Applied Vibro-Acoustics, Inc.

A New Portable and Non-destructive Instrument for Fruit Firmness Measurement using a Resonant Sensor

"A Reliable prediction method for fruit maturation"

Introduction

When fruits become edible, sugar contents increase and acidity decreases. Degree of sugar contents in the fruit is well predicted non-destructively by infra-red spectroscopy. However, there are several fruits whose maturity is difficult to be evaluated by the spectroscopy. Watermelon or melon is difficult to measure its maturity and/or internal sugar content by the spectroscopy because of their thick skin, and avocado maturity is also not evaluated by sugar content because of its low level within the fruit. Furthermore, the spectroscopy technique is not able to sort out the overripe fruit, since overripe fruits contain enough amounts of sugar but with less acidity and rotten parts.

Puncture test using a fruit pressure tester (Fig. 1), such as Magness-Tayler or Effe-gi type tester, has been used for the evaluation of fruit maturity. Hard fruit is evaluated as immature and too soft fruit as over-ripe. These testers insert a cylindrical probe into the fruit flesh, and measure the resistant force exhibited by the flesh. The method is destructive, and the tested fruit can not be shipped to the market.

Fig. 1 Puncture test with a fruit pressure tester.

New method and instrument using resonant frequency for the evaluation of fruit maturity

We developed a new instrument that non-destructively evaluates fruit maturity using resonant theory (Fig. 2, next page). The instrument consists of three parts;

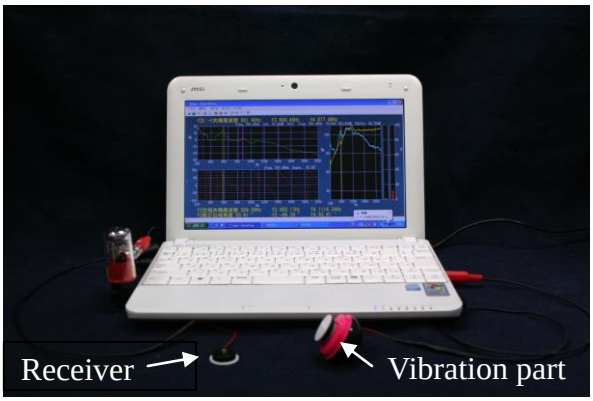

Fig. 2 Photograph of the portable vibration frequency measurement instrument for evaluation of fruit maturity.

Fig. 3 Measurement of resonant frequency of the tested material.
Right, vibration part; left, receiver.

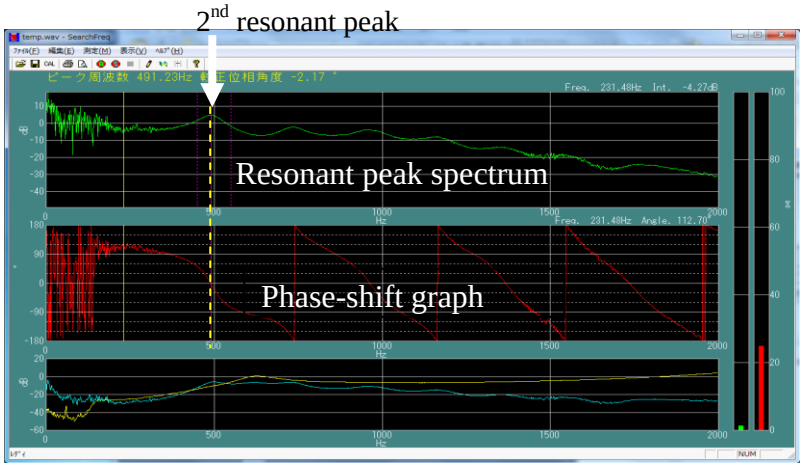

Fig. 4 PC screen on the resonant frequency measurement.
Upper panel, spectrum of the frequency response of sample. Middle, phase-shift graph. Bottom, signal from vibration part and receiver part.

one is note PC that analyses resonant frequency using FFT (Fast Fourier transformation), second is the vibration part, and third is the receiving part of vibration.

