# Nondestructive measurement of brix value and total acidity in satsuma mandarin by a hand-held near infrared instrument

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## Introduction

In 1993, we reported that NIR measurement in transmittance mode was an appropriate system of sample presentation for the determination of Brix values in Satsuma Mandarin. Nowadays, various makers are using that technique for commercial sweetness sorting machines. Even though the sweetness evaluation has become quite accurate and robust, the major obstacle limiting the complete quality evaluation of Satsuma is the measurement of total acidity (TA). In general, it is very difficult to measure TA by NIR spectroscopy non-destructively because of several factors, including the weak absorption of acids in this region, the low concentration compared to sugars and water, and other factors. Nevertheless, we found that a portable instrument the "FQA-NIR Gun" could possible serve as an accessory for transmittance measurement of TA in Satsuma mandarin. The instrument has a bright illuminator that could be placed next to the sample. Data collected by the sensor is communicated by a short fibre optics system. In this work, the system described was examined for determination of Satsuma quality. Brix value was used as reference calibration to evaluate the potential of the system for measurement of TA.

## Materials and methods

Two types of samples were used; intact Satsuma mandarins and juice of the Satsuma mandarin. In total, 119 samples were used in the intact set. A further 119 samples were squeezed and used to supply juice. Spectral acquisitions were performed in the transmittance mode, using the special sample holder and the FQA-NIR Gun (Shizuoka Shibuya Seiki, Hamamatsu, Japan), which operated in the region of 600–1100 nm, with 2 nm intervals (Figure 1).

Intact fruits were placed directly on the instrument, while juice was filled into a test tube. Sample temperature was controlled at 25°C using a water bath and dipping techniques: with

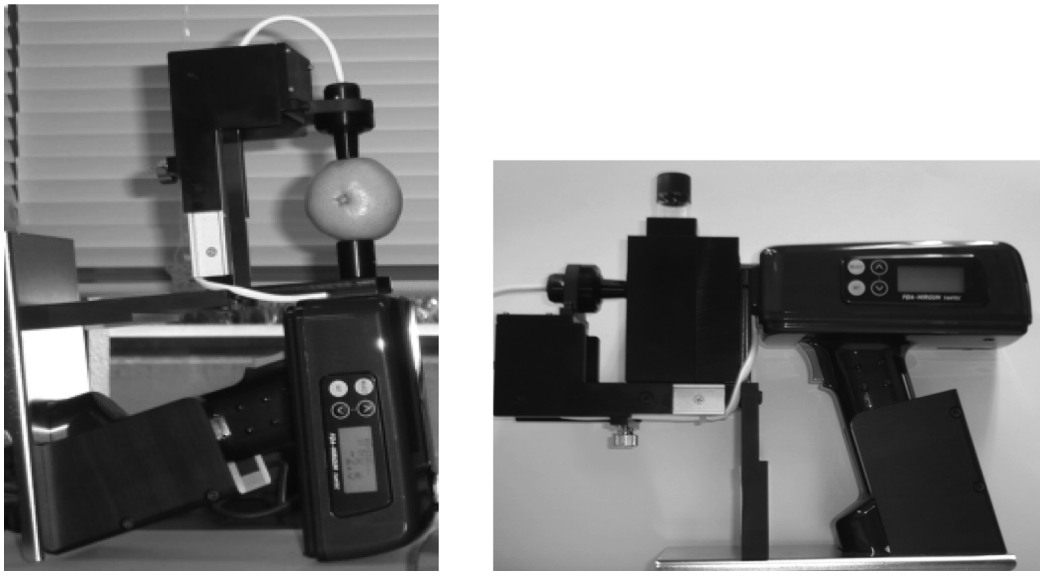

**Figure 1.** Spectral acquisition of intact (Left) and juice (Right) of Satsuma mandarin.

plastic sheet to protect intact fruit from getting wet, and directly for juice kept in test tubes. Brix and TA values were measured from fruit juice using a digital refractometer, and titration with sodium hydroxide solution, respectively. Partial least squares (PLS) regression was used to develop calibration equations on original and pretreated spectra. All calculations were conducted by The Unscrambler (CAMO, Oslo, Norway).

## Results and discussion

PLS calibration results for Brix and TA values of intact Satsuma mandarin, compared with those developed from juice are shown in Table 1.

**Table 1.** Sample characteristics and PLS calibration results for Brix and TA values of intact and juice of Satsuma Mandarin.

| Constituents | Samples | Range | | Wavelength region (nm) | *F* | R | SEC | SEP | Bias |
|---|---|---|---|---|---|---|---|---|---|
| | | Cal set | Val set | | | | | | |
| Brix (°Brix) | Intact | 8.9–13.2 | 9.7–12.9 | 700–950 | 7 | 0.91 | 0.33 | 0.33 | 0.03 |
| | Juice | 9.9–16.1 | 10.2–13.9 | 700–950 | 8 | 0.96 | 0.27 | 0.42 | 0.06 |
| TA (%) | Intact | 0.3–2.3 | 0.4–1.9 | 700–950 | 8 | 0.86 | 0.19 | 0.22 | 0.05 |
| | Juice | 0.3–1.3 | 0.3–1.3 | 700–950 | 6 | 0.75 | 0.15 | 0.14 | 0.00 |

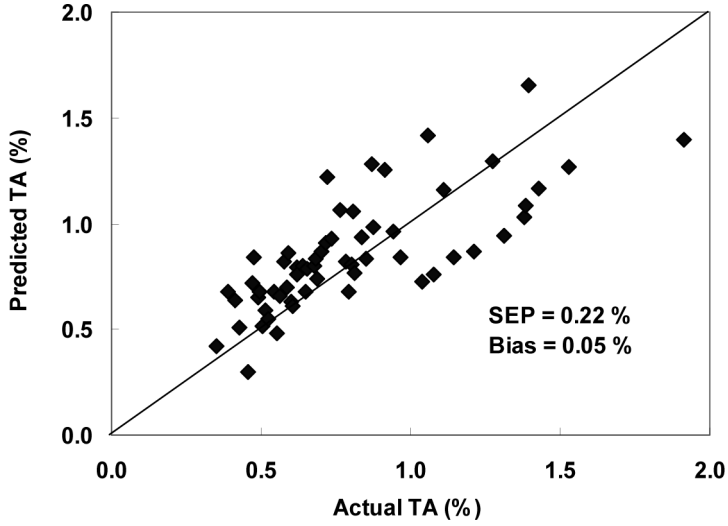


**Figure 2.** Scatter plots for TA values in the validation sample set calculated from second derivative NIR spectra of intact Satsuma mandarin.

Even though the *R* values for TA calibrations were not very high compared with that of Brix values, the scatter plots between actual and predicted TA values for the validation set showed promising results (Figure 2).