

Quality Attribute Changes in Intact and Fresh-Cut Honeydew Melon (*Cucumis melo* var. *inodorus*) cv. 'Honey World' during Storage

Suriyan Supapvanich*, Kantharat Boon-Lha and Nareerat Mhernmee

ABSTRACT

Honeydew melon (*Cucumis melo* var. *inodorus*) cultivar 'Honey World' is grown commercially in Thailand for its fruit. The purpose of this study was to investigate the quality changes in intact and fresh-cut 'Honey World' melon fruit during storage. The intact fruit were stored at room temperature (27 ± 2 °C) for 21 d and the fresh-cut fruit were stored at 4 ± 2 °C for 9 d. Weight loss, texture, electrolyte leakage, flesh color, total soluble solids (TSS), titratable acidity (TA), pH and TSS/TA ratio were determined. Marked loss of texture was detected in both the intact and the fresh-cut fruit throughout storage. The weight loss and electrolyte leakage of both the intact and fresh-cut fruit increased during storage. In the intact fruit, lightness and hue angle remained constant throughout storage. An increase in the whiteness index and a decrease in chroma were detected during storage. In the fresh-cut fruit, the lightness, whiteness index and chroma declined and hue angle remained constant throughout storage. The total soluble solids content of both the intact and fresh-cut fruit increased and then remained constant over storage. The titratable acidity and pH of both the intact and fresh-cut fruit remained constant during storage. The TSS/TA ratio of the intact fruit declined slightly at day 21 and that of the fresh-cut fruit increased at day 6 and remained constant during storage. In conclusion, a marked loss of texture was found and might be the key factor affecting the quality of both the intact and fresh-cut 'Honey World' melon fruit when compared to other parameters.

Keyword: 'Honey World' melon fruit, quality attributes, intact fruit, fresh-cut fruit

INTRODUCTION

Recently, melons have become the fourth most commercially important fruit in the world, after oranges, bananas and grapes (Aguayo *et al.*, 2004). Melons are a popular fruit because of their pleasant odor and sweet taste (Villanueva *et al.*, 2004). The main factors limiting the quality of melon fruit are texture, sweetness and odor

(Portela and Cantwell, 1998; Luna-Guzmán *et al.*, 1999). The market quality of melon fruit is determined on the basis of sugar content and more routinely as the total soluble solids content measured in °Brix (Lester and Dunlap, 1985; Villanueva *et al.*, 2004). The total soluble solids content recommended for melon fruit sold in markets should be higher than or equal to 10 °Brix (United National Economic Commission for

Faculty of Natural Resources and Agro-Industry, Chalermprakiat Sakon Nakhon Province Campus, Kasetsart University, Sakon Nakhon 47000, Thailand.

* Corresponding author, e-mail: csnsys@ku.ac.th

Europe, 2006) and specifically for honeydew-type melon fruit it should be higher than 8 °Brix USDA (1981). Portela and Cantwell (1998) reported that a small change in the sugar content of fully ripe muskmelon fruit was detected during storage. Lester and Dunlap (1985) also reported the accumulation of sugar in muskmelon fruit during ripening. It is widely recognized that flesh softening is one of the key factors limiting the quality, acceptability and shelf-life of fruit and vegetables; Simandjuntak *et al.* (1996) suggested that one of the most common problems of melon fruit during storage was softening. During ripening, melon fruit lose flesh firmness rapidly (Aggelis *et al.*, 1997). Portela and Cantwell (1998) reported that during storage, the firmness loss in fresh-cut honeydew melon (*Cucumis melo* var. *inodorus*) fruit was higher than that of fresh-cut cantaloupe melon (*Cucumis melo* var. *reticulatus*) fruit. The loss of texture is usually related to the loss of tissue turgor pressure, cell membrane degradation and cell wall disassembly (Brummell, 2006). Ergun *et al.* (2005, 2007) reported that the loss of texture in intact and fresh-cut Galia melon (*Cucumis melo* var. *reticulatus*) fruit was concomitant with an increase in tissue electrolyte leakage. Rojas *et al.* (2006) suggested that the loss of texture in honeydew melon fruit is related to the loss of turgor pressure. The relationship between the loss of firmness and the modification of pectin polymers and other cell wall components in melon fruit has been reported by Ranwala *et al.* (1992), Rose *et al.* (1998), Villanueva *et al.* (2004) and Supapvanich (2009).

