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Ultra-small angle neutron scattering studies on milk and cheese curd formation

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Milk and milk products are essential to global nutrition and the world-wide food industry. We have carried out ultra-small angle neutron scattering (USANS) studies on samples of “as-is” commercial food-grade milk and samples with added rennet, as the first step in cheese formation. Casein protein micelles are present in both skim and whole milk with median diameters of 120 nm with 16% polydispersity. In homogenized milk (3.25% milk fat) the median diameters of fat globules are 0.54 μm with a polydispersity closer to 40%. Despite various structural features implied by microscopy (rough kappa casein molecules, porosity, a membrane layer for fat globules, co-aggregation of micelles and fats) both of these components can be modelled by smooth, independent, uniform spheres. Contrast matching gives scattering length densities (SLD) of $0.20 \times 10^{-6} \text{ \AA}^{-2}$ for fats and $0.89 \times 10^{-6} \text{ \AA}^{-2}$ for casein micelles. A typical protein SLD is twice this value so the micelles are likely quite hydrated. Rennet dramatically increases the scattering at the smallest angles, consistent with the formation of large structures. As the curd making process continues, we observe further aggregation.

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