International Journal of Agricultural Technology 2014 Vol. 10(5):1201-1211
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Quality Evaluation of Fresh and Fresh-Cut Melon (*Cucumis Melo, L*) Fruit in A Tropical Environment

Falah, M. A. F[*], Khuriyati, N., Safitri, R. M. and Revulaningtyas, I. R.

Faculty of Agricultural Technology, Dept. Agroindustrial Technology, Gadjahmada University, Jl. Flora No 1 Bulaksumur Yogyakarta, Indonesia.

Falah, M. A. F, Khuriyati, N., Safitri, R. M. and Revulaningtyas, I. R. (2014). Quality evaluation of fresh and fresh-cut melon (*Cucumis melo, L*) fruit in a tropical environment. International Journal of Agricultural Technology 10(5):1201-1211.

Abstract The quality of fresh and fresh-cut melon fruit (*Cucumis melo*, L) var. Gama Melon Basket (non-commercial netted melon) and Glamour Sakata (commercial netted melon) was evaluated based on the effects of tropical conditions of Indonesia that are characterized by high temperature and relative humidity. Whole melons were stored after harvest for 1 day, 7 days and 10 days in a non-controlled tropical environment; fresh-cut pieces of melon were packaged with a plastic cling wrap or in polyethylene and then evaluated from the first day after cutting under different environmental conditions (non-controlled environment and controlled environment at 14-15 ^{o}C). Melons were evaluated on their quality of the physical characteristics (fresh weight, color of flesh melon, texture of skin and flesh melon fruit) and nutritional characteristic (soluble *solid* content, water content, total carotenoid, titratable acidity and ascorbic acid). Based on the evaluation results of the whole quality, the two cultivars were significantly different for texture of flesh fruit, water content, soluble solid content, total carotenoid, acidity and ascorbic acid content. Patterns of change on water content and soluble solid content of these two cultivars were significantly different during storage and still accepted to be eaten on 10 days. Furthermore, fresh-cut pieces did not significant differ between the two cultivars when kept under the tropical high temperatures of 27-30 ^{o}C and 60-80% relative humidity. Fresh-cut melon fruit, covered with plastic cling wrap or polyethylene, drastically decreased in their quality when stored under non-controlled tropical conditions and the fruit could not be eaten since one day after storage. However, when their fresh-cut melon fruit was kept in the storage room at 14-15 ^{o}C the several quality parameters were acceptable until 4 days of storage. The research indicates that the tropical environment had unfavorable effects on the fresh and fresh-cut melon fruit during storage.

Keywords: Fresh and Fresh-cut product, Melon fruit, Quality, Tropical environment

Introduction

Temperature and relative humidity are the most important environmental factors affecting quality of fresh produce and also the consumer acceptability for fruits and vegetables displayed in a produce department.Good temperature

[*]**Corresponding author**: Falah, M. A. F.**; E-mail:**affan_tip@ugm.ac.id.

management is the simplest and easiest way of delaying produce deterioration and it can be applied through low storage temperatures which can depress physiological activity of tissues and activity of spoilage microorganisms, and, in general, the lower the storage temperature, the longer the produce postharvest life (Nunes and Emond, 2002; Nunes *et al*., 2009). In a tropical environment, high temperature and high relative humidity were frequently occurred throughout the year and they will affect postharvest quality of fruit, include melon fruit quality. To maintain the quality of the fresh and fresh-cut fruit, it is possible to apply the temperature management using a cooling (lower temperature) technique. Cooling techniques have been used since the 1920s to remove field heat from fresh produce, based on the principle that shelf-life is extended 2- to 3-fold for each 10 ^{o}C decrease in temperature. Several methods were applied for rapid cooling the product to the lowest safe storage temperature within hours of harvest, reducing the respiration rate and enzyme activity, slower ripening/senescence, maintenance of firmness, inhibition of pathogenic microbial growth and minimal water loss (Talbot and Chau, 2002).

