Rapid estimation of protein, oil and moisture contents in whole-grain soybean seeds by near infrared reflectance spectroscopy

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Introduction

In Japan, the chemical compositions of soybean [*Glycine max* (L.) Merr.] seeds are very important, because protein, oil and moisture contents affect their suitability for food processing for traditional foods such as tofu, miso, natto, boiled beans etc.

Near infrared (NIR) relectance specotroscopy is a valuable tool for proximate analysis of grains. It is in common use for the analysis of ground grain samples. However, the preparation of ground samples requires considerable labor and time. So, all breeding lines could not be screened based solely on chemical compositions.

If the NIR relectance specotroscopy technique can estimate grain characteristics with direct reflectance from whole grains, it would result in considerable time-saving. Whole grain NIR relectance specotroscopy is advantageous because of simple sample preparation. Further, non-destructive analysis allows for additional tests for the next generation of seeds with genetic improvements without loss of the seed. This paper describes the application of NIR relectance specotroscopy using whole soybean seeds instead of using ground grain samples.

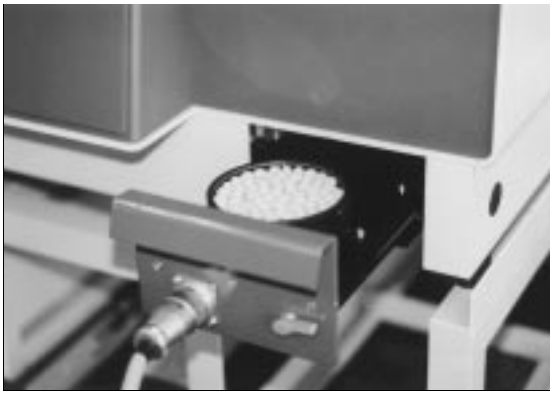

Figure 1. Whole grain cell and wide angle moving drawer.

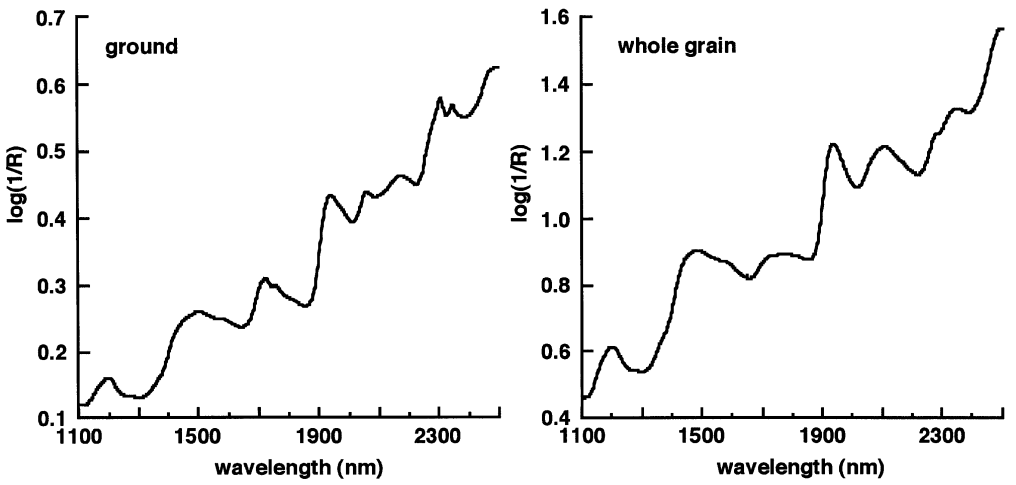

Figure 2. Comparison of raw NIR spectra of ground soybean sample and whole grain soybean sample.

Materials and methods

NIR spectra were measured using a Infralyzer 500 (Bran+Luebbe) with a whole grain cell and a wide angle moving drawer. The NIR analysis for protein, oil and moisture contents in whole soybeans was carried out in the reflectance mode. The sample cell and drawer are shown in Figure 1.

