

## Visual appearance maintenance of fresh-cut 'Nam Dok Mai' mango fruit by honey dip

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### Abstract

The effects of honey solutions on preventing browning discoloration and maintaining visual appearance in fresh-cut 'Nam Dok Mai' mango fruit and the comparison of honey dip and commercially used citric acid and ascorbic acid dips were investigated. The mango cubes were dipped in honey solutions at the concentration of 0, 5, 10, 15, 20 or 25 % (v/v) and the visual appearance and browning intensity ( $\Delta OD_{420}/100g$  FW) were determined after storage for 24 h. The cubes dipped in 25 % honey solution showed the lowest browning intensity and the best visual appearance compared to the others. The 25% honey dip and 1% citric acid dip inhibited the browning of the mango cubes stored at 4°C for 6 days more than 1% ascorbic acid dip and the control. All treatments had no effect on the changes in weight loss, yellowness ( $b^*$  value), hue angle and chroma over storage. The honey dip showed higher overall acceptance score and  $L^*$  value and lower colour difference ( $\Delta E^*$ ) than the others. In conclusion, 25% honey dip showed a potential maintaining visual appearance and inhibiting browning discoloration in fresh-cut 'Nam Dok Mai' mango fruit during storage.

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### Introduction

Recently, the commercial production of fresh-cut mango fruit has been increased as the demand of fresh-liked product in global market. 'Nam Dok Mai' mango (a commercial Thai cultivar) has been accepted for global market and the marketing demand of the fruit has been continuously increased. In Thailand, fresh-cut 'Nam Dok Mai' mango has become a popular commercial fresh-cut product. The quality and shelf-life of fresh-cut mango were limited by browning discoloration, poor texture, and water-soaked appearance (Rattanpanone *et al.*, 2001; Poubol and Izumi, 2005a,b; Dea *et al.*, 2010). Poubol and Izumi (2005a,b) reported that the shelf-life of fresh-cut 'Nam Dok Mai' mango fruit was approximately 2 days at 5°C which browning discoloration and water soaking appearance are the main problems. In other fresh-cut mango fruits, such as 'Tommy Atkins', 'Ataulfo', 'Kent' and 'Carabao', the same problems had also been reported as the key factors limiting their shelf-life (Rattanpanone *et al.*, 2001; Poubol and Izumi, 2005a; Gil *et al.*, 2006; Dea *et al.*, 2010; Plotto *et al.*, 2010).

Browning is widely accepted as one of major concerns related to quality of many fresh-cut

products. To prevent browning discoloration in fresh-cut product, different types of physical and chemical treatments are employed. In food industry, sulfite has been employed as antibrowning agent; however it is banned for fresh fruit and vegetables due to its adverse effects on health. Another commercial approach for preventing browning in fresh-cut product is the use of carboxylic acids which citric acid and ascorbic acid have been widely used commercially (Gacche *et al.*, 2009). Most carboxylic acids have shown inhibitory effects on enzymatic browning due to their chelating characteristics and lowering of pH (Son *et al.*, 2001). Since honey showed potent antibrowning activity in raisins (McLellan *et al.*, 1995) and juices (Lee, 1996; Gacche *et al.*, 2009), it can be used for preventing browning in fresh-cut fruit. Many previous works had reported that honey solution retarded browning discoloration in fresh-cut apple (Oszmianski and Lee, 1990; Son *et al.*, 2001; Jeon and Zhao, 2005) and fresh-cut persimmon (Ergun and Ergun, 2010). The objective of this study was to investigate the usage of honey in preventing browning and maintaining visual appearance of fresh-cut 'Nam Dok Mai' mango fruit and to compare its antibrowning effect with the commercially used citric acid and ascorbic acid.

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## Materials and Methods

### Plant material

'Nam Dok Mai' mango cultivar was chosen in this work as its famous commercial cultivar of Thailand and the high susceptibility of its tissue to browning. The mangoes were purchased from a main fruit market in Thailand, named Talad Thai. Fruits of uniform size and maturity stage (harvested at 16 weeks after fruit set) with absence physical damages were selected. The fruit were leaved at ambient temperature to ripen for 2 days before minimal processing.