The quality of the melon fruits are characterized by different factors that are associated with the characteristics of flesh as the soluble solids content, external and internal appearance of fruit, the thickness of the pulp and its aroma and flavor and all these characteristics determine the acceptance of the fruit by consumers and also are used as an index for grading and marketing (Guzman *et al*., 2009). The objectives of this study were to evaluate the quality of fresh melon fruit which is stored at a certain day (0.7 and 10 days) under tropical environmental condition on a whole fruit and also evaluate the quality of fresh-cut pieces melon fruit which stored under controlled and non-controlled environment of tropical condition with difference common wrapping using a non-commercial netted melon that compared with its commercial ones.

Materials and methods

Plant Materials

Melon fruit (*Cucumis melo*, L) var. Gama Melon Basket (non-commercial netted melon) and Glamour Sakata (commercial netted melon) were harvested at the same time (June 2010) at Agricultural Training and Research Development, Gadjah Mada University and local commercial farm in Yogyakarta, Indonesia, respectively. For measuring quality of fresh fruit, a whole melons were stored after harvest for 0 day, 7 days and 10 days in a non-controlled tropical environment (air temperature varied in the range of 26-30^{o}C). For measuring quality of fresh-cut pieces of melon, they were packaged with a plastic cling wrap from polyethylene and stored from the first day after

cutting under different environmental conditions (non-controlled environment with air temperature varied between 26-30^{o}C and controlled environment with air temperature between 14-15 ^{o}C). Figure 1 shows fresh and fresh-cut pieces of melon fruit under different environmental and wrapping conditions.

For fresh-cut melon fruit, all fruits were pre-washed for 1 min with tap water to remove traces of soil and organic matter. Using sharp sterile knives, melons were cut into two sections with longitudinal axis then cut into 8 trapezoidal-shaped sections with slices skin were peeled. The pieces of melon were placed into a mesh container and packaged with polyethylene plastics which thickness.of 0.02 mm.

Physical and Nutritional Evaluation of Whole and Fresh-cut Melon

The quality evaluation of fresh melon fruit were measured on their physical and nutritional characteristics. Fresh weight was measured using a balance (T and D,Co.Ltd, Osaka, Japan), color of flesh melon fruit was measured using a chromameter ((Minolta, CR-400, Japan) and texture of skin and flesh melon fruit as a fruit firmness was determined using a texture analyzer (UTM, Model *Zwick* Tipe DO FB0 5TS, Germany). Water content was evaluated using a thermogravimetri method (Sato *et al*., 2006), soluble solid content (% Brix) was measured using refractometer (PAL-1, Atago Co. Ltd. Japan), the titratable acidity of fruits was examined by the titratable acidity method (Sato *et al*., 2006), total carotenoid of flesh melon fruit was determined using a procedure described by Rodriguez Amaya (1999) and ascorbic acid or Vitamin C was determined using indophenols titration method (AOAC, 1990), total carotenoid and ascorbic acid were only measured at harvest (first day). Furthermore, quality evaluation of fresh-cut pieces melon fruit were also measured using same methods that mentioned above for firmness of flesh melon fruit, color of flesh melon fruit, water content and total soluble solids content.Finally, the acceptability to be eaten of fresh-cut pieces melon fruit was determined using visual evaluation.

Results and discussion

Fresh Food Quality of a Whole Melon

Table 1 shows the parameters of certain quality (physical and nutritional) in the fruit melon ‘Gama Melon Basket’ (GMB) and ‘Glamour Sakata’ (Sakata) recently harvested that measured for a whole melon. There were differences found for the fresh weight and diameter of these melon. However, total carotenoid and ascorbic acid content were higher in the GMB as non-

commercial netted melon. These results indicate that GMB is potential to be sold in the market, caused by their quality is better than the commercial product from Sakata melon.

