Effectiveness of Hot Water Treatment Incorporated with Calcium Ascorbate on Maintenance of Physiological and Sensory Qualities of Fresh-Cut Ripe Mango cv. Nam Dok Mai

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Abstract. Previous study revealed that hot water treatment (HT) at 50ºC for 30 min of whole mango fruit before fresh cut process can maintain the quality of fresh cut mango. In this study the combination of HT before fresh cut process and calcium ascorbate dip at post-fresh cut process was investigated. Ripe mangoes cv. Nam Dok Mai were dipped into hot water (HT, 50ºC for 30 min) then mangoes were peeled and cut into fresh cut mangoes. They were dipped into 2% w/v aqueous calcium ascorbate (CaAs). Non-calcium treated fresh cut mango was used as the control set. Both of CaAs and control treatment were stored at 4 ºC for 6 days. Changes in color of fresh cut surface mango, browning occurrence, sensory acceptance was evaluated. Polyphenol oxidase (PPO) activity was measured. CaAs treatment maintained color changes expressed as L* and Hue angle compared to control (HT). CaAs dips inhibited PPO activity resulting in browning reduction and high acceptance of sensory evaluation. The combination of HT of whole fruit and CaAs dips of fresh cut mango extended the overall quality to 6 days compared to 3 days for mango heated with HT but not dipped into CaAs. CaAs also showed the higher firmness than control sample. The combination of HT at 50ºC for 30 min of whole fruit followed by 2% CaAs dip of fresh cut mango can preserve the quality of fresh cut mango during storage.

Keywords: Browning, calcium ascorbate, fresh cut mango, hot water treatment

1. Introduction

Mango (Mangifera indica Linn.) is one of the economic fruit of Thailand, mango “Nam Dok Mai” cultivar is Thailand’s number one variety for domestic and export markets. The popularity of mango is due to its bright color, characteristic taste, and nutritional properties [1]. Nowadays, demand for fresh-cut products has increased in response to demand for quality and the modern lifestyle of consumers. Tesco, one of the big fresh-cut producers in global market, reported that demand for healthy fruit snacks such as melon and mango ‘fingers’ has increased by 400% over the last two years. Notwithstanding the wide appeal, fresh-cut processing of mango increase the risk of browning, dehydration and quality loss during storage. Browning and water-soaked appearance are reportedly the main problems that limit the shelf-life of fresh-cut ‘Nam Dok Mai’ mango variety during storage. Browning incidence in fresh-cut mango is caused by enzymatic activities of phenylalanine ammonia-
lyase (E.C. 4.3.1.5, PAL) and polyphenol oxidase (EC 1.14.18.1, PPO). PAL catalyzes the transformation of phenylalanine into trans cinnamic acid which, in subsequent reactions, is transformed into other phenolic compounds such as chlorogenic acid, a substrate of PPO. The latter enzyme oxidizes compounds synthesized by PAL to quinones that spontaneously polymerize resulting in enzymatic browning [2]. PPO activity is influenced by substrate type and displays a cultivar-specific logarithmic increase during postharvest ripening of mango [3].

Heat treatments alone or in combination with other agents such as calcium salts have also been used to prevent browning reactions and maintain texture in various vegetables and fruits. Heat treatment effectively inactivates enzymes. Heat treatment reduced respiration and moisture loss during storage of the cut fruit. It also reduced total microbial count during storage and prevented growth of lactic acid bacteria that occurred in untreated fruit [4]. Calcium ascorbate (CaAs) has been found to be the most effective anti-browning agent and can be marketed as a minimal chemical input. Its application increases the antioxidant status and extends shelf life of several fruits [5]. There are several researches have focused on combined techniques with better antifungal efficiencies than the chemical alternatives. The combination of hot water and calcium treatments has been used to control postharvest diseases and has been shown to maintain the postharvest quality of the fruits. Therefore, the aim of this research is to compare the effect of calcium ascorbate combination with hot water treatment and only hot water treatment on fresh cut mango.

2. Methods

2.1. Materials and Methods

2.1.1. Mangos

‘Nam Dok Mai’ mango variety were harvested at full-mature. They were purchased from an export company located in Prachuapkirikhan province, Thailand and transported to Division of Postharvest Technology, King Mongkut’s University of Technology Thonburi, Bangkok by air condition van. Mangos were selected for uniform size and free from physical damage and infections and then transported to the laboratory. The fruits were washed with tap water, dipped in 400 µL.L⁻¹ ethephon to induce ripening and then stored at room temperature (28 ± 2ºC) for 3 days. Ripened mangos with a firmness of 10-12 N were collected for the experiment. Fruits were immersed in 100 µL. L⁻¹ of sodium hypochlorite for 5 min and dried at room temperature (25ºC). Fruits were dipped into hot water treatment at 55ºC for 30 min. then they were peeled out and cut into 8 pieces per one fruit.

