

**PERPUSTAKAAN  
SULTAN ABDUL SAMAD  
UNIVERSITI PUTRA MALAYSIA**

**PENERBITAN PEGAWAI**

**CELLULAR CHANGES DURING FRUIT  
RIPENING OF HARUMANIS MANGO  
H. Muhammad and P. Ding**

## CELLULAR CHANGES DURING FRUIT RIPENING OF HARUMANIS MANGO

H. Muhammad and P. Ding \*

*Department of Crop Science,, Faculty of Agriculture, Universiti Putra Malaysia, 43400 Serdang Selangor, Malaysia.*

*A study on the cellular changes in the skin and pulp of Harumanis mango fruit during ripening was carried out. Mature green mango (day 0) was collected from Department of Agriculture, Perlis. Fruits were ripened in a fibre board carton at 27°C using 20 g calcium carbide/kg fruit for 24 h. Tissues of fruit at day 0, 2 and 4 were processed and viewed under scanning electron microscope. From this study, two regions were identified in Harumanis mango fruit as ripening progressed, namely the skin and pulp regions. The skin was composed by a single layer of epidermis with well-defined cuticle. Wax deposition and lenticels were found on the surface of cuticle. The cell containing crystals i.e. the idioblast could be seen in the skin region of Harumanis mango fruit especially in ripening day 4. Resin ducts could be seen in skin and pulp regions. The ducts could exist as individual structure or co-exist with vascular bundle in all skin and pulp regions and ripening days. As ripening progressed, the cell loses its integrity and starch granules were degraded.*

### INTRODUCTION

Mango is one of the most popular fruits in Malaysia and is highly demanded. The unripened fruit is consumed fresh as salad (or "rojak") or can be made into pickles. Other usages include dehydrated mango, processed juices, nectars and jams. Mango is among 15 types of fruit identified in the National Agricultural Policy 3 to be developed as an export crop. In 2001 about 3.8% of the total fruit cultivated area of 11,342 ha was mangoes, yielding 71,081 MT with 'Harumanis', 'Chok Anan', 'Masmuda' and 'MAHA' being the common varieties. In 2001, RM9.3 million

worth of mangoes were exported to Singapore, Brunei and Hong Kong.

Ripening is the result of a complex changes. During ripening, the green skin of mango will turn to yellow except for some cultivar such as Harumanis, due to breakdown of chlorophyll and unmasking of the carotenoid pigments [1]. Harumanis is marketed as green-ripened fruit with green skin and soft-edible pulp. The green-ripened fruit fail to attract consumer attention as consumer perceived it as unripened. It has been shown that the external colour of the

\*Corresponding author: Tel. + 6 (03) 8946 694 ; Fax. + 6 (03) 8943 5973  
E-mail: [phebe@agri.upm.edu.my](mailto:phebe@agri.upm.edu.my) (P. Ding)

fruit is an important factor in consumer preference [2]. Thus, colour is a primary component of fruit quality, and quality is a major determinant of cash value [3]. On the other hand, the green-ripen fruit triggered a lot of problems such as difficulties in determine fruit maturity for harvest.

Once Harumanis mango ripened, the texture of fruit softens progressively. The relative firmness of the fruit is greatly determined by physical and chemical attributes such as skin thickness and starch content [2]. The starch in the pulp of Harumanis mango will be hydrolysed into sugar [4] and organic acid, which give desirable sugar-to-acid balance. The distinct signs such as change in colour, texture and aroma of fruit tissue ripening are determined by changes in its structure and composition [5]. Information on the structure aspects during ripening is important in relation to fruit quality, storage and commercial value. There is lack of study on cell structural changes during ripening in Harumanis mango. Therefore, the objective of this study was to examine the cellular changes of skin and pulp during ripening at tropical temperature of 27±2°C, as observed with SEM.

