Effect of temperature and storage time on the thermal properties of Mango Nam Dok Mai cv. Si Thong during storage

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Mango fruit cv. 'Nam Dok Mai Si thong' (*Mangifera indica* Linn.) harvested at fully mature-green stage were stored at 5, 13 and 25°C. The specific heat and thermal conductivity of flesh mango during storage were determined by Modulated Differential Scanning Calorimeter (MDSC) following the ASTM-E1952 –98 method. The result showed that the specific heat and thermal conductivity of flesh mango increased rapidly within the 6 days storage at 25°C due to fully ripening of the fruit. For fruits stored at 13°C, the specific heat of flesh mango increased after 15 days storage but the value was slower than that of stored at 25°C. Whilst, the specific heat of flesh mango stored at 5°C was found stable. Thermal conductivity of the flesh mango decreased and increased after stored for 5 and 15 days, respectively, at 13°C but the values were slower than those of storage at 25°C But thermal conductivity of flesh mango stored at 5°C was increased rapidly during 5 days [it is not rapid] and then decreased and stable during the 25 days of storage time. Chilling injury such as peel pitting and discoloration were found after 5 days storage at 5°C and 20 days at 13°C and rapidly increased with the increasing of storage period. Corresponding effect on electrolyte leakage was noted. There was positive relation between the increasing of thermal properties and electrolyte leakage. The chilling injury occurred 5 days after storage at 5°C and 20 days after stored at 13°C like the increasing of thermal conductivity. Thermal properties may be useful to predict chilling injury of mango fruit.

Key word: Thermal properties, specific heat, thermal conductivity, mango, chilling injury

Introduction

Mango (*Mangifera indica* Linn.) is one of the important economic fruit crops in Thailand and Thailand is one of the major producers and exporters of mangoes. With an increasing demand and increased percentage of mango fruits that being exported aboard, its storage life is a major concern. After harvest, most fruits and vegetables including mangos remains alive and normal life

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process continue. The lives processes can be controlled to certain extend by low temperature storage (Moshenin, 1980; Wills et al., 1981). When mangos are stored at low temperatures for a period of time, there is the risk of physical changes due to chilling injury. The symptoms of chilling injury are surface pitting, discoloration, internal breakdown and decays (Kader, 1992 and Mitra and Baldwin, 1997). It has been shown that the chilling injury is initiated by a thermally-induced transition in the structure or phase state of some lipids which constitute the bilayers of cell membrane (Raison and Orr, 1986). Since the thermal properties are also related to the phase transition within a fruit (Marisela and Yahia, 1995; Aggarwal, 2000), they might be able to be used as an indicator of the chilling injury. The objectives of the study are to determine the effect of temperature on thermal properties of mango fruit and to relate these properties to the chilling injury.

Materials and methods

Export - graded 'Nam Dok Mai Si Thong' mango from local orchard in Chachoengsao province, Thailand, was used in this experiment. Fruits were selected for uniformity of shape, color and size, and blemished or diseased fruits were discarded. The fruits were stored at 5, 13 and 25±2°C.

Measurement of specific heat and thermal conductivity

The specific heat was measured by Modulated Differential Scanning Calorimeter (MDSC model Q100, TA instrument). Sample was prepared by taken out the middle of pulp mango by 4.20 mm-diameter cork borer. The cylindrical tissue sample in the cork borer was cut into small pieces by a razor blade to obtain 4.20 mm-diameter, <1 mm length. The sample disc was placed into hermetic aluminium pan and weight (10-11 mg) using a micro-balance. The sample containing the pulp mango tissue disc was sealed with the DSC sample sealer. The sealing procedure was completed within 30 second to prevent served moisture loss from the mango tissue. The encapsulated test sample was placed on the sample sensor. An empty hermetic aluminium pan was lid on the reference side. The heat capacity of sample was measured at 25 °C for 20 min. The specific heat (Cp) was recorded in unit of J/g°C.

