Influence of ISP from a polar sea-ice microalga on the microstructure of frozen cream as measured by cryo-Raman microscopy

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Objectives

The occurrence of recrystallization and large ice areas after storage of frozen food products makes the use of ice-structuring proteins (ISPs) in food products meaningful. Food products are frozen to extend shelf-life during long storage periods while preservation of the overall sensoric quality. Recrystallization processes alter and, in the worst case, damage the structure of the food, resulting in an unsightly thawed e.g. cream cake or cream puff product. Freezing and freeze storage behaviour of various food products should be investigated in order to optimize the manufacturing of frozen products and to maintain the product quality with appropriate storage until the consumers usage.

We present a study on the influence of ice-structuring proteins, isolated from the sea-ice microalgae *Fragilariopsis cylindrus* (fcISP), on frozen cream. The two main phases of the frozen cream, i.e. ice and fat, have been detected by cryo-Raman spectroscopy and visualized. The advantage of the unique cryo-Raman spectroscopy system at AWI is that the individual components can be detected not only qualitatively, but also localized in the frozen sample.

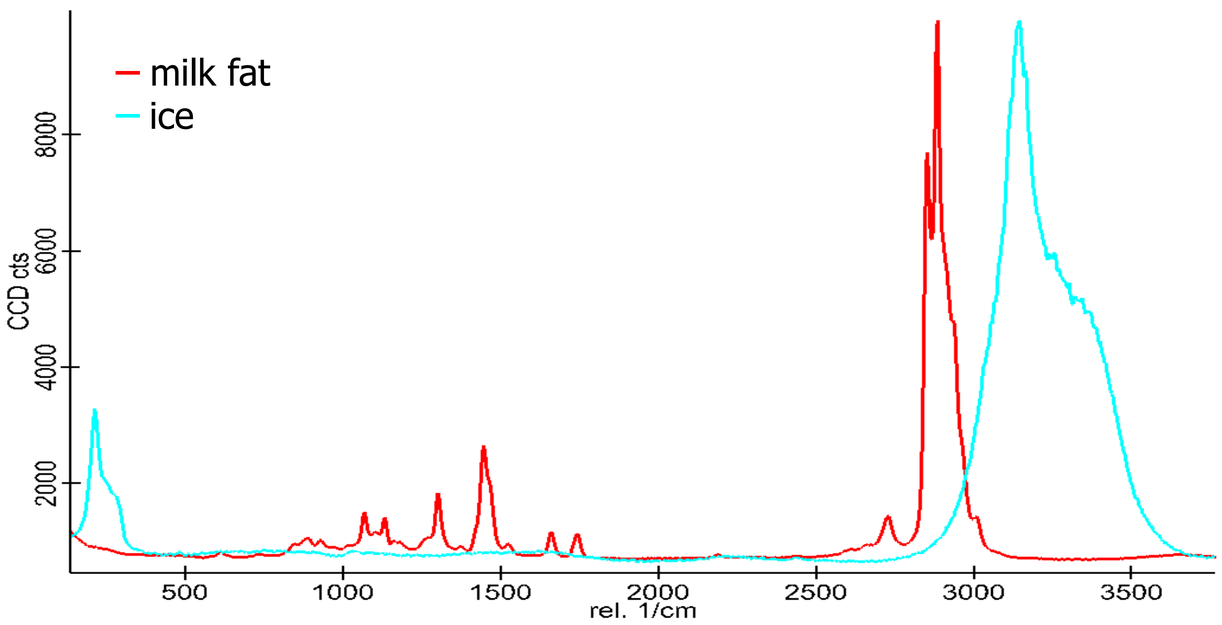
Methods

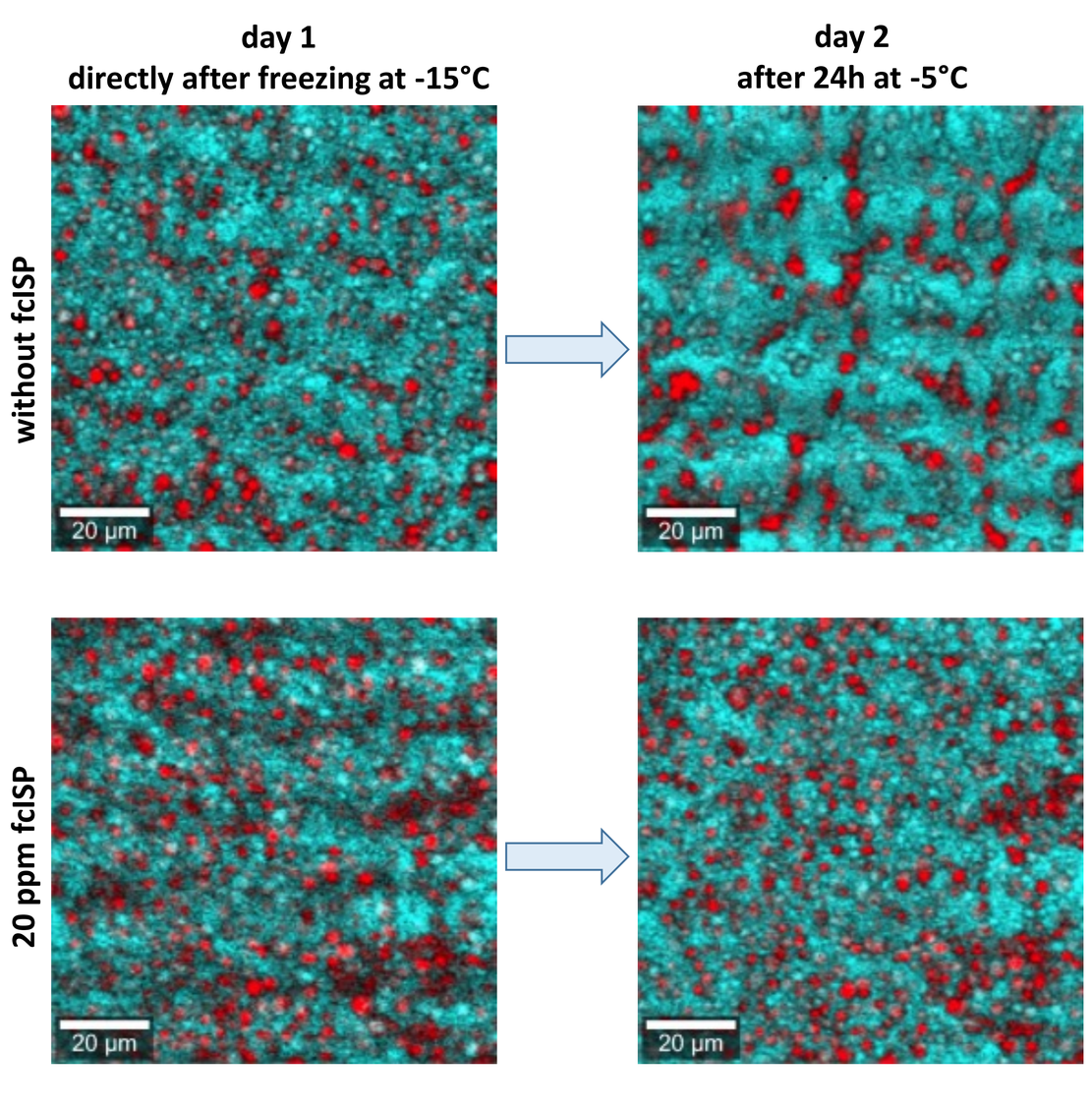
Raman spectroscopy utilizes the inelastic scattering of light photons on chemical bonds of molecules or molecular groups, called Raman effect. Due to vibrations in the chemical bonds the interaction with photons causes specific energy shifts in the back scattered light that appear in a Raman spectrum. The Raman spectrum is unique for each chemical composition and can provide qualitative and quantitative information of the material. On the basis of characteristic spectral