ผลของการให้ความร้อนก่อนตัดแต่งต่อคุณภาพของมังคุดที่ใช้สำหรับการแปรรูปขั้นต่ำ

Effect of Pre-cut Heat Treatment on Quality of Mangosteen Used for Minimal Processing

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บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาคุณภาพของมังคุดหลังจากการให้ความร้อนที่ระยะเวลาแตกต่างกันก่อนตัดแต่ง โดยนำมังคุด (ความสุกระยะที่ 5) มาให้ความร้อนโดยใช้ตู้อบลมร้อนที่อุณหภูมิ 50 องศาเซลเซียส นาน 2 4 6 และ 8 ชั่วโมง ก่อนนำไปวิเคราะห์สมบัติทางกายภาพ และกิจกรรมของเอนไซม์ พบว่า มังคุดมีการสูญเสียน้ำหนักเพิ่มขึ้นตามการเพิ่มขึ้นของระยะเวลาการให้ความร้อน ($p<0.05$) โดยพบการสูญเสียน้ำหนักสูงสุด (ร้อยละ 1.61) ที่การให้ความร้อนนาน 8 ชั่วโมง การให้ความร้อนนานถึง 4 ชั่วโมง ไม่มีผลต่อดัชนีความสดของกลีบเลี้ยง และความแน่นเนื้อของเนื้อมังคุด ($p>0.05$) โดยให้ค่าดัชนีความขาวของเนื้อมังคุดสูงสุด เมื่อเปรียบเทียบกับมังคุดที่ผ่านการให้ความร้อนที่ระยะเวลาอื่นๆ ($p<0.05$) พบการลดลงของกิจกรรมของเอนไซม์ฟีนิลอะลานีนแอมโมเนียไลเอส พอลิกาแล็กทูโรเนส และเพกทินเมทิลเอสเทอเรส เมื่อระยะเวลาการให้ความร้อนเพิ่มขึ้น ในขณะที่กิจกรรมของเอนไซม์พอลิฟีนอลออกซิเดสของมังคุดที่ผ่านการให้ความร้อนนาน 4 ชั่วโมง ไม่แตกต่างจากชุดควบคุม ($p>0.05$) ผลการทดลองแสดงให้เห็นว่า การให้ความร้อนมังคุดที่อุณหภูมิ 50 องศาเซลเซียส นาน 4 ชั่วโมง เป็นวิธีที่มีศักยภาพในการป้องกันการเกิดสีน้ำตาลของเนื้อหลังจากการตัดแต่ง โดยไม่มีผลกระทบต่อความสดของกลีบเลี้ยงและความแน่นเนื้อของเนื้อของมังคุด

คำสำคัญ : *Garcinia mangostana* L., การใช้ลมร้อน, คุณภาพทางกายภาพ, กิจกรรมเอนไซม์

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Abstract

This research aimed to investigate quality of mangosteen affected by heat treatment with different durations before cutting. Mangosteen (ripeness stage 5) was heated using a hot air oven at 50°C for 2, 4, 6 and 8 h, prior to evaluation for physical properties and enzyme activities. It was found that weight loss of mangosteen increased with the increase of heating duration ($p<0.05$) and the highest weight loss (1.61%) was found in those heated for 8 h. Heat treatment for up to 4 h had no effect on calyx freshness index and flesh firmness of the mangosteen ($p>0.05$). The highest whiteness index of mangosteen flesh was obtained from heat treatment for 4 h, compared with others ($p<0.05$). Decreases in phenylalanine ammonia lyase, polygalacturonase and pectin methyl esterase activities were detected with increased heating duration ($p<0.05$). Polyphenol oxidase activity was not different from the control when heat treatment was conducted for 4 h ($p<0.05$). The results revealed that heat treatment of mangosteen at 50°C for 4 h could be a potential approach to prevent flesh browning after cutting, without adverse effect on calyx freshness and flesh firmness of the mangosteen.

