grown in plastic pot (A), hard pruned (B), then the new brances had developed (C), the flowers were blossom (D), then fruit started setting (E) and developed to the pink color stage (F).
Figure 3. Weight loss (A), firmness (B), TSS:TA ratio (C), L* values (D), a* values (E) and anthocyanins content (F) of mulberry fruits from non-sprayed and sprayed with 2% calcium chloride before harvest.
Conclusion

Mulberry fruits sprayed with 2% CaCl₂ increased number of branches and number of fruits. Anthocyanin content also affected, slightly increased by calcium sprayed. Edible quality parameter as showed by TSS/TA ratio had lower in fruit sprayed with CaCl₂ than non-sprayed fruits.

Acknowledgement

This research was partially funding by the Department of Plant Production Technology, Faculty of Agricultural Technology, King Mongkut’s Institute of Technology Ladkrabang.

References


(Received: 28 October 2017; accepted: 25 November 2017)