## MATERIALS & METHODS

Green mature stage (day 0) of Harumanis mango fruit (*Mangifera indica* L.) were collected from Department of Agriculture, Perlis, and transported to Postharvest Laboratory, UPM within 12 h. The fruits were ripened in a fibre board carton at 27±2 °C using 20 g calcium carbide/kg fruit. After 24 h, the cover of the carton was removed and fruits were allowed to ripen for 4 days. Twelve

samples of 0.5 x 0.5 x 0.5 cm<sup>3</sup> were taken from the mid-region of the fruit at day 0, 2 and 4. The samples were fixed in FAA fixative, and then post-fixed in 1% osmium tetroxide followed by dehydration through graded series of ethanol to absolute ethanol. The tissues were critical point dried and subsequently prepared for SEM (JOEL 5610 LV) viewing.

## RESULTS & DISCUSSION

Harumanis mango fruit is made of skin and pulp (Fig. 1). Skin is the exocarp of fruit, protecting fruit from physical damage and desiccation. The pulp is the mesocarp of the fruit and is edible.

### Skin Region

The skin of Harumanis mango is about 1.3±0.5 mm. The skin of mature fruit was composed by a single layer of epidermis with lenticels and a well-defined cuticle with wax deposition (Fig. 2A). Stomata were present in the early stage of 'Kensington' mango fruit development and ruptured became lenticels at later stage of development [6]. Postharvest discolouration of mango fruit lenticels is a major problem and detracts from the aesthetic value of the fruit such as 'Tommy Atkins' and 'Keitt' mango [7]. The cutin layer of Harumanis mango is made up of regular polygonal platelets. The thinnest points of the cuticle were in the central cracks of the cuticular platelets. The cracking of cuticular platelets has been shown to play a role in fruit skin disorders such as etch browning [6],[8]. As ripening day progressed to day 4, the wax melted and sealed the cracks that exist in earlier

days of ripening (Fig. 2B). Therefore, the cracks could not be seen anymore in ripening day 4.

Hypodermal parenchymatous cells made up skin region. The arrangement of hypodermal parenchymatous cells was loose and intercellular spaces present at the cells adjoining. At ripening day 0, the cell wall of parenchymatous cells was firm and the structure breakdown as ripening day progressed. Intersperse in the hypodermal parenchymatous cells of mango skin were i) crystalliferous idioblast cells, ii) vascular bundles tissues, iii) latificer and iv) starch granules. The crystalliferous idioblast cell of Harumanis mango is an intracellular inclusion where the vacuoles of these cells are filled with druse crystals. These crystalliferous idioblast cells scattered randomly in the hypodermal layer of skin and it was not found in epidermal layer. In this study, the crystalliferous idioblast cells were only found in ripening day 4 of Harumanis mango. Whether the crystal only present in the advanced ripening cells or not was not clear.

The vascular bundle tissues were distributed randomly at the skin region and easily visible with naked eyes where it formed strands. Vascular bundle tissues appeared among hypodermal parenchymatous cells 10 - 14 rows subjacent to epidermal layer. Vascular bundle tissues in skin region were close to resin ducts. Resin ducts of Harumanis mango distributed randomly in the skin region with various size of diameter. The resin ducts exude sap, the cytoplasm fluid, when it wounds. In mango, sap exudes from the freshly harvested fruit, but this exudates decrease during ripening [2]. Resin ducts was found link to lenticels and caused discolouration of mango fruit [7].

The starch granules in the skin region of Harumanis mango were uniform in size and shape, mainly oval. As ripening progressed, the density of starch granules decreased. The starch could be hydrolyzed and used up by the fruit after it has been detached from mother plant.

### *Pulp region*

At ripening day 0 the pulp of Harumanis mango was pale yellow colour. As ripening progressed, the colour of pulp turned yellow orange which is attractive and appealing for consumption. The parenchymatous cells in pulp region were isodiametric in shape and larger than those in skin region. Intersperse in pulp region of Harumanis mango was i) vascular bundle tissues, ii) resin ducts and iii) starch granules. No crystal was observed in the pulp region. Unlike vascular bundle tissues found in skin region, there were two types of vascular bundle tissues in pulp region. The first type of vascular bundles tissues appear as individual tissues without accompanying resin ducts and was found more frequently in inner part of pulp. Another type of vascular bundle tissues was close to resin ducts as those occurred in skin region. The frequency of resin ducts found in pulp of Harumanis mango was lesser than those in skin region.

