Fast classification of rice (*Oryza sativa*) cultivars based on fragrance and environmental origins by means of near infrared spectroscopy

A A Munawar¹, Z Sabaruddin*²

¹Department of Agricultural Engineering, Syiah Kuala University, Banda Aceh, Indonesia
²Department of Agro-technology, Syiah Kuala University, Banda Aceh, Indonesia

*E-mail: zaksabar@unsyiah.ac.id

Abstract. Presented paper aimed to investigate the application of near infrared spectroscopy as a fast and robust approach in distinguishing two different rice cultivars based on their fragrance character. Spectra data of rice samples were acquired and recorded in wavenumbers range of 4000-10 000 cm⁻¹ with co-added of 32 scans and 4x optical gain. Further, multivariate analysis in form of principal component analysis (PCA) was employed to classify those samples based on near infrared optical properties. The result showed that both rice cultivars can be precisely clustered and discriminated with total explained variance of 100% using first two principal components (PC). The respective chemical parameters of these differences are fiber content, carbohydrates, amyllose content and fragrance. The mentioned three parameters were vibrated strongly in wavenumbers 4260, 7512 and 7900 cm⁻¹ for carbohydrates, amyllose and fragrance, while for fiber content, it vibrated at 5183 cm⁻¹ respectively. Based on obtained results, it may conclude that near infrared spectroscopy approach is able to classify and discriminate rice cultivars based on their fragrance by means of spectral optic properties in near infrared region.

1. Introduction

Rice is one of the main food crops of nearly half of the world's population. Every year the demand for rice continues to increase in line with the increase in population. For the people of Indonesia, rice is a daily staple food. Rice is the main carbohydrate source in almost all regions in Indonesia because it is easy to obtain, tastes good and can be combined with other foodstuffs [1,2].

Rice as food is composed of starch, protein and other elements such as fat, crude fiber, minerals, vitamins, and water with an uneven distribution. The outer layer of rice is rich in non-starch components such as protein, fat, fiber, ash and lignin, while the endosperm is rich in starch. The main carbohydrate in rice is starch and only a small portion cellulose, hemicellulose, and sugar [3]. Rice starch is composed of two carbohydrate polymers, namely amylose and amylopectin. The texture properties of rice can be seen from the ratio between the amyllose and amylopectin levels [4]. The ratio of amyllose to amylopectin can determine the appearance or fluffiness of the rice texture. Amylose content determines the texture properties of rice more than any other properties. The amyllose content in rice ranges from 1-37% [4,5]. Moreover, fragrant rices have gained significant market shares in the global rice trade recently [6] Consequently, efforts have been undertaken in rice production countries to increase or develop the production of this type of rice. The key compound of rice fragrance is 2-acetyl1-pyrroline (2AP). The availability of this component could be distinguished between fragrant rice or non-fragrant rice. The existence of this component affect the quality pf rice [7].

In order to determine and classify rice quality parameters, several methods were widely applied and implemented. However, many of those methods are based on chemical analysis and required several steps during measurement and analysis [8]. These methods are time consuming, destructive in nature, involve chemical materials and thus may cause environmental pollutions. In recent decades, many
efforts and research were attempted to define alternative methods that can be used to determine rice quality parameters and other agricultural products rapidly and non-destructively [9–11]. The advantage of this method are fast, effective, simple preparation, and environmental friendly [12,13]. Near infrared spectroscopy (NIRS) is one of the most promising approach used to determine several quality parameters simultaneously in many agricultural products. In many current applications, the NIRS method is widely employed especially in sorting and grading process. Numerous studies have been carried out regarding with the application of NIRS as a rapid and non-destructive method in agriculture such as fruit quality control assessment [14,15], crops and agricultural products inspection [16–19], soil properties determination [20–23], and also for animal product evaluation [24–27]. Based on previous study, we attempted to apply the NIRS approach in classifying and determining rice cultivars based on their fragrance or to classified between fragrant and non-fragrant rice.