ranges, confocal Raman microscopy allows a reliable identification and imaging of ice (3.080 - 3.200 cm^{-1}) and milk fat (2.855 - 2.935 cm^{-1}) in frozen whipped cream. Raman measurements were performed on a WITec Alpha 300R microspectroscope, a unique system located in the AWI ice labs at -15°C .

Liquid cream with 33% fat was homogenized with 20% of a 100 ppm fcISP solution. A reference cream sample was homogenized with 20% distilled water. A droplet of each sample (10 µL) was poured on a microscope slide and covered with a cover grass. Both samples were frozen at -15°C and imaged by cryo-Raman macroscopy. The samples were kept for 24h at -5°C. Finally, there were imaged again at the same position at -15°C.

Results

The Raman spectra presented below allow for a clear differentiation of milk fat and ice in the frozen sample. The milk fat phase, shown in red on the pictures, is discontinuous in the samples and appears as typical globules of around 1 µm diameter. In contrast, the ice phase, shown in blue, appears as a continuous phase.
Directly after freezing, both samples (with and without fcISP) have a similar microstructure. After 24h storage at -5°C, however, a strong recrystallization of the ice phase is visible in the sample without ISP. Coalescence of fat globules is also visible. In contrast, the microstructure of the sample with 20 ppm fcISP is almost unchanged.





Conclusion

We show that the fat and ice structure in frozen cream, and their temperature-induced changes, are well detectable by cryo-Raman spectroscopy. Furthermore, the effect of fcISPs on the microstructure shows an inhibition of ice recrystallization, leading to smaller grain aggregates and a finer fat distribution than without fcISPs. We therefore suggest that fcISPs are an effective mean in controlling recrystallization processes in frozen goods.

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