The cells in pulp region of day 0 Harumanis mango filled with starch granules. The granules were irregularly in shape with spheroid and ovular being predominant. The size of starch granules in pulp region was large as compared to those in skin region. The surface of starch granules was smooth. As ripening progressed to day 2, the starch granules

started to hydrolyze with rough surface. During ripening the starch granules are being hydrolyzed by amylase [4]. As a consequence of starch hydrolysis, total sugar increase during ripening, with glucose, fructose and sucrose constituting most of the monosaccharides [9]. In 'Alphonso' mango, the starch content decreased from 18 to 0.1% and total soluble solids increased from 7 to 20% as fruit ripened [10]. At ripening day 4, the integrity of Harumanis mango parenchyma cells loss. Similar observation was reported in Alphonso mango where the cell integrity loss with pectin decreased from 1.9 to 0.5%, cellulose decreased from 2 to 0.9% and hemicelluloses decreased from 0.8 to 0.2% as ripening progressed [10], [11].

### CONCLUSION

The skin of mature Harumanis mango fruit was composed by a single layer of epidermis with lenticels and a well-defined cuticle with platelets wax deposition. As ripening progressed, wax melted and sealed the cracks formed by thinnest point of the cuticular platelets. The parenchymatous cells lose their integrity due to cell hydrolysis as ripening progressed. The degradation of starch granules could also contribute to softening of fruits. The changes in cellular structure of Harumanis mango fruit could explain the biochemical changes as ripening progressed.

### ACKNOWLEDGEMENTS

The authors gratefully acknowledge the support provided by UPM.

### REFERENCES

- [1] Yuniarti, H. (1980). Physico-chemical changes of 'Arumanis' mango during storage at ambient temperature. *Buletin Penelitian Hortikultura*, 8, 11-22.
- [2] Lizada, M.C.C. (1993). Mango. In *Biochemistry of Fruit Ripening*, Ed. by Seymour, G., Taylor, J. & Tucker, G. (Chapman and Hall, London.) pp. 255-271.
- [3] Tourjee, K.R., Barcett, D.M., Romero, M.V. & Gradziel, T.M. (1998). Measuring flesh colour variability among processing clingstone peach genotypes differing in carotenoid composition. *Journal of American Society of Horticultural Science*, 123(3), 433-437.
- [4] Fuchs, Y., Pesis, E. & Zauberman, G. (1980). Changes in amylase activity, starch and sugar contents in mango fruit pulp. *Scientia Horticulturae*, 13, 155-160.
- [5] Rhodes, M.J.C. (1980). The maturation and ripening of fruits. In *Senescence in Plants*, Ed. by K. V. Thimann. (CRC Press, Boca Raton, FL.) pp. 158-199.
- [6] Bally, I.S.E. (1999). Changes in the cuticular surface during the development of mango (*Mangifera indica* L.) cv. Kensington Pride. *Scientia Horticulturae*, 24, 279-286.
- [7] Bezuidenhout, J.L.J., Robbertse, P.J. & Kaiser, C. (2005).

## CELLULAR CHANGES DURING FRUIT RIPENING OF HARUMANIS MANGO

- Anatomical investigation of lenticel development and subsequent discolouration of 'Tommy Atkins' and 'Keitt' mango (*Mangifera indica* L.) fruit. *Journal of Horticultural Science & Biotechnology*, 80(1), 18-22.
- [8] Maguire, K.M., Lang, A., Banks, N.H., Hall, A., Høpcroft, D. & Bennett, R. (1999). Relationship between water vapour permeance of apples and micro-cracking of the cuticle. *Postharvest Biology and Technology*, 17, 89-96.
- [9] Selvaraj, Y., Kumar, R. & Pal, D.K. (1989). Change in sugars, organic acids, amino acids, lipid constituents and aroma characteristics of ripening mango (*Mangifera indica* L.) fruit. *Journal of Food Science and Technology*, 26, 308-313.
- [10] Yashoda, H.M., Prabha, T.N. & Tharanathan, R.N. (2006). Mango ripening: changes in cell wall constituents in relation to textural softening. *Journal of the Science of Food and Agriculture*, 86(5), 713-721
- 
- [11] Parikh, H.R. (1990). Some structural changes during ripening of mangoes (*Mangifera indica* var. Alphonso) by abscisic acid treatment. *Annals of Botany*, 65, 121-127.