2. Material and Methods

2.1 Rice samples

Two rice cultivars from Aceh, indoensia and from Japan were used to evaluate the feasibility of NIRS to classify those samples. The progeny of Sigupai (T12009), fragrant rice cultivar from Aceh Province, Indonesia and koshihikari from Japan were used in this study.

2.2 Spectra data acquisition

Absorbance spectra data for a bulk of rice samples were acquired in wavenumbers range from 4000 to 10 000 cm\(^{-1}\), using a portable sensing device (PSD) NIRS instrument i16 IPTEK [28]. Spectra data were recorded by the photodiode array sensors with co-added of 32 scans and 4x optical gain [29].

2.3 Classification models

The ability of near infrared spectroscopy to distinguish and classify rice samples based on their environmental origins were established by constructing classification models by means of principal component analysis (PCA) followed with cross validation in non-iterative partial least square algorithm. Spectra data were projected onto the PCA and classification can be overviewed by looking the score plot either as two or three dimensions represented its principal components [30,31].

3. Result and discussion

Typical spectra data of intact rice samples from both cultivars in presented in Figure 1. The absorbance spectrum represent the chemical bonds vibrated at certain wavenumbers from which the quality parameters can be determined.

![Figure 1. Spectra feature of two different rice cultivars in near infrared region](image-url)
Moreover, the intrinsic bonds of chemical structures related to carbohydrates, amylose, fiber and other rice properties occurred along the near infrared wavelength region. As shown in Figure 1, rice samples from Aceh, sigupai progeny (T10029) has higher sugar content compared to rice samples from Japan. The second overtone for sugar content occurred in wavelength region from 2019-2158 nm and also in first overtone on 1865 nm. However, the amylpectin content on rice samples from Japan is higher than Sigupai progeny (T10029) rice samples from Aceh, Indonesia. Based on amylose content, rice is classified into glutinous or very low amylose rice (<10%), low amylose rice (10-20%), medium amylose rice (20-24%), and high amylose rice (> 25%) (5,32). Rice with low amylose content when cooked produces rice that is sticky, shiny, does not expand, and remains lumpy after it has cooled. Rice with high amylose content when cooked is not sticky, can expand, and becomes hard when cold, while medium amylose rice generally has a fluffier rice texture. The classification results of those both rice cultivar with different environmental origins using principal component analysis (PCA) approach is presented in Figure 2, while the PCA score plot of rice cultivars in three principal components mapping and Figure 3.

![Figure 2](image1.png)

**Figure 2.** Classification of rice samples based on spectral data using PCA approach

![Figure 3](image2.png)

**Figure 3.** The PCA score plot of rice cultivars in three principal components mapping.
The classification model performance derived from PCA method clearly can distinguish two different rice cultivars with total explained variance from first two principal components is 97% with leverage cross validation during model development. The main differences between those both samples mainly due to the amylose contents of respective cultivars from which related to rice textures and firmness when it cooked. The observed spectra feature of rice samples in near infrared region found in several wavenumbers related to C-H-O structures, fiber content and amylose content respectively as presented in Figure 4.

![Figure 4](image-url)

**Figure 4.** Observed relevant and optimum wavenumbers for classification model.

The relevant wavenumbers for C-H-O determination by means of spectra data can be predicted in the of 4622 – 4895 cm⁻¹, also at the range from 7512 to 7300 cm⁻¹ respectively. In addition, for fiber content, it vibrated strongly 5183 cm⁻¹. The differences between studied rice cultivars from the spectra data point view are clearly due to the content of chemical compounds related to C-H-O structures and fiber content due to amyllopectin contents.

**4. Conclusion**

This present work investigated the feasibility of near infrared technology in classifying two different rice cultivars based on their fragrance. The result showed that both rice cultivars can be precisely classified and distinguished with the support of principal component analysis (PCA) generating total explained variance 100%. The respective chemical parameters of these differences are fiber content, carbohydrates and amylose content. The mentioned three parameters were vibrated strongly in wavenumbers 4260, 7512 and 7900 cm⁻¹ for carbohydrates and amylose, while for fiber content, it vibrated at 5183 cm⁻¹ respectively. Based on obtained results, it may conclude that near infrared spectroscopy approach is able to classify and discriminate rice cultivars based on their fragrance by means of spectral optic properties in near infrared region.