In other hand, we also measured several quality parameter of fresh food (color of flesh melon, firmness of skin and flesh fruit, and nutritional parameter such us water content, soluble solid content and acidity) of a whole melon stored at 7 and 10 days after they harvested. Table 2 shows color of the flesh melon at harvest day (0 day), 7 days and 10 days storage at a tropical environment at a whole fruit. At 0 day, flesh lightness (L) value of GMB melon was lower than that of Sakata melon, however, the other parameter of color almost similar between them include hue angle as a true color indicator and chroma as pigment intensity. Furthermore, at 7 and 10 days on a whole storage, we that there were found significantly different between GMB melon and Sakata melon on lightness, hue angle and chroma.Sakata melon had a darker color of flesh, redder, and greater pigment intensity, than with GMB melon. These result indicate that Sakata melon will better visual appearance than GMB melon when stored at whole condition. Table 3 shows texture of skin and flesh as a firmness of melon at harvest day (0 day), 7 days and 10 days storage at a tropical environment. There were no firmness differences between skin and flesh of these melons during their storage. Furthermore, decreasing firmness of these melons or tend to be softened of their flesh was a common pattern for several fruit and it can be associated with the decline in cell wall strength, cell wall adhesion and turgor changes (Toivonen and Brummel, 2008).

Table 4 shows nutritional composition (water content, soluble solid content and acidity) of flesh melon at harvest day (0 day), 7 days and 10 days storage at a tropical environment. Water content of GMB melon was lower than Sakata melon and it will be increased when stored as a whole fruit at 7 and 10 days. Soluble solid content of GMB melon was higher than Sakata melon, although these will be decreased during storage. However, the acidity of both melon were similar and increased during storage. The profile of water content and soluble solid content of GMB melon during storage was not similar with Sakata melon. The increasing of acidity is represent for maturity, senescence of the fresh fruit and deterioration of fruit quality.

Higher carotenoid and ascorbic acid content, different pattern of water and soluble solid content is supposed caused by different cultivar of these orange melon, where effects of melon cultivar on sugar and vitamin was also found in orange fleshed genotype of cantaloupe melon (Saftner, *et.al.,* 2006).

Fresh-cut Quality of Melon at Different Environment

Fresh-cut pieces of melon fruit, GMB and Sakata melon was still acceptable to be eaten until 2 days and 1 day after storage, under cut pieces condition at tropical environment (non-controlled temperature). On the other hand, fresh-cut pieces of GMB and Sakata melon had a similar quality at controlled environment on 14-15 ^{o}C and were still acceptable to be eaten until 4 days stored. Table 5 shows texture of flesh as a firmness of fresh-cut melon measured with a universal testing machine during storage at difference environment and wrapping. Both of GMB melon and Sakata melon had a similar pattern for firmness of their fresh cut melon, where their firmness were decreased during stored for all conditions. Similar with result that mentioned above for firmness of both melons during storage at a whole fruit condition, where the softening for fresh-cut pieces melon fruit was immediately occurred just after cut caused by tropical environmental effects that affect cell wall strength and rapidly changes in turgor (Toivonen and Brummell, 2008), compare with those stored under controlled environment on lower temperature.

Table 6 shows water content of fresh-cut melon during storage at different environment and wrapping. Both of GMB and Sakata melon had a similar pattern for their water content of fresh cut melon, where their water content were gradually decreased at tropical environment condition and relatively stable at controlled environment for all wrapping conditions. This result indicate that wrapped of fresh-cut melon fruit can make water loss from fruit can be slightly inhibited and effect of tropical environment on fresh-cut melon fruit also can be delayed. Fresh-cut produce are highly susceptible to weight and water loss because of internal tissues are exposed and lack skin or cuticle (Watada and Qi, 1999), and wrapped the fresh-cut produce using a plastics film protected skin of fresh-cut and effect of external environment can be reduced.

