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Effects of Edible Chitosan Coating on Quality of Fresh-Cut Mangoes (Fa-lun) During Storage

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ABSTRACT

Fresh-cut Fa-lun mango samples (*Mangifera indica* L.) were coated with chitosan solutions at concentrations of 0% (control), 0.5 and 0.8%, respectively. They were then placed into plastic trays, over-wrapped with polyvinylchloride film and stored at 6°C for 7 d. Fresh-cut mangoes were evaluated by measuring weight loss, pH, total soluble solids, total acidity, color, firmness, total microbial counts and sensory qualities. It was found that chitosan coatings could preserve fresh-cut mango quality by reducing weight loss, delaying an increase of total soluble solids, change in color, growth of microorganisms and maintaining sensory attributes (visual appearance, firmness and overall liking).

Key words: chitosan, coating, Fa-lun mangoes, fresh cut, quality

INTRODUCTION

Mango (*Mangifera indica* L.) cv. Fa-lun is a climacteric fruit, which is cultivated widely in Thailand. Fresh-cut mango is one of the products with the highest potential due to increasing consumer demand for fresh and convenient foods (Souza *et al*., 2006). However, cutting or slicing of a fresh product exposes living and respiring tissue to considerable mechanical damage and physiological changes in color, texture, aroma and overall appearance that cause a reduction in fruit shelf life (Reyes, 1996). The internal and external quality of mango slices are critical to consumer acceptability and are important marketing considerations (Baldwin, 1999). Thus, methods to preserve the quality attributes of fresh-cut mango during handling, distribution and commercial storage are needed. Chitosan (a high molecular weight cationic polysaccharide) is soluble in dilute organic acids and has the potential to prolong storage life by controlling decay of many fruits, such as longan, pear, table grape, strawberry, litchi and chestnut (Zhang and Quantick, 1997; Jiang and Li, 2001; Pen and Jiang, 2003; Lin *et al*., 2008; Meng *et al*., 2008; Hermandz-Munoz *et al*., 2008). It has been reported that chitosan had antimicrobial activity through interactions between its positively charged molecules and the negatively charged microbial cell membrane. This interaction causes the disruption and death of the microbial cell (Young and Kauss, 1983; Helander *et al*., 2001). Therefore, the objective of this research was to investigate the effect of an edible chitosan coating on quality changes in fresh-cut mangoes (Fa-lun) during refrigerated storage at 6°C.

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MATERIALS AND METHODS

Fresh-cut mango preparation

Unripe mangoes (*Mangifera indica* L.) cv. Fa-lun were obtained from Baan Peow plantation in Samutsakorn province of Thailand. Mango maturity was standardized and controlled by harvesting the fruit at 90 d after its blooming and samples were selected for their uniformity in size, color, shape and absence of damage. Raw mangoes were washed in tap water and sanitized for 5 min in chlorinated water (200 ppm sodium hypochlorite). The fruits were peeled manually with a stainless steel knife. Fruit cheeks were cut from both sides of the seed. Chitosan coating was purchased from Seafresh Chitosan (Lab) Co., Ltd, Bangkok, Thailand (Seafresh Chitosan Power; 95% deacetylated; molecular weight 760 kDa). Chitosan solutions at various concentrations of 0, 0.5 and 0.8 g/100 ml of 1% acetic acid were prepared. The pH in all solutions was adjusted to 5.0 with 0.1 M NaOH. An acid solution at pH of 5.0, without chitosan was used as the control. Fresh-cut mangoes were dipped in chitosan solutions for 1 min. After being air-dried for 30 min at 25°C, the sliced fruit were placed into plastic trays and over-wrapped with polyvinylchloride film. All samples were stored at 6°C for 7 d.

Weight loss determination

Samples were separated for weight loss determination. Individual packs of raw mango slices were weighed at the beginning of the experiment just after coating and air-drying and thereafter at 1, 3, 5 and 7 d during the storage period. Weight loss was expressed as a percentage loss of the initial total weight.

pH, total soluble solids and total acidity determination

Sliced mangoes were cut into small pieces and homogenized in a grinder and then 50 g was filtered. The pH and total soluble solids of the samples were assessed using a pH meter (Radiometer PHM 210, Metro Lab, France) and a refractometer (Hand-Held Refractometer; Atago Co. Ltd., Japan), respectively. Total acidity was determined by adding 100 ml distilled water into 5 g of ground mango, which was subsequently titrated to pH 8.1 using 0.1 N NaOH. Total acidity was expressed in g of citric acid/100 g of mango.

