

Chapter 6

General Discussion

A major problem of mango production for export is deterioration of quality and short storage life after arriving at the destination markets. For export to Japan, mango must be subjected to VHT, which may damage fruit quality by the incidence of fruit injury such as internal breakdown. Alternative quarantine treatment is needed. Despite the effectiveness of the treatment the quality problem of VHT-treated fruits has been associated with many factors such as maturity, ripening stages, temperature and mineral contents of the fruits, and storage temperature.

Low temperature storage is considered to be the most effective method to preserve quality and to prolong storage life. Mango is, however, one of the chilling sensitive crops so cannot be stored under chilling temperature. In the present study the influence of the combination of VHT and low temperature storage on the changes of fruits such as ultrastructural, physiological and biochemical characteristics was investigated.

The changes in ultrastructural characteristics observed in mango tissues when stored at chilling temperature indicated the occurrence of cell wall degradation and deterioration which corresponded with an increase of electrolyte leakage and a large number of starch grains inside the cell. This implies that abnormal metabolism occurred during

ripening, although visual appearance of chilling injury symptoms could not be detected.

For the preliminary observation of imported mango from tropical countries (Thailand and The Philippines), the general physiological changes during postharvest period were observed to investigate the capacity of 'Carabao' and 'Nam Dok Mai' to withstand low temperature storage and losses during storage. Between the two cultivars of the imported mangoes, 'Nam Dok Mai' is the better cultivar for both domestic and export markets because of its sweetness and low fiber, but this variety is more susceptible to disease and chilling injury, and develops less peel color. Therefore, to export 'Nam Dok Mai' mango to a distant market it is very important to find a means to maintain fruit quality. Although this cultivar could be kept at 13 °C for 2-3 weeks, in this study fungal disease began to attack the mango fruit after 8 days in storage. This difference may be due to suffering from transportation from Thailand to Japan. For 'Carabao', CI symptom expression was not shown clearly. 'Carabao' mango of stage 3 (more green than yellow) could be kept at a low temperature of 5 °C for 14 days and at 13 °C for 12 days without any damage, but 'Nam Dok Mai' mangoes could be stored at 5°C only for 8 days followed by 6 days at 20 °C. The symptoms of chilling injury appeared after storage for 16 days at 5 °C, showing skin browning, abnormal ripening and disease. Also Ketsa et al. (1992) reported that when 'Nam Dok Mai' fruits were harvested at the age of 95-100 days after full bloom and stored in a polyethylene and a poly propylene bag at 10 °C,

CI symptoms appeared after more than 10-days storage whereas it was evident in less than 5 days storage without bags, showing brown-grayish skin, brown pulp and dark brown endocarp while seed coat and cotyledon were dark. The discrepancy in the reported optimum temperature and CI symptom may be attributed to locality, i.e., the area where the cultivar was grown, stage of maturity at harvest and ripeness before storage (Thomas and Oke, 1983).

Ripening stage of the fruit affected the storage capacity and the chilling injury symptom. 'Nam Dok Mai' mango could be kept longer at lower temperatures when the fruits attained a higher ripening stage. This result suggests that low temperature condition may inhibit the development of the ripening process. The more-ripened fruit had already started CO₂ accumulation before being placed in low temperature storage. When transferred to ripen at 25 °C, the mango fruit could recover the ripening process again, maybe because the ripening process was not totally inhibited as compared with the green mature fruits. Lin et al. (1993) also reported that ripe peppers were not susceptible to CI when stored at 1 °C for up to 2 weeks, and that the chilling-induced increase in CO₂ production occurred without CI development. Thus, more-ripened fruits may be more suitable for export to distant markets by storing them at the lower temperature without CI.

In this research VHT reduced disease and increased peel color but the rate of softening was not affected when transferred to ripen at 25 °C. Beside these beneficial responses, chilling injury after VHT was

reduced as shown by biochemical changes such as electrolyte leakage, ACC and polyamines content, and it benefited fruit performance. Electrolyte leakage may be related not only to CI but also to ripening processes due to changes in cellular permeability, while less amount of ACC during the first 15 days was accompanied by the development of CI in the mature green stage. In addition, the result of polyamines content during storage showed that Put accumulated in the fruits stored at lower temperature. Put accumulation may be a protective response to various kinds of stresses that cause physiological injury of tissues. It has been hypothesized that polyamines protect the integrity of membranes which, in turn, alleviate chilling injury (Faust and Wang, 1993; Gonzales-Aguilar et al., 1997; McDonald and Kushad, 1986). It is possible that the application of polyamine may ameliorate the development of chilling injury.