Table 7 shows the soluble solid content of fresh-cut melon during storage at different environment and wrapping. GMB melon had slightly lower content of their soluble solid compare with Sakata melon. Both of fresh-cut pieces of these melon were decreased their soluble solid content under controlled environment condition. Table 8 shows the titratable acidity of fresh-cut melon during storage at different environment and wrapping. Both of fresh-cut GMB and Sakata melon had a similar pattern for their acidity, where their acidity were small increased at all environments and wrapping conditions. Reducing their soluble solid content and increasing titratable acidity is a common and natural condition for postharvest fresh-cut in all fruit include melon fruit after ripening to be senescense and also can caused through increasing water loss or dehydration for increasing titratable acidity and to higher consumption rates of

carbohydrates due to an increased respiratory activity (Boynton *et al*., 2006; Brackmann *et al*., 2006).

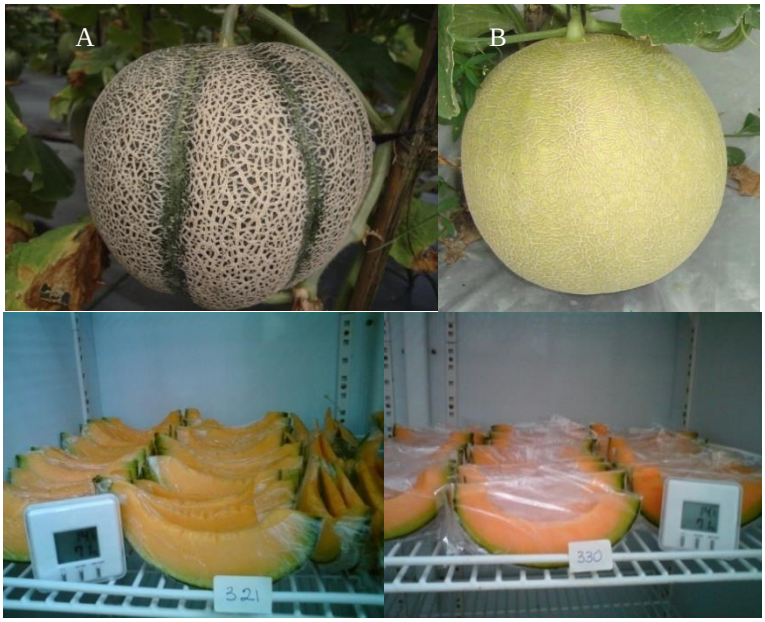

Fig. 1. An example of fresh and fresh-cut melon.Whole fresh fruit of melon fruit (A = Gama Melon Basket, non-commercial netted melon; B = Sakata melon, commercial netted melon) and fresh-cut pieces of melon fruit under controlled environment at 14-15^{o}C (C = fresh-cut melon wrapped using cling wrap and D = fresh-cut melon wrapped using polyethylene plastic).

Table 1. Fresh weight, size, carotenoid total and ascorbic acid of fresh melon at harvest day Data is average from 9 melon fruit.

Fruit Characteristic	Gama Melon Basket	Sakata Melon
Fresh weight (g)	1720.1 ± 191.1^{a}	1701.8 ± 192.9^{a}
Height diameter (cm)	16.1 ± 1.0^{a}	16.1 ± 0.7^{a}
Width diameter (cm)	15.2 ± 0.7^{a}	15.4 ± 0.6^{a}
Carotenoid total (mg/100g)	59.8 ± 1.1^{a}	65.4 ± 0.7^{b}
Ascorbic acid (mg/100g)	27.9 ± 1.7^{a}	11.3 ± 0.1^{b}

Different letters in the same row indicate significant difference by Student's t test at $P<0.05$.

