Coupling deterministic and random sequential approaches for structure and texture prediction of a dairy oil-in-water emulsion.

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Introduction and objectives

Dairy products made of concentrated milk proteins powder and milk fat have been experimentally shown to behave like complex systems. The resulting textures depend on various factors, including concentration and type of proteins, nature of heat treatment and homogenization process. The aim of this paper is to combine two models in order to predict the composition of the interface of an homogenized oil-in-water emulsion, and the resulting bridges structure between the fat droplets. This structure is then correlated to the texture of the emulsion.

Methodology

The complexity of the system can be described through the interaction of a significant number of possible and concurrent phenomena occuring at different scales. The final texture depends on the size of the fat droplets and on the presence of bridges between them. The bridges are created by the denatured whey proteins in two ways: the denatured whey proteins can form aggregates with high bridging capability; or they can associate with casein micelles to form particles that are less prone to form bridges.

The first model predicts the quantities of both types of particles, given initial protein concentrations and a heat treatment characteristics.

The second model deals with the adsorption phenomena that occur during homogenization. It is based on a stochastic approach similar to concurrent random sequential adsorption, extended by considering interfaces in three dimensions, and by simulating fat droplets size distributions according to experimental data.

Protein particles spreading is also considered, as it significantly reduces the available surface.

Finally, bridge creation is simulated using a stochastic process that takes into account distances between fat droplets and positions of aggregates on interfaces.

Results and discussion

Free unknown parameters of both models have been learned on experimental data using an evolutionary optimization algorithm. The resulting model fits the experimental data, and is coherent with the macroscopic texture measurements.

Conclusions

This combination of a deterministic and a stochastic model shows remarkable results in replicating the behaviour of the complex artificial concentrated milk protein mix under study. Some weakness have been however pointed out, regarding the lack of information on processes occuring during heat treatment and on adsorption dynamics in the homogenizer. Further work will be focused on the development of a model that considers coalescence phenomena during adsorption, with a more sophisticated process for bridge creation.

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