2.1.2. Calcium ascorbate treatment

Fresh cut mangos were dipped into 2% (w/v) Calcium ascorbate then packed into rigid plastic packaging and kept at 4ºC for 6 days. Color changes, firmness, sensory evaluation, browning score and polyphenol oxidase activity of CaAs treated and untreated fresh cut mangos were measured every 2 days interval.

2.1.3. Statistical analysis

Data were subjected to analysis of varience (ANOVA) using the general linear models procedure of SPSS software (version 15.0, IBM Crops; White Plains, NY, USA) for completely randomized design experiments. Each treatment contained four replicates. Significance was tested at p ≤ 0.05 using Duncan’s multiple range test.

3. Results and Discussion

Fresh cut mango showed browning symptom on the mango surface after fresh cut process within several hours. The results revealed that CaAs treatment remained color change expressed as L* (lightness) and hue angle in fresh cut mango during storage at 4ºC (Figure 1). In contrast, the HT alone (control) showed darker of fresh cut mango during storage at 4ºC for 6 days. The increases in L* and hue values using 2% of CaAs dips indicates that it is an effective way to reduce browning in
accordance with prior research [6, 7, 8]. Calcium ascorbate containing calcium and ascorbic acid partially preserve cell and membrane breakdown [9] and consequently reduces the release of PPO or its substrates thus improving the colour preservation of fresh-cut product. Others researchers have found that dipping treatments with CaAs and heat shock (60°C for 1 min) caused PPO inhibition and were less affected by discolouration [10]. This research revealed the inhibition of PPO activity occurring in the CaAs dipped fresh cut mango (Figure 2). This research has shown that use of a 2% calcium ascorbate dip in fresh-cut mango extended the shelf life from less than 2 days in untreated slices (HT) to 6 days when stored at 4 °C. The factor that ultimately limited the shelf life was the sensory quality. The mechanism for the increased shelf life related to use of HT treatments (55 °C, 30 min) before CaAs dips which lead to increased absorption of ascorbic acid into the fresh cut mango, enhancing the ascorbic acid content and consequently the antioxidant activity [11].

The appearance of fresh cut mango decreased with storage time in both treatments. The appearance of fresh cut mango was improved by dipping in 2% CaAs solutions. Fresh cut mango not treated in CaAs decreased in appearance to below marketability limit before 4 days of storage while as HT combination with CaAs treatment had sensory acceptance until 6 days of storage. Browning symptom
of untreated fresh cut mango (HT alone) appeared during storage until appearing the severe browning at the day 4 of storage. CaAs treatment showed the lower score of browning when compared with non-CaAs treated mango until the end of storage (Figure 3). The CaAs also improved the texture of the fresh cut mango (Figure 4). During storage time, CaAs treatment kept texture levels above the limit of marketability except the fresh cut mango heated at 55 °C for 30 min and not dipped in CaAs, which fell below marketability at 3 days. At day 4, the appearance from fresh cut mango not treated with CaAs fell down under the limit of marketability. Taking into account the combination of sensory parameters such as appearance and the overall acceptability score was found to be the highest for CaAs treatment extending the shelf life up to 6 days. In contrast, fresh cut mangoes not treated with CaAs had a very short shelf life (< 4 days). The use of HT before CaAs dips was a significant factor in the overall acceptability changes. The use of this combination helped to extend the shelf life from 2 days up to 6 days. Texture from fresh cut mango was improved with CaAs dips (Figure 4). HT had no significant effect on these changes in control treatment. The calcium present in CaAs may be the main effect influence on the retention of texture. However, many researchers have reported good results in maintaining or improving texture when a combination of HT and calcium dipping is used [12, 13] generally explained in terms of pectin esterase (PE) activation, cleaving the methoxy groups from methylated galacturonic acid residues in pectin [14] which contain newly available carboxyl groups.

**Figure 3.** Browning score, sensory evaluation and physical changes of fresh cut mango pretreated with hot water at 50°C for 30 min incorporated with 2% calcium ascorbate after peeled and cut then pack into semi rigid plastic box and storage at 4 °C for 6 days.
4. Conclusion
CaAs dips had a strong impact reducing the browning and therefore, extending the overall acceptability to 6 days. The combination of HT and CaAs treatment helped to maintain fresh-cut mango quality from 2 days to 6 days.

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