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Detection for Moisture Content of Sweet Tamarind Flesh by Transmittance Short Wavelength Near Infrared Spectroscopy

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Abstract. Moisture content of tamarind flesh is important for quality evaluation. It related to texture and internal defects of sweet tamarind. Appearance of tamarind flesh depends on moisture content. Flesh with low moisture content, the texture becomes dry and hard. Rotten flesh also has low moisture content. This research was aimed to nondestructively predict the moisture content of sweet tamarind flesh using transmittance near infrared spectroscopy in the wavelength range between 665-955 nm. Sweet tamarinds ('Prakaytong' variety) were studied in this research. A set of 150 samples (100 samples for a calibration set and 50 samples for a prediction set) were investigated for statistical quantitative analysis. Acquired spectra of each sample were averaged. A calibration model for moisture content of sweet tamarind flesh was established using partial least squares regression (PLSR). Original spectra obtained good results of calibration compared to others spectral pretreatments. The calibration model was efficient by cross-validation (the coefficients of correlation, R = 0.92 and the root mean square error calibration, RMSEC = 0.75). The results of prediction obtained good accuracy (R = 0.88 and the root mean square error prediction, RMSEP = 0.86). It showed that the transmittance near infrared spectroscopy was possible to use to predict the moisture content of sweet tamarind flesh. In the future, this study can be applied for nondestructive sorting unit of intact sweet tamarind.

Keywords: Tamarind, Moisture content, Near infrared, Nondestructive and prediction

1. Introduction

Sweet tamarind (*Tamarindus indica* L.) is one of important fruits which are popular for consumers. There are plantations in many provinces of Thailand such as Phetchabun, Lampang, Chiangmail, Nakhonratchasima and Ubonratchathani [1]. Sweet tamarind was exported and generated incomes for farmers. The growth of exported marketing of sweet tamarind has been increased. In 2007, 2008, 2009, 2010 and 2011, there were 38.2 million, 42.3 million, 37.5 million, 88.5 million and 52.2 million baht of the total export value respectively [2]. However, the export is obstructed due to poor quality of sweet tamarind especially internal qualities that cannot be inspected by visual inspection. Mold is often in sweet tamarind flesh [3]. Steam heating treatment was used to protect mold but it made moisture content low. Then, texture of flesh became hard and dry [1]. Moisture content of sweet tamarind flesh is one of main indexes that can be used to evaluate the internal quality of sweet tamarind. Therefore, nondestructive methods to detect the moisture content of sweet tamarind flesh are required.

Near infrared spectroscopy (NIRS) is a good technique for assessment of internal quality in intact fruits. It is nondestructive, fast and accurate [4]. There were many research reports which used NIRS as a nondestructive method to detect internal quality of fruit such as cantaloupe [5], mandarin [6], watermelon [7]. Transmittance NIR spectroscopy showed good results for evaluation of defects in intact fruits [8], [9]and [10]. Hence, transmittance NIR spectroscopy is considered to use for prediction of the moisture content of sweet tamarind flesh in this research.

2. Materials and Methods

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1.1 Sample

A set of 150 sweet tamarinds (‘Prakaytong’ variety) was purchased from auction markets in Thailand. Samples were selected by visual inspection. Good appearances without any defects such as size, length, color, non-breakage of the shell etc. were used in this research.

1.2 Data Acquisition

All samples were measured by transmittance NIR spectrophotometer (PureSpect, Saika TIF., Japan) in the wavelength range of 665-955 nm. Spectra were acquired from measurements at the center of seed pods in each sample. After spectral measurements, each sample was peeled out and flesh was removed. The moisture content wet basis of sweet tamarind flesh was measured by a hot air oven (Memmert, D 0601 Modell 500, Germany)

1.3 Data Analysis

Samples were divided into 2 groups which were used for the calibration set (100 samples) and the prediction set (50 samples). The average spectrum was calculated from measurements in each sample and used for statistical analysis. The spectral pretreatments were investigated in order to obtain the best results of calibration. The calibration model for the moisture content of sweet tamarind flesh was developed using partial least squares regression (PLSR). The coefficients of correlation, the root mean square error calibration and the root mean square error prediction were used for consideration of a performance of the calibration model. Unscrambler (CAMO, Oslo, Norway) was used for statistical analysis.

