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Challenges and Opportunities in Porous Media Modeling of Food Materials

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Foods provide challenging settings for testing porous media physics-based theories. Foods are heterogeneous materials composed of macromolecules such as carbohydrates, proteins, and lipids with continuously evolving structures and material properties during processing. Treating foods as porous materials to model the fundamental transport mechanisms and their effect on product quality is of significant interest to both multibillion-dollar food industry and the consumers. Industry desires at optimizing the food processes to obtain safe and nutritious food products with desirable taste, flavor and texture. However, it is challenging to optimize the food processes by purely experimental approaches due to the involvement of a large number of parameters, difficulties posed by continuously changing material characteristics and dynamic nature of processes. Porous media modeling helps to fill the gaps in understanding the mechanisms and identifying the desired process parameters. For example, during frying of French fries, the structure of potatoes changes from a rigid raw material with high tortuosity to a structure with variable mechanical properties from the center to the surface and low tortuosity. The process involves unsaturated transport of oil, water, vapors and heat with the capillary and pore pressures playing a critical role to affect oil uptake. Besides, thousands of desirable and detrimental chemical compounds are generated during frying. High frying temperatures make instrumental techniques challenging, which leaves a considerable gap in our understanding of the underlying transport mechanisms. In such cases, performing computer simulations with multiscale porous media models allows filling the gaps in our knowledge of transport mechanisms, keeping track of chemical compounds transport and predicting thermomechanical changes in food biopolymers. While mathematical representation of these materials with multiphases, multispecies and continuously evolving structures has become possible with mixture theoretic approaches, challenges remain on collecting the material properties and validation data. Often a process may be occurring at a temperature much higher than the boiling point of water or at a subfreezing temperature, where property data acquisition by instrumental techniques is limited. It is also challenging to utilize molecular theories due to the involvement of macromolecules for which there is insufficient information on three-dimensional structures. This presentation will discuss some examples of porous media physics' applications in food science by presenting challenges and opportunities.

References

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Primary author: Prof. TAKHAR, Pawan Singh (University of Illinois at Urbana-Champaign)

Presenter: Prof. TAKHAR, Pawan Singh (University of Illinois at Urbana-Champaign)

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