

Tangerine and Mango Fruits Quality Detection by Near Infrared Spectroscopy

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ABSTRACT

Near infrared spectroscopy (NIRS) appears a prominent technique for non-destructive fruit quality assessment. This research work was focused to evaluate the use of NIRS in detection of the quality characteristic of Thai fruit such as chemical properties and physiological disorder. Two kinds of Thai fruit, tangerine and mango were used in this research. Tangerine and mango fruits were harvested at the commercial maturity and transported to Postharvest Technology Research Institute, Chiang Mai University. The fruits were measured the spectra by using NIR-System6500 in wavelength range 700-1100 nm. Total soluble solid (TSS) and titratable acidity (TA) were determined by digital refractometer and titrated with 0.1 N sodium hydroxide. Before calibration, the spectral data were transformed with the various of mathematical techniques and the prediction models were developed based on partial least square regression (PLSR). Physiological disorder detection, mango fruits were kept in the chamber at 5±1°C to induce the chilling injury symptom. NIRSystem6500 was used to measure the spectra of fruits in wavelength region from 700 nm to 1100 nm and then, determined the electrolyte leakage of the flesh at initial time on days 15 and 30. Spectral data were analyzed by using principle component analysis (PCA). NIRS could be used to detect the quality of both fruits, tangerine and mango, in term of TSS and TA. The PLSR models contained the correlation of determination about 0.7-0.9. Moreover, it was found that chilling injury of mango fruit responded differently to near infrared. It could be separated into two groups with PC2 and PC3. The first group was the spectrum of normal mango: no chilling injury symptom. The second group was the spectrum of mango which had been kept at 5±1°C for 15 and 30 days and showed severe chilling injury symptom; similar to the electrolyte leakage of the flesh which increased from 8.6% at the initial time to 15.4% and 13.0% when the mangoes were kept at 5±1°C for 15 and 30 days, respectively.

Key words: Fruit, Quality detection, Near infrared spectroscopy

INTRODUCTION

Near infrared spectroscopy (NIRS) appears a prominent technique for non-destructive fruit quality assessment such as peach, apple, melon and others. Since, it is a chemical free, rapidness and requiring less labour (Liu et al., 2010). Their chemical composition molecules contain O-H, C-H and N-H bonds that can absorb energy at NIR frequencies (Osborne et al., 1993). NIR light is defined as the wavelength region from 730 to 2300 nm, lying between the visible light and the infrared light. NIR reflecting spectra are characterized by overtone and combination bands of fundamental vibrations (Williams and Norris, 2001). All organic bonds have the absorption bands in the NIR region, whereas minerals may only be detected in organic complexes and chelates or indirectly by their effect on hydrogen bonds. As the overtones and combination bands are much

weaker than the fundamental absorption bands, NIRS allows the analysis of samples up to several millimeters in thickness.

Tangerine is an important economical fruit in the north of Thailand and it could be produced all year round. Their main quality parameter are total soluble solid (TSS) and titratable acidity (TA) (Antonucci et al., 2011). Whereas mango is a tropical fruit with large export markets in Asia, Europe and North America. Mangoes contain simple and complex carbohydrates, organic acids, proteins, fats and vitamins, all of which contribute to fruit quality (Kalra et al., 1995). Fruit quality is very important which affects on consumer preference and the price of fruit. It relates to the chemical and physical properties which can be determined by the conventional methods (Gomez et al., 2006). It takes a lot of time, uses a highly skilled person, produces waste, and destroys the sample before going to analysis. Then, this research work was focused to evaluate the use of NIRS in detection of the quality characteristics of tangerine and mango fruit. There are the chemical properties and physiological disorder, in case of the chilling injury (CI) symptom. It will be appear as a dark, scald-like disorder with pitting or sunken lesions on the peel when the fruit is stored at the temperature lower than 13 °C (Wang et al., 2008). These disorders affect to the consumer preference and the price. Moreover, it has to be detected by a skilled person.

