Mat NN, Rowshon KM, Guangnan C, Troy J. 2014. Prediction of Sugarcane Quality Parameters Using Visible- shortwave Near Infrared Spectroradiometer. Journal of Agriculture and Agricultural Science Procedia 2, 136– 43. Available from: http://linkinghub.elsevier.com/retrieve/pii/S2210784314000217

MicaSense. RedEdge camera. Available online: https: / / www. micasense. com/ rededge/ (accessed on 01 December 2017)

MSF Sugar PTY LTD (AU). 2016. Cane Pricing Guide. Available at: https: / / www. msfsugar. com. au/ wp-content/ uploads/ 2016/ 08/ MSF- Sugar- Cane-Pricing- Guide- 2016. pdf. Accessed on 12 December 2017

Peñuelas, J., Gamon, J.A., Fredeen, A.L., Merino, J. and Field, C.B., 1994. Reflectance indices associated with physiological changes in nitrogen- and water- limited sunflower leaves. Remote sensing of Environment 48,135-146.

Pix4D. Pix4Dmapper, Photogrammetry software for professional drone- based mapping purely from images. Versions 4.0. Available online: https: / / pix4d. com/ product/ pix4dmapper-photogrammetry- software/ (accessed on 01 December 2017)

Wojtowicz M, Wojtowics A, Piekarczyk J. 2015. Application of remote sensing methods in Agriculture. Journal of Communications in Biometry and Crop Science 11, 31–50.

The 11th TSAE International Conference
26-27 April 2018
Available online at www.tsae.asia

Chemometric Approaches for Improvement of the Results of Different Particle Size on the Near Infrared Spectra of White Pepper

Ravipat Lapcharoensuk[1]*, Jeerayut Hongwiangjan[1]

[1]Department of Agricultural Engineering, Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang, Bangkok, 10520, Thailand
*Corresponding author: Tel: +66-8-4433-1156, Fax: +66-23-298-336, E-mail: ravipat.la@kmitl.ac.th

Abstract

This research aims to investigate chemometric approaches for improvement of near infrared spectra of white pepper which was affected by different particle size. White pepper samples obtained from Chanthaburi province. The samples of pepper ball and pepper powder (pounded and sieved with 50, 100 and 200 mesh) were used in this study. Near infrared spectra of pepper samples were measured using FT-NIR spectrometer on 12,500 to 4,000 cm-1 (800 to 2,500 nm) with diffuse reflectance mode. NIR spectra record was done with 20 repeats per each sample. Absorbance band of water (5,155 cm-1), protein (4,878 cm-1), amino acid (4,690 cm-1) and starch (4019 cm-1) were selected for analysis of influence of particle size on NIR spectra. The results showed that particle size affected significantly those absorbance band. The 4 chemometric techniques consisting of mean normalization, maximum normalization, range normalization and multiple scatter correction (MSC) were applied for pepper spectra treatment. All chemometric techniques except mean normalization could solve the effect of different particle size on near infrared spectra of white pepper. This finding point is useful information for selecting optimal chemometric techniques in NIR spectroscopy modeling of pepper quality evaluation.

Keywords: Near infrared Spectra, Chemometric, Particle size, Pepper

1 Introduction

Pepper (*Piper niqrum Linn*) is important herb and spice of the world. Pepper is used to season many foods because of the tastes of pepper are hot and spicy. Otherwhile pepper is also produced mostly appearing in the form of berries and flour with black, white and green colors. White pepper is seed with the skin removed (Zhu et al., 2017). Pepper contains high chemical constituents such as starch, protein, vitamin (A, C and K) essential oils, polyphenols, and piperrine (Zhu et al., (2017); Butt et al., (2013); Srinivasan et al., (2007)). The pepper is well known as "King of Spice" (Mamatha *et al,* 2008). Thailand is major pepper exporter of the world. Office of Agricultural Economics (2016) reported that Thailand exported pepper product about 209-322 Tons (57.6 and 51.15 million Baht) in 2015 and 2016. Currently, pepper exporting of Thailand is done without excellent quality control practice. Therefore, consumer might not satisfy and reject the pepper product.