3. Results and Discussion

Table 1 showed statistical characteristics of the calibration set and the prediction set of samples for quantitative analysis. The moisture content was used as a dependent variable and the wavelengths were used as independent variables.

Table 1: Characteristics of the calibration set and the prediction set of sweet tamarinds.

Items	The calibration set	The prediction set
Number of sample	100	50
Unit of moisture content	% (w.b.)	% (w.b.)
Range	12.95-22.86	13.87-22.47
Mean	20.32	20.48
SD	1.93	1.82
Wavelength	665-955 nm	665-955 nm
Interval	1.29 nm	1.29 nm

% (w.b.) = Moisture content wet basis (%)

Samples were classified into three groups by different levels of flesh moisture content (12.95-14.9% for a group of low moisture content, 15.32-19.99% for a group of middle moisture content and 20.03-22.86% for a group of high moisture content). NIR absorbance spectra of each group were averaged. Figure 1 showed averaged NIR absorbance related to moisture content of sweet tamarind flesh. Averaged absorbance of low moisture content was higher than those of middle moisture content and high moisture content respectively.

Prediction results of the calibration model for sweet tamarind flesh moisture content from various spectral pretreatments were investigated by cross validation in the calibration set as shown in Table 2. It showed that original spectra obtained the best result (R= 0.91 and RMSEP = 0.79). Therefore, original spectra were used for establishment of the calibration model for flesh moisture content in this research.

In Table 3, the calibration model for flesh moisture content was developed and cross-validated (R= 0.92 and RMSEC = 0.75). The results of prediction obtained good accuracy (R= 0.88 and RMSEP = 0.86). The scattered plot of actual moisture content versus predicted moisture content in the calibration set was shown in Figure 3 (a) while the scattered plot of actual moisture content versus predicted moisture content in the prediction set was shown in Figure 3 (b). The results showed that the calibration model was efficient to use for prediction of moisture content in sweet tamarind flesh.

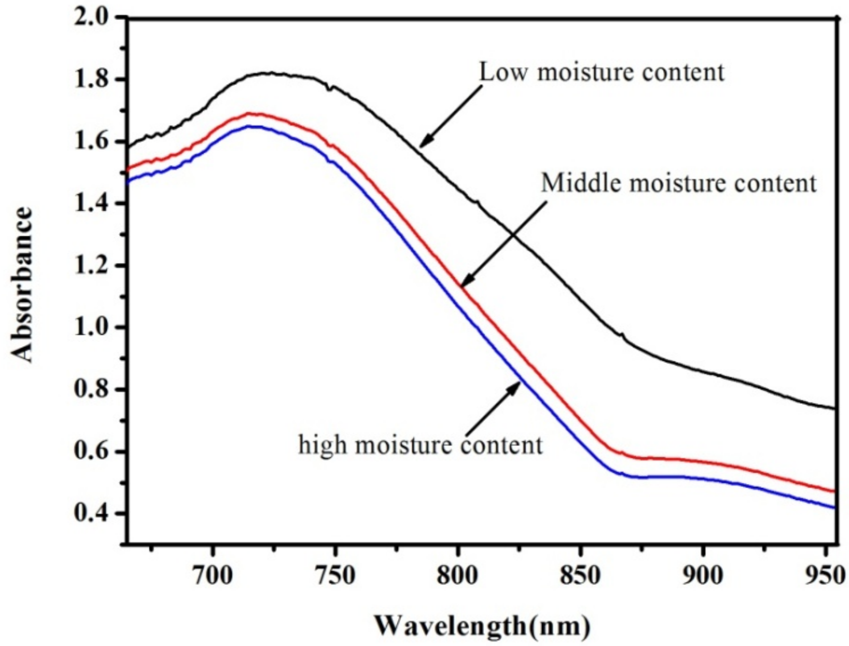

Fig. 1: Average absorbance spectra of samples in three groups with different moisture content.

Table 2 Statistical results for prediction of moisture content with different techniques of spectral pretreatment.

