

## **Edible nanostructures – the pleasures of chocolate**

Alejandro G. Marangoni  
Professor and Canada Research Chair  
Food and Soft Materials Science  
Guelph-Waterloo Physics Institute  
Dept. of Food Science  
University of Guelph  
Guelph, ON N1G2W1  
Canada

The functional properties of fats and fat-structured foods, such as butter and chocolate, are a function of the structure and rheological properties of their underlying fat crystal networks. This fat crystal network arises upon crystallization of triacylglycerol molecules present in the fat into nanocrystals which rapidly aggregate into progressively larger mesostructures until a network is formed. Work in our laboratory has established quantitative relationships between the different levels of structure present in fats, from chemical composition, crystallization kinetics, solid state structure and microstructure to mechanical properties. A fractal scaling model was developed to explain these relationships, which has helped explain why fats with similar solid fat contents can have very different mechanical responses, and has changed our view of a fat from an orthodox crystalline solid to a colloidal gel. More recent work has focused on the characterization of the nanoscale of these plastic soft solids. Cryo-TEM and small-angle X-ray scattering techniques have revealed the “primary” crystals present in these materials in fact are an agglomerate of platelet-shaped single crystals of  $\sim 100 \times 60 \times 40$  nm dimensions. These clusters, in turn, grow by cluster-cluster aggregation into larger fractal aggregates until a space-filling network is formed. We have also started characterizing inter-crystalline interaction forces using Lifshitz theory. Our measurements suggest that van der Waals’ forces at the nanoscale are sufficient to explain the mechanical strength of a fat, and that, very surprisingly. Using synchrotron X-ray diffraction, our group was the first to report that fats can be oriented crystallographically by laminar shear, basically a nanotemplating process. The nanotemplated fat demonstrates increased mechanical strength and is more impermeable to oil. Moreover, we have also demonstrated the universality in the acceleration of polymorphic transformations in fats in a shear field. Our efforts also include the development of kinetic models to mechanistically describe phase transformation kinetics from solid state structure data, as well building a nanotemplating machine. In this talk we discuss cocoa butter, the structuring material in chocolate and confections, from solid-state structure and polymorphism to melting behavior and mechanical strength. The reason for a tempering chocolate while mixing will become clear upon review of the effects of shear on the crystallization behavior of cocoa butter. Recent advances on our understanding of how oil migrates through chocolate and causes blooming and chocolate softening will also be discussed.

You will never look at chocolate in the same way after this talk.