Maturity at harvest was also one of the important factors that determined storage life and fruit quality when mango fruits were subjected to heat treatment followed by low temperature storage. The maturity of fruit has been reported to highly affect the incidence of disease and internal breakdown after heat treatment. The susceptibility to internal breakdown of VHT-treated fruits was higher for immature than mature fruit. Similar results were reported for pepper (Autio and Bramlage, 1986) and mango (Esguerra et al., 1990). Therefore, mango fruit for export should be harvested at a proper maturity and then treated with VHT before storage at the optimum temperature for maximizing fruit quality. When sending to distance markets, the fruits

should be separated according to the different maturity stages. In this present study, mature fruit with VHT could be stored at a temperature lower than 13 °C without any damage and still remained in acceptable marketability for 2-3 weeks.

Moreover, the present study revealed that the production region and mineral content of the soil exerted a profound influence on the occurrence of physiological disorders and chilling injury, as reported by Jacobi and Wong (1992) and Sinclair and Lindgren (1995). There existed high positive correlations between Ca concentration and/or (Ca+Mg)/K in soil and fruit, and the storage life of the fruits taken from different sites and showing different maturities. Thus, mineral composition in soil and fruits is an important factor controlling fruit quality. The X-ray analysis technique to locate the distribution of mineral element content within the fruit confirmed the previous result of chemical analysis with a more reliable pattern. The results from X-ray mapping showed that Ca was located at a considerably higher level in the fruits from the orchard which could yield higher quality fruit. This coincided with the results such as the relationship between soil and fruit mineral nutrition, and postharvest fruit quality. Thus, it is possible to predict the storage quality by means of preharvest mineral analysis. Also application of Ca to the trees and/or the fruits may be recommended to maintain fruit firmness and prolong storage life at low temperatures.

It was reported that Ca affected fruit quality by increasing the structural integrity of cell walls (Ferguson and Drobax, 1988). Also,

high Ca concentration could reduce the rate of softening (Bower and Cutting, 1988) and decrease fruit respiration and ethylene evolution (Marcelle, 1991). Changes in Ca element as detected by x-ray analysis showed that the amount of Ca in mesocarp was highest in the outer, mesocarp while lowest in the inner mesocarp, where there was yellow coloration and pronounced softening around the stone as jelly seed (Raymond et al., 1998). This also implies that in fruit Ca may move from the inner mesocarp to the outer mesocarp according to the direction of Ca transport. After harvesting, low transpiration of tissues in fruit may cause the inability of Ca movement, which, in turn, may result in the breakdown and softening of the inner tissue region. Further research is needed to find the techniques to improve availability and distribution of Ca to inner mesocarp region to overcome the problem of inability of Ca movement and the translocation from the soil to the inner part of fruit. The LTSEM (low temperature scanning electron microscope) and x-ray microanalysis technique can be applied to monitor the structural modifications and distribution of elements in cells or tissues.

Based on the result of this research, the following may be recommended to improve the cultural practice and postharvest handling for exporting mango:

- 1) Preharvest condition: as soil nutrient can greatly influence the storage life of mango fruits, the ratio of Ca/N and (Ca+Mg)/K in the soil should be kept at least above 0.88 and 1.55, respectively.

2) Prestorage condition: the commercial practice with Thai mangoes is usually to harvest the fruits before full maturity, which results in poorer quality and storability. Thus, to minimize the occurrence of physiological disorders (CI and IB) after storage, mature fruits should be harvested with careful postharvest management. Acceleration of the ripening stage to a more-ripened stage (stage 2) before VHT is recommended in order to reduce chilling injury in low temperature storage.

3) Postharvest condition: if the appropriate prestorage conditions have been met, it is possible to prolong the storage life at much lower temperatures without any damage. After beneficial vapor heat treatment (VHT) the fruits can be stored at a temperature between 8 and 13 °C.

Thus, this information may provide Thai mango growers with a better understanding of the preharvest factors which relate to fruit quality and storability. It may also be very useful for commercial packers and exporters to understand the appropriate handling methods and storage conditions for fruits destined for distant markets.