### Minimal processing

Fruit were cleaned with tapped water twice, then dipped in 100 ppm NaClO for 3 min and air-dried at ambient temperature. After that the fruit were peeled and sliced into cubes (2.5 x 2.5 x 2.5 cm, approximately) with a sharp knife. All utensils using in the process were disinfected by dip in 200 ppm NaClO for 5 min.

### Experiments

Experiment 1, the mango cubes were dipped in honey solution at the concentration of 0, 5%, 10%, 15%, 20% or 25% for 2 min. Eight cubes were placed in a clear hinged PET box (8 Oz size) and then stored at 4°C and 85 %RH for 24 h. Photographs of the cubes were taken and browning intensity ( $\Delta OD_{420}/100g$  FW) was recorded.

Experiment 2, a proper concentration of honey solution inhibiting browning from the previous experiment was chosen. The cubes were dipped in honey solution, 1% citric acid or 1% ascorbic acid for 2 min. The cubes were packed as described in experiment 1 and stored at 4°C for 6 days. Four boxes of each treatment (4 replications) were sampled in every 3 days of storage. Weight loss, browning intensity, superficial colours, total colour difference and overall acceptance score were determined compared to the control (without dip).

### Weight loss

The weight of each container was monitored before storage and storage for 3 and 6 days. The percentage of weight loss during storage was calculated compared to the weight before storage.

### Browning intensity

Browning intensity was determined by extracting 3 g of the cube in 30 mL 65% (v/v) ethanol. The sample was stirred at ambient temperature for 1 hr and then filtered using Whatman No.1 filter paper.

Absorbance at 420 nm was measured using a Helios UV visible spectrophotometer (Thermo Spectronic, UK). The unit of browning intensity was expressed as  $\Delta OD_{420}/100g$  FW.

### Superficial colour

Superficial colour measurement was performed using a Minolta (CR-300; Minolta Camera Co., Japan). Lightness ( $L^*$ ), green to red ( $a^*$ ), blue to yellow ( $b^*$ ), hue angle and chroma values were recorded. Total colour difference ( $\Delta E^*$ ) of the cubes during storage compared to the initial day were calculated according; formula (1), respectively.

$$\Delta E^* = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \quad (1)$$

### Sensory score

Ten semi-trained judges scored the mango cubes for overall acceptance. The panellists were asked to rate the liking in visual appearance and smell. A 9 points hedonic scale was used to determine the overall acceptance using the following scales: 9 = like extremely, 5 = neither like nor dislike, the limit of acceptance, and 1 = dislike extremely.

### Statistical analysis


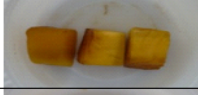
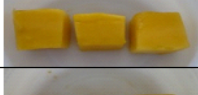
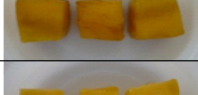

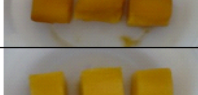


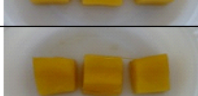


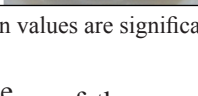
A Complete Randomized Design (CRD) was used. Statistical analysis was carried out using ANOVA and the means compared using the Least Significant Difference (LSD) test at a significance level of  $p < 0.05$  using SPSS software (version 15.0, IBM Crops; White Plains, NY, USA). The data were presented as the means  $\pm$  SD of 4 replications.

