Title:

Water/ice transitions and food quality

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Abstract:

Water is without doubt the most important compound on planet Earth; it is omnipresent in almost all terrestrial parts. Although the water molecule seems to be a simple, tiny chemical compound, it is characterized by anomalous and strange properties. Some of its eccentricities are that the water volume expands on freezing, it is densest in the liquid state at 4ºC, and it has a surprisingly high heat capacity and odd viscosity. Most of these abnormalities, which make water unique, compared with other liquids, are due to the standard, tetrahedral, hydrogen bonded water network. Water also constitutes the dominant compound in most food systems and it is related with their freshness but also with the spoilage mechanisms upon storage.

In modern societies, preservation is employed mainly to ensure the quality of our diet, minimize food loss, and facilitate transportation. Freezing is the most widely used technique for food preservation, and it is very common on both domestic and industrial scales. When compared to other preservation techniques, freezing is advantageous because the decrease in microbial and enzymatic activity is attained without the use of preservatives or heating, which significantly alter the native structure and characteristics of the food. The freezing of food is based on the phase transition of unbound water into ice. More specifically, during freezing, when a biological system reaches its nucleation temperature, the first group of nuclei can be formed in both extracellular and intracellular fluids. Nucleation is followed by the growth of dendrites resulting in growth of crystals, the size of which depends on several freezing parameters. During freezing, the majority of a food matrix will transform into ice. The interactions between nucleation and crystal growth are of great importance, as they are responsible for the size, distribution, and morphology of the resultant ice crystals. Very often, frozen food has to be thawed prior to consumption, which also an important step based on the reverse transition of ice into water. Therefore, the form of ice crystals is crucial to the final quality of the frozen food, because they can cause mechanical stress and extended irreversible damage to the cellular structure which in turn degrades the texture, color, taste, and nutritional value of the food.

In recent years several studies have been carried out and many innovative techniques and patents have been introduced for the control of ice nucleation and the subsequent crystal growth during freezing as well as their controlled melting upon thawing. Aspects and outcomes of those methods will be discussed.