One of interesting technology which can be used for estimation the quality of product is near infrared spectroscopy (NIRs). This technique was applied to estimate food, pharmacy and agricultural products both in qualitative and quantitative analyses (Krämer and Ebel, (2000); Teye et al., (2014)). There are several literatures using NIRs technique to apply with sample in form of powder such as powdered red paprika, green tea powder and lotus root powder (Niu el at., (2012); Sinija and Mishra, (2009); Moros et al., (2008)). According to literatures mentioned above, NIRs show high possibility to estimate the quality of powdered pepper. However, particles of powdered pepper are various size, light scattering effect of NIRs source light would occur and the base line of NIR spectra would shift (Thanapase et al., 2012). These phenomena affect absorbed spectra including information used to estimate the quality of sample. There is multiplicative signal correction (MSC) and standard normal variate (SNV) techniques that can be used to remove the light scattering effect (Niu el at., (2012); Hernández-Hierro et al., (2008)). To study the possibility of NIRs technique, investigation of reducing scattering effect due to various size of pepper particle is important part.

Therefore, the aim of this study is to test and optimize the chememotic technique with powdered

pepper to reduce the scattering effect occurred from the various size of pepper particle. This is one of procedure to develop the monitor system in quality control mount in the online process.

2 Materials and Methods

2.1 Sample preparation

White pepper sample were purchased from Bannumjon community enterprise, Thamai district, Chanthaburi province, Thailand. The four of particle size of sample were ball pepper and 3 sizes of powdered pepper (pounded and sieved with 50, 100 and 200 mesh).

2.2 NIR spectra collection

NIR spectra record was done with 20 spectra per each particle size of pepper sample. Pepper samplen were poured into quartz cup with the following dimensions 46.25 mm diameter and 45.95 mm height. Near infrared spectra of pepper samples were measured using FT-NIR spectrometer (MPA, Bruker Ltd., Germany) with diffuse reflectance mode between 12,500 to 4,000 cm^{-1} (800 to 2,500 nm) at a resolution of 8 cm^{-1}. A total of 64 successive scans were recorded and averaged for each sample.

Figure 1 NIR spectra collection by FT-NIR spectrometer.

2.3 Data analysis

The NIR absorbance peaks of some chemical component of pepper were selected to analyze effects of different particle size on the NIR spectra of white pepper. The obvious peaks displayed on NIR spectra and Savitsky Galay 2nd derivatives spectra were considered for study.

The mean and standard deviation of the absorbance values were calculated. The results of different particle size on the near infrared spectra of white pepper were studied by One-way ANOVA and Dancan's multiple range tests at 95% confidence interval. Chemometric Approaches were used to study improvement results of different particle size on the near infrared spectra consisting of mean normalization, maximum normalization, range normalization and multiplicative scatter correction (MSC).

3 Results and Discussion

Figure 2 show NIR spectra and Savitsky Golay 2nd derivatives spectra of white pepper at different particle sizes. In figure 2(a), the difference particle size affected the spectral level of the absorbance peak. The intensity of the peak was highest for ball pepper while absorbance peak of pepper powder sorted according level of particle size. Savitsky Golay 2nd derivatives spectra of white pepper are showed in Figure 2(b). Important chemical component absorbance peaks of pepper showed obviously at 5155, 4878, 4690 and 4019 cm^{-1} (1940, 2050, 2132 and 2488 nm respectively). Therefore, those absorbance peaks were selected to analyze results of different particle size on the near infrared spectra of white pepper. The prominent peak at 5155 cm^{-1} is the absorbance peak associated with the combination of O-H stretching and O-H deformation of water (Osborne and Fearn, 1986). The peak at 4878 cm^{-1} is the combination absorbance of N-H symmetrical stretching and amide II of protein (Osborne and Fearn, 1986). The absorption band at 4690 cm^{-1} corresponded to a combination of N-H and C=O stretching, and that at 4019 cm^{-1} corresponded to a combination of C-H and C-C stretching, which is attributed to amino acid and starch respectively (Osborne and Fearn, 1986).

Table 1 presents the results of different particle size on the some NIR absorbance values of white pepper and improvement NIR absorbance values using chemometric approaches. All NIR absorbance values decreased significantly according to particle size. This indicated that difference particle size affected NIR spectra of pepper. The 4 NIR absorbance peaks which were treated using maximum normalization, range normalization and multiple scatter correction (MSC) did not differ significantly on 50, 100, and 200 mesh of pepper powder except ball pepper. This result confirmed that those techniques could solve results of different particle size on near infrared spectra of powdered pepper. The result of improvement of NIR spectra using mean normalization technique presented significant difference on all particle size of white pepper.

