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LS-8-P-1909 Determination of micro-mechanical properties of apple cells (Malus domestica) by means of bio-atomic force microscope (bio-AFM) and analysis of the multidimensional images

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Morphometric parameters and micro-mechanical properties of vegetable cells can be considered as an index of quality and ripeness of climacteric fruits. After harvest, the cells undergo biochemical changes that modify their cell size, texture and flavor which are key quality features that influence consumer acceptability of fruits and functional properties. The aim of this work was to study the mechanical properties of apple cells by indentation with a bio-atomic force microscope (bioAFM) to contribute to the understanding of the maturity process on climacteric fruits. In this study was carried out the isolation of parenchymatic cells from the central cortex of the unripe apple (Malus domestica) by dissolution in mannitol (0.3M) at 45 °C and 30 min according to Schaffer et al., (2009). Isolated cells were contrasted to be observed in microscope (Nikon Eclipse 50i, Japan). Images obtained were analyzed in order to characterize the size and cellular morphology (about 300 cells were used). The values of cellular area had a normal distribution with a mean of 352.2±86.16 µm2, while diameter and circularity values were not normally distributed with a mean of 245±36.7 µm and 0.68±0.12 respectively (Figure 1). Also, mechanical properties were studied by means of a bio-AFM (Bioscope Catalyst, Bruker, USA) to indent apple tissue by means of microcantilevers with pyramidal tips (ScanAsyst, radius: 20 nm). Force curves were obtained in several areas of cells and their Young's modulus were obtained by two fit mathematical models (Hertz and Sneddon). Figure 2 shows the force curves obtained during the indentation. Furthermore, multidimensional images of height, error, DMT modulus (e.g. Figure 3 and 4), deformation, dissipation, and adhesion mapping images were obtained. Otherwise, the Young´s modulus was calculated from the force curves and a mean of 0.281±0.125 MPa was obtained to cells analyzed, which it is within the range for biologic materials as reported by Zdunek et al., (2013). An optimizing of the fit models showed that the best fit was the Sneddon model with an R2average of 0.99. The study of cellular mechanical of vegetable cells by atomic force microscopy imaging and the mechanical properties obtained from Bio-AFM could be important for understanding the maturity process that occur during the storage and postharvest handling of climacteric fruits.

Schaffer R.J., McAtee, A.P., Hallet I.C., Jhonston J.W. (2009) A rapid method of fruit cell isolation for cell size and shape measurements. BioMedCentral Plant Methods 9, 5:5

Zdunek A., Kurenda A., (2013) Determination of the Elastic Properties of Tomato Fruit Cells with an Atomic Force Microscope. Sensors, 13, 12175-12191

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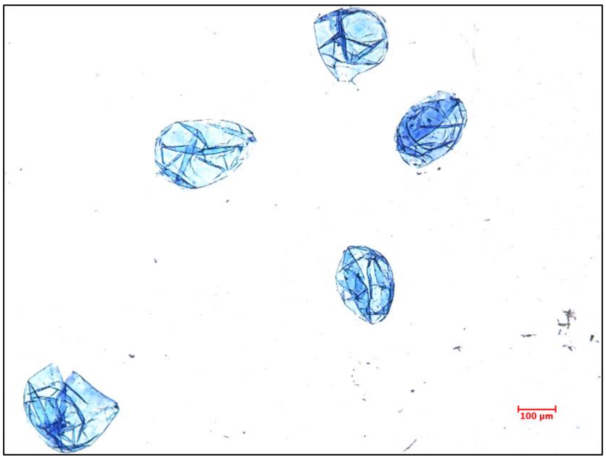

Fig. 1: Isolated apple cells used for morphometric characterization by means of image analysis, stained with methylene blue.

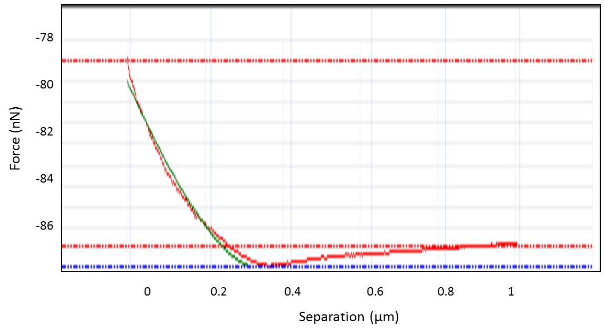

Fig. 2: Typical curve force (red line) and fitted with Sneddon model (green line) for isolated apple cells

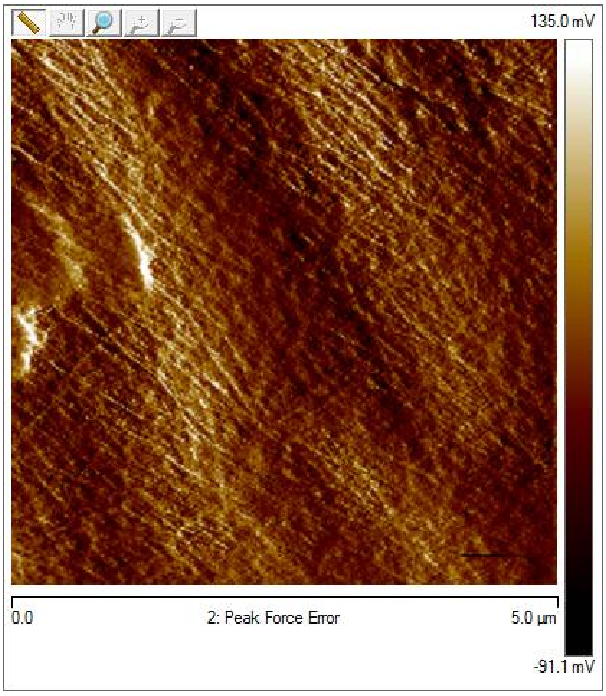

Fig. 3: Mapping image of peak force error signal of cell wall unripe apple

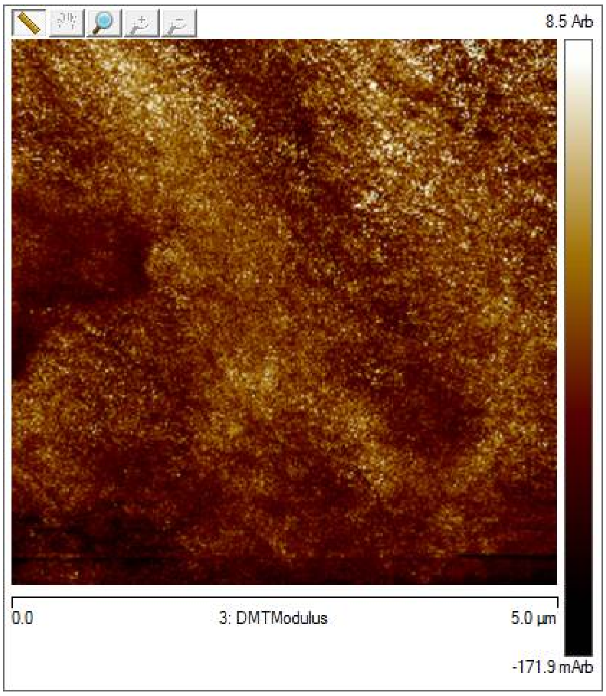

Fig. 4: Mapping image of DMT modulus signal of cell wall unripe apple