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CELLULAR STRUCTURES OF MATURE GREEN BANANA *MUSA* AAB CV. 'RASTALI' AND *MUSA* AAA CV. 'BERANGAN'

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Both mature green of Musa AAB *cv 'Rastali' and Musa* AAA *cv 'Berangan' consist of peel, peel-pulp transition and pulp regions. Epidermal cells form the outer layer of peel and were covered by cuticles and wax. Stomatal density of Rastali and Berangan banana was 360 and 400 stomatal/cm², respectively. Inclusions that appeared in the peel of both bananas were i) vascular bundles surrounded by a ring of laticiferous ducts and ii) tannin bodies. Idioblast cells containing raphide were appeared in Berangan banana peel however Rastali banana did not contain these cells. Cuboid crystals were found dispersed abundantly in the peel cells of Rastali banana near the epidermal layer. The shape of crystal became elongated in the cells near the transition region. The transition region for both bananas was characterized by air spaces and starch granules containing cells. Most of the starch granules were in oval or rod shape. Inclusions that appeared in the pulp of both bananas were i)starch containing cells and ii) vascular bundles surrounded by a ring of laticiferous ducts. The size of starch granules in pulp was much bigger and denser as compared to those in transition region. The shape of pulp starch granules were mostly flat discs.*

INTRODUCTION

Banana is one of the world's major crops. It ranks amongst citrus, pome fruits and grapes as major international trading commodities. Inhabitants of all continents in the tropics make their living directly or indirectly from bananas and plantains as a source of food or export earning. In Peninsular Malaysia, banana is the second largest cultivated fruit crop after durian [1]. The major commercial bananas cultivated by smallholders are Berangan, Mas and Rastali, while the plantations grow Cavendish.

A sensory evaluation on four samples of bananas in Kelantan, Kuala Lumpur, Pulau Pinang and Johor revealed that Cavendish was the most preferred followed by Mas, Berangan and Rastali [2]. Malaysian preferred bananas of yellow peel, free from freckles, easily detachable, easy to peel, medium length (8 cm) and size (150 g), yellow pulp, good aroma, sweet taste and with firm and dry texture. The peel of Rastali banana develops many dark brown to black blotches when fully ripe which affect its visual appearance. Visual appearance is a very important postharvest quality as consumers buy with their eyes.

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Similarly, peel of Cavendish, Mas and Berangan bananas do not develop freckles naturally. As a result, these three cultivars of bananas perceive good response from domestic and export markets but not Rastali banana. Rastali banana fruit is only palatable when the fruit is fully ripens otherwise its taste astringent. This does not occur to other cultivars of bananas such as Berangan.

To our knowledge, no work has been carried out to study the cellular structures of Rastali banana in order to obtain a better knowledge of its postharvest quality characteristics. The objective of this study was to examine the cellular structures of Rastali banana as compared to Berangan banana.

MATERIALS & METHODS

Green mature stage of *Musa* AAB cv. Rastali and *Musa* AAA cv. Berangan fingers each weighing 70-80 g and 90-100 g, respectively and free from mechanical injury, insect and fungal damage were used in the experiment. Stomata were examined by means of peel surface imprints made using clear nail varnish. Thin layers of the nail varnish were dried for 10 min. The layers with the impression imprinted were then peeled and placed on 1-mm^2-grated slide. The slide was then observed under compound microscope model Lietzs M. Lux with a magnification of 100, and the stomatal number per cm^2 was counted. Fruits from the upper row of second and third hands were used. Fifteen imprints were taken from five faces of a finger at the stem end, mid region and floral end of fruits.

The peel thickness was measured at the mid region of fruit using vernier caliper. Samples of the peel and the outer part of the pulp, measuring 0.5 cm x 1.0 cm, were cut from the mid region of the fruit and fixed in formalin acetic acid fixative. The tissue was post-fixed in 1% osmium tetroxide followed by dehydration through graded series of ethanol to absolute ethanol. Tissues post fixed in osmium tetroxide was CPD and subsequently prepared for SEM viewing.

RESULTS AND DISCUSSION

Peel Region

Banana finger is a berry fruit and develops parthenocarpically from the inferior ovary. The fruit is made of pulp enclosed in a thick layer of peel (Fig. 1). The peel is the ovary wall. The peel of green mature Rastali and Berangan bananas was 0.25±0.05 and 0.35±0.04 cm thick, respectively. The peel of both bananas consisted of epidermal and hypodermal layers which were parencyhmatous cells. The epicuticular cells for both bananas were arranged in row with a layer of unstructured ridges of thick wax deposition giving papillae surface topography. The epicuticular cells of both bananas cultivars were hexagonal in shape and helped in strengthening cell structures. There was no set pattern of stomatal arrangement. The stomata were elliptical in shape with guard cells surrounded by subsidiary cells. The extended wings were pronounced. The stomatal density for Rastali banana was 360±15 stomata/cm^2 which was lesser than Berangan banana that contains 400±17 stomata/cm^2. Stomata were thought to be the principal route for gaseous exchange

[3]. The stomatal densities could affect postharvest treatments to control water loss and ripening of the fruit.

Both bananas cultivars showed a quite similar cell structures. Intersperse in the rows of hypodermal layers of peel were i) vascular bundles surrounded by laticiferous ducts, ii) tannin bodies containing cells or known as tanniferous cells and iii) crystal containing cells or known as idioblast cells. The vascular bundles consisted of large metaxylem, protoxylem and phloem vessels. Xylem tracheid which was a water-conducting tissue, form ladder like series called scalariform. The lignified fibers unsheathed the vascular bundle and provided mechanical support for the peel. Laticiferous or latex vessels formed rings and encircle the vascular bundles tissues. The coagulated latex appeared as a solid and firm structure. The latex of banana contains tannin [4]. Besides tannin, three types of colloidal suspension was also found in banana latex that is lipid globules, lutoid and cytoplasmic fragments [5].