Keywords : *Garcinia mangostana* L., hot air heat treatment, physical quality, enzymatic activity

Introduction

Mangosteen (*Garcinia mangostana* L.), a tropical tree belonging to the Guttiferae family, is an economically important fruit crop in Thailand. It is a climacteric fruit and usually harvested at different stages according to pericarp color, from light greenish yellow with scattered pink spots to dark purple. Ripeness stage of mangosteen can be categorized into 6 stages: yellowish white or yellowish white with light green (stage 0), light greenish yellow with 5-50% scattered pink spots (stage 1), light greenish yellow with 51-100% scattered pink spots (stage 2), spots not as distinct as in stage 2 or reddish pink (stage 3), red to reddish purple (stage 4), dark purple (stage 5) and purple black (stage 6) (Palapol *et al*., 2009). The edible fruit aril is white and juicy with a sweet and slightly acidic taste when ripe. Mangosteen is generally consumed fresh due to the pleasant flavor of flesh, and therefore is considered to be a fruit with good potential for marketing as a fresh-cut product. Minimal processing of mangosteen into fresh-cut product offers a possibility to preserve freshness of the mangosteen product. The convenience and fresh-like quality of fresh-cut fruit are important factors in its increasing popularity in the food supply and the consumer's demand (Lamikanra, 2002). However, rapid quality deterioration, especially discoloration of the mangosteen flesh after peeling is a crucial problem of fresh-cut mangosteen. Minimal processing increases metabolic activity, and decompartmentalization of enzymes and substrates which can accelerate quality deterioration such as browning and softening of the products (Toivonen & Brummell, 2008). Use of chemical treatment has been reported to be an effective method for preventing discoloration and firmness loss of various fresh-cut products (Rico *et al*., 2007; Alandes *et al*., 2009; Bico *et al*., 2009). However, nowadays, consumers are increasingly concerned about relationship between health and food consumption, and demand for food product without chemical preservative (Granatstein *et al*., 2016). Heat treatment is one of alternative approaches to chemical immersion for maintaining the quality of fresh-cut fruit. Heat treatment has been used to control postharvest decay and improve the storage quality in intact fruit (Lurie, 1998; Mirdehghan *et al*., 2007; Sui *et al*., 2016). Postharvest heat treatment at 35°C for 6 h has been found to be efficient in retarding chilling injury of mangosteen fruit stored at 7°C (Manurakchinakorn *et al*., 2014). With regard to fresh-cut product, postharvest heat treatment has also been shown to delay ripening and senescence processes (Dea *et al*., 2010; Silveira *et al*., 2011). However, reports on the effect of heat treatment before peeling on the quality of mangosteen are limited. The purpose of this work was to examine the impact of postharvest heat treatment using hot air oven on some important physical and enzymatic properties of mangosteen used for minimal processing.

Methods

Plant material

Mangosteen was purchased from an orchard in Nakhon Si Thammarat province, Thailand. Fruit (average weight 100±20 g) at ripeness stage 5 (the stage of fruit with dark purple pericarp according to Palapol *et al*. (2009)) was selected by uniformity of freshness, color and size.

Hot air heat treatment

Mangosteen was put in a basket and covered with perforated plastic film before heat treatment to prevent water loss during the heat treatment (Florissen *et al*., 1996). The heat treatments were conducted using a hot air oven (UFE600, Memmert, Schwabach, Germany) at 50°C for different heating durations (0, 2, 4, 6 and 8 h). Thereafter, the mangosteen was cooled down by storing in cold room at 5°C for 30 min, prior to quality measurement.

Weight loss

Weight loss was determined by weighing mangosteen fruit before and after the heat treatment. Weight loss (%) was calculated using the following formula (Zhou *et al*., 2002):

$$\text{Weight loss} = \frac{(\text{Weight before - Weight after the heat treatment}) \times 100}{\text{Weight before the heat treatment}} \quad (1)$$

Appearance of calyx

The calyx freshness of mangosteen fruit was evaluated using a scale of 1-5 according to the appearance of calyx: 5 = green color, 4 = degreening, 3 = slight browning, 2 = moderate browning and shrinkage, 1 = severe browning and shrinkage. Calyx freshness index of the mangosteen fruit for each heat treatment was calculated using the following formula (Ratanachinakorn, 2003):

$$\text{Calyx freshness index} = \frac{\text{(Freshness score) x (Number of mangosteen fruit at each score)}}{\text{Total number of mangosteen fruit in the treatment}} \quad (2)$$

Color

Color at the flesh surface of mangosteen was determined immediately after peeling, using a HunterLab chromameter (Model ColorFlex, Reston, VA). Tristimulus color (L*, a*, b*) was randomly obtained from two different areas of each fruit. Whiteness index was used to assess the extent of browning of fresh-cut mangosteen using the following formula (Rocculi *et al*., 2007):

$$\text{Whiteness index} = 100-((100-L^*)^2+a^{*2}+b^{*2})^{1/2} \quad (3)$$

Flesh firmness

A compression test was performed to evaluate the firmness of mangosteen flesh using a Texture analyzer (Model LR 5K, Lloyd Instrument, Hampshire, UK) equipped with a ball probe (0.25 cm diameter head) through the flesh in two locations around the equator of each fruit with a cross head speed of 200 mm/min.

