INDUSTRIAL PILOT PROJECT

Using SAXS/WAXS to study fat crystal morphology and crystallization kinetics in emulsified and continuous fat systems

THE INDUSTRIAL CHALLENGE

AAK is a leading producer of speciality fats and oils for the food industry. Vegetable fats and oils are crucial ingredients in sustainable plant-based food products to obtain desired mouthfeel, texture, and taste release. It is well known that fat crystallization influences the functionality and final structure of different fat-containing food products, and that it in turn is influenced by foreign surfaces. Many plant-based alternatives to for example cream, yoghurt and cheese are based on oil in water emulsions where fat is dispersed in a water phase as many small fat droplets. How different fats crystallize in these fat droplets is important for final product quality and function. A product with related challenges is chocolate, where fat crystallization is influenced by the surfaces induced by the addition of sugar and cocoa particles.

WHY USING A LARGE SCALE FACILITY

X-ray scattering is a powerful tool to reveal the lamella structure and the fat crystal polymorphs. The polymorphs are shown as sharp peaks. The fat structure depends on the thermal history. In case of the quick cooling used in this study, only the intense synchrotron-based X-ray scattering could follow the fat crystallization in bulk and emulsions with a desired time resolution of sub-seconds, while lab-based counterpart need minutes to reach a decent signal.

HOW THE WORK WAS DONE

The effects of two different fats and three emulsifiers in bulk and emulsions were investigated by time-temperature controlled small and wide X-ray scattering (SAXS/WAXS) experiments at NCD-SWEET beamline of ALBA in Spain. Secondly, time-temperature controlled SAXS experiments were performed at the CoSAXS beamline of MAX IV, Sweden to investigate the effect of the addition of sugar, cocoa particle, and two additional fats on fat crystallization in cocoa butter . In both cases, the Linkam heating stage was used for temperature control. The fat was melted at 90°C and cooled down to 5°C. Mac Malfois, ALBA, and Ann Terry, MAX IV, are acknowledge for the beamtime supports.

Figure Linkam capillary temperature cell at CoSAXS, MAX IV.

THE RESULTS AND EXPECTED IMPACT

By following the cooling and preservation stage, for the emulsions, we could conclude that the confinement and additional surfaces imposed by the emulsification have a large impact on the fat crystallization kinetics. It was found that the initiation of the fat crystallization and the type of polymorphs formed depend on the emulsifier. Figure 2 shows the increase of crystallinity as a function of time and decreasing temperature for bulk and two emulsions. The emulsifiers generally delayed the start of crystallistaion and formation of new polymorphs. For the chocolate, the results showed that the sugar and cocoa particles mainly work as fillers at length scales above a few nanometers and did not influence the lamella development so much.

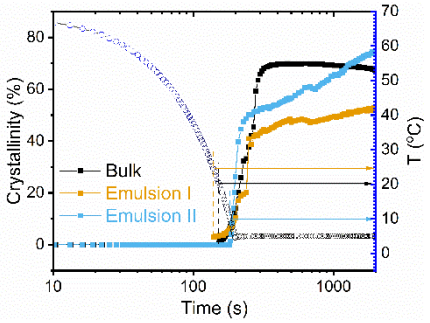

Figure 2. Crystallinity of the bulk fat and emulsions.

In all, time resolution, sensitivity and the combination of SAXS/WAXS are essential to analyze fat crystallization kinetics and polymorph development in foods. The tools can be used for designing fat systems and to increase the mechanistic understanding.

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