Color

The color of each mango slice was measured at three points (above, middle, below) with a chromameter (Mini Scan XE Plus, Hunter Associates Laboratory, Inc., Virginia, United state). CIE L* a* b* coordinates were recorded using a D65 illuminant and a 10° standard observer as a reference system. The chromatic coordinates were defined as: L* (lightness), a* (- greenness to + redness) and b* (- blueness to + yellowness).

Texture analysis

The firmness of the mango samples was determined using a texture analyzer (TA-XT2i; Stable Micro System Co., Ltd., UK.). Mangoes were cut into cubes of 2×1.5×1 cm, measured in the central zone. Firmness was measured as the maximum penetration force (N) reached during tissue breakage, and determined with a 5 mm diameter cylinder stainless probe. The equipment settings used were: preset speed, 5 mm/s; test speed, 1 mm/s; distance, 60% strain; time, 1 s.

Microbiological analysis

The microbiological characteristics of a 25 g sample were obtained after homogenization in 225 ml 0.1% peptone water. Other decimal dilutions were prepared from a 10^{-1} dilution. The total plate count was determined using the pour plate method and Plate count agar as the medium. Incubation occurred at 37°C for 48 h (BAM, 1995). Microbial counts were reported as log CFU/g (colony forming units per g of sample).

Sensory analysis

Sensory analysis was performed by 30 untrained panelists to evaluate visual appearance, firmness, flavor and overall liking, using a 9-point hedonic scale (1-dislike extremely, 2-dislike very much, 3-dislike moderately, 4-dislike slightly, 5-neither like nor dislike, 6-like slightly, 7-like moderately, 8-like very much, and 9-like extremely). The samples were evaluated at day 0 and day 7 of storage.

Statistical analysis

The experimental design was completely randomized with two replications. Data were analyzed and means were compared by Duncan's multiple range test with significance determined at the 0.05 level. The data analysis was assisted by statistical software (SPSS for Windows Ver. 12.0, SPSS Inc., Thailand).

RESULTS AND DISCUSSION

Weight loss, pH, total soluble solids and total acidity

Weight loss of fruit was mainly associated with respiration and moisture evaporation through the skin. The experimental results indicated that the chitosan coating could retard the weight loss of fresh-cut mango (Figure 1). Throughout storage, the weight loss of uncoated mango slices (0% chitosan) was significantly greater than that of chitosan-coated mango slices ($p \leq 0.05$). However, there was no significant difference between the fruit treated with 0.5% and 0.8% chitosan ($p>0.05$). At the end of storage, the uncoated sample had 3.00±0.08% loss in weight, whereas the weight loss of samples coated with 0.5 and 0.8% chitosan was 2.54±0.25 % and 2.45±0.35%, respectively. The results were in accordance with previous studies in which chitosan was found to be more effective at delaying weight loss in peeled litchi fruit (Dong *et al.*, 2004), strawberry (Ribeiro *et al.*, 2007; Hermandz-Munoz *et al.*, 2008) and longan fruit (Jiang and Li, 2001).

The pH values of uncoated and chitosan-coated samples after 0, 1, 3, 5 and 7 d were not significantly different ($p>0.05$) (Figure 2). After seven days of storage, the pH of uncoated, 0.5 and 0.8% chitosan samples was 4.39±0.06, 4.44±0.14 and 4.59±0.14, respectively. Coating with various concentrations of chitosan solution did not affect the pH of mango slices. This finding was supported by Hermandz-Munoz *et al.* (2008) who reported that a chitosan concentration from 1.0 to 1.5% did

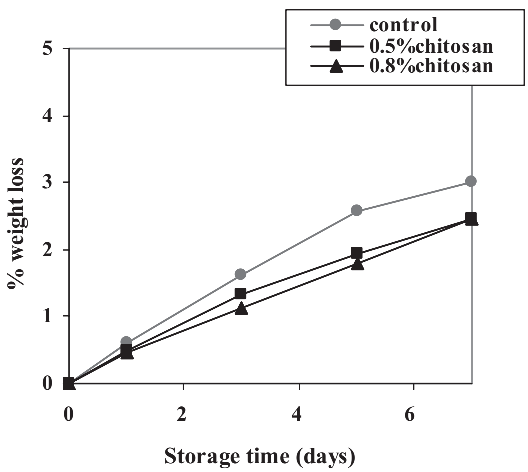

Figure 1 Change in weight loss of fresh-cut mangoes stored at 6°C.