MATERIALS AND METHODS

Two kinds of Thai fruit, tangerine cv. Sai Nam Pung and mango cv. Nam Dok Mai Si Thong were used in this research. The chemical properties detection, tangerine and mango fruit were harvested at the commercial maturity and transported to Postharvest Technology Research Institute, Chiang Mai University. Sample preparation, fruits were controlled the temperature at 25°C by dipping in the low temperature bath for 20 minutes. Data acquisition, the fruit were measured the spectra by using NIRSystem6500 in wavelength range 700-1100 nm (Figure 1). Total soluble solid (TSS) and titratable acidity (TA) were determined by digital refractometer and titrated with 0.1 N sodium hydroxide. Before calibration, the spectral data were transformed with the various of mathematical technique and the prediction models were developed based on partial least square regression (PLSR). For the physiological disorder detection, mango fruit were kept in the chamber at 5±1°C to induce the chilling injury symptom. NIRSystem6500 was used to measure spectra of mangoes in wavelength region from 700 nm to 1100 nm and then, determined the electrolyte leakage of the flesh at initial time on days 15 and 30. Spectral data were analyzed by using principle component analysis (PCA) and the chemical data was analyzed by the statistical technique.



Figure 1. Measurement of NIR spectrum of fruit by using (a) NIRSystem6500 obtained with fiber optic probe (b) temperature control unit of fruit at 25°C.

RESULTS AND DISCUSSION

The range of TSS and TA value of tangerine fruit were 11.2-13.6% and 0.41-0.57%, respectively. The spectral data were transformed with the multiplicative scatter correction (MSC) and second derivative (10 nm averaging for left and right side) and used to develop the model.

The PLSR models of tangerine fruit for TSS contained the correlation of determination (R^2) about 0.72, the standard error of calibration (SEC) about 0.28%, the standard error of prediction (SEP) about 0.31% (Figure 2a, 2b). The regression coefficient plot showed the high value around at 908 nm which related to sugar band (Kawano et al., 1992; Williams and Norris, 2001). In term of TA, the spectral data were transformed with smoothing and second derivative (second derivative: 5 nm averaging for left and right side) and developed the model. PLSR model obtained with R^2 , SEC and SEP equal to 0.70, 0.04% and 0.06%, respectively (Table 1; Figure 3a, 3b). TSS and TA of mango fruit were 10.16-18.35% and 0.78-1.59%, respectively. The spectral data for PLSR model development were transformed with second derivative (10 nm averaging for left and right side). PLSR model of mango fruit for TSS prediction obtained the value of R^2 , SEC and SEP equal to 0.96, 0.60% and 0.64%, respectively (Figure 4a, 4b). TA PLSR model obtained with R^2 , SEC, SEP equal to 0.82, 0.16% and 0.16% (Table 2; Figure 5a, 5b).

Table 1. PLSR calibration results of total soluble solid and titratable acidity of tangerine fruit.

Properties	Pretreatment	Wavelength (nm)	F	R^2	SEC	SEP	Bias
TSS	MSC+2 nd derivative	850-1050	8	0.72	0.28	0.31	0
TA	SM+2 nd derivative	850-1000	8	0.70	0.04	0.06	0

MSC: multiplicative scatter correction, SM: smoothing (Savitzky-Golay),
 2nd: second derivative F: number of factors used in the calibration equation,
 R^2 : coefficient of determination, SEC: standard error of calibration,
 SEP: standard error of prediction, Bias: average of difference between actual value and NIRS predicted value

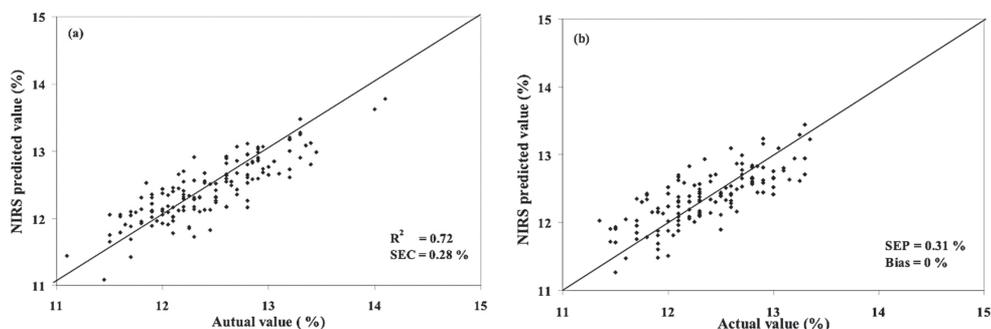


Figure 2. Plot of actual vs predicted total soluble solid of tangerine fruit in (a) calibration set and (b) prediction set.