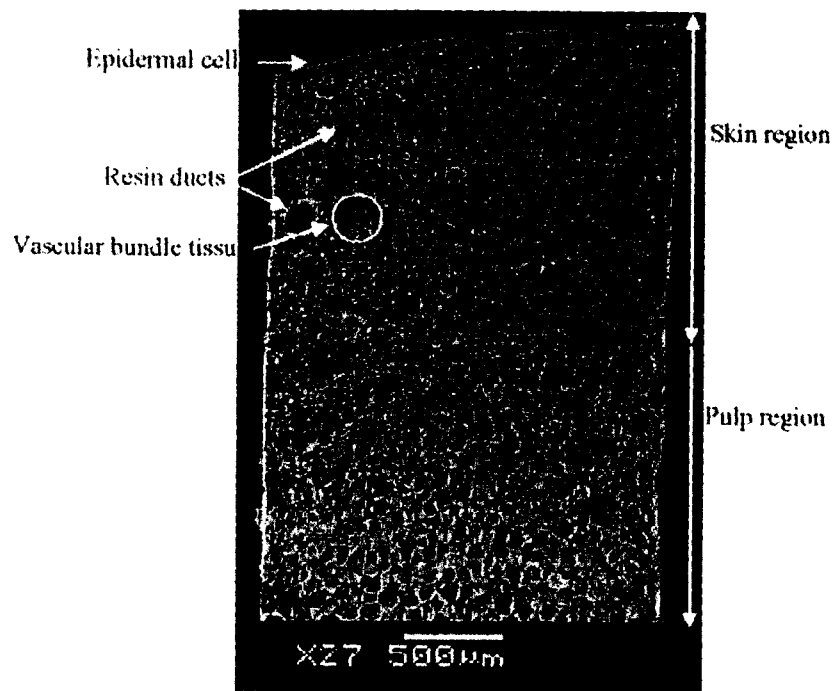


Fig 1: Scanning electron micrograph of a transverse section of Harumanis mango fruit in ripening day 0 ripened at  $27 \pm 2$  °C. The fruit consists of skin and pulp regions.

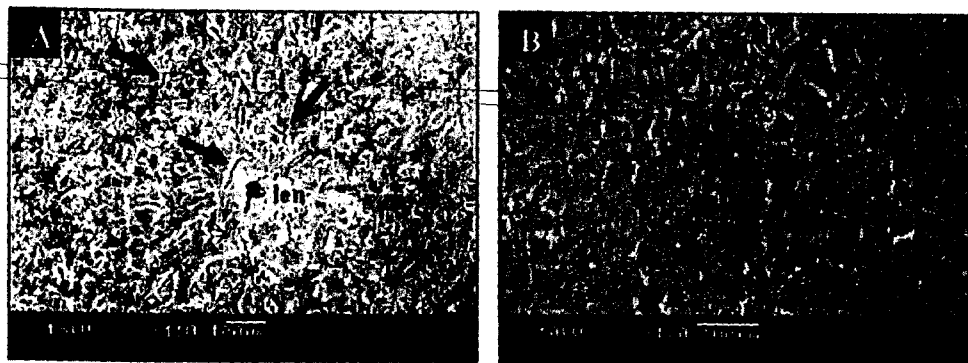


Fig. 2: Scanning electron micrograph of Harumanis mango epicuticular wax. (A) A lenticel (len) on the cuticle surface of Harumanis mango at ripening day 0. Cracks (arrow) are seen around the lenticel. (B) The skin morphology of ripening day 4 appears smoother and less cracks as compared to ripening day 0.