Effect of Pulsed Electric Field Treatment on Plant Tissues with Heterogeneous Structure Assessed by Magnetic Resonance Imaging

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PEF treatment causes an increase in the permeability and conductivity of the cell membrane. This is explained by the creation of water pathways in the lipid domain of the cell membrane exposed to the external electric field. The change in permeability of the cell membrane is also associated with physical changes in cell structures, such as changes in intracellular and extracellular volume, as well as the volume of the vacuole, and consequently with the leakage of water and solutes from the intracellular to the extracellular space. Understanding such changes in target foods is of great importance for the desired treatment outcome. The aim of our study was to investigate the possible non-uniform effect of PEF treatment due to the structural heterogeneity of plant tissues. We selected three types of plant tissues that have different structural complexity and are commonly used in industrial PEF applications: apple, potato tuber and carrot taproot. Magnetic resonance imaging (MRI) was used to monitor the spatially-dependent effect of PEF treatment in the selected plant tissues. The transverse relaxation time T2 (also known as spin-spin relaxation time) was used as an indicator of the re-distribution of water and solutes in the tissues after PEF treatment. In addition, magnetic resonance electrical impedance tomography (MREIT), an MRI-based technique, was used to reconstruct the distribution of the electric field in the tissue during PEF treatment. Changes in T2 relaxation times were observed over the course of 6 hours after treatment to investigate the relationship between the local electric field and tissue structures. The results showed an increasingly inhomogeneous distribution of T2 relaxation times with increasing complexity of the plant structure (carrot > potato > apple). The ability to analyse water distribution and redistribution within the electroporated tissue is important not only for determining treatment intensity and the appropriateness of a particular treatment protocol in a given food matrix, but also for fundamental studies of material properties and their change as a result of processing with new technologies.