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Near Infrared Scanning Precision Test for Texture Characteristics of Parboiled Rice.

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Abstract

The objective of this research is to evaluate the precision of FT-NIR spectrometer for measuring the texture characteristics of parboiled rice. The precision test of FT-NIR spectrometer at wavenumbers of 6897, 6711 and 5154.6 cm^{-1} which were the vibration bands of starch (the first two wavenumbers) and water were indicated by scanning repeatability and reproducibility. The scanning repeatability and reproducibility were 0.002769 and 0.017151 respectively, which indicated that the FT-NIR spectrometer was precise. The precision of the reference method i.e. ISO 11747 Rice-Determination of Rice Kernel Resistance to Extrusion after Cooking, using texture analyser was indicated by reference method repeatability. It was found that the repeatability were 4.45 N, 0.20 mm and 61.56 N mm for hardness, toughness distance and toughness respectively. Therefore the R^2_{max} of these parameters were 0.94, 0.84 and 0.81 respectively. This indicated that if there was no error from NIR spectra, the calibration models can be performed at these best levels.

Keywords: Parboiled rice, Texture characteristics, Near infrared spectroscopy

1 Introduction

Rice is the most widely consumed staple food for nearly half of the world's population for centuries (Ghasemi el at. 2009). About 20% of the world rice production is processed as parboiled rice. The parboiling process improves structural and nutritional properties of rice. (Villanova el at. 2017). In 2017, Thailand exported over 10 million ton of rice (Thai Rice Exporters Association, 2017) including the parboiled rice.

The parboiling process consists of three additional steps to conventional rice processing, which are: soaking, pressure steaming and drying (Leethanapanich el at. 2016; Paiva et al., 2016; Sarangapani et al., 2016; Villanova el at. 2017). Soaking and steaming regimes affected texture cooked rice of parboiled rice (Graham-Acquaah, 2015). Among multiple texture attributes of the cooked rice that may affect consumer acceptability including hardness and toughness (Juliano, 1981). Therefore, the texture of cooked rice is considered important factors for the consumer.

The instruments have been used to measure the texture of cooked rice including Texture Profile Analysis (TPA). Another instrumental method that can assess rice properties, including cooked rice texture, is near infrared spectroscopy (NIRS) (Siriphollahul et al. 2017). The NIR is the nondestructive technique. This method has been used for extremely precise apparent amylose content (Villareal et al. 1994), protein content (Shuso et al. 2003), amino acid content (Wu, 2002), gelatinization temperature, gel consistency (Bao et al. 2001), and rapid visco analysis (RVA) parameters (Frederick &Franklin, 2002; Sirihollakul et al. 2015). Most of the rice quality prediction models have high precision and accuracy (Siriphollakul et al. 2017). It is interesting to make the NIR spectroscopy model development for prediction the texture of parboiled rice. Before NIR spectroscopy models development, it is needed to check for both repeatability and reproducibility of the spectral data and the repeatability of reference test.

The objective of this research was to evaluate the overall precision of FT-NIR spectrometer scanning and that of reference test for measuring the texture characteristics of parboiled rice.

2 Materials and Methods

2.1 Samples

Parboiled rice samples were collected from Capital Chainat Rice Mill company limited, in Saphaya District, Chainat Province, Thailand. A total of 7 samples were collected on 9, 10, 11, 12, 14, 15 and 16-Oct-2017.

2.2 NIR scanning

FT-NIR spectrometer (MPA, Bruker, Germany) in the wavenumber range of 12500 - 4000 cm-1 were used for scanning of parboiled rice in absorbance mode at room temperature of 25±2 ºC, where the reference material was gold. Parboiled rice sample

was scanned in a quartz cup with the diameter and height of 9.7 cm and 9 cm, respectively.

2.3 Repeatability and reproducibility of NIR scanning

In the NIR repeatability of scanning test, the samples were loaded and scanned 10 times in same location to check the difference of parboiled rice spectrum. For the reproducibility, the samples were scanning the sample for 10 times reloaded and rescanned every time to check the homogeneity of parboiled rice sample. The calculating was done by first selected 3 wavenumbers at 6897, 6711 and 5154.6 cm-1 which were the vibration bands of starch (the first two wavenumbers) and water of parboiled rice samples. Then the standard deviation (SD) of absorption at each wavenumber was calculated and averaged. The SD was repeatability or reproducibility depended on how the spectra was obtained.

2.4 Reference method

The reference method used was ISO 11747 Rice-Determination of Rice Kernel Resistance to Extrusion after Cooking, using texture analyser (TA.HD.plus, Stable Micro Systems, UK). The texture of cooked parboiled rice including hardness, toughness distance and toughness were evaluated.