Table 2. Color of flesh melon measured with a chromameter at harvest day (0 day), 7 day and 10 day storage at a tropical environment

Color of Flesh Melon	Gama Melon Basket	Sakata Melon
0 day Lightness (L)	56.3 ± 1.3^{a}	61.2 ± 0.1^{b}
Redness (a)	11.0 ± 0.8^{a}	10.9 ± 0.3^{a}
Yellowness (b)	22.2 ± 0.9^{a}	23.1 ± 0.3^{a}
Hue	-0.50 ± 0.1^{a}	-0.6 ± 0.1^{a}
Chroma	24.8 ± 1.1^{a}	25.5 ± 1.1^{a}
7 day Lightness (L)	53.3 ± 2.5^{a}	67.9 ± 1.3^{b}
Redness (a)	11.6 ± 0.4^{a}	12.7 ± 1.2^{a}
Yellowness (b)	22.0 ± 0.9^{a}	38.3 ± 1.6^{b}
Hue	-0.3 ± 0.1^{a}	-6.5 ± 3.3^{b}
Chroma	24.9 ± 0.9^{a}	40.4 ± 1.5^{b}
10 day Lightness (L)	54.8 ± 1.6^{a}	65.4 ± 1.1^{b}
Redness (a)	12.3 ± 0.1^{a}	10.7 ± 0.3^{a}
Yellowness (b)	22.6 ± 0.7^{a}	33.7 ± 1.4^{b}
Hue	-0.3 ± 0.1^{a}	-3.2 ± 1.7^{b}
Chroma	25.8 ± 0.6^{a}	33.7 ± 1.4^{b}

Data is average from 9 melon fruit. Different letters in the same row indicate significant difference by Student's t test at $P<0.05$.

Table 3. Texture of Skin and Flesh as a firmness of melon measured with a Universal Testing Machine at harvest day (0 day), 7 day and 10 day storage at a tropical environment

Firmness of Melon (N)	Gama Melon Basket	Sakata Melon
0 daySkin	8.8 ± 1.6^{a}	8.8 ± 0.6^{a}
Flesh	6.5 ± 0.6^{a}	6.1 ± 0.6^{a}
7 daysSkin	5.9 ± 0.8^{a}	6.0 ± 1.2^{a}
Flesh	3.8 ± 0.7^{a}	3.5 ± 0.3^{a}
10 daysSkin	3.4 ± 0.1^{a}	2.7 ± 0.7^{b}
Flesh	3.1 ± 0.3^{a}	2.5 ± 0.4^{b}

Explanation of table caption is mentioned in caption of table 2.

Table 4. Nutritional composition (water content, soluble solid content and acidity) of flesh melon at harvest day (0 day), 7 day and 10 day storage at a tropical environment

Nutritional Composition	Gama Melon Basket	Sakata Melon
0 day Water content (%)	89.5 ± 1.2^{a}	93.9 ± 0.4^{b}
Soluble solid content (%)	10.1 ± 0.2^{a}	8.8 ± 0.6^{b}
Acidity (mg/100 g)	0.9 ± 0.1^{a}	1.1 ± 0.3^{a}
7 day Water content (%)	91.6 ± 0.6^{a}	92.5 ± 0.4^{a}
Soluble solid content (%)	9.6 ± 0.7^{a}	6.1 ± 0.6^{b}
Acidity (mg/100 g)	1.9 ± 0.3^{a}	1.5 ± 0.3^{a}
10 day Water content (%)	93.3 ± 0.2^{a}	90.3 ± 1.0^{b}
Soluble solid content (%)	6.1 ± 0.2^{a}	6.0 ± 1.2^{a}
Acidity (mg/100 g)	2.5 ± 0.1^{a}	1.6 ± 0.4^{b}

Explanation of table caption is mentioned in caption of table 2.

Table 5. Texture of flesh as a firmness of fresh-cut melon measured with a universal testing machine during storage at difference environment and wrapping (A, non-controlled environment with plastic cling wrap; A-1, non controlled environment with polyethylene wrap; B, controlled environment at 14-15 ^{o}C with plastic cling wrap and B-1, controlled environment at 14-15 ^{o}C with polyethylene wrap) on a respective day (D-1 is storage one day after cutting, D-2 is storage two days after cutting, D-3 is storage three days after cutting, and D-4 is storage four days after cutting)