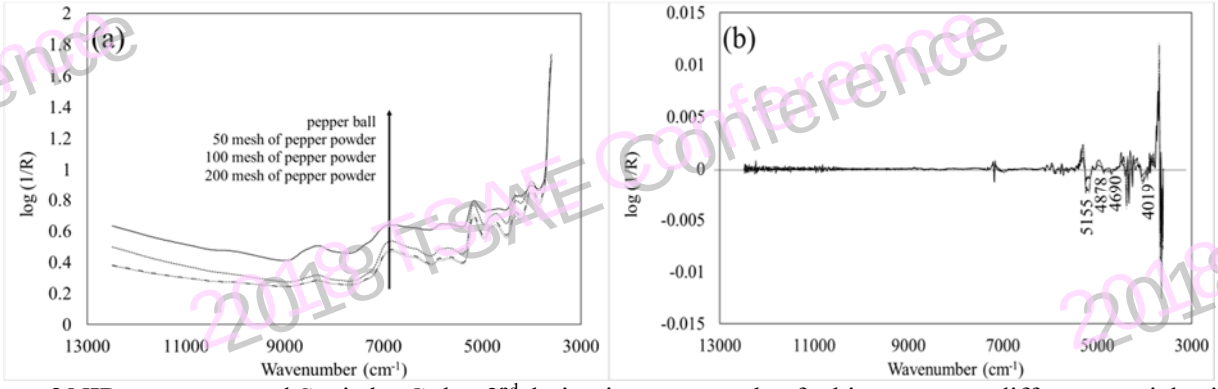

Figure 2 NIR spectra (a) and Savitsky Golay 2nd derivatives spectra (b) of white pepper at different particle size.

Table 1 The results of different particle size on the some NIR absorbance values of white pepper and improvement NIR absorbance values using chemometric approaches.

Particle size (Mesh)	NIR absorbance value				
	Raw spectra	Mean Normalization	Maximum Normalization	Range Normalization	Multiple Scatter Correction (MSC)
	absorbance peak of water (5155 cm^{-1})				
Pepper ball	0.79±0.02^{a}	1.34±0.02^{a}	0.47±0.01^{a}	0.61±0.02^{a}	0.70±0.00^{a}
50 mesh of powder pepper	0.77±0.03^{a}	1.71±0.03^{b}	0.41±0.01^{b}	0.48±0.02^{b}	0.74±0.01^{b}
100 mesh of powder pepper	0.70±0.01^{b}	1.73±0.02^{c}	0.40±0.01^{b}	0.47±0.01^{b}	0.74±0.00^{b}
200 mesh of powder pepper	0.68±0.07^{b}	1.70±0.06^{b}	0.40±0.03^{b}	0.47±0.04^{b}	0.73±0.01^{b}
	absorbance peak of protein (4878 cm^{-1})				
Pepper ball	0.73±0.02^{a}	1.24±0.01^{a}	0.43±0.01^{a}	0.57±0.02^{a}	0.63±0.01^{a}
50 mesh of powder pepper	0.68±0.03^{b}	1.48±0.03^{b}	0.36±0.01^{b}	0.42±0.02^{b}	0.65±0.01^{b}
100 mesh of powder pepper	0.60±0.01^{c}	1.50±0.02^{c}	0.35±0.01^{b}	0.41±0.01^{b}	0.65±0.01^{b}
200 mesh of powder pepper	0.59±0.06^{c}	1.48±0.05^{b}	0.35±0.03^{b}	0.41±0.03^{b}	0.65±0.01^{b}
	absorbance peak of amino acid (4690 cm^{-1})				
Pepper ball	0.74±0.02^{a}	1.26±0.01^{a}	0.44±0.01^{a}	0.57±0.02^{a}	0.64±0.01^{a}
50 mesh of powder pepper	0.71±0.03^{b}	1.58±0.03^{b}	0.38±0.01^{b}	0.44±0.02^{b}	0.68±0.01^{b}
100 mesh of powder pepper	0.65±0.01^{c}	1.60±0.02^{c}	0.37±0.01^{b}	0.44±0.01^{b}	0.69±0.01^{b}
200 mesh of powder pepper	0.63±0.07^{c}	1.58±0.05^{b}	0.37±0.03^{b}	0.43±0.03^{b}	0.68±0.01^{b}
	absorbance peak of starch (4019 cm^{-1})				
Pepper ball	0.90±0.03^{a}	1.52±0.02^{a}	0.53±0.01^{a}	0.69±0.02^{a}	0.83±0.01^{a}
50 mesh of powder pepper	0.92±0.04^{a}	2.09±0.04^{b}	0.50±0.02^{b}	0.59±0.02^{b}	0.89±0.00^{b}
100 mesh of powder pepper	0.86±0.01^{b}	2.14±0.02^{c}	0.50±0.01^{b}	0.58±0.01^{b}	0.89±0.00^{b}
200 mesh of powder pepper	0.84±0.09^{b}	2.11±0.07^{b}	0.50±0.04^{b}	0.58±0.04^{b}	0.89±0.00^{b}

Mean sharing the same latter in a column are not significantly ($p>0.05$) different from one-way AVONA analysis.

