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Modeling and Validation of the Crystallization Process in Food Sprays

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Abstract

A freezing model for food sprays has been implemented into the computational fluid dynamics code *KIVA-3* and validated with experimental data. The model consists of three stages. In the first stage, the cooling of the droplet down to the freezing temperature is described as a convective heat transfer process in turbulent flow. In the second stage, when the droplet has reached the freezing temperature, the solidification process is initiated via nucleation and crystal growth. It is assumed that the droplet solidification starts on the drop surface and moves towards the center. This inhomogeneous structure is taken into account by a progress variable that accounts for the different heat capacities of the liquid and solid states. After completion of the crystallization process, in stage three, the cooling of the solidified droplet (particle) is described again by a convective heat transfer process until the particle temperature is close to that of the gaseous environment. The freezing model constants have been determined from experimental data of a single cocoa butter droplet suspended in air. The subsequent spray validations were performed with data obtained from sprays of a cocoa butter melt in an experimental spray tower.

Key words: food sprays, spray freezing, cocoa butter crystallization

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