**References**

[1] Awanthi MGG, Jinendra BMS, Navaratne SB, Navaratne CM. Adaptation of visible and short wave Near Infrared (VIS-SW-NIR) common PLS model for quantifying paddy hardness. Journal of Cereal Science. 2019;89(June):102795.

[2] Heman A, Hsieh CL. Measurement of moisture content for rough rice by visible and near-infrared (NIR) spectroscopy. Engineering in Agriculture, Environment and Food. 2016;9(3):280–90.
3. Li X, He Y, Wu C. Non-destructive discrimination of paddy seeds of different storage age based on Vis/NIR spectroscopy. Journal of Stored Products Research. 2008;44(3):264–8.
4. Sampaio P, Soares A, Castanho A, Almeida AS, Oliveira J, Brites C. Dataset of Near-infrared spectroscopy measurement for amylose determination using PLS algorithms. Data in Brief. 2017;15:389–96.
5. Zhang J, Li M, Pan T, Yao L, Chen J. Purity analysis of multi-grain rice seeds with non-destructive visible and near-infrared spectroscopy. Computers and Electronics in Agriculture. 2019;164(7):104882.
6. Calpe C. International trade in rice: recent developments and prospects. Rice is life: scientific perspectives for the 21st century Proceedings of the World Rice Research Conference held in Tsukuba, Japan, 4-7 November 2004. 2005;492–4.
7. Routray W, Rayaguru K. 2-Acetyl-1-pyrroline: A key aroma component of aromatic rice and other food products. Food Reviews International. 2018 Aug 18;34(6):539–65.
8. Chuang YK, Hu YP, Yang IC, Delwiche SR, Lo YM, Tsai CY, et al. Integration of independent component analysis with near infrared spectroscopy for evaluation of rice freshness. Journal of Cereal Science. 2014;60(1):238–42.
9. Pasquini C. Near infrared spectroscopy: A mature analytical technique with new perspectives – A review. Analytica Chimica Acta. 2018;1026:8–36.
10. Comino F, Aranda V, García-Ruiz R, Ayora-Cañada MJ, Domínguez-Vidal A. Infrared spectroscopy as a tool for the assessment of soil biological quality in agricultural soils under contrasting management practices. Ecological Indicators. 2018;87(January):117–26.
11. Munawar AA, von Hörsten D, Wegener JK, Pawelzik E, Mörlein D. Rapid and non-destructive prediction of mango quality using Fourier transform near infrared spectroscopy and chemometrics. Engineering in Agriculture, Environment and Food. 2016;9(3):208–15.
12. Nordey T, Joas J, Davrieux F, Chillet M, Léchaudel M. Robust NIRS models for non-destructive prediction of mango internal quality. Scientia Horticulturae. 2017;216:51–7.
13. Munawar AA, Kusumiyati, Hafidh, Hayati R, Wahyuni D. The application of near infrared technology as a rapid and non-destructive method to determine vitamin C content of intact mango fruit. INMATEH - Agricultural Engineering. 2019;58(2):1–12.
14. Munawar AA, Kusumiyati, Wahyuni D. Near infrared spectroscopic data for rapid and simultaneous prediction of quality attributes in intact mango fruits. Data in Brief. 2019;27:104789.
15. Arendse E, Fawole OA, Magwaza LS, Opara UL. Non-destructive prediction of internal and external quality attributes of fruit with thick rind: A review. Journal of Food Engineering. 2018;217:11–23.
16. Agustina R, Munawar AA. Electro-Optic Properties of Dried Pliek U Powder: Local Ingredients from Aceh. In: IOP Conference Series: Earth and Environmental Science. Institute of Physics Publishing; 2019.
17. Sudarjat, Kusumiyati, Hasanuddin, Munawar AA. Rapid and non-destructive detection of insect infestations on intact mango by means of near infrared spectroscopy. In: IOP Conference Series: Earth and Environmental Science. Institute of Physics Publishing; 2019.
18. Suci RH, Zulfahrizal, Munawar AA. Applying LIBS-QCL spectrum coupled with principal component analysis to distinguish gayo arabica and robusta coffee. International Journal of Scientific and Technology Research. 2019 Oct 1;8(10):919–24.
19. Saputri Y, Yusriana, Munawar AA. Infrared spectroscopic features of turmeric powder. In: IOP Conference Series: Earth and Environmental Science. Institute of Physics Publishing; 2019.
20. Munawar AA, Devianti, Satriyo P, Syahrul, Yunus Y. Rapid and simultaneous prediction of soil quality attributes using near infrared technology. International Journal of Scientific and Technology Research. 2019 Sep 1;8(9):725–8.
21. Munawar AA, Yunus Y, Devianti, Satriyo P. Calibration models database of near infrared spectroscopy to predict agricultural soil fertility properties. Data in Brief. 2020 Jun 1;30.
[22] Darusman, Zulfahrizal, Yunus Y, Munawar AA. Soil quality assessment by near infrared spectroscopy: Predicting ph and soil organic carbon. International Journal of Scientific and Technology Research. 2019;8(10):2512–6.

