The Nano World of Espresso: Oil Droplets and Rigid Polymer Structures Shape the Shot

Pascal Bertsch [1,2], Abinaya Subramaniyan [1], Chahan Yeretzian [3], Stefan Salentinig [1,2]

[1] University of Fribourg, Department of Chemistry, Ch. du Musée 9, 1700 Fribourg, Switzerland
[2] University of Fribourg, Food Research and Innovation Center, Ch. du Musée 9, 1700 Fribourg, Switzerland
[3] Institute of Chemistry and Biological Chemistry, Coffee Excellence Center, Zurich University of Applied Sciences, Einsiedlerstrasse 31, 8820 Wädenswil, Switzerland

pascal.bertsch@unifr.ch

Coffee is one of the most popular beverages worldwide, and the preparation of the perfect espresso has become an entire culinary discipline that combines science and craftsmanship. Espresso involves the extraction of finely ground coffee under high pressure, yielding a concentrated coffee rich in emulsified lipids, polysaccharides, and solids that contribute to its unique aroma and mouthfeel. While the aroma and flavor compounds in coffee have been meticulously studied for decades, relatively few studies have addressed these colloidal structures. In this presentation, I will present our insights on the colloidal structures present in our daily coffee. We combined imaging, scattering, and rheological techniques to unravel the size, structure, and interactions of espresso colloids. We find extracted oil droplets, mostly in the submicron range, stabilized by protein-polysaccharide complexes at their interface, and relatively long fiber-like polymer structures. The size of extracted oil droplets gradually decreases as a function of extraction time, and the first fraction shows clear evidence for unfolded polymers in its scattering profile. The rheological characterization of espresso revealed that the first milliliters of espresso exhibit a considerable shear viscosity and even viscoelasticity, while later fractions have negligible viscosity. Combined, our results show that the size and structure of extracted lipids and polymers strongly depend on the extraction time. Mostly the first 6-ml fraction (of a 18 mL espresso) contributes to the 'body' of espresso due to its highest concentration of dispersed colloids and the early extraction of unfolded polymers.

Keywords:
Coffee, Emulsions, Polymers, SAXS, Rheology

References:

Bertsch P, Subramaniyan A, Yeretzian C, Salentinig S. The Nano World of Espresso: Oil Droplets and Rigid Polymer Structures Shape the Shot. ChemRxiv. 2025; doi:10.26434/chemrxiv-2025-r0nrj

Acknowledgements:
The Swiss National Science Foundation funded this work through project No. 186251 and the National Center of Competences in Research (NCCR) Bioinspired Materials