‘Honey World’ melon is known as a cultivar of the honeydew-type of melons (*Cucumis melo* var. *inodorus*). The surface of the fruit is white-green with some net lines. The flesh is sweet, firm, white-green in color and delicate and juicy. As a commercial melon cultivar grown in Thailand, there were no reports available for ‘Honey World’ melon fruit regarding quality changes during storage or the postharvest quality

attributes of either the whole fruit or fresh-cut products that were investigated in this study.

MATERIAL AND METHODS

Plant material

‘Honey World’ melon (*Cucumis melo* var. *inodorus*) fruit were obtained from a local orchard in Pannanikhom district, Sakon Nakhon province. The fruit were harvested at 35 d after anthesis and then delivered to the Food Technology Laboratory on the campus of Kasetsart University in Sakon Nakhon province, and screened for uniformity so that all samples were free from any defects. The surface of each fruit was cleaned with 100 µL.L⁻¹ sodium hypochlorite at room temperature (27 ± 2 °C) and air-dried.

Quality changes in intact ‘Honey World’ melon fruit

The whole fruit samples were stored at room temperature (27 ± 2 °C and 63–67% relative humidity) for 21 d. The texture, weight loss, electrolyte leakage (EC), flesh color, total soluble solids, titratable acidity, TSS/TA ratio and pH were recorded throughout the storage period. Three replicates were measured.

Minimal processing of ‘Honey World’ melon fruit

The melon fruits were screened and prepared as described in the previous section. All materials used for processing were disinfected using 200 µL.L⁻¹ sodium hypochlorite. The fruits were sliced in half with a sharp knife and each half was cut at the exposed end into four equal pieces. The seeds, cavity tissues and peel were then removed. The fruits were cut into cubes approximately 2 × 2 × 2 cm. Seven cubes were kept in polyethylene plastic containers wrapped with punctured wrapping film (10 holes, 0.5 mm in diameter, were made using a needle). The containers were kept at 4 ± 2 °C for 9 d. The

texture, weight loss, EC, flesh color, total soluble solids, titratable acidity, TSS/TA ratio and pH were recorded throughout the storage period. Three replicates were measured.

Physicochemical measurements

Weight loss

The weight loss of both the intact and the fresh-cut fruit was monitored before and after storage. The percentage of weight loss during storage was calculated compared to the initial weight.

Texture

Flesh texture was determined using a TA-XT II texture analyzer (Stable Micro Systems, Surrey, England), equipped with a 2 mm diameter probe. The probe was driven at a crosshead speed of 10 mm.sec⁻¹ to a depth of 5 mm. The maximum force exerted (expressed as kilograms per square centimeter) was used for texture data.

Electrolyte leakage

Electrolyte leakage measurement was modified from the method described by Ergun *et al.* (2005). Flesh melon cylinders (9 mm in diameter) were removed from the equatorial part of the fruit using a cork borer. The cylinders were cut to produce 4 mm thick discs. Seven discs per fruit were rinsed with deionised water and dried using Whatman filter paper. The discs were placed into a 100 mL beaker and then 30 mL of 500 mM mannitol was added. The conductivity of the solution was immediately measured using a conductivity meter (sensionTM5, Hach Company, USA). The discs were left in the mannitol for 4 hr and the conductivity of the solution was then recorded. For total electrolyte determination, the discs and bathing solution were stored in a freezer for 24 hr, thawed and then boiled for 15 min. After the solution was cooled to room temperature, the conductivity was measured. The electrolyte

leakage was expressed as the percentage of mesocarp total electrolyte content.

Flesh color

The color of the melon flesh was measured using a HunterLab MiniScan[®]XE Plus (Hunter Associates Laboratory Inc., USA). The flesh color was interpreted using values for L* (lightness), chroma ($C^* = [a^{*2} + b^{*2}]^{1/2}$) and hue angle ($h^\circ = 180 + \tan^{-1}[b^* / a^*]$), where 0° = red purple; 90° = yellow; 180° = bluish green; and 270° = blue.

