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Precision Test for Spectral Characteristic of On-line Vis-NIR versus At-line NIR Spectroscopy for Measuring Total Soluble Solids of Durian (Durio zibethinus cv Monthong)

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Abstract

Near Infrared (NIR) Spectroscopy is a quick method for evaluating fruit and vegetable quality. It is important to measure the precision of an instrument before we start experiment for the model development. The main objective of this paper was to determine scanning repeatability and reproducibility of UV-VIS–NIR spectrometer (on-line) and FT-NIR spectrometer (at-line) for measuring total soluble solids of Durian (*Durio zibethinus* cv Monthong) and its corresponding reference method using pen refractometer to measure for comparison. Results shows that the repeatability and reproducibility of on-line scanning spectrometer was 0.0786 and 0.0831, similarly for at-line scanning spectrometer was 0.0044 and 0.0110 repectively. The repeatability of reference method was 0.2. The maximum coefficient of determination (R^2_{MAX}) of reference method is 0.997. This indicated that the error from the reference method was only 0.3%.

Keywords: Precision test, Spectral characteristic, On-line, At-line, Total Soluble Solids, Durian.

1. Introduction

Durian is an important fruit of Thailand. The major durian fields are located in the east and the south. In 2014, Thailand exported 17.143 million tonnes of frozen durian pulp to a value of 1,131 million baht (Office of Agricultural Economics, 2014). Durian exporters are often faced with a problem of exporting unripe durian which not having the required sweetness. This makes export market unrelieable. This problem is due to a faulty selection of unripe durians that do not have the desired sweetness after aging. At present, durian collection requires a lot of experience and expertise which are farmers. Therefore, there is a chance of error in the selection. In the export of frozen durian pulp, durian peels are completely peeled, leaving only the durian pulp that makes it easy to separate the ripeness and sweetness of durian meat, which fairly reduce the unripe problems.

The near infrared (NIR) spectroscopy technique have outstanding capabilities such as fastness, accuracy and precision, the ability to analyze data in multiple properties and multiple components Garrido, 2006) and a method for evaluating the quality of organic compounds such as total soluble solids, protein, etc. Bangwaak et al. (2014) investigated the NIR spectroscopy technique by measuring the absorption of light at the stem of durian and established the relationship with total soluble solids and evaluated the maturity of durian. The results were as follows: r = 0.93 and SEP = 1.58. Onsawai and Sirisomboon, 2015 evaluated durian total soluble solids with NIR spectroscopy which provided r^2 =0.55 and RMSEP =1.63ºBrix

Recently the NIR on-line systems was developed to be used in industry to control qualitative analysis of different types of vegetables or fruit. For example, olive fruits, Chaparro et al. (2012) studied on olive-based on-line scanning of the olive fruits using a diode array spectrometer mounted on the top of the conveyor belt to determine focal distance and integration time. The result found that the suitable focal length and integrating time were 13 mm and 5 s, respectively. The NIR Spectroscopy technique is an interesting way to assess the total soluble solids of Durian pulp online.

For the online NIR spectroscopy process, the precision test for spectral characteristic of on-line NIR spectroscopy for measuring total soluble solids of durian is important. Therefore, this study is interested in investigating precision test for spectral characteristic of on-line VIS-NIR versus at-

line FT-NIR spectroscopy for measuring total soluble solids of durian (*Durio zibethinus* cv Monthong) by determination of repeatability and reproducibility of scanning the durian pulp on-line and at-line and determination of repeatability of reference method for total soluble solids. This will be useful for the development of on-line NIR spectroscopy protocol.

2. Materials and Methods

2.1 Samples.

The three samples of durian fruits were from an orchard in Chumphon province, Thailand. The fruits were peeled for three lopes of pulp.

2.2 Near Infrared Absorption Measurement.

For online measurement, the durian pulp was sent on the belt conveyor for scanning using AvaSpec-ULS2048 (AvaSpec-ULS2048-USB2-VA-50, AVANTES, Netherlands) in wavelength range of 350-1100 nm with absorbance measurement mode and using spectralon as reference material where one spectrum resulting from one scan on the middle of the durian lope and then take the same sample to measure the absorbance with FT-NIR Spectrometer(MPA FT-NIR, Bruker Optik GmbH, Ettlingen, Germany) where the absorption was measured at 1 point per 1 area in the wavenumber range of 12500-4000 cm^{-1} (800 - 2500 nm) at 16 cm^{-1} resolution and gold is reference material, where one spectrum resulting from an average of 32 scans.

2.3 Mearsurment of total soluble solids content of durian pulp.

The scanned area of durian pulp was measured for the total soluble solids at 3 consecutively at 1 point the value was read 3 times and then average with a pen refract meter (PEN-PRO, Measurement Range Brix 0.0 to 85.0%, ATAGO, Japan).

2.4 Repeatability, reproducibility and maximum coefficient of determination.

Repeatability of NIR scanning was determined by scanning the same sample in the same location for 10 times, then calculating the standard deviation (SD) of the absorption by selecting 3 wavelengths (970, 1440, 1900 nm) from 10 spectra and averaged.

Reproducibility of NIR scanning was determined by scanning the sample for 10 times, but it was reloaded every time, then the SD of the absorption of the 3 selected wavelengths was calculated and average.

Repeatability of reference method (Rep) is a measure of repeatability from standard measurements. This value was determined by calculating the SD value of the maximum difference in repetition of the same sample of all samples.

R^2_{MAX} is the maximum possible R^2 for testing when no error from the NIR spectrometer and has only the errors occurring from reference method of the laboratory. For laboratory accuracy, R^2_{MAX} can be calculated from the following formula.

$$R^2_{max} = \frac{SD_y^2 - Rep^2}{SD_y^2} \quad (1)$$

where SD_y^2 is the standard deviation of the calibration set data.

3. Results and Discussion

Table 1 shows the repeatability and reproducibility of on-line scanning spectrometer was 0.0786 and 0.0831, for at-line scanning spectrometer, it was 0.0044 and 0.0110, respectively. The repeatability and reproducilbility of at-line was less than that of the on-line displayed that the scanning in at-line was more effective than the on-line but on-line system capabled to be applied in the industry for frozen durian pulp. The repeatability of reference method was 0.2 indicated the high precision of reference method. The maximum coefficient of determination (R^2_{MAX}) was 0.997. This indicated that the error from the reference method was only 0.3% and the NIR spectroscopy model could be established.

Table 1 repeatability and reproducibility of on-line and at-line scanning spectrometer and reference method and R^2_{MAX}.

Category	Scanning method		Reference method	
	Repeatability	Reproducibility	Repeatability	R^2_{MAX}
On-line	0.0786	0.0831	0.2	0.997
At-line	0.0044	0.0110		

4. Conclusions

The at-line scanning was more precise than the on-line spectrometer. However, the on-line method could be applied on the belt conveying system of durian pulp in factory. The maximum coefficient of determination (R^2_{MAX}) of reference method in laboratory experiment is 0.997 with an error only of 0.3% was acceptable and indicated that the NIR spectroscopy models for predicting of total soluble solids of durian pulp should be developed.

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