[23] Devianti D, Sufardi S, Zulfahrizal Z, Munawar AA. Rapid and Simultaneous Detection of Hazardous Heavy Metals Contamination in Agricultural Soil Using Infrared Reflectance Spectroscopy. In: IOP Conference Series: Materials Science and Engineering. Institute of Physics Publishing; 2019.

[24] Iskandar CD, Zainuddin, Munawar AA. Rapid assessment of frozen beef quality using near infrared technology. International Journal of Scientific and Technology Research. 2020;9(5):156–60.

[25] Iskandar CD, Zainuddin, Munawar AA. Beef Freezing Optimization by Means of Planck Model Through Simulation. In: IOP Conference Series: Earth and Environmental Science. Institute of Physics Publishing; 2019.

[26] Samadi, Wajizah S, Munawar AA. Near infrared spectroscopy (NIRS) data analysis for a rapid and simultaneous prediction of feed nutritive parameters. Data in Brief. 2020 Apr 1;29.

[27] Samadi, Wajizah S, Munawar AA. Fast and simultaneous prediction of animal feed nutritive values using near infrared reflectance spectroscopy. In: IOP Conference Series: Earth and Environmental Science. Institute of Physics Publishing; 2018.

[28] Agussabti, Rahmadiansyah, Satriyo P, Munawar AA. Data analysis on near infrared spectroscopy as a part of technology adoption for cocoa farmer in Aceh Province, Indonesia. Data in Brief. 2020 Apr 1;29.

[29] Munawar AA, Syah H, Yusmanizar. Fast and robust quality assessment of honeys using near infrared spectroscopy. In: IOP Conference Series: Earth and Environmental Science. Institute of Physics Publishing; 2019.

[30] Yunus Y, Devianti, Satriyo P, Munawar AA. Rapid Prediction of Soil Quality Indices Using Near Infrared Spectroscopy. In: IOP Conference Series: Earth and Environmental Science. Institute of Physics Publishing; 2019.

[31] Munawar AA, Hörsten D V., Mörelm D, Pawelzik E, Wegener JK. Rapid and non-destructive prediction of mango sweetness and acidity using near infrared spectroscopy. In: Lecture Notes in Informatics (LNI), Proceedings - Series of the Gesellschaft fur Informatik (GI). Gesellschaft fur Informatik (GI); 2013. p. 219–22.

[32] Hu J, Wang Z, Wu Y, Liu Y, Ouyang J. Rapid determination of the texture properties of cooked cereals using near-infrared reflectance spectroscopy. Infrared Physics and Technology. 2018;94(September):165–72.