In the peel region of both varieties banana, there were cells containing small round bodies in the cytoplasmic vacuoles. These cells are known as tanniferous cell and are smaller in size than surrounding cells. Tannins are chemically defined phenolic substances that contribute to astringency of fruit [6]. In the two cultivars of bananas studied, cells containing tannin were much smaller than other parenchymatous cells. There were two types of tanniferous cells found in banana [7]. Another type was located in latex vessels present in all three regions of peel, peel-pulp transition and pulp. It seems that AAA and AAB genome bananas share the similarity in this aspect.

The crystals found in Rastali and Berangan bananas were totally different. In Rastali banana, the size of cell containing crystal was similar to the surrounding cells. The crystals are cuboid and dispersed abundantly in the peel region cells near to epidermal layer of Rastali banana (Fig. 2A). The shape of crystal became elongated with sharp pointed end in the cells near to transition region (Fig. 2B). In Berangan banana, the cells containing crystal or idioblast cells were larger than surrounding cells. The crystals are needle shaped with sharply pointed ends and arranged in a bundle. It is known as raphide (Fig. 2C). The crystals are calcium oxalate and its chemical makeup, shape and location in a given tissue or cell type are considered to be specific for a particular species [8]. The differences in crystal shape found in Rastali and Berangan bananas fruit could due to variation in genome where genome of Rastali is AAB and Berangan is AAA.

Another difference can be noticed between Rastali and Berangan bananas was the existing of starch granules in peel region of Berangan banana. In peel region of Rastali banana, starch granule was hardly found.

Peel-pulp Transition Region

The peel-pulp transition region for both cultivars of bananas was similar with existing of air spaces and starch granules containing parenchymatous cells. The existence of these air spaces weakened the structure between the peel and pulp region, thus, allowing the peel to be removed easily. The cells in peel-pulp transition region of Rastali banana were isodiametric in shape. Unlike Rastali banana, the peel-pulp transition cells of Berangan banana

were hexagonal in shape and formed honeycomb structure. The starch granules in peel-pulp transition region for both cultivars of bananas were uniform in shape, mainly rod shape. The starch granules of Berangan banana in the peel-pulp transition region were larger in size but less density than those occurred in the peel.

Pulp Region

Intersperse in the pulp region of both Rastali and Berangan bananas were i) vascular bundles surrounded by a ring of laticiferous ducts, ii) tannin bodies and iii) starch granules containing cells. The occurrence frequency of vascular bundles and tannin bodies in pulp region was much lesser than peel region for both cultivars of bananas. The density, size and shape of starch granules vary for both cultivars of bananas. However, both of mature green banana starch granules surface appear smooth, indicating amylase that hydrolyzed polysaccharides of starch granules into monosaccharides have not yet started reacting on starch granules [9]. The shape and size of starch granules in pulp region of both cultivars was different and bigger as those in peel-pulp transition region.

The starch granules in pulp of Rastali banana were denser than Berangan banana and some were flat discs shape. The size of Rastali banana pulp starch granules was 35.8±11.9 μm x 13.9±2.1 μm and bigger as compared to 17.0±4.7 μm x 6.4±0.9 μm that in peel-pulp transition region. Pulp of mature green Berangan banana was full of irregular shape of starch granules with oval and rods being predominant. The size of Berangan banana pulp starch granules was 29.3±3.6 μm x 15.1±1.0 μm, apparently, the size was shorter than those found in Rastali banana.

CONCLUSION

Both Rastali and Berangan bananas made up of peel, peel-pulp transition and pulp regions. The stomatal density of Rastali banana was lesser and has thinner peel than Berangan banana. Crystal containing cells appeared in the peel region of both varieties of bananas were different. The density, shape and size of pulp starch granules for Rastali and Berangan bananas were different. The cuboids crystals that present and dispersed in the peel region of Rastali banana could contribute to the astringencies of this fruit. Further study is needed to look into the presence of these crystals and its role as Rastali banana ripened.

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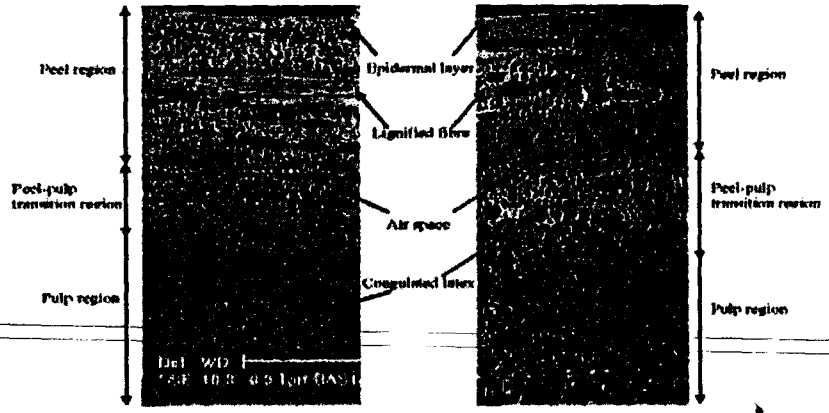

Fig. 1. Longitudinal section of green mature banana (A) Rastali banana x 25 (B) Berangan banana x 23.

Fig. 2. Cells containing crystal found in Rastali (A & B) and Berangan (C) bananas. (A) Cuboid crystals dispersed abundantly in peel cells near to epidermal layer. x 8,050 (B) Elongated with sharp-pointed crystals dispersed abundantly in peel cells near to peel-pulp transition region. X 2,030 (C) Raphide with needle-like end points arranged in bundle can be found in peel region of Berangan banana. x 1, 200