Estimation of the flavour of green soybean during storage from single pod measurements using dedicated near-infrared transmission spectrometer

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Introduction

Green soybeans are now an economically important and popular food product in Japan. We have been studying the determination of the eating quality-related constituents of green soybean (edamame), using a dedicated NIR transmission spectrometer for the determination of the constituents of a single pod of green soybean. A recently-developed NIR transmission spectrometer was found to have reasonable accuracy for both sucrose and NRQ (defined by ninhydrin reaction, which has a high positive correlation with total free amino acids), both of which are indices of the eating quality.[1] In this paper we introduce the results from the investigation of the quality changes during storage, using the new NIR transmission spectrometer.

Materials and methods

Spectrometer

The optical layout of the developed NIR transmission spectrometer is shown in Figure 1.[1]

The wavelength range was 710–1045 nm with 1024 pixels. The exposure time was 10 ms. A single exposure was repeated 500 times. The spectra were then converted into 1 nm regular interval data.

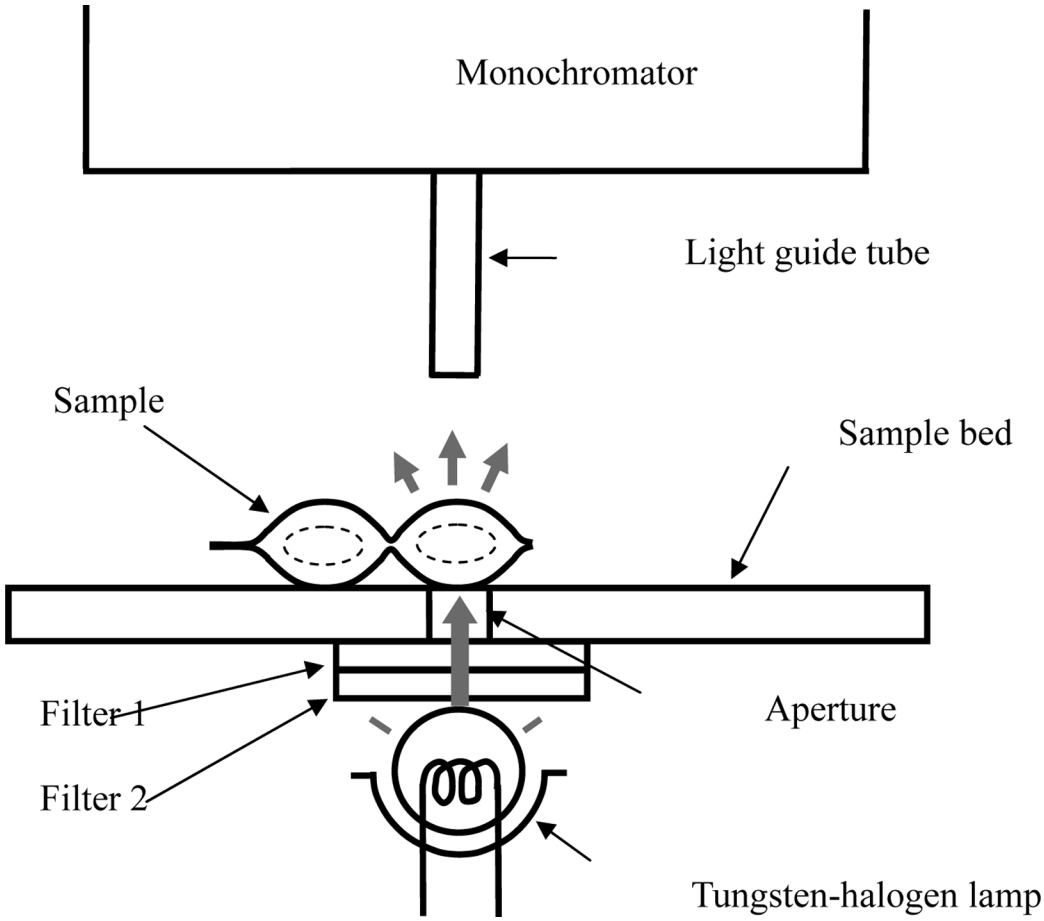

Figure 1. Optical layout of the recently-developed NIR transmission spectrometer.