Firmness of fresh-cut melon	D-1	D-2	D-3	D-4
Gama Melon Basket				
A	3.8 ± 0.1^{a}	3.2 ± 0.1^{a}	NA	NA
A-1	3.9 ± 0.2^{a}	2.7 ± 0.3^{b}	NA	NA
B	3.8 ± 0.2^{a}	3.3 ± 0.1^{a}	3.0 ± 0.1^{a}	2.9 ± 0.3^{a}
B-1	3.2 ± 0.1^{b}	2.4 ± 0.2^{b}	2.1 ± 0.2^{b}	2.0 ± 0.1^{b}
Sakata Melon				
A	3.3 ± 0.1^{b}	NA	NA	NA
A-1	3.8 ± 0.1^{a}	NA	NA	NA
B	3.9 ± 0.1^{a}	3.5 ± 0.1^{a}	3.3 ± 0.2^{a}	3.1 ± 0.1^{a}
B-1	3.9 ± 0.2^{a}	3.6 ± 0.2^{a}	3.7 ± 0.1^{c}	3.6 ± 0.1^{c}

Data is average from 3 melon fruit with triplications. Different letters in same column indicate significant difference by Student's t test at $P<0.05$.NA is indicator of fresh-cut melon not acceptable to be eaten

Table 6. Water content of fresh-cut melon measured during storage at different environment and wrapping

Water content of fresh-cut melon	D-1	D-2	D-3	D-4
Gama Melon Basket				
A	94.1 ±1.1[a]	92.3 ±1.5[a]	NA	NA
A-1	94.3 ±0.8[a]	93.6 ±0.7[a]	NA	NA
B	92.9 ±1.0[a]	92.9 ±1.1[a]	92.2 ±0.8[a]	91.9 ±1.0[a]
B-1	92.8 ±0.9[a]	92.9 ±1.0[a]	93.2 ±1.3[a]	92.2 ±1.4[a]
Sakata Melon				
A	92.1 ±1.2[a]	NA	NA	NA
A-1	89.9 ±1.4[a]	NA	NA	NA
B	92.1 ±0.3[a]	92.2 ±1.2[a]	92.3 ±0.6[a]	92.6 ±0.6[a]
B-1	89.8 ±1.9[a]	90.1 ±0.6[a]	91.2 ±0.4[a]	91.3 ±0.4[a]

Table explanation is mentioned in caption of table 5.

Table 7. Soluble solid content of fresh-cut melon during storage at different environment and wrapping

Soluble solid content of fresh-cut melon	D-1	D-2	D-3	D-4
Gama Melon Basket				
A	8.5 ±1.1[a]	9.1 ±0.4[a]	NA	NA
A-1	9.8 ±0.4[b]	8.0 ±0.8[a]	NA	NA
B	9.5 ±0.3[b]	9.5 ±1.1[a]	8.2 ±0.4[a]	7.8 ±0.9[a]
B-1	8.1 ±1.4[a]	7.5 ±1.0[b]	6.4 ±1.0[b]	5.9 ±1.2[b]
Sakata Melon				
A	10.4 ±1.1[b]	NA	NA	NA
A-1	10.8 ±0.4[b]	NA	NA	NA
B	9.3 ±0.5[b]	8.3 ±0.3[a]	8.0 ±0.4[a]	8.1 ±0.9[a]
B-1	9.8 ±0.6[b]	10.8 ±0.5[b]	9.2 ±1.2[b]	8.5 ±1.2[a]

Table explanation is mentioned in caption of table 5.

Table 8. Titratable acidity content of fresh-cut melon during storage at different environment and wrapping

Titratable acidity of fresh-cut melon	D-1	D-2	D-3	D-4
Gama Melon Basket				
A	1.4 ±0.1[a]	3.4 ±0.5[a]	NA	NA
A-1	1.3 ±0.2[a]	1.8 ±0.2[b]	NA	NA
B	0.9 ±0.1[b]	1.4 ±0.1[b]	1.9 ±0.1[a]	2.4 ±0.1[a]
B-1	1.0 ±0.1[a]	1.1 ±0.1[c]	1.7 ±0.1[a]	2.3 ±0.1[a]
Sakata Melon				
A	1.3 ±0.1[a]	NA	NA	NA
A-1	1.2 ±0.2[a]	NA	NA	NA
B	1.2 ±0.2[a]	2.4 ±0.1[d]	2.4 ±0.1[a]	2.7 ±0.1[a]
B-1	1.4 ±0.1[a]	1.9 ±0.1[b]	2.4 ±0.2[a]	2.6 ±0.1[a]

Table explanation is mentioned in caption of table 5.

