# Use of X-ray computed tomography and 3D image analysis to characterize internal browning in 'Fuji' apples after exposure to $CO_2$ stress

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## Abstract

In this study X-ray computed tomography (X-ray CT) was used to determine microstructural properties of 'Fuji' apple *(Malus domestica* Borkh.*)* tissue affected by internal browning (IB) and unaffected tissue after short-term exposure (3 days) to a storage atmosphere with 0.1 % $O_2$ and 50 % $CO_2$. The incidence of IB disorders were concentrated in the core of the fruit. IB developed in 31 % of fruit at varying degrees of severity, due to differences in microstructural and morphological properties of individual fruit. X-ray CT scanning was able to give pore and cell microstructural information such as porosity, length, sphericity, connectivity, equivalent diameter, and anisotropy. High-resolution scans showed that fruit tissue with IB had a lower total porosity and pore connectivity compared to unaffected fruit tissue, possibly due to membrane damage and flooding of intercellular spaces with cellular fluids. The pores in affected brown tissue were significantly more spherical as compared to the other tissue types. Low-resolution (full fruit) scans showed that the density of fruit tissue affected by IB was not significantly different from that of unaffected fruit tissue. Low porosity in the fruit core region restricts gas transport and predisposes the core region to $CO_2$ induced IB. This work provided a novel and in-depth insight into the effects of short-term high $CO_2$/low $O_2$ stress conditions on the microstructural properties of South African grown 'Fuji' apples. Furthermore, this study showed that tissue microstructure influences the susceptibility of different regions within the same fruit to stress-induced IB symptoms.