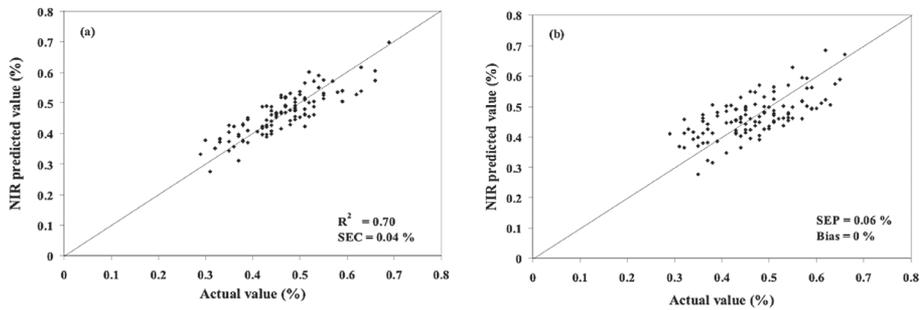


Figure 3. Plot of actual vs predicted titratable acidity of tangerine fruit in (a) calibration set and (b) prediction set.

Table 2. PLSR calibration results of total soluble solid (TSS) and titratable acidity (TA) of mango fruit.

Properties	Pretreatment	Wavelength (nm)	F	R ²	SEC	SEP	Bias
TSS	2 nd derivative	800-1080	6	0.96	0.60	0.64	0.04
TA	2 nd derivative	850-950	6	0.82	0.16	0.16	-0.01

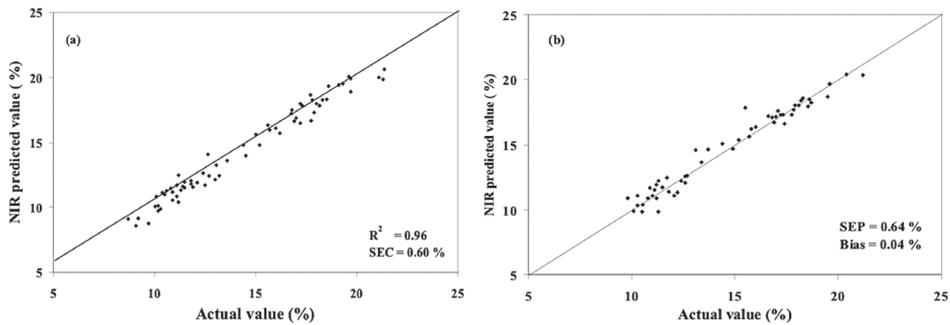


Figure 4. Plot of actual vs predicted total soluble solid of mango fruit in (a) calibration set and (b) prediction set.

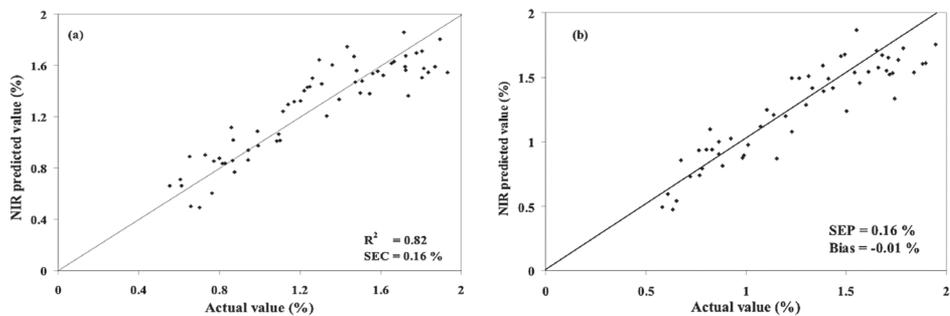


Figure 5. Plot of actual vs predicted titratable acidity of tangerine fruit in (a) calibration set and (b) prediction set.