Samples and method

A total of six varieties/cultivars of domestically grown soybeans were used in this study. They consisted of four dadachamame cultivars collected around Tsuruoka, and two commercially available soybean cultivars. Samples were placed in the room and in the refrigerator for seventy-two hours storage, with MA (Modified Atmosphere) packaging using P-plus (SUMITOMO BAKELITE Co., Ltd., Tokyo, Japan), and with no packaging (i.e. open-air.). Spectra were obtained every six hours during storage.

Reference analysis

Each kernel was freeze-dried and ground, using a vibrating sample mill (TI-100, Heiko, Japan). Ethanol extraction was then carried out. The sucrose content was determined by Sucrose/D-Glucose Test Kit (Roche, Switzerland), and the free amino acid content was determined by ninhydrine reaction method.

Calibrations and estimations

Calibrations for both sucrose content and NRQ were developed by partial least squares (PLS) regression modeling with full cross validation methods using The Unscrambler 9.2 (CAMO, Norway) software. Calibration models were then used for the estimation of quality changes during storage.

Results and Discussion

Figure 2 shows the scatter plot for the calibration for sucrose content.

There are no particular tendencies such as bias, skew and stratification regarding time; hence they were considered as applicable to the estimations during storage.

The results were then statistically analyzed using SAS (SAS Institute Inc., Cary, USA). The ANOVA result for sucrose content is summarized in Table 1.

The factor that contributed most to the variance was variety/cultivar, particularly in the case of NRQ. Packaging and storage temperature also had significant effects for both constituents. Figure 3 shows the combined effect of time and temperature on changes in the sucrose content during storage.

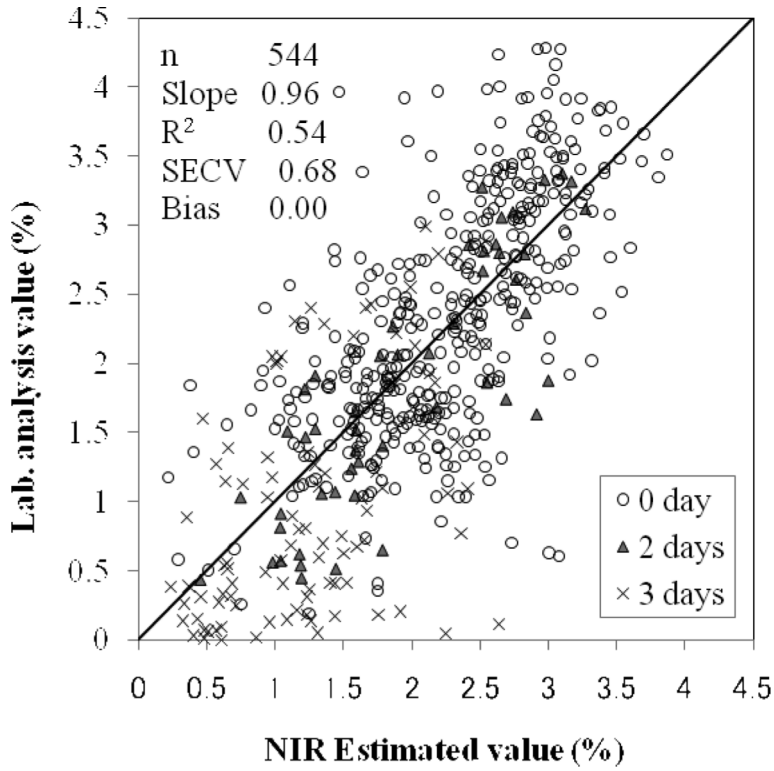

Figure 2. Sucrose content calibration.