## Results and Discussion

### Effect of honey dips on browning retardation

Table 1 shows the visual appearance and browning intensity ( $\Delta OD_{420}/100g$  FW) of the mango cubes dipped in honey solution at the concentration of 0, 5, 10, 15, 20 and 25% (v/v) stored for 24 h. We obviously found that honey solution inhibited browning in the mango cubes depending on increased concentration. The 25% honey dip represented the best result in retarding browning intensity and maintaining visual appearance of the cubes during storage for 24 h. This result is similar to previous works demonstrating antienzymatic browning function of honey solution in fresh-cut fruit (Son *et al.*, 2001; Jeon and Zhao, 2005; Lin *et al.*, 2006; Ergun and Ergun, 2010). As possessing high reducing compounds like ascorbic acid, riboflavin and antioxidants (White *et al.*, 1961), honey could be an excellent alternative for controlling oxidative browning (McEvily *et al.*, 1992). Gacche *et*

Table 1. Photographs and browning intensity of fresh-cut 'Nam Dok Mai' mango fruit dipped in honey solution at various concentrations during storage for 24 h

Treatments	Duration (h)	Visual appearance	Browning intensity ( $\Delta OD_{420}/100g$ FW)
Control	0		
	24		13.17±1.33 e
5% Honey	0		
	24		6.90±0.67 d
10% Honey	0		
	24		5.06±0.65 c
15% Honey	0		
	24		3.40±0.48 b
20% Honey	0		
	24		3.00±0.32 b
25% Honey	0		
	24		1.55±0.80 a

<sup>a</sup> Different letter in the same column that mean values are significantly different by LSD test ( $P < 0.05$ )

*al.* (2009) reported that browning inhibition in apple juice treated with honey was due to inactivation of PPO and the presence of reducing substances in honey. In fresh-cut apple slices, honey is an inhibitor of PPO-mediated browning (Oszmainski and Lee, 1990). Although PPO activity was not determined in this work, a similar antibrowning reaction by honey dip might be explained as the previous works.

#### *Effect of honey or carboxylic acid dips on browning retardation*

As the result shown in table 1, 25% honey solution was selected to compare with commercial carboxylic acids (1% citric acid and 1% ascorbic acid) which used as antibrowning agent in fresh-cut product. The browning intensity ( $\Delta OD_{420}/100g$  FW)

of the mango cubes were shown in Figure 1. The browning intensity of all treatments were significantly increased with storage time ( $P < 0.05$ ). The honey dip retarded browning in the mango cubes during storage more than citric dip, ascorbic dip and control, respectively. On day 3 of storage, browning intensity of honey dip, citric acid dip and ascorbic acid dip were significantly lower than that of the control ( $P < 0.05$ ). At the end of storage, browning intensity of ascorbic acid dip reached to close the control whilst that of both honey dip and citric dip was significantly lower than that of the both dips. A similar result had been reported by Son *et al.* (2001) which citric acid and honey solution were better browning inhibitor than ascorbic acid. These confirm that honey solution is a potential natural antibrowning agent for fresh-

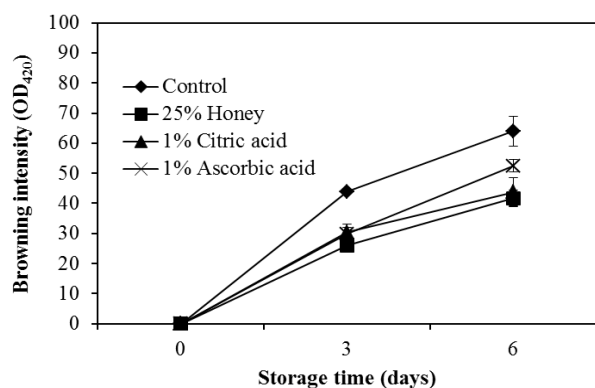


Figure 1. Browning intensity ( $\Delta OD_{420}$  /100g FW) (A) of fresh-cut 'Nam Dok Mai' mango fruit dipped in honey, citric acid and ascorbic acid solutions during storage at 4°C for 6 days. Data are means  $\pm$  standard deviation of 4 replications

cut fruit. Moreover, honey solution had been used to retain quality including browning inhibition in fresh-cut pears by using impregnation technique (Lin *et al.*, 2006). Ergun and Ergun (2010) reported that 20% honey dip could retard browning in persimmon cubes by stabilizing browning metabolites. Jeon and Zhaw (2004) had found that antioxidant capacity in honey had inhibitory effect against superoxide anion radicals resulting to browning inhibition in apple slices. Oszmianski and Lee (1990) and Gacche *et al.* (2009) suggested that honey is an effective inhibitor of PPO-mediated browning in minimally processed fruit. These works could support our work in the reason of why 25% honey dip retarded browning in 'Nam Dok Mai' mango fruit during storage.

