Bio-impedance and circuit parameters: An analysis for tracking fruit ripening

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Abstract

The evaluation of fruit quality from the field to the table, through its storage, handling and transport has become of paramount importance to meet production and consumers demands. For this purpose, fast, reliable and low-cost non-destructive techniques are highly desirable, to avoid food waste and allow a real-time decision making. Among non-destructive techniques, Electrical Impedance Spectroscopy (EIS) has shown great potential due to the possibility to correlate the physio-chemical evolution of the fruit to changes of electrical parameters. In this paper, the effect of ageing on apples and bananas during 13 d at room temperature was studied using a microcontroller-based EIS system, in a frequency range from 100 Hz to 85 kHz.

The bio-impedance changes were evaluated over time and the influence of the applied frequencies on its variation was investigated. Data were fitted with a proposed equivalent circuit, modelling both the interaction between the fruit and the sensor and the flow of current in the samples tissues. To validate the results, the circuit parameter changes were physiologically explained and the fitting compared with models found in literature. The results highlighted the potential of this non-destructive technique for monitoring the ripening and senescence of fruit, obtaining a good correlation of the impedance evolution with the low frequency points. The model fitting resulted in a Root Mean Squared Error (RMSE), for apples (376.5 Ω - 2.66%) and bananas (110.8 Ω - 2.82%), was comparable or better than best literature models. Finally, changes of circuit component values over time was explained for the electrode-fruit interaction and for the current flow in the plant tissues, giving a better insight of fruit ripening and senescence.