Quality evaluation of 'Shonan Gold' by near infrared spectroscopy

M. Yoshida,[a] A. Soga[a] and S. Asada[b]

[a]*Kanagawa Agricultural Technology Center, Hiratsuka 259-1204 Japan.*
E-mail: yoshida.f6as@pref.kanagawa.jp
[b]*Department of Agriculture, Tamagawa University, Machida 194-8610 Japan*

Introduction

"Shonan gold" (SG), a new Mandarin orange variety released from Kanagawa Prefecture in 2003, has a yellow pericarp and flesh, with fresh fragrance and good balance of sugar and acid.[1] Cavities sometimes occur in the flesh during storage from March to May, leading to a decrease in quality (Figure 1).

In this study, we developed a non-destructive method that can measure the flesh cavities and Brix value at the same time, by near-infrared (NIR) spectroscopy.

Materials and methods

Sample fruits were harvested in March 2008 and 2009, and stored either in a conventional storehouse or an ordinary refrigerator for further analysis. After leaving the sample fruits at 22°C for 30 minutes NIRS measurements were performed with an FQA-NIR GUN (Shizuoka Shibuya Seiki, Hamamatsu, Japan) in the short-wavelength region (588–1092 nm), at 4 points on the equator of the fruits (Figure 1). The average spectra were used for calculations. Fruit density was calculated from the fruit weight and volume, using an acoustic type volume meter (Measurement Science Laboratory, Tokyo, Japan). The degree of fruit internal cavity was visually evaluated by the amount of sound flesh and cavity at the fruit equator, and the cavity ratio was calculated by following formula: Cavity ratio= area of cavity/area of sound flesh per fruit. Brix value of the fruit juice was measured by a digital refractometer RX-5000a (Atago, Tokyo, Japan). Data analysis was carried out by Pirouette (Infometrics, U.S.A.) using second derivative spectra. Cavity ratio and evaluation of the cavity area were determined by discriminant analysis by Soft Independent Modeling of Class Analogy (SIMCA). SIMCA regression was applied to predict the classification value "1" (cavity ratio 0.0–0.1), "2" (0.1–0.4), "3" (0.4–0.8) and "4" (0.8–1.0). Density and Brix values were analysed by partial least square (PLS) regression.

Results and discussion

Cavity ratio was negatively correlated with density value, indicating that the cavity ratio and density value can be used as an index of the degree of cavity occurring in the fruits. SIMCA

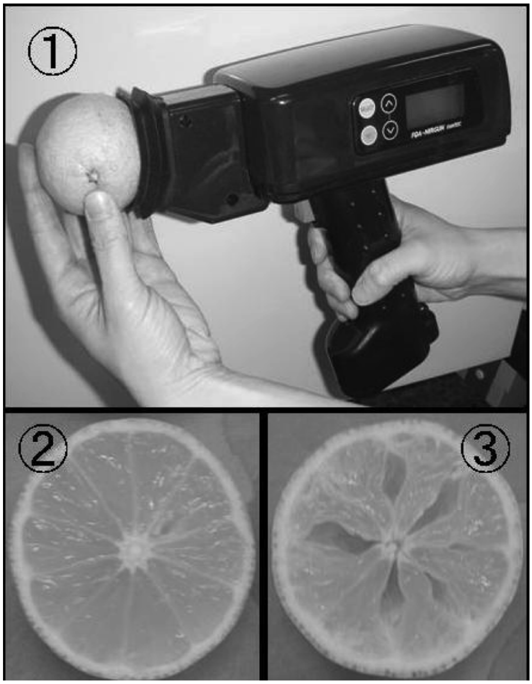

Figure 1. (1) Measurement of FQA-NIR GUN: (2) Normal, and (3) Cavities in Shonan Gold (SG) mandarin orange.