Spectral Pretreatments	F	N	RMSEP	R
Original	5	100	0.79	0.91
Smoothing	6	100	0.79	0.91
1st derivative	4	100	0.91	0.88
2nd derivative	6	100	1.07	0.83
MSC	4	100	0.86	0.89
Mean	5	100	0.79	0.91
SNV	6	100	1.10	0.82
Smooth + 1st derivative	6	100	0.80	0.91
MSC + Smoothing + 1st derivative	5	100	1.09	0.83
mean + Smoothing + 1st derivative	6	100	0.82	0.90

F = Factors
N= number of sample;
Smoothing = Savitzky-Golay smoothing
1st derivative = Savitzky-Golay first derivative
2nd derivative = Savitzky-Golay second derivative
MSC = multiplicative scatter correction pretreatment
Mean = mean center
SNV = standard normal variate transformation

Table 3: PLSR results of the calibration model for flesh moisture content in the calibration set and prediction set.

Model	Training set				Test set			
	F	N	R	RMSEC	F	N	R	RMSEP
original	5	100	0.92	0.75	5	50	0.88	0.86

4. Conclusions

NIR absorbance related to moisture content of sweet tamarind flesh. Averaged original spectra of each sweet tamarind were used to establish the calibration model for flesh moisture content. The results of prediction showed the calibration model had a good performance (R = 0.88, RMSEP = 0.86). Therefore, transmittance NIR spectroscopy had a good potential to use for non-destructive prediction of the moisture content of sweet tamarind flesh (‘Prakaytong’ variety).

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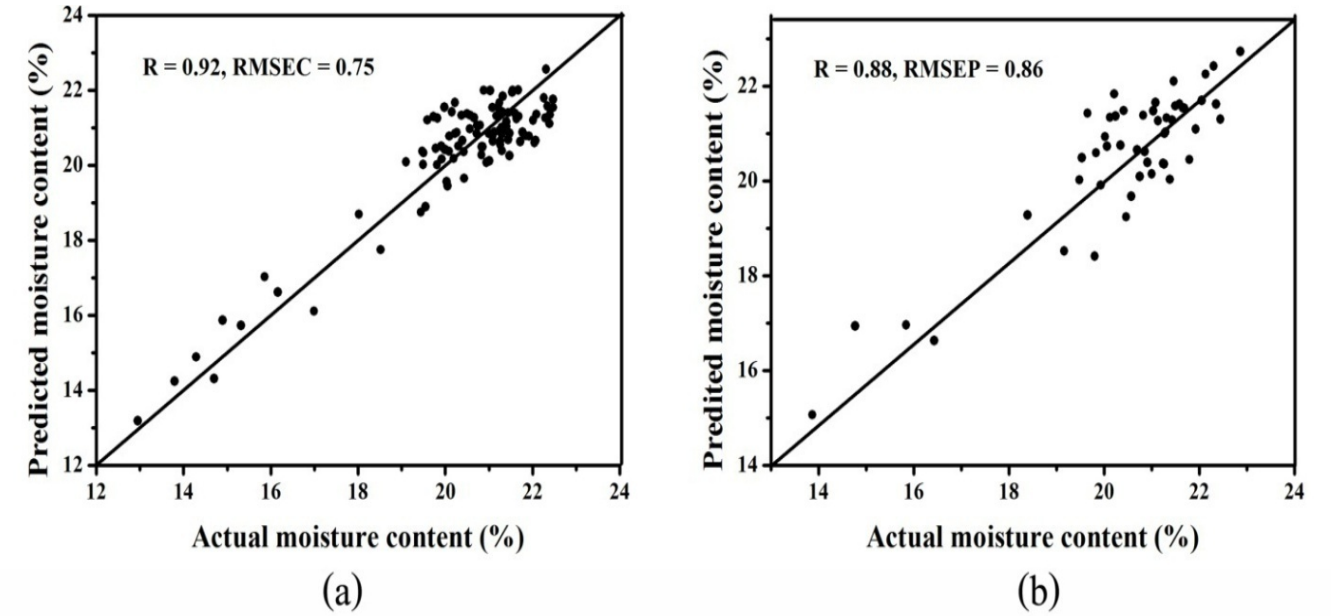

Fig. 3: Scattered plot for moisture content prediction by the calibration model (a) in the calibration set (b) in the prediction set.

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