Near infrared scanning precision analysis for intact durian fruits (cv. Chanee, Kanyao and Monthong)

K Chanachot¹, W Saechua¹ and P Sirisomboon¹
¹ NIR Spectroscopy Research Center for Agricultural Products and Foods, Agricultural Engineering Department, Faculty of Engineering, King Mongkut’s Institute of Technology Ladkrabang, Bangkok, Thailand

Email: kingdow_c@hotmail.com

Abstract. In order to develop a model of near infrared (NIR) spectroscopy, it is important to first perform the precision analysis of scanning of the NIR spectrometer. Therefore, it was the main aim of this paper by evaluating the scanning repeatability and reproducibility on intact durian fruit of 3 varieties including Chanee, Kanyao and Monthong using 3 spectrometers including FT-NIR spectrometer (MPA.), Long wavelength diode array spectrometer (MICRO NIR PRO) and Short wavelength diode array spectrometer (FQA NIR GUN). Results show that the lowest repeatability was of MPA for the scanning of Chanee and Kanyao. The lowest reproducibility was of the scanning by MICRO NIR PRO for all varieties. Therefore, from precision analysis of intact durian scanning, the MPA and MICRO NIR PRO could be recommended for the scanning to get the spectra for development the NIR predictive model for identify the geographic origin and variety of the durian.

1. Introduction
Durian is an important export product of Thailand. Each varieties of durian had a different flavor and texture. The price of durian depends on the season and geographical. Durian could not be predicted the geographic origin, flavor or texture by visualization. In export market, the geographic origin should be identified otherwise it would impact the image of that country. As a result, the variety authentication and geographical discrimination is importance. There are many research studies about variety authentication and geographical discrimination. There is the method of combining chemical and statistical analyses of cabbage. But that method required experts to analyze and use chemicals which was bad toxic to the environment, destroy the sample and be an expensive instrument. [1] The use of chromatographic methods and/or DNA analysis enables the identification of geographical origins, however, for these methods are waste time and samples of preparation. [2] There were using near-infrared diffuse reflectance spectroscopy for variety identification for fruit, such as peach. [3] And geographical discrimination of apples [4] and Goji Berry. [5]

As mentioned above, the author would like to use the NIR spectroscopy for variety authentication and geographical discrimination of durian. In terms of the NIR spectroscopy, it is a rapid technique for non-destructive testing. The NIR spectroscopy emit radiation on the sample and molecules of sample absorb energy from radiation that cause vibration in overtone and combination mode. The precision of the instrument is measured by the value of repeatability and reproducibility that can indicate whether the model should be continues for developed or not. Therefore, we need to determine repeatability, reproducibility of NIR scanning instrument. Additional, for repeatability, it can describe the precision
of scanning because we scanned at the same position of the biggest locule of durian fruit. And for reproducibility, it was determining the homogeneity/similarity of the durian. [6]

In order to develop a model based on off-line scanning, the precision test of the instrument by determining the scanning repeatability and reproducibility was needed. The main aim of this paper was to do the test for scanning of intact durian fruits of 3 varieties including Chanee, Kanyao and Monthong.

2. Materials and Methods

2.1. Sample preparation
Durian 3 samples of each variety were brought from Talaad Thai market, Phathumthani province Thailand to NIRS Research Centre of Agriculture Product and Food (www.nirsresearch.com), Department of Agricultural Engineering, Faculty of Engineering, King Mongkut’s Institute of Technology Ladkrabang, Thailand. There were Chanee, Kanyao and Monthong varieties. And they were scanned at the biggest locule of durian fruit.

2.2. Off-line Scanning
Off-line scanning was performed by 3 spectrometers. Using 1) FT-NIR Multi-Purpose Analyzer (MPA) (Bruker optics, Germany) with scanning resolution of 16 cm\(^{-1}\) in absorbance mode and there were 32 scans for 1 average spectrum of the sample. Before sample scanning gold plate was scanned as a background. Wavenumber was from 12,500-4,000 cm\(^{-1}\) or 700-2500 nm 2), Long wavelength diode array spectrometer (Micro NIR PRO) (Viavi, USA) with wavelength of 950-1650 nm and integrating time of 11.8 µs, using 5 spectra for 1 average spectrum. The type of scanning was diffuse reflectance. The reference material was Teflon. 3) Short wavelength diode array spectrometer (FQA NIR Gun) (Fantec, Japan) with wavelength 600-1100 nm and integrating time of 15 ms. The reference material was Teflon.

2.3. Repeatability and reproducibility of scanning test
Each sample were scanned for 10 times at the same position using the 3 spectrometers for determination of repeatability. Likewise, for reproducibility the samples were reloaded and rescanned for 10 times. The repeatability and reproducibility were calculated by standard deviation (SD) of the absorbance of specific wavelengths. The wavelengths of 1450 nm and 1490 nm were selected for the calculation of repeatability and reproducibility for MPA spectrometer and Micro NIR PRO. The wavelengths of 760 and 970 nm were selected for FQA NIR Gun. The SD at each wavelength was calculated and then average.

