
Changes in tissue structure and electrical properties of apple by vacuum impregnation treatment

OSHIMA T. (1), IMAIZUMI T. (2,3), KATSUNO N. (2), NISHIZU T. (2,3)

1 United Graduate School of Agricultural, Gifu University, Gifu, Japan

2 Faculty of Applied Biological Sciences, Gifu University, Gifu, Japan

3 Preemptive Food Research Center, Gifu University, Gifu, Japan

Electrical impedance spectroscopy has been used as a method for evaluating the cell membrane structure of fruits and vegetables. However, in addition to cell membrane damage, tissue structure changes due to tissue shrinkage and water influx are caused by various processing operations, which may affect electrical properties. In this study, impedance and porosity were measured on apples treated by vacuum impregnation to clarify the relationships between tissue structure and electrical properties. Apple samples which cut into cylindrical pieces with a diameter of 5.5 mm and a length of 20 mm were prepared and subjected to vacuum impregnation treatment. Vacuum impregnation was performed by immersion in distilled water at 100, 200, 400, 600, and 800 MPa for 1 minute. For impedance measurements, needle electrodes were inserted into each sample, and the resistance and reactance were measured at 100 points between 50 Hz and 5 MHz. Then, equivalent circuit analysis using the CPE model was performed to quantitatively evaluate the electrical characteristics, and the intracellular resistance, extracellular resistance, and cell membrane capacitance were determined. The porosity was calculated from X-ray micro-CT images using the software CTAn. In the equivalent circuit analysis, the CPE model was well fitted to the measured values. The intracellular resistance did not change significantly with impregnation pressure. On the other hand, the extracellular resistance became smaller as the impregnation pressure was lowered, suggesting that the conductive area increased due to the inflow of water into the voids. The vacuum impregnation treatment also induced increase in the cell membrane capacitance, thus it was assumed that the treatment caused tissue shrinkage and cell membrane density between electrodes increased. Porosity decreased with decreasing impregnation pressure. A strong negative correlation was observed between the capacitance and porosity ($R=-0.929$). In apples, porosity was found to contribute to the impedance parameter, and impedance measurement could be used to predict porosity.