Measurement of construction sugar in Japanese pear using near infrared spectroscopy

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Introduction

Japanese pear contains four kinds of construction sugar, namely sucrose, glucose, fructose and sorbitol. As a Japanese pear ripens, total sugar content increases gradually, but the ratio of these sugar conponents changes at the same time. In this study, non-destructive measurement of these sugar contents in the developing Japanese pear was conducted by near infrared (NIR) spectroscopy to evaluate the ripeness of the fruit.[1–5]

Material and methods

Samples and method of chemical analysis

A total of 133 fruits of Japanese pears (*Pyrus serotina* var. *culta* "Kousui", cultivated in Saga prefecture, Japan) were harvested periodically during fruit growth from March to July in 1993. One day after harvest, the equatorial portion of Japanese pear was cut off to squeeze out the juice.

Construction sugars in the juice, namely sucrose, glucose, fructose and sorbitol, were analyzed by high performance liquid chromatography (HPLC). Standard errors of HPLC values (%w/w) of these sugars were 0.004, 0.012, 0.035 and 0.039, respectively. The values measured by HPLC was sufficiently accuracate for the NIR analysis.

Measurement of NIR spectra

NIR spectra of the juices were measured by diffuse trans-reflectance from 1100 to 2500 nm at 2 nm interval using Bran+Luebbe InfraAlyzer 500. The temperature of the juice was about 28ºC during measurement. NIR original and 2nd derivative spectra of the Japanese pear juice are shown in Figure 1.

Multiple linear regression (MLR)

The IDAS program by Bran+Luebbe was used for multiple linear regression. MLR was conducted between the second derivative spectra and each construction sugar contents. Calibration and prediction sets were prepared for each construction sugar and statistical characteristics of these sets are shown in Table 1.

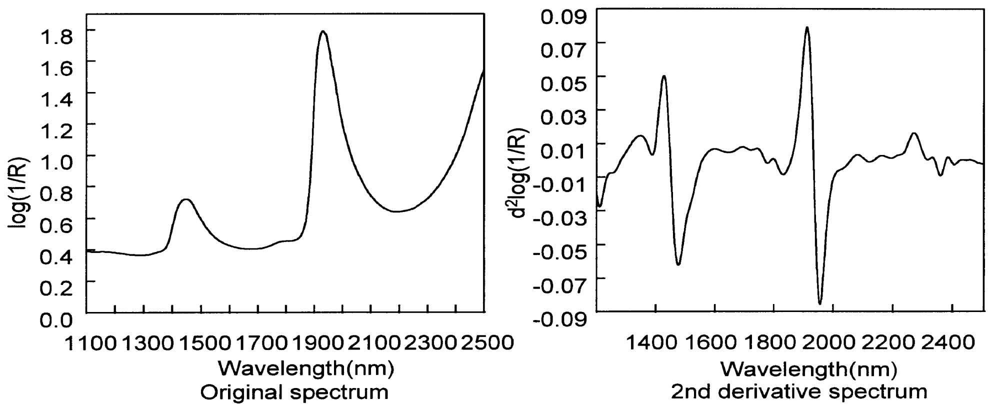

Figure 1. Near infrared original and 2nd derivative spectra of the juice of Japanese pear.

Table 1. Statistical characteristics of calibration and prediction sets selected for multiple

	Calibration set				Prediction set			
	n	Range	Mean	*SD*	*n*	Range	Mean	*SD*
Sucrose	98	0.00–3.00	0.43	0.73	35	0.00–2.85	0.56	0.85
Glucose	98	0.19–1.88	1.10	0.38	35	0.84–1.80	1.28	0.21
Fructose	99	0.24–6.47	3.51	1.82	34	2.94–6.30	4.62	0.93
Sorbitol	96	2.04–6.87	3.86	1.25	36	2.05–6.84	3.73	1.29

n: Number of samples
SD: standard deviation

Results and discussion

Results of multiple linear regression

Results of MLR are shown in Table 2 and indicate that sugar contents could be measured by the regression equations using two to six wavelengths. The correlation coefficients (R) of sucrose, glucose, fructose and sorbitol were 0.97, 0.90, 0.98 and 0.97, with the bias-corrected standard error of prediction (SEP) equal to 0.23, 0.15, 0.23 and 0.43 respectively.

Calibration equations of each construction sugar are given below, where C indicates each sugar content (%w/w) and $L(1)$ means 2nd derivative absorption at specific wavelength.

For sucrose content:

$$C = -2.47 - 4128.49\,L(1594) - 316.26\,L(1758) + 1066.77\,L(2094) + 1450.973\,L(2130) - 1361.09\,L(2278) - 378.98\,L(2314)$$

For glucose content:

$$C = 1.663 - 801.29\,L(1750) - 161.65\,L(2262) + 183.561\,L(2282)$$

For fructose content;

$$C = 1.27 + 693.50\,L(2098) - 1263.83\,L(2262)$$

Table 2. MLR of second derivative reflectance measurements for construction sugars in juice of Japanese pears.

	Wavelength selected									
	λ_1	λ_2	λ_3	λ_4	λ_5	λ_6	*R*	*SEC*	*SEP*	Bias
Sucrose	1594	1758	2094	2130	2278	2314	0.97	0.18	0.23	–0.02
Glucose	1750	2262	2282				0.90	0.17	0.15	–0.00
Fructose	2098	2262					0.98	0.33	0.23	–0.13
Sorbitol	1430	1542	2050	2410	2434		0.97	0.29	0.43	0.10

R: Multiple correlation coefficient.
SEC: standard error of calirbation.
SEP: standard error of prediction.

For sorbitol content:

$$C = -7.40 + 156.55\,L(1430) + 3585.90\,L(1542) - 2443.78\,L(2050) + 799.75\,L(2410) + 704.65\,L(2434).$$

In these calibration equations, the most important wavelengths i.e. sucrose 2094 nm, glucose 2262 nm, fructose 2262 nm and sorbitol 2050 nm, are included as characteristic absorption bands of sugars.

Evaluation of the ripeness of the fruit

Results of prediction from each kind of sampling day are shown in Figure 2. The results of measurement using these regression equations showed that, when the fruit was ripe, sorbitol content was increasing at first and decreasing thereafter, while the other sugars were increasing

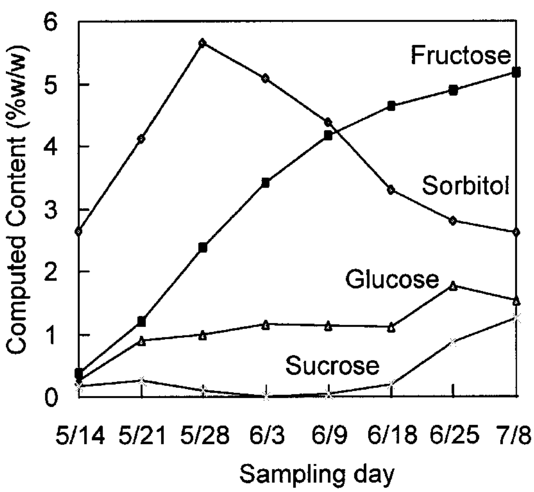

Figure 2. Change of each construction sugar content measured by NIR spectroscopy.

in all the developing stages. The highest sugar content in the ripe pear was fructose. Thus NIR spectroscopy can be applied for the evaluation of the ripeness of the fruit.

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