

Title Magnetic resonance imaging and relaxometry to visualize internal freeze damage to pickling cucumber

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Abstract

Magnetic resonance (MR) images and tissue relaxometry (T_1 and T_2) data, using a 9.4 T MR system, were used to assess freeze damage to pickling cucumbers. Freeze damage was induced by placing cucumbers at $-18\text{ }^\circ\text{C}$ for 150 min and the samples were then stored in a controlled atmosphere. T_1 and T_2 -weighted images were generated at echo time (TE) of 10 ms at specific intervals for cucumbers stored for a period of 7 d. Texture profile analysis of the control and freeze-damaged samples was also carried out on the day of MR imaging. MR images showed good contrast between different physiological constituents of a pickling cucumber. A subsurface region in the freeze damaged samples was distinctly different in all MR images which could be physically correlated with damaged tissues visible in a cut-away section of the freeze-damaged pickling cucumber. Spin–lattice relaxation time (T_1) was not different for different constituents of a pickling cucumber and could not be used to resolve between control and freeze damaged samples. Whereas, spin–spin relaxation time (T_2) values for all the regions of a cucumber slice were higher for the freeze-damaged samples than that for control samples. The T_2 values for seeds and the gel around seeds sections were also significantly different from the rest of the cucumber constituents. However, T_2 values did not change significantly over the storage period. Firmness and chewiness characteristics of pickling cucumbers changed during the storage; however, there was no correlation seen between T_2 values and firmness of the fruit.