Total soluble solids

The TSS content was used to estimate the sweetness using a hand-held refractometer (ATAGO MNL-1125, Japan). Juice from the melon flesh was used to assay the TSS (expressed as °Brix).

Titratable acidity (TA) and pH

A sample of 10 mL of the juice was titrated with 0.1 N NaOH using 1% (w/v) phenolphthaleine as the indicator. The volume of 0.1 N NaOH used in the titration was recorded. Titratable acidity was defined as the percentage of titratable acidity (%TA). For the pH determination, a 15 mL sample of the juice was measured using a pH meter (Metrohm, Switzerland).

Statistical analysis

A complete randomised design was used. Statistical analysis was carried out using ANOVA and the means compared using the least significant difference test at a significance level of $P < 0.05$ using SPSS software (version 15.0; now a part of IBM Corp.; White Plains, NY, USA). The data for the triplicate measurements were presented as the mean \pm standard error (SE).

RESULTS

Texture, weight loss and electrolyte leakage

A significant decrease in texture was detected in both the intact and the fresh-cut 'Honey World' melon fruit throughout storage (Figure 1A₁ and A₂). In the intact fruit, texture decreased from 181 kg.cm⁻² at day 0 to 137 and 103 kg.cm⁻² at days 7 and 21, respectively. In the fresh-cut fruit, texture decreased from 177 kg.cm⁻² at day 0 to 124 and 87 kg.cm⁻² at days 6 and 9, respectively.

The weight loss of both the intact and the fresh-cut fruit also increased significantly during storage (Figure 1B₁ and B₂). At the end of storage, the weight loss of the intact fruit reached 7.8% and that of the fresh-cut fruit reached 18.2%. The electrolyte leakage (EC) of the intact fruit remained constant over the first 7 d and a marked and significant increase in EC was detected on day 21 (Figure 1C₁). In the fresh-cut fruit, EC increased significantly throughout storage (Figure 1C₂).