Forty-seven soybean samples harvested in Kyushu National Agriculture Experiment Station in 1992 and 1993 were used in this experiment. The samples were divided into two sets. One set of 36 samples was used for establishing a calibration and the other set was used for confirmation of accuracy of the calibration established. Calibrations for moisture, protein and oil were carried

Table 1. Results of calibration established by MLR analysis between the absorbances of NIR and the data of the contents by chemical analysis.

Components		Wavelengths used (nm)				*SEE*	*R*
Ground	Moisture	1408	1696	1956		0.0892	0.9981
	Protein	1728	2144	2204		0.4728	0.9828
	Oil	1738	1746	2258		0.6268	0.9635
Whole	Moisture	1844	1860			0.2343	0.9618
	Protein	1176	1200	1260	1276	0.8168	0.9172
	Oil	1154	1174	1206		0.6946	0.9304

SEE: standard error of estimation.
R: multiple correlation coefficient.

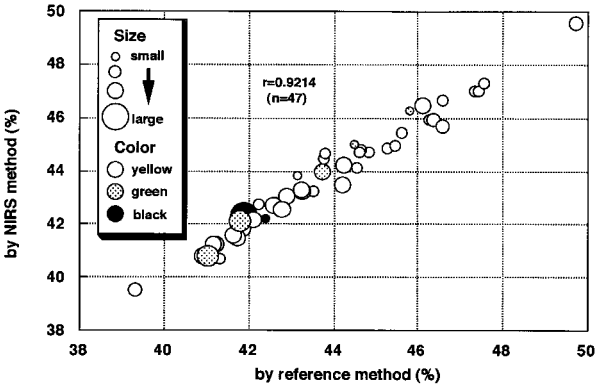

Figure 3. Relation of protein content determined by chemical analysis and by NIR analysis of whole grain (calibration and prediction sets).

out by stepwise multiple linear regression (MLR) analysis with the chemical data and the NIR data. Near infrared absorbance of whole grain soybean seeds was measured over the spectral region from 1100 to 2500 nm at 2 nm intervals. Scannings were performed eight times per sample to obtain the average spectrum of the individual soybean seeds. A multiple linear regression analysis was performed with the data obtained by chemical analysis methods (protein by Kjeldahl method, oil by diethyl ether extraction method and moisture by drying method (105°C, 24 hr).

Results and discussion

The absorptions at about 1450 and 1940 nm due to water were strong in both samples (Figure 2). In the case of whole grain samples, however, the absorptions at about 2180 nm due to protein and those at about 1700 nm and 2300 nm due to oil were weak and were not characterized. Possibly, the seed coats affected the absorptions.

Results of multiple linear regression analysis with the data between a chemical analysis and NIR analysis on protein, oil and moisture of calibration set and wavelengths used in the regression

Table 2. Comparison of prediction by NIR of ground soybean samples and whole soybean samples.

Components		*SEP*	*r*	Bias
Ground	Moisture	0.2183	0.9962	0.1800
	Protein	0.3822	0.9806	–0.0526
	Oil	0.4004	0.9636	–0.0597
Whole	Moisture	0.5100	0.9539	–0.3462
	Protein	0.7879	0.9214	0.2386
	Oil	0.5741	0.9343	0.2668

SEP = standard error of prediction.

r = correlation coefficient of determination for chemical analysis and NIR determination.

are shown in Table 1. The multiple correlation coefficient (*R*) and the standard error of estimate (*SEE*) for each component with the regression obtained were satisfactory.

Performance of the calibration obtained was confirmed by using prediction samples (Table 2). The standard error of prediction (*SEP*) for each component was small. The values of the correlation coefficient (*r*) between the results of chemical analysis and NIR (non-destructive) samples was found to be adequate in comparison with the ground samples case. In addition, no influence of the size of seeds and the color of seed coats was found (Figure 3), therefore breeders could use this NIR method as a selecting tool in all breeding lines of soybean.

The results of NIR analysis on protein, oil and moisture of soybean, indicate that NIR relectance spectroscopy offers possibilities for the rapid determination of these constituents for soybean breeding lines, with analysis using whole grain seeds on protein, oil and moisture sufficiently successful.

Conclusion

The accuracy of NIR relectance spectroscopy using whole grain is an acceptable accuracy.