Table 2 show the results of F-value from one-way ANOVA of difference chemometric approaches. The maximum normalization revealed the lowest F-value on absorbance band of water, amino acid and starch. These results indicated that the maximum normalization is the best chemometric technique for improvement of the results of different particle size on those NIR absorbance peak of white pepper. The best chemometric method for improving NIR absorbance of protein is multiple scatter correction (MSC).

Table 2 The results of F-value from one-way ANOVA of difference chemometric approaches.

absorbance peak	F-value			
	Mean Normalization	Maximum Normalization	Range Normalization	Multiple Scatter Correction (MSC)
water (5155 cm^{-1})	525.8	53.9	189.8	110.2
protein (4878 cm^{-1})	318.9	112.6	284.4	28.1
amino acid (4690 cm^{-1})	516.3	61.9	199.1	182.3
starch (4019 cm^{-1})	1052.3	9.6	93.8	600.9

4 Conclusions

All chemometric techniques are maximum normalization, range normalization and multiple scatter correction (MSC) except mean normalization could solve results of different particle size on near infrared spectra of white pepper. This finding point is useful information for selecting optimal chemometric techniques in NIR spectroscopy modeling of pepper quality evaluation.

5 Acknowledgements

The authors are very grateful to NIRS Research Center for Agricultural Product and Food, King Mongkut's Institute of Technology Ladkrabang, Thailand for providing instrument and technical assistance during the experiment. We also acknowledge the financial support from the King Mongkut's Institute of Technology Ladkrabang research fund.

6 References

Butt, M. S., Pasha, I., Sultan, M. T., Randhawa, M. A., Saeed, F., & Ahmed, W. 2013. Black pepper and health claims: A comprehensive treatise. Food Science and Nutrition 53, 875-886.

Hernández-Hierro, J. M., García-Villanova, R. J., González-Martín, I. 2008. Potential of near infrared spectroscopy for the analysis of mycotoxins applied to naturally contaminated red paprika found in the Spanish market, Analytica Chimica Acta. 622(1–2), 189-194.

Krämer, K., Ebel, S, 2000. Application of NIR reflectance spectroscopy for the identification of pharmaceutical excipients. Analytica Chimica Acta 420(2), P155-161.

Mamatha, B.S., Prakash, M., Nagarajan, S., Bhat, K.K. 2008. Evaluation of the flavor quality of pepper (piper nigrum l.) cultivars by gc-ms, electronic nose and sensory analysis techniques. Journal of Sensory Studies 23, 498–513.

Moros, J., Llorca, I., Cervera, M. L., Pastor, A., Garrigues, S., Guardia de la, M. 2008. Chemometric determination of arsenic and lead in untreated powdered red paprika by diffuse reflectance near-infrared spectroscopy, Analytica Chimica Acta 613(2), 196-206.

Niu, X., Zhao, Z., Jia, K., Li, X. 2012. A feasibility study on quantitative analysis of glucose and fructose in lotus root powder by FT- NIR spectroscopy and chemometrics. Food Chemistry 133(2), 592-597.

Office of Agricultural Economics. 2016. Exported statistics of pepper. Available at: http://www.oae.go.th/oae_report/export_import/export_result.php. Accessed on 1 February 2017.

Osborne, B. G., Fearn, T. 1986. Near Infrared Spectroscopy in Food Analysis. UK: Longman Science & Technical.

Sinija, V.R., Mishra, H.N. 2009. FT-NIR spectroscopy for caffeine estimation in instant green tea powder and granules. LWT - Food Science and Technology 42(5) 998-1002.

Srinivasan, K. (2007). Black pepper and its pungent principle- piperine: A review of diverse physiological effects. Critical Reviews in Food Science and Nutrition 47, 735-748.

Teye, E., Huang, X. Y., Lei, W., Dai, H. 2014. Feasibility study on the use of Fourier transform near- infrared spectroscopy together with chemometrics to discriminate and quantify adulteration in cocoa beans. Food Research International 55, 288-293.

Thanapase, W., Kasamsumran, S., Pathaveerat, S., Thoetwongworakun, A., Ritthiruangdej, P., Suwonsichon, T., t Rittiron, R. 2012. Near-Infrared technology and applications in industries. Bangkok, Thailand: Kasetsart Agricultural and Agro- Industrial Product Improvement Institute (KAPI).

Zhu, F., Mojel, R., Li. G. 2017. Structure of black pepper (Piper nigrum) starch. Food Hydrocolloids, Volume 71, October 2017, Pages 102-107.