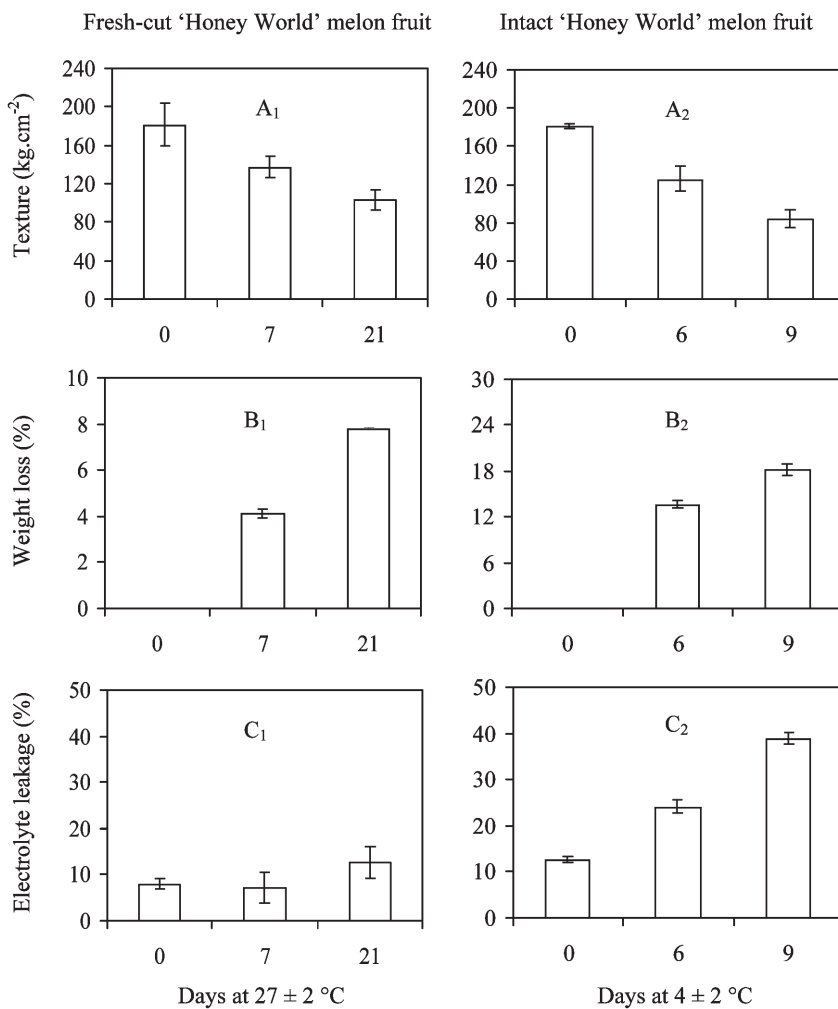


Figure 1 Texture (A), weight loss (B) and electrolyte leakage (C) of the flesh, where the subscripts 1 and 2 for A, B and C represent: (1) Intact 'Honey World' melon fruit stored at room temperature (27 ± 2 °C) for 21 d; and (2) Fresh-cut 'Honey World' melon fruit stored at 4 ± 2 °C for 9 d. Vertical bars represent ± standard error of mean (n=3).

Flesh color

The flesh color of the intact fruit is shown in Figure 2. Lightness (Figure 2A) and hue angle (Figure 2C) remained constant throughout storage. An increase in the whiteness index was found in the intact fruit at day 7 and then remained constant until day 21 (Figure 2B). In contrast, a slight decrease in chroma was detected in the intact fruit at day 7 and then this also remained constant until day 21 (Figure 2D). Figure 3 shows the color of the fresh-cut fruit. Lightness (Figure 3A) and the whiteness index (Figure 3B) of the fresh-cut fruit remained constant from day 0 to day 6 and decreased at day 9. Hue angle also remained constant throughout storage (Figure 3C). A slight decrease in chroma was found in the fresh-cut fruit at day 6 and then it remained constant over storage (Figure 3D).

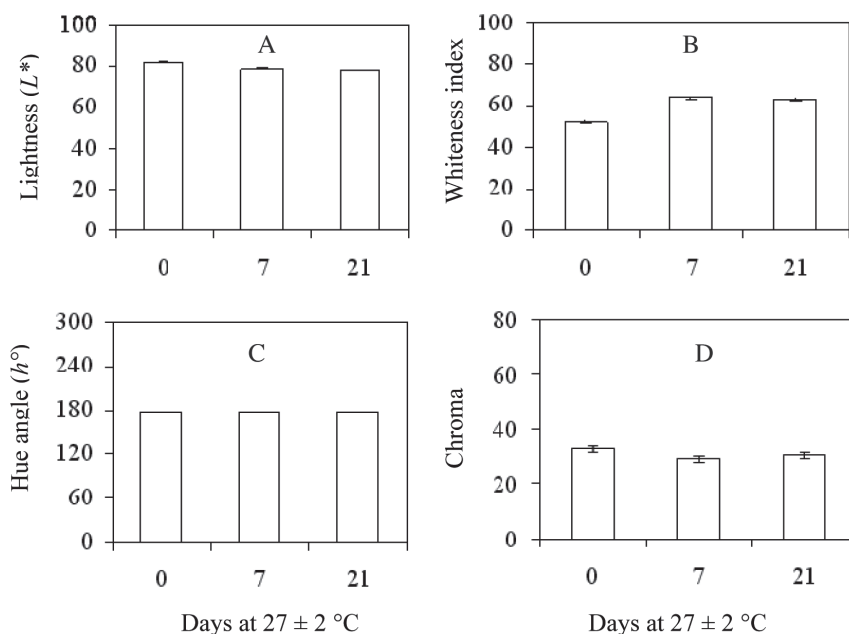


Figure 2 Lightness (L^*) (A), whiteness index (B), hue angle (C) and chroma (D) of the flesh of intact 'Honey World' melon fruit during storage at room temperature ($27 \pm 2^\circ\text{C}$) for 21 d. Vertical bars represent \pm standard error of mean ($n=3$).

