The application of near infrared reflectance spectroscopy to determine the moisture and protein content in soybean seeds

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Introduction

Soybean is an industrial crop that is very important and useful for domestic consumption. Soybeans are widely used in human nourishment, animal feeds and industrial applications because of their functional characteristics.¹ Soybean is rich in chemical constituents, such as fat, vitamins and carbohydrate, but mostly, it is an important source of plant protein. Generally, soybean chemical composition is determined by standard methods which are time-consuming and costly, and destroy the sample.² In this study near infrared (NIR) spectroscopy was used to predict the moisture and protein content, since NIR spectroscopy is a valuable tool for proximate analysis of grain.³ It has also been used for the accurate analysis of the chemical constituents of cereals and other foods.⁴

Materials and methods

Soybean seed cv. Chiangmai 60 (CM 60) was dried, cleaned and stored at room temperature (30°C) for six months. In each month, 30 samples were taken and packed in the NIRSystems coarse sample cell. Then, the cell was loaded into an NIRSystems Model 6500 to measure the spectrum over the wavelength region from 1100 nm to 2500 nm. Determination of moisture and protein content of the same sample set were also done by hot air oven⁵ and Kjeldahl methods,⁶ respectively. Partial least squares regression (PLSR) was used to develop the calibration equation by the Unscrambler software version 7.6. (CAMO, Oslo, Norway).



Wavelength (nm)

Figure 1. The original reflectance spectra of moisture content in soybean seed stored for six months.

Results and discussion

Figure 1 showed the original reflectance spectra of moisture content in the long wavelength region.



Wavelength (nm)

Figure 2. Regression coefficient plot for moisture content calibration equation of soybean seed stored for six months.



Wavelength (nm)

Figure 3. Regression coefficient plot for protein content calibration equation of soybean seed stored for six months.

The clear peak at 1474 nm and 1936 nm were due to water bands. Similar peaks at wavelength 1450 nm and 1940 nm were found in other studies.⁷

To develop the PLSR calibration equations for prediction of moisture and protein contents, the Savitzky-Golay smoothing, multiplicative scatter correction (MSC) and second derivative (4 nm averaging for left and right side) techniques were used to treat the spectra. Using this procedure,

Table 1.	. PLSR	calibration	results	of mo	isture	and	protein	content	using	spectra	treated	with	smooth	ing-
second o	cond derivative and multiplicative scatter correction (MSC) – second derivative.													

Component	Pre-treatment	Wavelength (nm)	F	r	SEC	SEP	Bias	RPD
Moisture content	Smoothing–Second derivative	1260–2360	9	0.94	0.30	0.36	0.01	2.36
Protein content	Multiplicative scatter correction (MSC)–Second derivative	1108–2260	5	0.94	1.34	1.36	0.03	2.69

F: number of factors used in the calibration equation; \mathbf{r} : multiple correlation coefficients *SEC*: standard error of calibration

SEP: standard error of prediction

Bias: average of difference between actual value and NIR value

RPD: ratio of standard deviation of reference data in validation set to SEP

the light-scattering effect, base line shift and overlapping peak could be reduced.^{8,9} The regression coefficient plot of moisture content calibration equation showed high values at wavelength 1446 nm and 1966 nm (Figure 2).

Meanwhile, the regression coefficient plot of protein content calibration equation showed high values at wavelength 1180 nm, 1734 nm, 1980 nm and 2178 nm (Figure 3).

The peaks at 1186 nm, 1724 nm, 1734 nm, 1978 nm, 2180 nm and 2274 nm were related to protein bands.⁹⁻¹²

Both the calibration equations obtained had the correlation coefficient (r) equal to 0.94 (Table 1).

The equations were considered to be usable with caution for most applications, including research.⁷

Conclusion

This study described that NIR reflectance spectroscopy can be successfully applied to analysis for moisture and protein content in soybean seeds cv. Chiangmai 60.

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