Precision Test for Spectral Characteristic of On-line Vis-NIR versus Off-line NIR Spectroscopy for Measuring Dry matter of Durian (*Durio zibethinus* cv Monthong)

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Abstract

Near infrared (NIR) spectroscopy is a rapid and environmental friendly method to evaluate the constituents of fruit and vegetable. The precision and accuracy of the instrument and reference methods is important. The purpose of this paper is to determine the scanning repeatability and reproducibility of UV-VIS–NIR spectrometer (on-line) and NIR spectrometer (off-line) for measuring dry matter of Durian (*Durio zibethinus* cv Monthong) and compare their measurements with reference method by using hot air oven. The results showed the repeatability and reproducibility of off-line scanning spectrometer was 0.0044 and 0.0110, and for on-line scanning spectrometer was 0.0786 and 0.0831, respectively. The repeatability of reference method was 0.98 and the maximum co-efficient of determination (R^2_{MAX}) was 0.941. The error of reference measurement is only 5.9%. This result indicated that it was worth to develop the NIR spectroscopy model.

Keywords: NIRs, Precision test, Spectral characteristic, On-line, Off-line, Dry matter, Durian.

1. Introduction

Thailand is a major exporter in the world agricultural market and durians is important export-product of Thailand. Thailand exports all kinds of durians including fresh durians, frozen durians and processed durian products such as durian paste and durian chips. The export value of frozen durian in 2016 was quantity totaled approximately 19.436 million ton. The export value was 2,029 million bath (Office of Agricultural Economics, 2016). Due to the fact that durian of Thailand is tasty and has high quality so it is acceptable and popular for foreign consumer. Durians harvesting seasonal period is from June to August. But there are problems to consider in durian production between immature durians and mature durians. Immature durians can destroy the reputation durian of Thailand and this problem also decrease demand of export durian. Durian classification requires expert knowledge and experience. However, there are a number of researches which study quality of durian by non-destructive maturity measurement method. In 2004, the quality of durian by measuring strength of durian stem and analyze natural resonant frequency was studied (Neamsorn and Terdwongworakul, 2004) and dried durian pulp for measuring its dry matter which is used to be maturity reference. The statistical correlation analysis of various stem strength related parameters showed that the multiple linear regression analysis indicated that the area under the force-deformation curve and the resonant frequency could be used in linear combination for the best prediction of durian maturity with multiple coefficient of correlation (r) = 0.844 and multiple coefficient of determination (R^2) = 0.713. (Timkhum and Terdwongworakul, 2012). Furthermore, visible spectroscopy of the spine of durian was investigated for classification of maturity. Partial least squares discriminant analysis was performed to model the classification. The model using absorbance spectra transformed by the standard normal variate achieved the best accuracy of classification (94.7%) into four maturity classes ranging from 113 to 134 days after anthesis. The classification was attributable to the absorbance of chlorophyll a, carotenoids and anthocyanins in the spine. Onsawai and Sirisomboon (2015) evaluated the dry matter of durian by using diffuse reflectance near infrared spectroscopy. Near infrared (NIR) spectroscopy is used as a non-invasive technique and a rapid and environmental friendly method to evaluate the consti-tuents of fruit and vegetable which has high precision and accuracy.

This experiment studied the repeatability and reproducibility of scanning to find the precision of NIR spectrometer and repeatability of reference method for measurement of dry matter of durian pulp to find its overall precision. In addition, the maximum coefficient of determination was also determined to be the indicator whether it is approoriate to develop a model or not.

2. Materials and Methods

2.1 Samples.

Durian "Monthong" (3 fruits) from Chumphon, Southern Thailand, are transported by train to King Mongkut's Institute of Technology Landkrabang, Bangkok, Thailand on July 5, 2017. All samples was openned for durian pulp and the pulp was kept in a plastic box at room temperature (25 ± 2°C).

2.2 NIR scanning.

FT-NIR spectrometer.

The durian pulp sample was measured for spectral data at the middle of the lobe using an FT-NIR spectrometer (MPA, Bruker, Ettlingen, Germany) in reflection mode at 12,500- 4000 cm-1 (800-2500 nm) with a resolution of 16 cm-1, accumulating 32 scans per 1 averaged spectrum and using gold as a reference material. All experiments were performed at 25 ± 2°C.

Fiber-optic Spectrometer.

For on-line measurements, Fiber-optic Spectrometer (AvaSpec-2048-USB2-VA-50), The Netherland) in absorbance mode at wavelength range of 350-1100 nm using spectralon as reference material was used. The pulp was conveyed for scanning on the belt conveyor. This was done at 25 ± 2°C.

2.3 Reference test for Dry matter measurement.

After scanning, durian pulp without seed from the scanned position of each lobe was cut, chopped and mixed. The moisture content of a 5 g durian mash sample was analysed in duplicate using a hot air oven (UF 260, Memmert, Germany) at a temperature of 60°C until a constant weight was reached. The moisture content (MC) was calculated from following equation.

$$\mathrm{MC}(\%) = \frac{(\mathrm{W1}-\mathrm{W2})}{\mathrm{W1}} \times 100$$

Where W1 is the original weight (g), and W2 is the oven-dried weight (g)

The dry matter (DM) was calculated from MC using the below equation.

2.4 Repeatability, reproducibility and maximum coefficient of determination.

Repeatability.

Repeatability of NIR scanning was determined by scanning the same sample at the same location 10 times, then find the standard deviation (SD) of the absorption of each wavelength for 3 wavelengths (970, 1440, 1900 nm) and averaged.

Repeatability.

Reproducibility of NIR scanning was determined by scanning the sample for 10 times, but it was reloaded every time, then the SD of absorption at each wavelength was calculated. The data was calculated for the 3 selected wavelengths and averaged.

Repeatability of reference method and maximum coefficient of determination.

The precision of the reference test of DM of durian pulp was determined using the repeatability value (Rep), which was calculated from the standard deviation of the different between duplicates. Then, the maximum coefficient of determination (R^2_{Max}) was calculated followed Dardenne (2009) using the following equation.

$$\mathrm{R}^2_{\mathrm{Max}} = \frac{\mathrm{SD}_y^2 - \mathrm{Rep}^2}{\mathrm{SD}_y^2}$$

where SD_y is the standard deviation of DM of samples. According to Dardenne, the maximum R^2 is possible only when there are no errors in the spectra or the model, and the SD_y and Rep can indicate that the range in values for the samples is too narrow, and a reference method is not sufficiently precise.

3. Results and Discussion

The repeatability and reproducibility of off-line scanning (FT-NIR) spectrometer was 0.0044 and 0.0110, and for on-line scanning (Fiber optic) spectrometer was 0.0786 and 0.08314, respectively. The repeatability of reference method was 0.98 and the maximum coefficient of determination (R^2_{MAX}) was 0.941. The error of reference measurement is only 5.9%.

Category	scanning		Reference	
	repeatability	reproducibility	reproducibility	R^2_{Max}
On-line	0.0786	0.0831		
Off-line	0.0044	0.0110	0.98	0.941

4. Conclusions

The value of repeatability and reproducibility in on-line scanning was not better than the off-line which may be due to various factors (for example focal length and signal to noise ratio ans so on) during on-line scanning. However the on-line scanning is the only method used in industrial plants because of the scanning speed. The maximum coefficient of determination (R^2Max) of the reference method is 0.941 with error 5.9% which was acceptable and indicated that it is worth to develop the NIR spectroscopy model.

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