Fruit to be tested is sandwiched between the vibration part and the receiving part (Fig. 3). In Figure 3, an apple is sandwiched between two parts. The vibration part (Fig. 3 right) applies the vibration to the tested apple by sinusoidal wave vibration from 10Hz to 2000Hz in a manner of sweep mode. The receiver (Fig. 3 left) receives the vibration of the apple and the received vibration signals are transported to the PC. When the applied vibration reaches the inherent resonant frequency of the tested apple, the amplitude of vibration becomes maximum. One can get several resonant frequencies of the sample in this way. The analysis is performed by the note PC, and displays on the screen (Fig. 4).

Upper part in the Fig. 4 shows the spectra of frequency response of the sample. Abscissa is frequency, and ordinate is amplitude of the vibration. There are several peaks in the upper panel.

One peak appearing around 500Hz is designated 2^{nd} resonant frequency that affords important information of the firmness of the sample. The firmness of the sample (Elastic Index, EI) can be calculated by the equation,

$$EI = m^{(2/3)} * f_2^2$$

where m is mass and f_2 is the second resonant frequency. The second resonant peak is always found at the same phase-shift, so that one can easily confirm which peak is the second resonant peak. The PC automatically tells you the 2^{nd} resonant frequency and 3^{rd}

and 4th as well on the screen. The bottom graph shows the signal from vibration part and receiver part to check the normal function of the parts. Using this resonant method, you can non-destructively get fruit firmness that tells you the maturity of the fruit sample.

A new type resonant instrument for the evaluation of fruit maturity

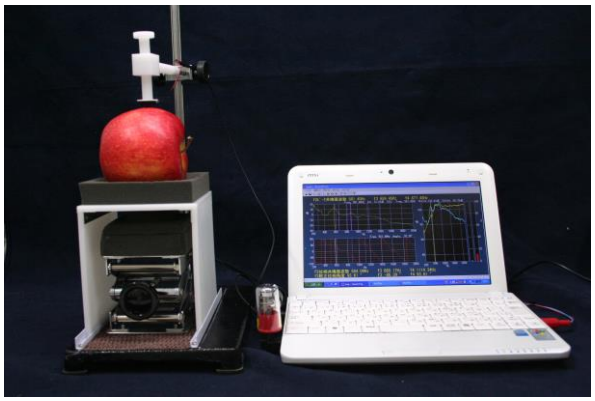

Fig. 5 Photograph of a stationary type instrument of resonant frequency.

A stationary type of resonant instrument has been developed (Fig. 5). The sample (an apple in the figure) is placed on the vibration stage and a receiver sensor is attached on the upper surface of the sample. This instrument allows you to use both hands, so that you may concentrate on the PC and repeatedly measure the same fruit.

You may use not only 2nd resonant frequency but also 3rd and 4th as well for the evaluation of the interior quality of fruit.

The resonant frequency also tells you an infection of fungi that deteriorate the inner fruit flesh that can not be found from its appearance.

The non-destructive method for evaluation of fruit quality using resonant theory makes it possible to ship all the tested fruit to the market. It reduces the daily expense of fruit tested by the destructive method, such as a fruit pressure tester.

Instrument

- Portable Instrument for Resonant Frequency Measurement
  (Including a note PC, a vibration device, and a receiver)
- Stationary Instrument for Resonant Frequency Measurement
  (Including a note PC, a vibration stage and a receiving sensor)

AC 100~240V is required. (Pat. 3062071, 3927996)

Applied Vibro Acoustics

Applied Vibro-Acoustics, Inc.

Adress VBL 305, Kagamiyama 2-313, Higashihiroshima, Hiroshima, Japan, 739-0046
Tel & Fax 81-824-424-7889 Email nsakura at hiroshima-u.ac.jp (replace “at” with @)