Heat and Mass Transfer in Food Processing: Enhancement Strategies and Innovative Processes

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Heat and mass transfer govern many food processing operations, affecting product safety, quality, energy consumption and process efficiency. The complexity of food materials—including temperature-dependent properties, non-Newtonian behaviour and evolving structures—makes the prediction and control of transport phenomena particularly challenging. These challenges also create opportunities for process innovation through a closer integration of fundamental understanding, experimental investigation and modelling.

This keynote explores heat transfer enhancement strategies and innovative processing technologies, with particular attention to the relationship between transport mechanisms, equipment design and product characteristics. Passive enhancement approaches, including modified surface geometries and mixing-promoting configurations, are discussed alongside microwave-assisted thermal processing and other innovative also non thermal technologies. The analysis considers how enhanced convection and volumetric energy generation influence heating rates, temperature uniformity and treatment effectiveness, while addressing trade-offs involving pressure losses, energy requirements and product quality.

A central theme is the integration of advanced thermal measurements, inverse heat transfer methods and numerical modelling to identify transport mechanisms and support process development. Coupled heat and mass transfer models provide a framework for interpreting experimental observations, comparing processing alternatives and assessing the potential to reduce treatment times and overprocessing while meeting safety targets.

Drawing on applications and research perspectives in food engineering, the keynote highlights how transport-based design can support more efficient and controllable processes. Particular emphasis is placed on translating enhancement concepts into practical solutions that account for the constraints of industrial food production.