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Abstract

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Investigation into the reconstitution, structure and formation of dairy derived systems and gels: Use of Advanced Microscopy and Ultrasound Spectroscopy

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The manufacture, transport and reconstitution of dairy derived powders are of industrial interest on a global scale. The production process needs to be understood and characterised physically in order to deliver a final product that has the same qualities as those made from native fresh milks. A combination of Super-resolution imaging and Ultrasound spectroscopy provides an overview of the dynamics, interactions and structural properties of reconstituted dairy products. The speed of sound and acoustic attenuation are dependent on a material's physical properties. Ultrasound Reflection Spectroscopy has been used to monitor the dissolutions of dairy powders and protein aggregation under changing pH. The attenuation spectrum can be used to size particles in concentrated colloidal dispersions without dilution and is sensitive to slow temporal rehydration kinetics in reconstituting systems.

Stimulated Emission Depletion (STED) microscopy has been used to image dairy gels, where protein structures have been resolved to under 100 nm using an imaging protocol, that aside from dye addition is non-perturbative. Quantitative image analysis has been developed using an empirically validated model to extract the size of protein domains, interpore distance and fractal dimension of the protein network. These three parameters can discriminate between gels produced from fresh or reconstituted milk and between gels induced by acidification or renneting. In two colour images fat droplet size can be extracted and the distance between fat droplets and local maximum protein distribution can be determined. The distance between fat and protein changes significantly following homogenisation. The distribution and quantity of protein around individual fat droplets can be determined with region specific analysis. Coherent Anti-Stokes Raman Scattering (CARS) microscopy provides a label free negative control for the use of a fluorescent dye in STED imaging. Fluorescence time-life imaging provides spatially resolved micro-viscosity measurements within dairy gels and can be correlated to the different levels of moisture binding in gels produced from milks with different thermal processing histories.

Effective combination of these techniques provides a unique insight into the entire process of characterising a reconstituted dairy derived gel with unprecedented temporal and spatial resolutions for given conditions.