QUANTITATIVE STRUCTURAL ANALYSIS OF FAT CRYSTAL NETWORKS BY MEANS OF RAMAN IMAGING

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STRUCTURAL FEATURES OF FAT CRYSTAL NETWORKS

Determining the structural features of fat crystal networks is critical for designing healthier and more sustainably manufactured lipid based food products with superior sensory properties. The fractal nature of fat crystal networks currently presents a bottleneck in their structural analysis, as a range of distinct features can be detected on different length scales [1]. The techniques that are currently available to assess micron scale structural features are compromised with respect to sample preparation and ability to quantitatively assess fat and oil in a spatially resolved manner.

RAMAN IMAGING FOR STRUCTURAL ANALYSIS

As a non-invasive hyperspectral technique, Raman imaging coupled to multivariate curve resolution can address these bottlenecks, but its capabilities were hitherto unexplored for fat-based food products. The relatively rapid acquisition of images with a wide field of view and high resolution (11 minutes for 50 by 50 µm with 0.23 µm lateral resolution) make Raman imaging a good candidate for resolving changes in fat crystal networks induced by ageing or shear. In this study, multivariate curve resolution (MCR) with an Alternating Least Squares (ALS) algorithm is used for the analysis of hyperspectral image data. The MCR-ALS approach employs a constrained decomposition of the 3D data array using a fixed set of pure component spectra that are also present in the sample (sunflower oil and solid fat).

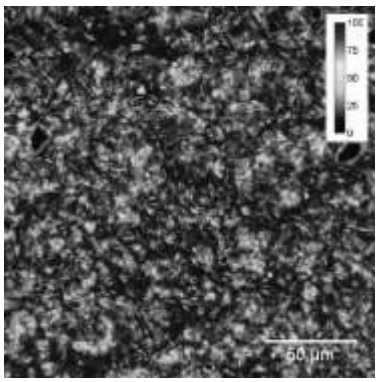

Figure 1: Raman MCR concentration map of solid fat in a dispersion of 20% solid fat (MFC) in sunflower oil.

The combination of Raman imaging with MCR-ALS was applied to dispersions of micronized fat crystals (MFC) in oil to assess the fat crystal floc size, 2D and 3D fractal network dimension, floc porosity and solid fat content in the continuous oil phase. The floc size increases with solid fat content and decreases with applied shear. The researched MFC dispersions have very porous flocs (66-70% oil), with a significant amount of fat in the oil phase (13-18% fat), both novel observations in the field. The fractal dimension of the MFC was found to be constant across the tested solid fat content range, with a 1.0 difference between 2D and 3D fractal dimensions, indicative of a self-similar rather than self-affine network. The wealth of quantitative structural features that can be obtained by Raman imaging complement the current analytical toolbox for establishing the intricate relations between multiscale structure and macroscopic properties of lipid based food products.

REFERENCES

[1] A. G. Marangoni, "The nature of fractality in fat crystal networks," *Trends Food Sci. Technol.*, vol. 13, no. 2, pp. 37–47, 2002.