Table 1. ANOVA result for sucrose content.

Source[1]	DF[2]	Sum of squares	Mean square	*F* value[3]		Contribution (%)
A	12	14.050	1.171	8.1	***	2.1
B	5	249.780	49.956	346.4	***	43.4
C	1	40.403	40.403	280.2	***	7.0
D	1	36.754	36.754	254.9	***	6.4
A*B	60	39.887	0.665	4.6	***	5.4
A*C	12	2.395	0.200	1.4	ns	0.1
A*D	12	8.574	0.714	5.0	***	1.2
B*C	5	14.639	2.928	20.3	***	2.4
B*D	5	4.394	0.879	6.1	***	0.6
C*D	1	0.000	0.000	0.0	ns	0.0
Error	1133	163.394	0.144			31.3

[1] A: Time, B: Variety/Cultivar, C: Packaging, D: Temperature; [2] Degree of Freedom;
[3] *, **, ***, ns mean that it is statistically significant at 5%, 1%, 0.01% and not significant, respectively

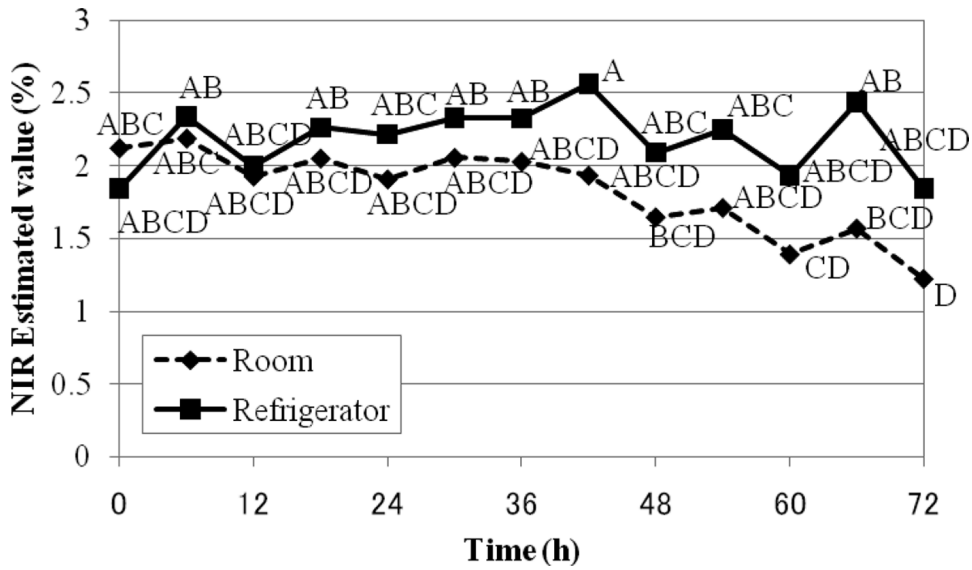

Figure 3. Sucrose content changes during storage (Cultivar: Shonai 3).

The sucrose content showed significant reduction after 72 hours at room temperature storage, while NRQ showed no significant reduction for both temperature conditions.

Conclusion

The new NIR transmission spectrometer could be applicable for the rough estimation of eating quality-related constituents, such as sucrose content and NRQ during storage with or without MA packaging and with or without refrigeration. The ANOVA results showed that the factor with most influence on the quality changes during three days storage was variety/cultivar, particularly in the case of NRQ. Packaging and storage temperature also had significant effect for both constituents. At this stage the NIR transmission spectrometer is bench-type and can be used in the laboratory only. Our next focus will be on the development of a battery-operated portable NIR transmission spectrometer, that can be used in the field.

Reference

1. M. Natsuga, Y. Sue, T. Ikeda, H. Egashira, T. Akazawa and N. Ura, *J. Near Infrared Spectrosc.* **12,** 327 (2007).