A decrease in  $L^*$  value is an indicator of flesh browning (Dea *et al.*, 2010). As shown in Fig. 2A, the  $L^*$  value of the mango cubes continuously decreased with storage time which was concomitant with the browning increase as shown in Fig. 1. We found that honey dip reduced  $L^*$  value decrease more than organic acids dips whilst the  $L^*$  value of the control was significantly lower than others ( $P < 0.05$ ). The higher  $L^*$  value of the honey dipped cubes could be attributable to the lower browning and good appearance of the cubes when compared to other dips. Son *et al.* (2001) addressed that honey dip could reduce browning in apple slices but they were not significantly different in  $L^*$  value with ascorbic acid. However, we found that mango cubes dipped in honey solution were significantly difference in  $L^*$  value with ascorbic acid and citric acid ( $P < 0.05$ ). Our result was supported by the work of Lin *et al.* (2006) which 20% honey immersion retarded  $L^*$  value reduction in pear slices during storage. Oszmianski and Lee (1990) found that a peptide in natural honey retarded the browning in apple and grape juice. The  $b^*$ , hue angle and chroma values represent yellow colour of the

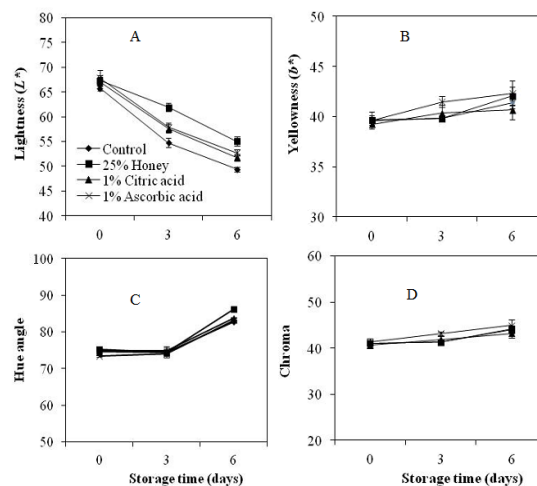


Figure 2. Superficial colours, lightness (A), yellowness (B), hue angle (C) and chroma (D), of fresh-cut 'Nam Dok Mai' mango fruit dipped in honey, citric acid and ascorbic acid solutions during storage at 4°C for 6 days. Data are means  $\pm$  standard deviation of 4 replications

cubes which increased with storage time (Fig 2B, 2C and 2D) However, no difference in these parameters among the all treatments was noticed. These indicate that honey dip and organic acid dips inhibited the loss of  $L^*$  value and had no effect on other colour parameters of 'Nam Dok Mai' mango cubes.

Figure 3 shows the difference of total superficial colour ( $\Delta E^*$ ) of the mango cubes treated with honey, citric acid and ascorbic acid solution and untreated cubes. The mango cubes dipped in 25% honey had significantly lower  $\Delta E^*$  than others over storage ( $P < 0.05$ ). The  $\Delta E^*$  of the control was significantly higher than other dips ( $P < 0.05$ ). No significant difference in  $\Delta E^*$  of both carboxylic acids dips during storage was found. The low  $\Delta E^*$  in the cubes dipped in 25% honey solution was clearly related to the browning inhibition and high  $L^*$  value as shown in above. These could suggest that honey dip could retain superficial colour of the mango cubes during storage.

