Pulsed Electric Field Technology in Food Processing: Insights into Treatment Protocol Optimization

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Pulsed electric field (PEF) technology has found applications in various industrial food sectors, including the potato industry, winemaking, biorefinery, and juice extraction. It is widely known that PEF treatement of biological tissues leads to an increased permeability and conductivity of the cell membrane. This phenomenon is attributed to the formation of water pathways in the lipid domanin of the cell membrane exposed to the electric field. The alteration in membrane permeability is also linked to physical changes in cell structures, including changes in intracellular and extracellular volume, vacuole volume, and subsequent leakage of water and solutes from the intracellular to the extracellular spaces. Despite its potential, the practical integration of PEF technology in the food industry still faces several challenges. The detection and quantification of PEF effects are complex due to the variability in characteristics and properties of raw materials, including cellular composition, structural organization, textural properties, and tissue porosity. Moreover, numerous PEF treatment parameters (e.g., pulse amplitude, duration, shape, rate), and process parameters (e.g., temperature, pH, medium conductivity) further complicate the optimization of PEF protocols, requiring often a case-by-case approach. Therefore, knowledge of treated material properties and their functional dependence on PEF is imperative for the design of successful treatment protocols. To further understand the underlying physical changes induced by PEF, we performed a series of experimental studies focusing on assessing membrane permeabilization levels in plant and animal food matrices (potato, apple, chicken), emplying various assessment methods, such as electrical impedance spectroscopy, current-voltage measurements, magnetic resonance imaging, and texture analysis. The outcomes provided valuable insights that could be in support of the selection of appropriate PEF treatment conditions and also for fundamental studies of material properties and their changes as a result of processing with PEF and other new technologies.

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