2.5 Repeatability of reference test and maximum coefficient of determination

The repeatability (Rep) of reference test was the standard deviation of the different between the duplicates of the test of 7 samples. Then the repeatability was used to determine the maximum coefficient of determination (R^2_{max}), which was calculated using following formula (Dardenne, 2010). using equation (1)

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

Where SD_y is the standard deviation of data of measured value in 7 samples. According to Dardenne 2010, the maximum R^2 is possible only when there are no error in the spectra or the model, and SD_y and Rep can indicate that the range in value for the samples is too narrow, and/or reference method is not sufficiently precise.

3 Result and Discussion

Table 1 show the standard deviation of repeatability and reproducibility for scanning of parboiled rice using FT- NIR spectrometer at 3 wavenumbers were 6896.6, 6711.45, 5153.16 cm^{-1} that were selected. The absorbance band at 6896.6 cm^{-1}(1450nm) and 6711.45 cm^{-1}(1490nm) region were the absorption bands of starch (Workman and Weyer, 2008). The absorbance band at 5153.16 cm^{-1}(1940nm) region was of water band (Figure 1). The scanning repeatability and reproducibility were 0.002769 and 0.017151 respectively, which indicated acceptable. Low repeatability value indicated highly precise scanning instrument.

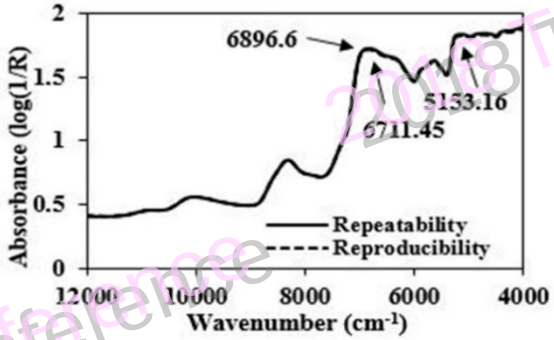

Figure 1 Average Spectra of FT-NIR spectrometer for parboiled rice.

Table 2 shows the precision for the reference method i.e. ISO 11747 Rice-Determination of Rice Kernel Resistance to Extrusion after Cooking. The repeatability were 4.45 N, 0.20 mm and 61.56 N mm for hardness, toughness distance and toughness, respectively. The R^2_{max} of hardness, toughness distance and toughness were 0.94, 0.84 and 0.81 respectively which were calculated from equation (1). The R^2_{max} was possible only when there is no error in the spectra or model (Dardenne, 2010). The error from reference method was 6, 16 and 19 % for hardness, toughness distance and toughness, respectively.

Table 1 Repeatability and reproducibility of NIR scanning using FT-NIR spectrometer for parboiled rice.

Samples	Repeatability				Reproducibility			
	Wavenumbers (cm^{-1})			Average	Wavenumbers (cm^{-1})			Average
	6896.6	6711.45	5153.16		6896.6	6711.45	5153.16	
1	0.00277	0.00091	0.00119	0.00163	0.01899	0.01945	0.02057	0.01967
2	0.00257	0.00753	0.00124	0.00378	0.01310	0.01326	0.01402	0.01346
3	0.02053	0.00071	0.00093	0.00739	0.00803	0.00830	0.00852	0.00830
4	0.00350	0.00287	0.00231	0.00290	0.01979	0.01953	0.02069	0.02000
5	0.00082	0.00071	0.00071	0.00074	0.01282	0.01298	0.01331	0.01304
6	0.00147	0.00161	0.00125	0.00143	0.00956	0.01037	0.01210	0.01068
7	0.00143	0.00156	0.00158	0.00152	0.09444	0.00437	0.00595	0.03492
		Average		**0.00277**		Average		**0.01715**

Table 2 The repeatability of hardness, toughness distance and toughness respectively by the reference method i.e. ISO 11747 Rice- Determination of Rice Kernel Resistance to Extrusion after Cooking.

Texture	Repeatability
hardness	4.45 N
toughness distance	0.20 mm
toughness	61.56 N mm

4 Conclusions

From the results presented in this study, The repeatability value was better than the reproducibility value of the NIR scanning using FT- NIR spectrometer for parboiled rice which may be due to non homogeneous of samples. However, the values indicated that the FT-NIR spectrometer for parboiled rice was precise. The precision analysis for reference laboratory indicates that good model can be developed for hardness but fair model for toughness distance and toughness.

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