The sensory overall acceptance score among treatments did differ statistically on day 6 ( $P < 0.05$ ) (Fig. 4). The control scored lower than other treatments which was  $4.85 \pm 0.20$  score. The lower score of the control obviously associated with the higher browning intensity and BI when compared other treatments as shown in Fig 1. The 25% honey dip eventually reached the highest overall acceptance score at the end of storage which was  $6.41 \pm 0.18$  and the value was higher than 1% citric acid and 1% ascorbic acid dips. We found that the overall acceptance score of 1% citric acid and 1% ascorbic acid dips were  $5.72 \pm 0.8$  and  $5.60 \pm 3.45$ , respectively. The highest score of overall acceptance



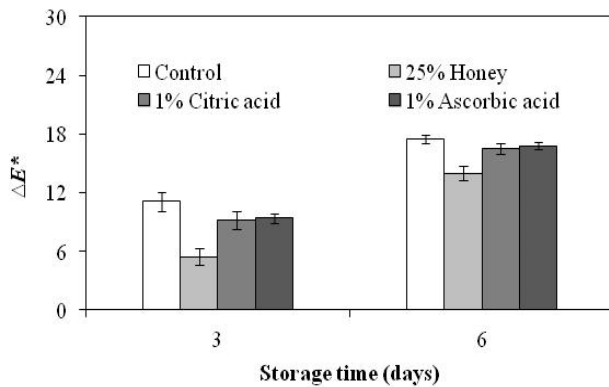


Figure 3. Colour difference ( $\Delta E^*$ ) of fresh-cut 'Nam Dok Mai' mango fruit dipped in honey, citric acid and ascorbic acid solutions during storage at 4°C for 6 days. Data are means  $\pm$  standard deviation of 4 replications

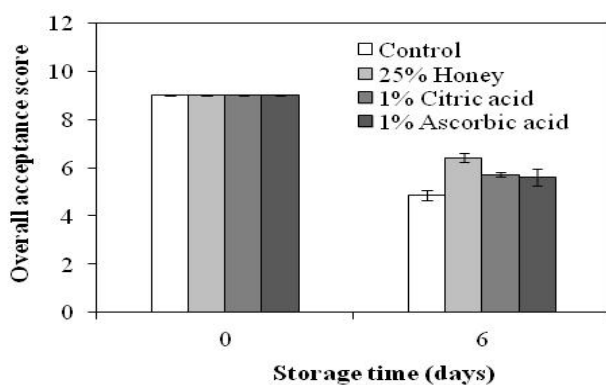


Figure 4. Overall acceptance score of fresh-cut 'Nam Dok Mai' mango fruit dipped in honey, citric acid and ascorbic acid solutions during storage at 4°C for 6 days. Data are means  $\pm$  standard deviation of 4 replications

was clearly related to the lowest browning (Fig. 1) and  $\Delta E^*$  (Fig. 3) and the highest  $L^*$  value (Fig. 2A). These suggest that people might accept the use of honey as a potential natural antibrowning agent for fresh-cut fruit more than traditional commercial natural antibrowning agents such as citric acid and ascorbic acid use. Moreover, there are previous works supporting our study which 20% honey-based vacuum impregnation - treated pear slices had a high score of consumer acceptability (Lin *et al.*, 2006) and 20% honey treated fresh-cut persimmon had higher visual quality than 0 and 10% honey treated fruit (Ergun and Ergun, 2010). Thus, honey dip is a potential alternative for maintaining fresh-like appearance of fresh-cut fruit.

## Conclusions

As a conclusion, honey dipping was effective to prevent browning of 'Nam Dok Mai' mango cubes during storage at 4°C for 6 days. The inhibitory effects of honey solution increased depending on its concentration. We found that 25% honey was

effective to retain superficial colour, to prevent browning and to provide a high overall acceptance score. Compared to commercial carboxylic acids for browning inhibition, honey solution is a natural alternative having a high potential in browning prevention and superficial colour maintenance of fresh-cut fruit. Furthermore, the effect of honey solution on prevention browning of other fresh-cut fruits and its anti-browning mechanism must be considered in future work.

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