Total soluble solids, TSS/TA ratio, Titratable acidity and pH

Figure 4 shows the TSS, TSS/TA ratio, TA and pH of the intact 'Honey World' melon fruit. The TSS and TA increased slightly at day 7 and then remained constant until day 21 (Figure 4A). The TSS/TA ratio remained constant until day 7 and a slight increase was detected by day 21 (Figure 4B). The pH of the intact fruit remained constant throughout storage (Figure 4D). The TSS, TSS/TA ratio, TA and pH of the fresh-cut fruit are shown in Figure 5. A slight increase in the TSS was detected in the fresh-cut fruit at day 6 and then it remained constant (Figure 5A). The TSS/TA ratio increased significantly from day 0 to day 6 (Figure 5B). The TA (Figure 5C) decreased slightly and pH (Figure 5D) remained constant throughout storage.

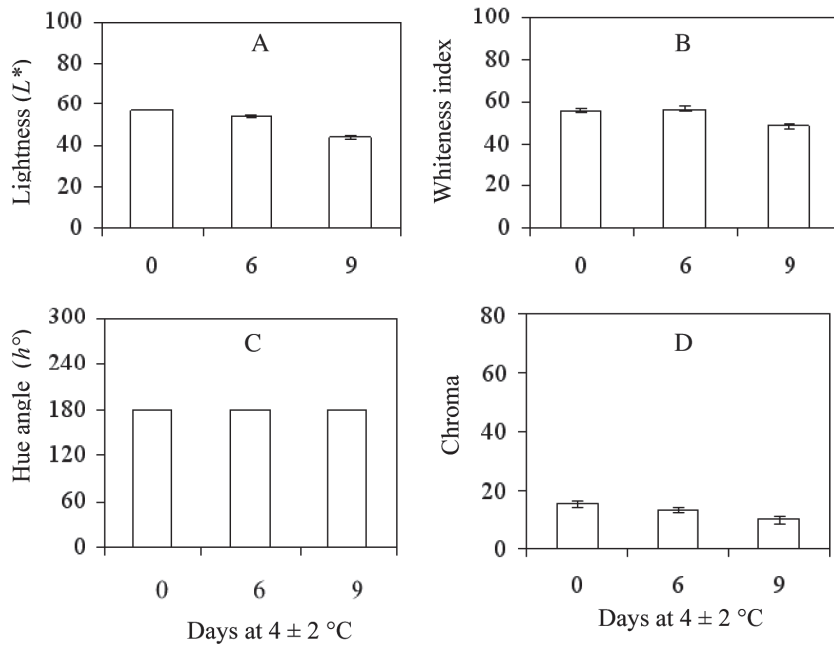


Figure 3 Lightness (L^*) (A), whiteness index (B), hue angle (C) and chroma (D) of fresh-cut 'Honey World' melon fruit during storage at 4 ± 2 °C for 9 d. Vertical bars represent \pm standard error of mean (n=3).

