

## Evaluation of freshness Japanese San Fuji apples – comparison of Biospeckle and Optical coherence tomography measurements

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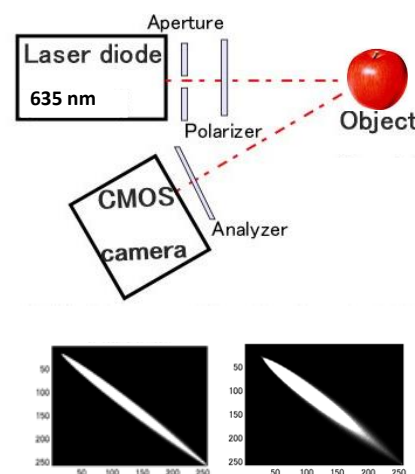
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### Introduction

In this paper, we have applied non-invasive optical methods of biospeckles for evaluation of freshness of Japanese SanFuji apples. Biospeckles are formed when a biological tissue is illuminated by monochromatic light due to scattering by organelles moving within the tissue. We have employed Optical Coherence Tomography and Speckle imaging for evaluation. Apples were purchased from a single dealer and they were spaced every five days starting from November 4 till December 20. All the apples were stored at room temperature of 21deg C.

### Biospeckle measurement

The system with a CMOS camera (1024x1280 pixels) used for speckle imaging is shown in Figure. Speckle images binned to 240 x320 pixels sampled at the rate of 15fps were obtained over a period of 14 sec. A total of



three apples with three different points for each apple were measured at every 5<sup>th</sup> day over a period of more than a month. Next speckle images were characterized offline using by different parameters of cross-correlation between the neighboring frames, co-occurrence matrix and speckle contrast. Based on the analysis, a significant broadening could be seen in the co-occurrence matrix (See figure; left: recent and right: old). With increasing storage there is broadening of co-occurrence matrix indicating the deterioration correlation. These results were correlated with the thermal images as well smell measurements

### Biospeckle analysis using Fourier OCT

A spectral domain OCT (SD-OCT) system using a superluminescent diode (SLD) centered at wavelength 836.1 nm and a bandwidth of 55.2 nm containing a line scan CCD camera with 2048 pixels was used. The axial and lateral resolutions of the OCT system were estimated to be 6  $\mu\text{m}$  and 22  $\mu\text{m}$ , respectively. The spectral imaging data were acquired through an image grabber while laterally scanning the sample surface by galvano mirrors. Hundred OCT speckle frames (2048x1024) from a single lateral position were continuously acquired every 500ms and resulting correlation length vs position along depth is shown in Figure for Nov4 (left) and Dec 20 apples(right). Recent one was found to have higher correlation in deeper region. In conclusion, biospeckles reflect the freshness of the apple. However, the physiological reasons need to be investigated.

