Gamboge (GD) and transparent flesh disorders (TFD) in mangosteen. What causes them?

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Mangosteen is primarily consumed as a fresh fruit. The fruit is common delicacy and often referred to as the "Queen of Fruit" in Southeast Asia. Thailand is the world's largest producer of mangosteen, producing approximately 240,000 metric tons (MT) annually, with exports recorded at 15,000 MT in 2006. Malaysia, Vietnam, and Indonesia are also major producers. Recent production in Central America is being exported into Europe. A modest commercial production occurs in Hawaii, primarily for local markets (Osman and Rahman, 2006).

Most people enjoy mangosteen and the fruit now categorised as a "superfruit" has a ready market in western countries where it is considered a tropical delicacy. The volume of production in is increasing and fruit is now being processed into value-added products such as jam, candy, and wine. In traditional communities, the fruit pericarp (rind) was used as an antibacterial agent and for curing diarrhea. The use of the fruit rind and or whole fruit as a medicinal/nutriceutical beverage has been a recent trend in western societies. Mangosteen extracts and processed products have now entered the worldwide health food and nutritional supplement market.

As an outstanding tropical fruit to Southeast Asia, mangosteen remains localised in its natural habitat probably due to its rather specialised ecological requirements. The tree only can grow well in tropical areas and requires abundant regular rainfall and moisture in the soil. The fruit has a good postharvest life which is beneficial for export markets.

The main problems in mangosteen cultivation are slow growth and long jenile period, low productivity, short fruit shelf life and low fruit quality due to transparent flesh (TFD) and gamboge (GD) disorders. Translucent flesh disorder (TFD) and gamboge disorder (GD) are physiological disorders of mangosteen (*Garcinia mangostana* L.) fruits caused by excess water or heavy rainfall prior to pre-harvest (Sdoodee and Limpun-Udom, 2002). The incidence of TFD and GD are both major problems of mangosteen production in the humid tropics (Yaacob and Tindall, 1995), because these disorders cause hard flesh with poor flavour.

Incidently, it appears that both transparent flesh (TFD) and gamboge (GD) disorders remains almost as "unsolveable" physiological disorders until today especially when it deals with agro-climatology and other enviromental factors. Consequently, these disorders downgrade the fruit which affects its marketability and price both in the local markets and the international as well.

Gamboge Disorder. What is it? What causes it?

In gamboged mangosteen (GD) fruit, the pericarp and the fruit pulp are discolored by yellowish resin which turns reddish brown and hardened later (*refer to photos below*). Affected fruit exude yellow latex which is responsible for the discoloration and change in taste. In fact, the yellow resin is naturally produced by several organs which consist of branched canal-liked secretory ducts. They are found in the exocarp, mesocarp and endocarp, aril of the fruit, flower, stem and leaf. The biggest secretory ducts are located in the endocarp which continues from the fruit stalk to the fruit. The bitter yellow resin permeates into the aril as a result of broken latex secretory ducts caused by excessive rain (Sdoodee and Limpun-Udom, 2002), winds, careless fruit handling which induce physical damage to the fruit pericarp and also due to some types of pest infestation, particularly by caspids.

Fruit spotted with yellow resin

Desecrated yellow latex in the aril

According to Poerwanto et. al (2009), latex secretory ducts are usually broken at 5-15 weeks after anthesis during the rapid fruit growth period. The seed and aril growth rates are reported to be faster than the pericarp causing a building up of internal pressure to the endocarp. The resultant pressure causes the secretory ducts to break especially when the epithelial cells of the ducts are weak. However, this physiological problem is rectifiable by application of adequate calcium.nutrient to mangosteen trees. Calcium as one of the important components of the middle lamella in the form of calcium pectate that

binds together the contiguous cell walls is a major factor in withstanding such pressure. Hence, application of dolomite fertilizer at rate of 18-24 tons/ha has been reported to improve calcium content in the exocarp and leaves; and at the same time, it effectively reduces gamboge (GD). Also, it is reported that applications of $CaCl_2$ spray effectively reduced yellow spots either on the pericarp or the aril of mangosteen. Meanwhile, a mild soil water deficit of approximately -70 kPa should be maintained during pre-harvest. However, some balance will be needed as any abrupt changes in such soil water potential values, as a result of rainfall, are likely to lead to a high occurrence of GD.

Transparent Flesh Disorder. What is it? What causes it?

Flesh translucency (TFD) of mangosteen fruit shows as a water soaking of the flesh. The incidence of TFD was caused by excess water during the pre-harvest stage of fruit development, where water-uptake was driven by the difference in osmotic potential between that of rain water and that of the affected fruits. When water content in fruit is high, this leads to a breakdown of apoplast or symplast compartmentation which is exhibited as the occurrence of TFD (Luckanatinvong, 1996). It was found that the threshold of TFD incidence of mangosteen fruits subjected to excess water is around 9 weeks after bloom Chutinunthakun (2001). It is suggested that the risk of TFD incidence could be avoided by maintaining mild soil water deficit around -70 kPa during pre-harvest. Under severe conditions of excess water, fruit cracking is also concurrently found in fruits with translucent flesh disorder (Sdoodee and Limpun-Udom, 2002).

Transparent flesh disorder (TFD)

Cracked fruit

Conclusion

The incidence of both TFD and GD in mangosteen can be avoided by the management of soil moisture during pre-harvest. A mild soil water deficit of approximately -70 kPa should be maintained during pre-harvest. However, some balance will be needed as any abrupt changes in such soil water potential values, as a result of rainfall, are likely to lead to a high occurrence of GD. Consequently, some irrigation is desirable to avoid such abrupt changes and the rate of reduction in soil water potential may be able to be

delayed until as close as possible to the time of harvest to minimize the impact on fruit size while still achieving the goal of minimizing the incidence of TFD. However, it should be noted that, although TFD incidence decreases under low soil moisture during pre-harvest, water deficit may be detrimental to fruit size.

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