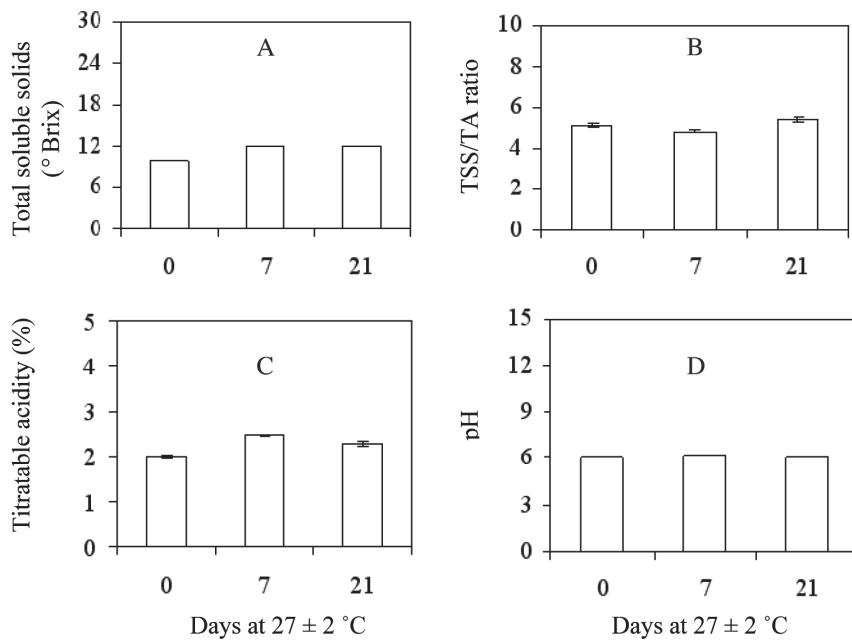


Figure 4 Total soluble solid (TSS) (A), TSS/TA ratio (B), titratable acidity (TA) (C) and pH (D) of intact 'Honey World' melon fruit during storage at room temperature (27 ± 2 °C) for 21 d. Vertical bars represent \pm standard error of mean (n=3).

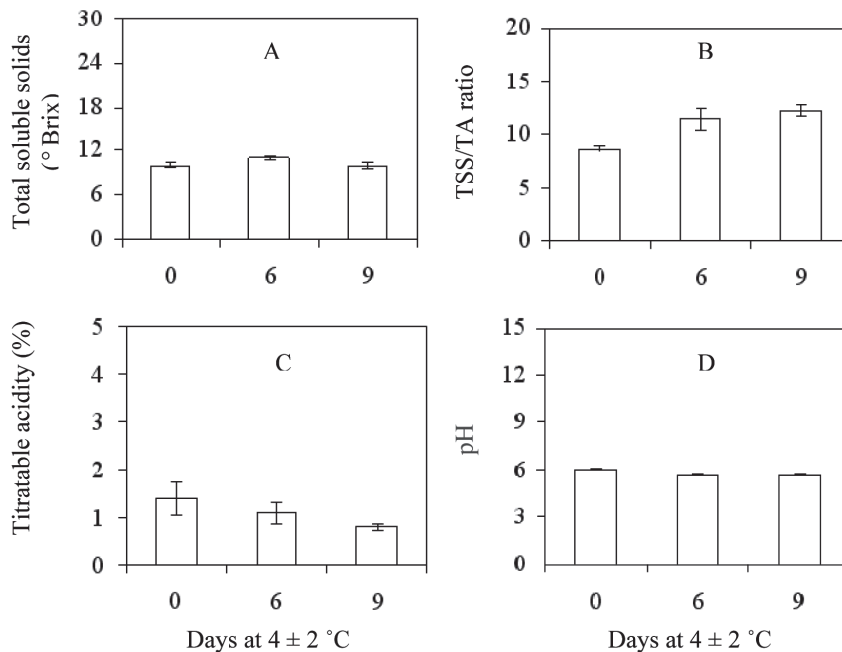


Figure 5 Total soluble solid (TSS) (A), TSS/TA ratio (B), titratable acidity (TA) (C) and pH (D) of fresh-cut 'Honey World' melon fruit during storage at 4 ± 2 °C for 9 d. Vertical bars represent \pm standard error of mean (n=3).

DISCUSSION

It is widely accepted that softening is a key factor affecting the quality of fruit. This study showed a marked decrease in texture of both the intact and the fresh-cut 'Honey World' melon fruit during storage which was concomitant with the increase in weight loss and EC (Figure 1). Loss of turgor pressure, membrane degradation and disassembly of cell wall polymers are the three main factors affecting the loss of texture in fruit and vegetables (Brummell, 2006). Toivonen and DeEll (2002) and Brummell (2006) reported that the increase in electrolyte leakage indicates a degradation of membrane integrity. Marked loss of texture in intact melon fruit during storage has been reported for cantaloupe melon fruit (Simandjuntak *et al.*, 1996; Gil *et al.*, 2006), Charentias melon fruit (Rose *et al.*, 1998; Nishiyama *et al.*, 2007), and Galia melon (Ergun *et al.*, 2005). Similarly, Aguayo *et al.* (2004)