Enzymatic activities

Extractions and assays of polyphenol oxidase (PPO), phenylalanine ammonia lyase (PAL), polygalacturonase (PG) and pectin methyl esterase (PME) were performed according to the modified method of Boonsiri *et al*. (2007), Yingsanga *et al*. (2008), Teixeira *et al*. (2007) and method of Hagerman & Austin (1986), respectively. The mangosteen flesh was collected and used for enzyme extraction. Protein content of the crude enzyme extracts was determined according to the method of Bradford (1976).

Statistical analysis

The experiments were run in triplicate. Statistical analysis was conducted using SPSS version 15.0 (SPSS Inc., Chicago, IL). An analysis of the variance was processed using the general linear model procedure. Mean comparisons were performed using Duncan's multiple range test.

Results and Discussion

Effect of heat treatment on physical qualities of mangosteen fruit

Weight loss of mangosteen fruit significantly increased ($p<0.05$) with increased heat treatment duration at 50°C (Figure 1). Longer duration of heat exposure led to the increased water vapor pressure deficit between the fruit and the surrounding air, resulting in the higher loss of moisture from the surface of fruit (Will, 1998). Dimitris *et al*. (2005) reported that heat treatment of cactus pear fruit changed the cuticle structure leading to enhanced water loss. However, weight loss of mangosteen after heat treatment at 50°C for 8 h in this study was only 1.61%. The similar result was observed for the freshness of mangosteen calyx (Figure 2). Calyx freshness index of the fruit heat-treated for 6-8 h significantly decreased ($p<0.05$), compared with the control. Nevertheless, heat treatment for up to 4 h did not affect calyx freshness of mangosteen ($p>0.05$). The freshness of the calyx was evaluated based on the changes of color and shrinkage. Browning and shrinkage of the calyx could be due to chlorophyll degradation and water loss, respectively. Chlorophyll degradation after long duration of heat exposure could be attributed to the heat-induced pheophytinization (Schwartz *et al*., 2008).

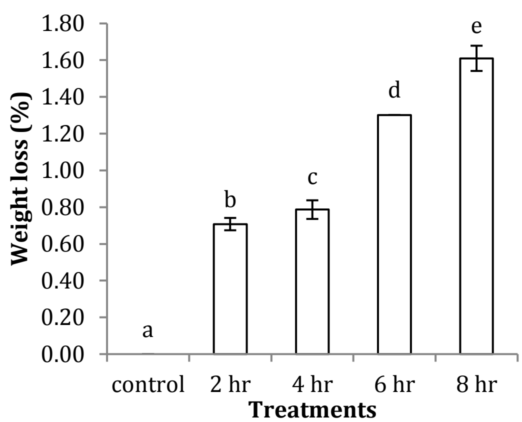

Figure 1 Weight loss of mangosteen heat-treated at 50°C for various durations. Means followed by the same letter are not significantly different ($p>0.05$).

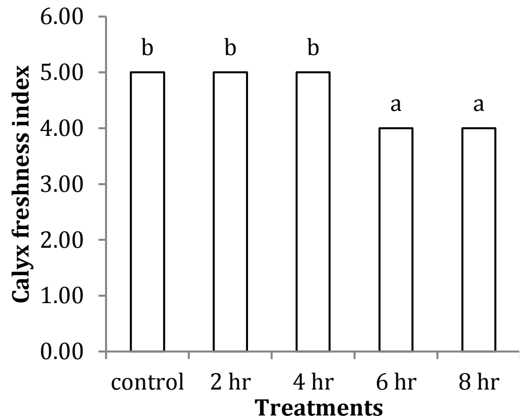

Figure 2 Calyx freshness index of mangosteen heat-treated at 50°C for various durations. Means followed by the same letter are not significantly different ($p>0.05$).