The thermal conductivity was measured by MDSC following the method of ASTM E 1952-98 (ASTM, 1998). Sample was prepared by taken out the middle of pulp mango by 6.0 mm-diameter cork borer, < 4 mm length. The diameter (d), length (L) and weight of the sample were measured. A small drop of silicone oil was placed on the DSC sample and reference sensor. Then a thin aluminum disk was placed over each drop of the oil. The thick sample was carefully placed on the aluminum disk that covered the sample sensor. The apparent heat capacity (*C*) of the sample was measured at 25°C for 20 min and was recorded in the unit of mJ/°C. Six replications from 6 fruits were taken for each experiment and then the mean values were reported.

Electrolyte leakage measurement

For each treatment, five samples disc (10 mm-diameter x 4 mm length) of the sample tissue were rinsed with deionized water for 3 seconds two times to eliminate the electrolyte at the cut surface. The samples were placed into a beaker containing 30 ml of 0.4 M mannitol. After incubated at 25°C for 3 hours, electric conductivity were measured in a suspending solution with a conductivity meter (Sartorious Professional Meter pp-20) as an initial reading. These sample were oiled at 121°C and at the pressure of 15 lb/inch^2 for 30 min. After boiling, the conductivity of solution were measured again (as 100% leakage). The percentage of ion leakage were calculated from the equation:

$$\%\textit{Electrolyte leakage} = \frac{\textit{initial reading}}{\textit{final reading}} \times 100$$

Result and discussion

Electrolyte leakage

At all temperature, the Electrolyte leakage (EL) in flesh was increased as the fruit storage time was set longer. At 25 ± 2°C and 13°C, the EL values were rapidly increased because the fruits were ripening. But at 13°C, after more than 20 days storage, the internal browning and discoloration of the fruits occurred resulting in the increasing of EL. As these also depend on the ripening and chilling so that it could not be used to differentiate between the effects of chilling injury and ripening. While for the fruits stored at 5°C, the flesh EL has only slightly increased (Fig. 1). Fruits stored at 5°C for 10 days, peel electrolyte leakage increased faster than fruits stored at 13°C, because of chilling. By visual observation, the fruits showed pitting after 7-10 days stored at 5°C (data not shown).

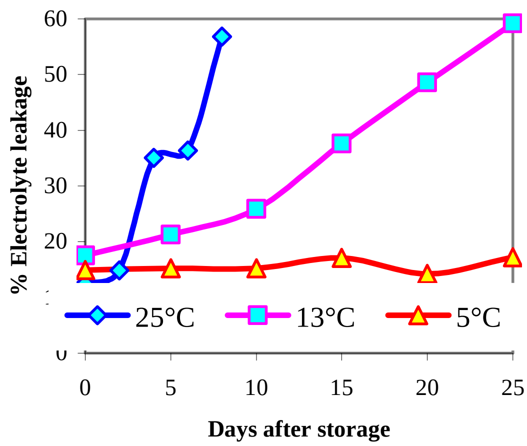

Fig. 1. Electrolyte leakage of mango flesh.

Specific heat (Cp) and thermal conductivity (k)

The specific heats of mango flesh increased as they were stored at 25±2°C and 13°C, as shown in Fig.2, while the one stored at 5°C was relatively unchanged. It can be seen from Fig. 3 that the thermal conductivity of the mango flesh increased to the maximum value after 6 days, 20 days and 5 days when the fruits were stored at 25± 2, 13 and 5°C respectively. The electrolyte leakage increased similar to the increase of the thermal conductivity, except at 5°C. However, the electrolyte leakage also depends on the ripening (Wang, 1990), and the fruit at the first two storage temperatures ripened in the meantime, therefore it was also could not be used to differentiate between the effects of chilling injury and ripening. By visual observation, the fruit showed pitting after 7-10 days stored at 5°C. For the one stored at 13°C, this symptom as well as internal browning and discoloration happened after 20 days of storage.

