# Rheology of aerated buttercream icings

**WILSON I. (1), HAYES D. (1), MURPHY A. (1), ROSARIO FERNANDES R. (2), PERALTA J. (3), MEZA B. (3), ZORRILLA S. (3)**
1 University of Cambridge, Cambridge, United Kingdom
2 University of Illinois at Urbana-Champaign, Urbana, United States
3 Instituto de Desarrollo Tecnolico para la Industria Quica (INTEC), Santa Fe, Argentina

*Objective*
Aerated icings are a fat-rich, sweet and uncooked type of glaze made by mixing powdered sugar and fat (e.g. butter, vegetable oil shortening) to form a bubbly fluid. An ideal aerated icing will exhibit viscoplasticity, flowing when the imposed stresses exceed a critical (yield) stress and retaining its shape otherwise.
Much research on bubbly liquid rheology has focused on systems with a Newtonian continuous phase. In aerated icings the continuous phase is non-Newtonian, with a relatively high critical stress, making it difficult to characterise in standard rotational rheometers.
Methods developed for dense suspensions (pastes) were used here to quantify the yielding, flow, and creep behaviour of aerated icings, and to determine how aeration determines these properties.
*Methods*
Aerated icings were prepared by mixing sugar and unsalted butter in the mass ratio 2:1 followed by whisking in a planetary mixer. The critical stress was studied using a controlled stress rheometer equipped with a vane tool to reduce wall slip effects. Extensional flow behaviour was studied by squeeze flow, using lubricated discs to reduce wall friction. The data were fitted to Herschel-Bulkley fluid models. The impact of replacing some of the butter by a concentrated native starch suspension to give a reduced fat product was also investigated.
*Results*
The icing air volume fraction, Ø, increased with mixing time, following the relationship , where the parameters  and depended on mixing speed and mixer design. A simple mechanistic model for this behaviour is presented. Optical microscopy indicated that the bubble sizes were log-normally distributed with a modal value of approximately 10 µm.
The critical stress decreased with increasing Ø, as expected, but the dependency differed from existing models for bubbly liquids. The Herschel-Bulkley fluid parameters were also dependent on Ø. Noticeable deaeration occurred over a period of several hours, indicating that the continuous phase is not a perfect yield stress fluid.
*Conclusions*
The rheology of these aerated materials is controlled by the air volume fraction and hence determined by the aeration process. The observed behaviour can be quantified reasonably well by simple models based on physical processes.