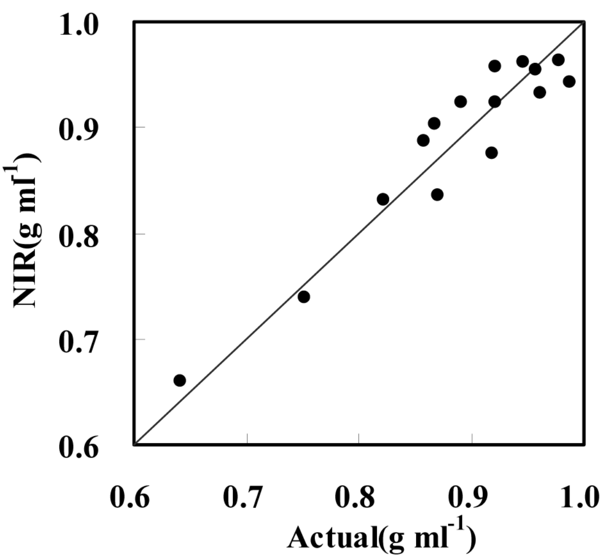

Figure 2. Scatter plot of density versus predicted values on the calibration sets.15 samples of SG were used. Validation was performed by leave-one-out full cross validation. Factors: 4; R^2: 0.95; *SEC*: 0.05; *SEV*: 0.03.

Table 1. PLS calibration results for SG Brix value.

Wavelength (nm)	Treatment	*F*	R^2	*SEC*	*SEV*
600–1000	org	5	0.79	0.75	0.80
600–1000	D2	5	0.86	0.63	0.71
650–1000	D2	6	0.91	0.52	0.59
650–1000[z]	D2	7	0.92	0.47	0.55
600–970	D2	5	0.89	0.55	0.61
650–970	D2	3	0.80	0.73	0.76

154 samples of SG were used. Validation was performed by leave-one-out full cross-validation. [z] without one outlier, *F*: number of factors. R^2: the coefficient of determination. *SEC*: the standard error of calibration. *SEV*: the standard error of validation by cross-validation. Treatment: treatment of NIR spectra. org: original NIR spectra. D2: the second derivative NIR spectra.

classification resulted in a misjudgement rate of 7%, demonstrating that the distinction was excellent, because no outliers could be detected by SIMCA,[2] and fruit density could be predicted precisely by PLS (Figure 2). The results were influenced by the optical path-length at about 840 nm.[3]

Table 1 shows PLS calibration results for Brix values obtained by the results of calibration on 154 samples, using different wavelength ranges, and 153 samples with one outlier removed. The wavelengths below 650 nm and above 970 nm were excluded in the prediction of the Brix values, using PLS. The visible region would be influenced by the pericarp colour, while wavelengths

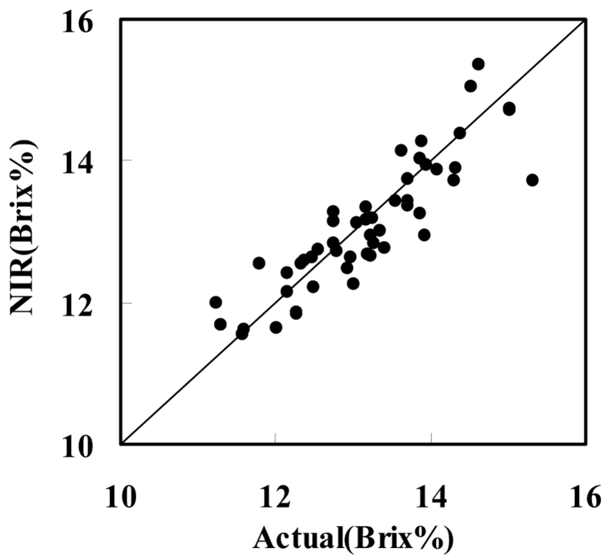

Figure 3. Scatter plot of Brix value versus predicted values on the validation sets. Validation was performed by leave-one-out full cross validation. Factors: 7; R^2: 0.95; *SEC*: 0.44; *SEP:* 0.55; Bias: 0.10.

above 970 nm would be affected by the absorption of water in the fruit. One outlier was detected by outlier analysis, and the sample was excluded from the analysis because of differences detected in the vicinity of 950–970 nm in the second derivative spectrum. This was attributed to pericarp softening during the long-term storage. Results obtained from the present study demonstrated that Brix values can be predicted with high levels of accuracy by NIR spectroscopy (Figure 3).

Conclusion

It was concluded that NIRS has the potential to detect cavities, and predict Brix value of SG mandarin oranges. More work will focus on developing the calibrations for practical use, and storage methods for the SG fruit.

References

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