reported that the loss of texture is a key factor limiting the quality of fresh-cut cantaloupe melon fruit and a similar result has also been reported for fresh-cut Galia melon fruit (Ergun *et al.*, 2007). The present study determined the relationship between the increase in weight loss and electrolyte leakage and the loss of texture (Figure 1). In a similar vein, Miccolis and Saltveit (1995) reported that the softening of melon fruit during storage is associated with the loss of moisture. Ergun *et al.* (2005, 2007) reported that the decrease in firmness of intact and fresh-cut Galia melon fruit is concomitant with the increase in electrolyte leakage during storage. Rojas *et al.* (2006) reported that softening in honeydew melon fruit was associated with the change in tissue turgor pressure. Moreover, the increase in weight loss and electrolyte leakage are not the only factors related to the increase in the loss of melon fruit texture; cell wall disassembly is also important, as described by Ranwala *et al.* (1992), McCollum

et al. (1989), Rose *et al.* (1998), Nishiyama *et al.* (2007) and Supapvanich (2009).

The color of 'Honey World' melon flesh is light-green. As shown in Figures 2 and 3, the hue angle of both the intact and fresh-cut fruit was approximately 178° and did not change throughout storage. Even though the lightness, whiteness index and chroma changed during storage, these might not have any influence on the changes in flesh color of both the intact and fresh-cut melon fruit. Similarly, Aguayo *et al.* (2004) reported that there was no change during storage in the flesh color of fresh-cut white flesh melon samples—namely 'Galia' melon, 'Amarillo' melon and 'Piel de Sapo' melon. These studies suggest that the change in flesh color during storage was not the key factor affecting the quality of both the intact and fresh-cut 'Honey World' melon fruit.

Taste is an important factor limiting the quality of melon fruit. For the commercial market, the TSS of melon fruit should be higher than or equal to 10 °Brix and below that level, melons are not usually suitable for market (United Nation Economic Commission for Europe, 2006). USDA (1981) recommended that the minimum soluble solids content of honeydew-type melons should be equal to or higher than 8 °Brix. The results from the present study show that the TSS of 'Honey World' melon grown in Sakon Nakhon province just reached the minimum required TSS level (Figure 2A) as recommended by USDA (1981); however, the TSS of both the intact and the fresh-cut fruit did not markedly change during storage. Similarly, no difference in the soluble solids content of both intact and fresh-cut cantaloupe melon fruit during storage was reported by Gil *et al.* (2006). Portela and Cantwell (1998) also reported that no changes in the TSS was detected in fresh-cut honeydew melon fruit during storage. In the present study, the TA and pH of both the intact and the fresh-cut melon fruit seemed constant during storage. In a similar vein, Gil *et al.* (2006) reported that the TA and pH of both

intact and fresh-cut cantaloupe melon fruit did not change during storage for 6 d at 5 °C. A similar result was also reported for fresh-cut cantaloupe melon fruit by Supapvanich (2009). The change in the TSS/TA ratio of both the intact and the fresh-cut melon fruit was concomitant with the changes in the TSS and TA during storage. However, these results suggest that the TSS, TA, TSS/TA and pH may not be the key factors limiting both intact and fresh-cut 'Honey World' melon fruit quality during storage.

CONCLUSION

The marked loss of texture in 'Honey World' melon fruit is concomitant with the increases in electrolyte leakage and weight loss during storage. The loss of texture is a key factor limiting the quality of both intact and fresh-cut melon fruit. The changes in the flesh color, TSS, TA, TSS/TA ratio and pH may not be the key factors influencing the quality of both the intact and the fresh-cut melon fruit during storage. The results of this work will benefit further studies using postharvest technology to maintain quality attributes and prolong the shelf life of the melon fruit.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the Faculty of Natural Resources and Agro-Industry, Chalermprakiat Sakon Nakhon province campus of Kasetsart University for research funding support.

LITERATURE CITED

- Aggelis, A., I. John and D. Grierson. 1997. Analysis of physiological and molecular changes in melon (*Cucumis melo* L.) varieties with different rates of ripening. **J. Exp. Bot.** 48: 769–778.

