Finite element simulation of the micromechanical changes of the tissue and cells of potato response to impact test during storage by scanning electron microscopy

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Abstract

Impact damage in potatoes affects its microstructure and leads to quality loss. The finite element simulation of the micromechanical alterations in the tissue and cells of potato in response to impact test during storage by scanning electron microscopy (SEM) analysis have been investigated. Two macro-scale and micro-scale finite element method (FEM) models were developed to investigate impact damage of potato tubers and cells, respectively. Physical (density and turgor pressure) and mechanical (modulus of elasticity, yield stress, and tangent modulus) properties of potato tissue were determined during storage. Impact damage at the contact point and cell dimensions were obtained using the SEM images. A macro-scale FEM model, simulating impact damage of a tuber was meshed using the solid elements and the mesh size sensitivity was checked. A mesh is a group of interconnected finite elements joined together. The impact simulation scenarios included two impact levels of 0.032 J and 0.335 J at two week intervals during storage. The FEM results revealed that the maximum von Mises stress and impact damage increased at high impact energy while it decreased during storage. The impact damage prediction using the FEM model had a maximum error of 32.279 %. SEM images provided a reliable way to calculate the impact damage. The FEM simulation of impact tests on the micro-scale included a set of potato cells, each made of a cell wall and protoplast. The sensitivity of the mesh was checked and the appropriate element size for the potato tissue model was found to be 0.03 mm. The results showed a decrease in contact force due to the decrease in the elasticity modulus of the cell wall and protoplast during storage. Overall, it is concluded that the impact loading of potato after a period of storage leads to low impact damage and high quality of potato tissue.