The results of PLSR model for prediction of TSS and TA of both fruits showed that the accuracy of the model of tangerine fruit was lower than mango fruit since the effect of light scattering. Its cause from the tangerine fruit texture was highly complicated. Their consist of pericarp (exocarp and mesocarp) and locule or segment (Ladaniya, 2008). When the light illuminates on the sample, it does not always travel the same distance in their before it is detected (Williams and Norris, 2001). However, NIRS could be used to detect the quality of both of fruits, tangerine and mango, in term of TSS and TA.

In case of physiological disorder detection, chilling injury symptom was appeared on mango fruit after stored at $5\pm 1^{\circ}\text{C}$ for 15 and 30 days (Figure 6). it was found that chilling injury of mango fruit responded differently to near infrared which was the importance properties for detecting the chilling injury symptom. Mango spectra could be separated into two groups with PC2 and PC3 (Figure 7). The first group was the spectrum of normal mango: no chilling injury symptom. The second group was the spectrum of mango which it had been kept at $5\pm 1^{\circ}\text{C}$ for 15 and 30 days and showed severe of chilling injury symptom. Similar to the electrolyte leakage of the flesh increased from 8.6% at the initial time to 15.4% and 13.0% when the mangoes were kept at $5\pm 1^{\circ}\text{C}$ for 15 and 30 days, respectively (Table 3). The electrolyte leakage were significantly different ($P<0.05$). However, it should be considered on the physical properties such as color, texture and chilling injury score (Suwapanich, 2006).

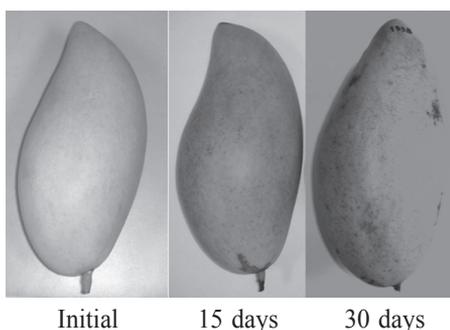


Figure 6. Mango fruit at the initial time, 15 days and 30 days after storage at $5\pm 1^{\circ}\text{C}$.

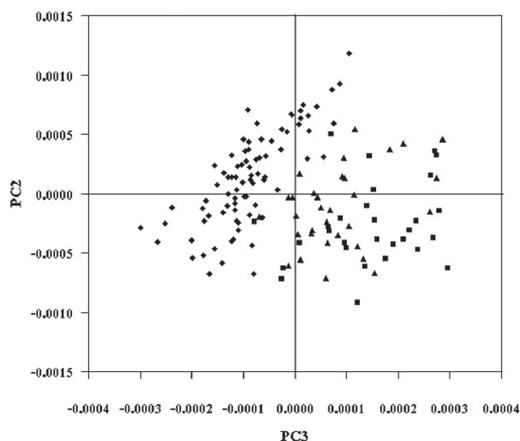


Figure 7. PCA score plot (PC2 vs. PC3) of mango fruit spectra at the initial time (◆), 15 days (▲) and 30 days (■) after storage at $5\pm 1^{\circ}\text{C}$.

Table 3. The electrolyte leakage of the mango flesh at the initial time, on days 15 (T15) and 30 (T30) when they were kept at $5\pm 1^{\circ}\text{C}$.

Storage time (days)	Electrolyte leakage (%)
Initial	8.6
15	15.4
30	13.0
LSD _(0.05)	1.2
CV(%)	15.6

CONCLUSION

Near infrared spectroscopy could be used to detect the quality of fruit in terms of chemical properties (TSS and TA) and physical properties (chilling injury symptom).

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