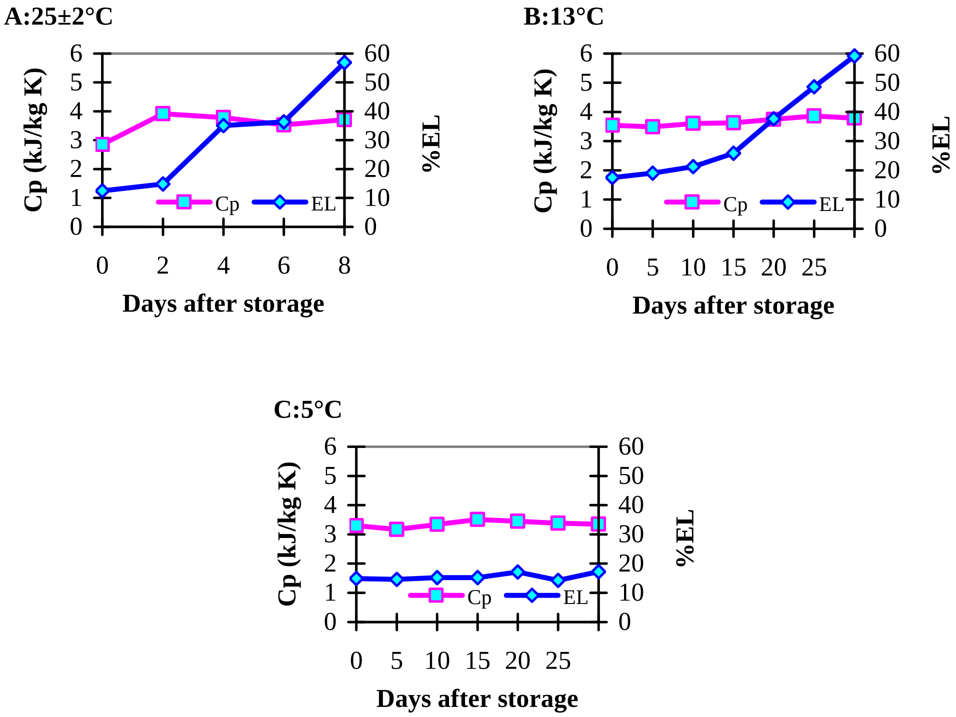

Fig. 2. Specific heat of mango flesh.

Conclusion

From the results, it could be concluded that the thermal properties of mango flesh was influenced by the temperature and storage time. There is a relationship between thermal properties and the chilling injury.

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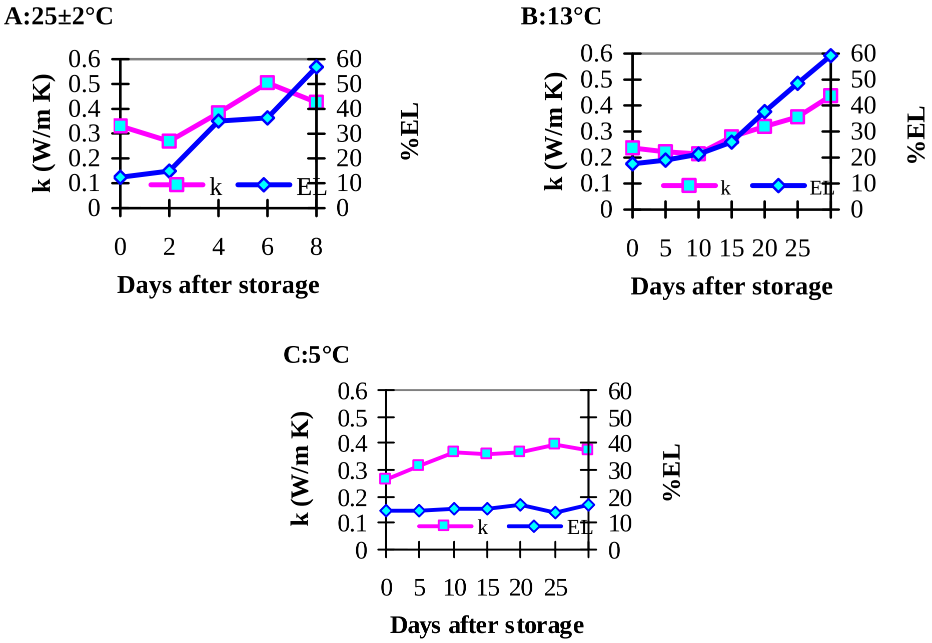

Fig. 3. Thermal conductivity of mango flesh.

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