434h Effects of Processing Conditions and Formulation on Ice Crystallization in Scraped Surface Freezer

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Ice crystal size in ice cream plays an important role in determining the quality of the product. A small mean ice crystal size ranging from 10-20 µm is desired in order give a creamy mouthfeel, which can increase consumer's acceptance of ice creams, especially the reduced fat variety. Ice crystal size is affected by formulation, processing and storage conditions. During processing, nuclei formation must be promoted and ice crystal growth minimized to create many small ice crystals. The objectives of this research were to compare ice crystal size distributions (ICSD) of ice creams by altering latent heat generation, frictional heat input, rate of heat removal, and throughput rate through three processing parameters, draw temperature, dasher speed, and flow rate. The heat removed from the system is from latent heat generation and frictional heat input, which are related to draw temperature and dasher speed, respectively. An increase in frictional heat input causes an elevation of product temperature resulting in dissolution of small crystals and a larger mean ICSD. At lower draw temperatures, the coolant temperature decreases allowing for rapid nucleation and greater ice formation, releasing more latent heat. With slower throughput rates, ice remains in the barrel at temperatures where recrystallization occurs quickly resulting in larger ice crystal sizes. Ice cream mixes were made with either 28 dextrose equivalent (DE) corn syrup (CS), sucrose, or high fructose corn syrup (HFCS) as the sweetener. This was done to change the freezing point depression and the ice phase volume. Mix composition was 12% milkfat, 17% sweetener, 11.5% milk solids not fat (MSNF), 0.1% emulsifier, and 0.28% stabilizer, giving approximately 41% total solids. A Box-Behnken experimental design with additional center points for each sweetener was implemented using three levels of each processing variable: dasher speed, draw temperature, and flow rate. The freezing point depression of the mixes was measured using a thermal (seeding) method. The mixes were then frozen in a continuous Hoyer Frigus KF 80 F scraped surface heat exchanger (SSHE). All mixes were frozen at 80% overrun. Draw temperature and overrun were measured at the outlet. The ICSD for fresh drawn ice creams was also determined using a refrigerated glove box, a light microscope with a black and white video camera, and image analysis software. Mean ice crystal sizes were analyzed using an analysis of variance. Ice crystal sizes were significantly affected ($p < 0.05$) by draw temperature, dasher speed, and residence time. Residence time ($p<0.0001$) had the most pronounced affect on ice crystal size followed by draw temperature ($p=0.0005$) and dasher speed ($p=0.03$). Shorter residence times produced a smaller ice crystal size. Ice crystal sizes increased with increasing dasher speed and draw temperature. A linear regression model to predict mean ice crystal size through changes in sweetener and processing parameters was developed.