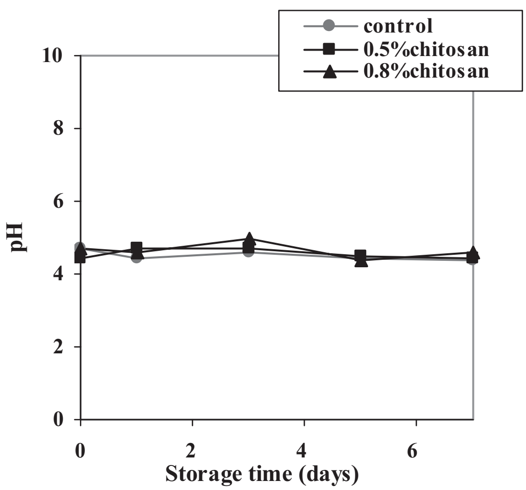

Figure 2 Change in pH of fresh-cut mangoes stored at 6°C.

not significantly affect the pH of chilled strawberry fruit during storage.

Changes in the total soluble solids of fresh-cut mango over the storage period are shown in Figure 3. The total soluble solids of fruit increased with increasing storage time. At 0, 1 and 3 d storage time, the total soluble solids content of uncoated and chitosan-coated samples was not significantly different (p>0.05), but at 5 and 7 d storage there was a significant difference. However, the amount of total soluble solids was not significantly different between the fruits treated with 0.5 and 0.8% chitosan. Fresh-cut mango slices that were not treated with chitosans contained higher total soluble solids than chitosan-coated mango slices. A plausible explanation for the observed increment in total soluble solids is the considerable loss of water during storage (Hermandz-Munoz *et al.* , 2008).

Total acidity was reported as the percentage of citric acid per mango wet weight. It was found that the total acidity of uncoated and chitosan-coated samples was not significantly different (p>0.05). After 7 d of storage, the total acidity of uncoated, 0.5 and 0.8% chitosan samples was 0.13±0.04, 0.11±0.07 and 0.08±0.02, respectively (Figure 4). The results obtained in this study indicated coating with chitosan did not affect the total acidity of samples for all storage durations.

Color analysis

Color is an important factor in the perception of fresh-cut mango quality. Figures 5, 6 and 7 show the changes in surface color of fresh-cut mango stored at 6°C for 7 d, as indicated by L*, a* and b*, respectively. At the end of the storage period, the L* values of fresh-cut coated samples and that of chitosan-coated samples were significantly different (p≤0.05). However, the L* values were not significantly different between the fruit treated with 0.5% and 0.8% chitosan. The values of redness (a*) and yellowness (b*) of uncoated and chitosan-coated sliced samples at 0, 1, 3, 5 and 7 d were not significantly different. At the end of storage, redness (a*) and yellowness (b*) values of samples were approximately (-2.70)-(-2.90) and 24.37-25.51, respectively.

Firmness

Texture is a critical quality attribute influencing consumer acceptability of fresh fruit and vegetables. It is related to metabolic changes and water content (Garcia *et al.*, 1998). Figure 8

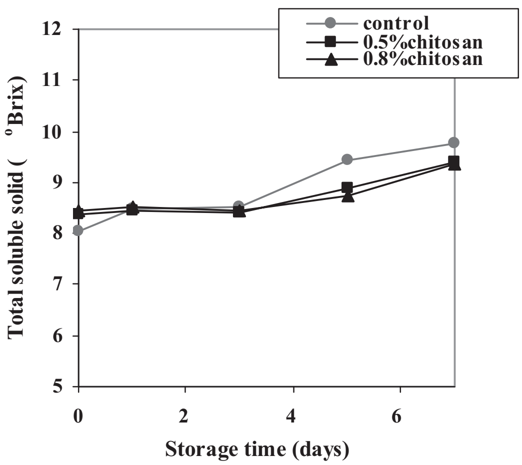

Figure 3 Change in total soluble solid of fresh-cut mangoes stored at 6°C.