- Aguayo, E, V.H. Escalona and F. Artece. 2004. Metabolic behavior and quality changes of whole and fresh processed melon. **J. Food Sci.** 69: 148–155.
- Brummell, D.A. 2006. Cell wall disassembly in ripening fruit. **Funct. Plant Biol.** 33: 103–119.
- Ergun, M., J. Jeong, D.J. Huber and D.J. Cantliffe. 2005. Suppression of ripening and softening of ‘Galia’ melons by 1- methylcyclopropene applied at preripe or ripe stages of development. **Hort. Sci.** 40: 170–175.
- . 2007. Physiology of fresh-cut ‘Galia’ (*Cucumis melo* var. *reticulatus*) from ripe fruit treated with 1-methylcyclopropene. **Postharvest Biol. Technol.** 44: 286–292.
- Gil, M.I., E. Aguayo and A.A. Kader. 2006. Quality changes and nutrient retention in fresh-cut versus whole fruits during storage. **J. Agri. Food Chem.** 54: 4284–4296.
- Lester, G.E. and J.R. Dunlap. 1985. Physiology changes during development and ripening of ‘Perlita’ muskmelon fruits. **Scientia Hort.** 26: 323–331.
- Luna-Guzmán, I., M. Cantwell and D.M. Barrett. 1999. Fresh-cut cantaloupe: effect of CaCl₂ dips and heat treatments on firmness and metabolic activity. **Postharvest Biol. Technol.** 17: 201–213.
- McCollum, T.G., D.J. Huber and D.J. Cantliffe. 1989. Modification of polyuronides and hemicelluloses during muskmelon fruit softening. **Physiologia Plantarum** 76: 303–308
- Miccolis, V. and M. Saltveit. 1995. Influence of storage period and temperature on the postharvest characteristics of six melon (*Cucumis melo* L., *Inodorus* Group) cultivars. **Postharvest Biol. Technol.** 5: 211–219
- Nishiyama, K., M. Guis, J.K.C. Rose, Y. Kubo, K.A. Bennett, L. Wangjin, K. Kato, K. Ushijima, R. Nakato, A. Inaba, M. Bouzagen, A. Latche, J. Pech and A.B. Bennett. 2007. Ethylene regulation of fruit softening and cell wall disassembly in Charentais melon. **J. Exp. Bot.** 58: 1281–1290.
- Portela, S.I. and M.I. Cantwell. 1998. Quality changes of minimally processed honeydew melons stored in air or controlled atmosphere. **Postharvest Biol. Technol.** 14: 351–357.
- Ranwala, A.P., C. Suematsu and H. Masuda. 1992. The role of β -galactosidase in the modification of cell wall components during muskmelon fruit ripening. **Plant Physiol.** 100: 1318–1325.
- Rojas, A.M., M.A. Castro, S.M. Alzamora and L.N. Gerschenson. 2006. Turgor pressure effects on textural behavior of honeydew melon. **J. Food Sci.** 66: 111–117.
- Rose, J.K.C., K.A. Hadfield, J.M. Labavitch and A.B. Bennett. 1998. Temporal sequence of cell wall disassembly in rapidly ripening melon fruit. **Plant Physiol.** 117: 345–361.
- Simandjuntak, V., D.M. Barrett and R.E. Wrolstad. 1996. Cultivar and maturity effect on muskmelon (*Cucumis melo*) colour, texture and cell wall polysaccharide composition. **J. Sci. Food Agri.** 71: 282–290.
- Supapvanich, S. 2009. **Factors Affecting Quality of Intact and Minimally Processed Muskmelon Fruit During Storage**. PhD. dissertation. The University of Nottingham. United Kingdom. 161 pp.
- Toivonen, P.M.A. and R. DeEll. 2002. Physiology of fresh-cut fruits and vegetables, pp. 91–123. In O. Lamikanra, (ed.). **Fresh-cut Fruits and Vegetables: Science, Technology and Market**. CRC Press. Boca Raton, FL, USA.
- United Nation Economic Commission for Europe. 2006. Melon. **UNECE Standard FFV-23 Concerning Marketing and Commercial Quality Control of MELONS 2006 edition**. United Nations. New York.
- USDA. 1981. U.S. standards for grades of honey dew and honey ball type melons. **USDA Agricultural Marketing Service, Fresh Fruit Division Fresh Products Branch**. Washington DC. 3 pp.
- Villanueva, M.J., M.D. Tenorio, M.A. Esteban and M.C. Mendoza. 2004. Composition changes during ripening of 2 cultivars of muskmelon fruits. **Food Chem.** 87: 179–185.