Whiteness index of mangosteen flesh after heat treatment at 50°C for different durations is shown in Figure 3. Whiteness index of mangosteen flesh heat-treated for 2, 4 and 6 h significantly higher ($p<0.05$) than that of the control, whereas heat treatment for 8 h resulted in the significant decrease in whiteness index of mangosteen flesh. The highest whiteness index ($p<0.05$) was detected in mangosteen flesh heat-treated for 4 h. Browning of mangosteen flesh after peeling was reported to mainly associate with the action of PPO (Suttirak *et al*., 2009). Inhibitory effect of heat treatment on enzymatic browning could be due to the destruction of PPO by heat. On the other hand, severe heat exposure might adversely affect the membrane integrity (Porat *et al*., 2000), resulting in the heat injury of mangosteen flesh with the increased degree of browning. Change of mangosteen flesh firmness is presented in Figure 4. Flesh firmness of mangosteen significantly decreased ($p<0.05$) after heat-treated at 50°C for 6 and 8 h, whereas no significant difference in flesh firmness was detected in mangosteen heat-treated for up to 4 h, compared with the control. Stress induced by long duration of heat treatment might cause modification of cell wall composition (Lara *et al*., 2006) resulting in heat injury with the decreased firmness of fruit.

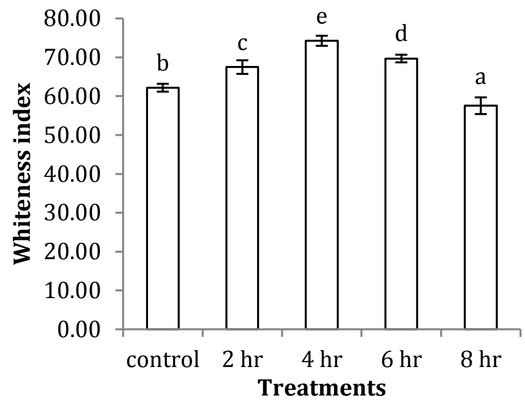

Figure 3 Whiteness index of mangosteen heat-treated at 50°C for various durations. Means followed by the same letter are not significantly different (p>0.05).

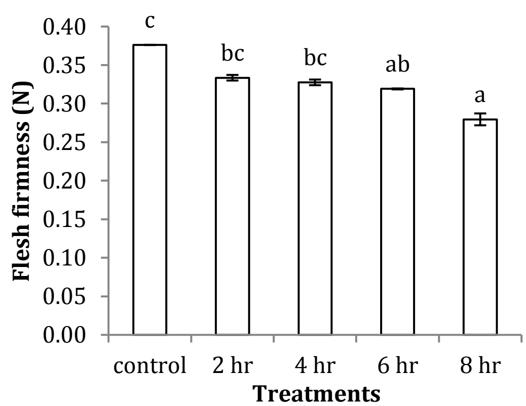

Figure 4 Flesh firmness of mangosteen heat-treated at 50°C for various durations. Means followed by the same letter are not significantly different (p>0.05).

Effect of heat treatment on enzymatic activities of mangosteen flesh

Enzyme activities including polyphenol oxidase (PPO), phenylalanine ammonia lyase (PAL), polygalacturonase (PG) and pectin methyl esterase (PME) activities, were evaluated from mangosteen flesh after heat treatment with different heating durations at 50°C. For PPO activity (Figure 6), the significant decrease of enzyme activity was observed with increased heating time, especially those from 6 and 8 h ($p<0.05$), compared with the control. However, there was no difference of PPO activity between the mangosteen with 4-h heat treatment and the control ($p>0.05$). On the other hand, the increase of heating duration resulted in the significant decrease of

PAL activity ($p<0.05$), compared with the control (Figure 6). PPO and PAL play important roles in enzymatic browning of fresh-cut fruit. PPO is involved in the oxidation of phenolic compounds leading to the formation of brown pigments (Pourcel *et al*., 2007), whereas PAL is associated with the production of the free phenolic compounds that are the basis of browning reaction (Lamikanra, 2002). PPO is not a very heat-stable enzyme; thermal inactivation occurs at temperatures higher than 40°C (Lamikanra, 2002). It was reported that PAL activity of fresh-cut lettuce could be reduced by using mild heat treatment before cutting (Roura *et al*., 2008). The result was in accordance with the increase of whiteness index of mangosteen flesh with heat treatment, compared with the control (Figure 3). These results indicated that heat treatment before peeling by using hot air oven at 50°C with proper period could effectively suppress the PPO and PAL activities, in which 2-6 h heat treatment showed the potential on improvement of whiteness index of mangosteen flesh.

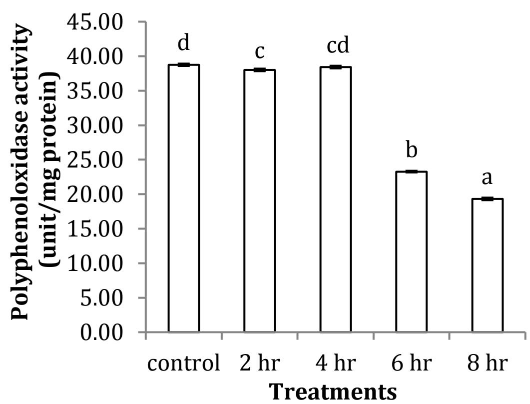

Figure 5 Polyphenol oxidase activity of mangosteen flesh heat-treated at 50°C for various durations. Means followed by the same letter are not significantly different ($p>0.05$).