3. Results and discussion
Figure 1, figure 2 and figure 3 show the average spectra of Chanee, Kanyao and Montong obtained from MPA, MICRO NIR PRO and FQA NIR Gun respectively. From figure 1, wavenumber 10215 cm\(^{-1}\) (978 nm), 8403 cm\(^{-1}\) (1190 nm) 6853 cm\(^{-1}\) (1458 nm) and 5138 cm\(^{-1}\) (1946) i.e bands of water were shown.
Figure 1. Average Spectra of MPA.

Figure 2, wavelength 970 nm, 1193 nm and 1453 nm i.e bands of water were shown.

Figure 2. Average Spectra of MICRO NIR PRO.

And from figure 3, wavelength of 971 nm i.e band of water and 655 nm i.e band of chlorophyll were shown.
Figure 3. Average Spectra of FQA NIR GUN.

Table 1. Repeatability and reproducibility by 3 spectrometers scanning of durian fruit.

| Varieties of durian | Repeatability | Reproducibility |
|---------------------|---------------|-----------------|
| Chanee<sup>a</sup>  | 0.00243       | 0.09926         |
| Chanee<sup>b</sup>  | 0.00266       | 0.02711         |
| Chanee<sup>c</sup>  | 0.05745       | 0.08532         |
| Kanyao<sup>a</sup>  | 0.00338       | 0.05425         |
| Kanyao<sup>b</sup>  | 0.00901       | 0.02268         |
| Kanyao<sup>c</sup>  | 0.01582       | 0.06010         |
| Monthong<sup>a</sup>| 0.00320       | 0.05091         |
| Monthong<sup>b</sup>| 0.00299       | 0.01267         |
| Monthong<sup>c</sup>| 0.02407       | 0.22390         |

<sup>a</sup> scanned by MPA spectrometer  
<sup>b</sup> scanned by MICRO NIR PRO spectrometer  
<sup>c</sup> scanned by FQA NIR GUN spectrometer

From table 1, the comparison of repeatability of 3 spectrometers shows that FQA NIR GUN gave largest repeatability value indicated that the instrument was least precise in scanning. The better precise scanning was by MPA and MICRO NIR PRO where the repeatabilities are comparable. The result of repeatability and reproducibility of scanning of 3 durian varieties including Chanee, Kanyao and Monthong is shown in table 1.

The repeatability is the variation between the measurements of different sample by using same device under same sample with same position. Low repeatability value means low variation among the scans/measurements which indicates the ability in the precision or repeated measurements of the instrument. For this experiment, the lowest repeatability of Chanee and Kanyao was of MPA. The repeatabilities were 0.00234 and 0.0038 respectively. But for Monthong, the lowest repeatability was 0.00299. it was scanning by MICRO NIR PRO.
On the other hand, the reproducibility gave the dispersion of result under different condition. It is calculated by varying the orientation of durian scanning. The lowest reproducibility of all varieties was of the scanning by MICRO NIR PRO. The reproducibilities were 0.02711, 0.02268 and 0.01276, respectively.

4. Conclusions
It could be concluded that from the repeatability test of intact durian scanning the MPA and MICRO NIR PRO were the best precise for scanning and they are comparable. From the reproducibility test of 3 varieties of durian fruit, the matrix of the peel of Monthong variety was the most homogeneous and it was better to scanned by MICRO NIR PRO.

Therefore, from precision analysis of intact durian scanning, the MPA and MICRO NIR PRO could be recommended for the scanning to get the spectra for development the NIR predictive model for identify the geographic origin and variety of the durian.

References
[1] Bong Y S, Song B Y, Gautam M K, Jang C S, An H J and Lee K S 2013 Food Control 30 626-30
[2] Lee S, Choi H, Cha K, Kim M K, Kim J S, Youn C H, Lee S H and Chung H 2012 Bull. Korean Chem. Soc. 33 426-7
[3] Guo W, Gu J, Liu D and Shang L 2016 Computers and Electronics in Agriculture 123 297–303
[4] Schmutzler M, Huck C W 2014 Vibrational Spectroscopy 72 97–104
[5] Tingting S, Xiaobo Z, Jiyong S, Zhihua L, Xiaowei H, Yiwei X, Wu C 2016 Food Anal. Methods 9 68–79
[6] Sharma S and Sirisomboon P 2017 10th TSAE International Conference p 5

Acknowledgments
The authors would like to thank the NIRS Research Centre for Agriculture Product and Food (www.nirsresearch.com) and Department of Agricultural Engineering, Faculty of Engineering, King Mongkut’s Institute of Technology Ladkrabang, Thailand for providing and supporting the space and the instrument during the experimentation.