Conclusion

The fresh whole melon fruit is still acceptable to be eaten for 10 days after harvested when they stored under tropical environment, although the quality was decreased. The quality of fresh-cut melon was drastically change during storage at non-controlled tropical environment. The quality of fresh-cut melon will be gradually change during storage at controlled environment and shelf-life of fresh-cut melon for acceptable to be eaten will be extended until 4 days storage.

Acknowledgements

The authors want to make grateful thanks to Faculty of Agricultural Technology for supporting this research. The first author also thanks to Dr. Budi S Daryono from Faculty of Biology, UGM, for supporting seed of Gama Melon Basket and Dr. Jumeri from Faculty of Agricultural Technology for his comments.

References

AOAC (1990). Official methods of analysis, 15th ed. Association of official analytical Chemists, Arlington, VA.

Boynton, B. B., Welt, B. A., Sims, C. A., Balaban, M. O., Brecht, J. K. and Marshall, M. R. (2006). Effects of low-dose electron beam irradiation on respiration, microbiology, texture, color, and sensory characteristics of fresh-cut cantaloupe stored in modified-atmosphere packages. Journal of Food Science 71:149-155.

Brackmann, A., Eisermann, A. C., Giehl, R. F. H., Faban, E. B., Medeiros, S. L. P. and Steffens, C. A. (2006). Qualidade de meloes (cucumis melo l. Var. Cantalupensis naud.), hı´brido Torreon, produzidos em hidroponia e armazenados em embalagens de polietileno. Ciencia Rural 36:1143–1149.

Guzmán, M., Sánchez, A. and Valenzuela, J. L. (2009). Postharvest quality of melon fruits in soil and soilless crops. Acta Horticulturae 843:211-218.

Nunes, M. C. N. and Emond J. P. (2002). Storage temperature. In: bartz, j.a., brecht, j.k. (eds.), postharvest physiology and pathology of vegetables. New York: Marcel Dekker, Inc. pp. 209–228.

Nunes, M. C. N., Emond, J. P., Rauth, M., Dea, S. and Chau, K. V. (2009). Environmental conditions encountered during typical consumer retail display, affect fruit and vegetable quality and waste. Postharvest Biology and Technology 51:232–241

Rodriguez -Amaya, D. B.（1999). A guide to carotenoid analysis in foods. Washington: ILSI Pres. 63 pp.

Saftner, R., Abbott, J. A., Ester, G. L. and Vinyard, B. (2006). Sensory and analytical comparison of orange-fleshed honeydew to cantaloupe and green-fleshed honey dew for fresh-cut chunks. Postharvest Biology and Technolog 42:150–160.

Sato, S., Sakaguchi, S., Furukawa, H. and Ikeda, H. (2006). Effects of NaCl application to hydroponics nutrient solution on fruit characteristics of tomato (*Lycopersicon Esculentum* Mill.). Scientia Horticultura 248-253.

Talbot, M. T. and Chau, K. V. (2002). Precooling strawberries agricultural and biologicalengineering department, florida cooperative extension service. Gainesville: Institute of Food and Agricultural Sciences, University of Florida. 11 pp.

Toivonen, P. M. A. and Brummell, D. A. (2008). Biochemical bases of appearance and texture changes in fresh-cut fruit and vegetables. Postharvest Biology and Technology 48:1–14.

Watada, A. E. and Qi, L. (1999). Quality of fresh-cut produce. Postharvest Biology and Technology 15:201–205.

(Received 19 September 2013; accepted 31 August 2014)