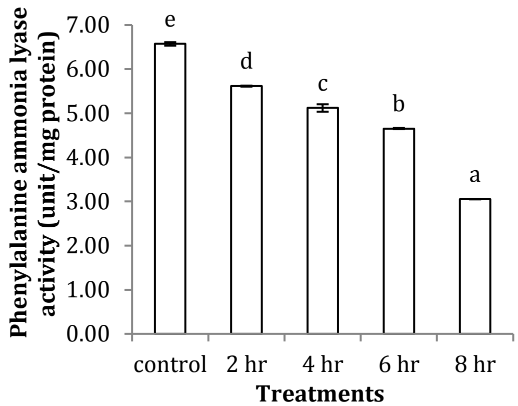

Figure 6 Phenylalanine ammonia lyase activity of mangosteen flesh heat-treated at 50°C for various durations. Means followed by the same letter are not significantly different (p>0.05).

PG activity of mangosteen flesh heat-treated at 50°C for 4-8 h significantly decreased (p<0.05) with the increasing of heat duration, compared with the control (Figure 7). Similarly, extended heat duration resulted in the significant decrease in PME activity (p<0.05) (Figure 8). PG and PME are key enzymes involving in the firmness loss of fruit during ripening and storage. Fruit softening has been shown to correlate with solubilization and depolymerization of cell wall constituents (Brummell & Harpster, 2001). Although the flesh firmness of heat-treated mangosteen might have been declined to some extent (Figure 4), the reduced PG and PME activities by the appropriate pre-cut heat treatment might have beneficial effect on firmness retention during storage of fresh-cut mangosteen. Koukounaras *et al*. (2008) reported that application of heat treatment of whole peach before minimal processing effectively delayed softening of fresh-cut peach during storage.

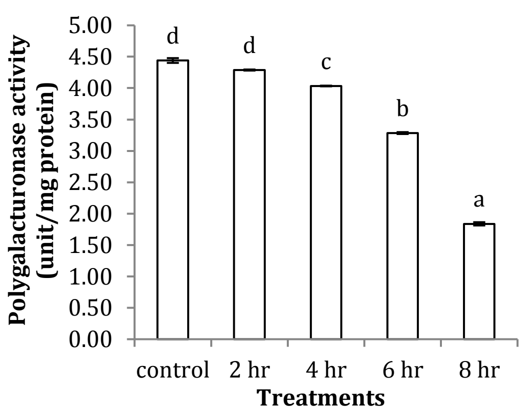

Figure 7 Polygalacturonase activity of mangosteen flesh heat-treated at 50°C for various durations. Means followed by the same letter are not significantly different (p>0.05).

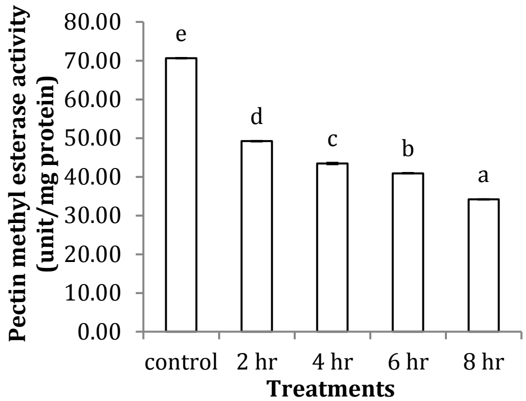

Figure 8 Pectin methyl esterase activity of mangosteen flesh heat-treated at 50°C for various durations. Means followed by the same letter are not significantly different ($p>0.05$).

Conclusions

The impact of hot air heat treatment of mangosteen with different heating durations at 50°C was studied on weight loss, calyx freshness, color, texture and enzyme activities. The heat treatment tested resulted in the small extent of weight loss. Calyx freshness and flesh firmness of mangosteen heated for 4 h were comparable to those of the control ($p>0.05$) with the highest whiteness index ($p<0.05$). PPO, PAL, PG and PME activities could be reduced with pre-cut heat treatment tested. Therefore, hot air heat treatment at 50°C with the proper time was greatly beneficial in preventing discoloration of mangosteen flesh after peeling and maintaining overall quality of mangosteen.

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