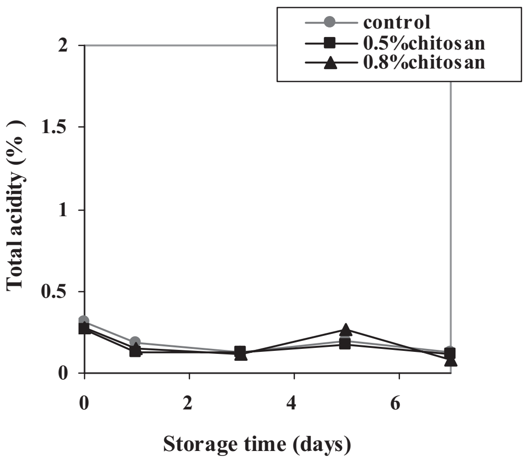

Figure 4 Change in total acidity of fresh-cut mangoes stored at 6°C.

shows changes in mango flesh firmness of the control and coated fruit during the storage period. The firmness of fresh–cut mangoes decreased with increasing storage time. The firmness of samples coated with 0, 0.5 and 0.8% chitosan was 29.75±1.95, 29.92±3.28 and 31.65±7.97 N, respectively.

Microbiological analysis

The growth of microorganisms on uncoated and chitosan-coated samples significantly increased ($p \leq 0.05$) from 1, 3, 5 and 7 d (Table 1). The total microbial count of uncoated samples increased from 2.83±0.06 to 5.67±0.06 log CFU/g at the end of the storage. The chitosan coating on the mango slices effectively inhibited the growth of microorganisms. Nevertheless, increasing chitosan concentration from 0.5% to 0.8% did not further affect the growth of microorganisms ($p>0.05$). The results were in agreement with the studies of Campaniello *et al.* (2008) and Simoes *et al.* (2009), which reported

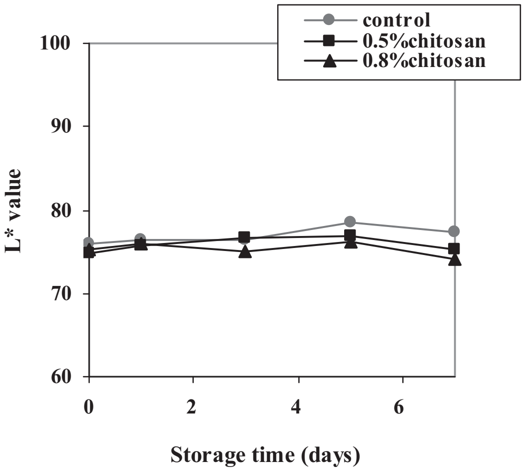

Figure 5 Change in L* value of fresh-cut mangoes stored at 6°C.

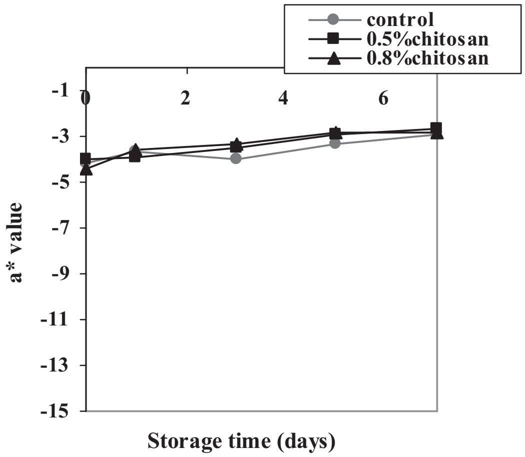

Figure 6 Change in a* value of fresh-cut mangoes stored at 6°C.

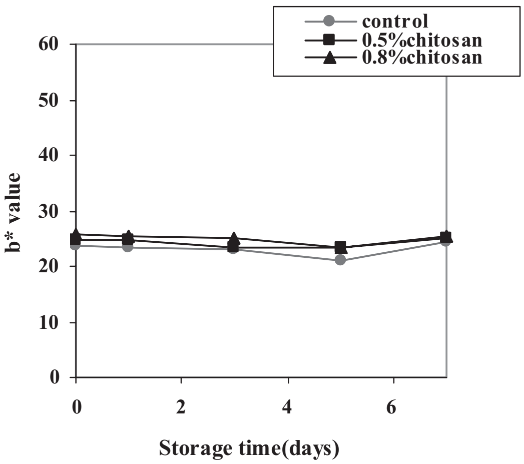

Figure 7 Change in b* value of fresh-cut mangoes stored at 6°C.

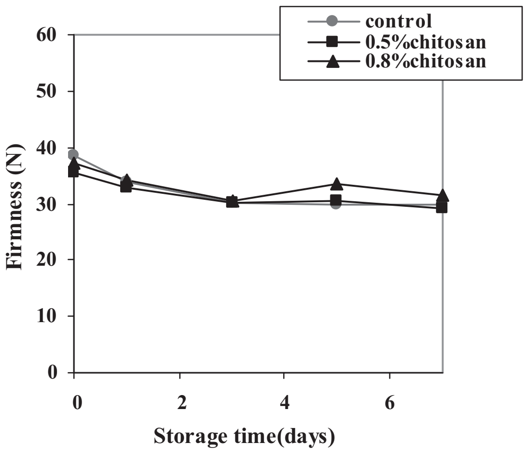

Figure 8 Change in firmness of fresh-cut mangoes stored at 6°C.

that the application of chitosan to strawberries and carrot sticks, respectively, could inhibit the growth of microorganisms.

Sensory evaluation

Sensory data for Fa-lun mangoes stored for 7 d at 6°C are presented in Table 2. Four characteristics of mango pulp (visual appearance, firmness, flavor and overall liking) were analyzed for acceptability. Initially (0 d), the liking scores of uncoated and chitosan-coated mangoes were not significantly different (p>0.05). At the end of the storage period, there were significant differences (p≤0.05) in the liking scores of uncoated and chitosan-coated mangoes, except in the flavor liking score which was not significantly different (p>0.05). There was no significant difference in liking scores between the fruit coated with 0.5% and 0.8% chitosan. The results were supported by the study of Hernandez-Munoz *et al*. (2008), which reported that chitosan coating improved the quality and extended the shelf life of strawberry fruit. Chitosan coating delayed the sensory quality deterioration of peeled litchi fruit (Dong *et al.,* 2004) and the change in eating quality (Jiang and Li, 2001).

CONCLUSIONS

Chitosan coating could prolong fresh-cut Fa-lun mangoes during storage at 6°C for 7 d. Chitosan could reduce weight loss, maintain total soluble solids and retard the growth of microorganisms in fresh-cut Fa-lun mangoes. In addition, sensory perception indicated the superior quality of the chitosan-treated product compared with the non-treated product at the end of the storage period. Therefore, the application of chitosan appears highly promising in the food industry for maintaining fresh-cut mangoes during refrigerated storage.

Table 1 Change in microbial counts of fresh-cut mango stored at 6°C.

Time (day)	Microbial counts (Log CFU/g)		
	0% chitosan	0.5% chitosan	0.8% chitosan
0	2.83±0.06 [a]	2.84±0.09 [a]	2.80±0.11 [a]
1	3.45±0.04 [a]	3.31±0.05 [b]	3.30±0.03 [b]
3	3.94±0.05 [a]	3.71±0.08 [b]	3.71±0.04 [b]
5	4.80±0.03 [a]	4.53±0.07 [b]	4.57±0.04 [b]
7	5.67±0.06 [a]	5.47±0.05 [b]	5.44±0.04 [b]

[a-b] = Means within a row with different letters are significantly different (p≤0.05).

Table 2 Effect of chitosan coating on sensory quality of fresh-cut Fa-lun mangoes stored at 6°C.

Attributes	Time (day)	0% chitosan	0.5% chitosan	0.8% chitosan
Appearance	0	6.92±1.31 [a]	6.85±1.15 [a]	7.02±1.19 [a]
	7	5.92±0.98 [b]	6.38±1.00 [a]	6.31±0.89 [a]
Firmness	0	6.85±1.45 [a]	6.70±1.38 [a]	6.45±1.47 [a]
	7	6.02±1.26 [b]	6.42±1.06 [a]	6.52±0.95 [a]
Flavor	0	6.40±1.32 [a]	6.27±1.23 [a]	6.20±1.58 [a]
	7	6.00±1.13 [a]	6.07±0.95 [a]	5.95±0.95 [a]
Overall liking	0	6.75±1.27 [a]	6.67±1.08 [a]	6.60±1.14 [a]
	7	5.92±1.11 [b]	6.32±0.85 [a]	6.25±0.89 [a]

[a-b] = Means within a row with different letters are significantly different (p≤0.05).

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