Food and Function

Frictional Behaviour of Molten Chocolate as a Function of Fat Content

Supplementary Material

TABLE S1 *Yield stress (σ_y), consistency index (K) and flow behaviour index (n) of chocolate as a function of solid fraction (%), predicted by fitting the Herschel-Bulkley model to viscosity measurements. Note that 0% refers to pure cocoa butter, and 71 – 74% correspond to chocolates of varying fat content.*

Solid Fraction (w/w)	σ_y (Pa)	K (Pa.s)	n
0 %	0.0	0.05	1.00
1.5 %	0.0	0.06	1.00
11.1 %	0.0	0.06	0.99
22.2 %	0.2	0.09	0.98
37.0 %	0.3	0.21	0.93
51.8 %	2.0	0.54	0.92
59.2 %	4.6	1.05	0.90
66.6 %	13.6	2.76	0.88
68.8 %	11.9	7.43	0.77
71 %	20.1	19.71	0.70
73 %	25.6	28.09	0.69
74 %	25.1	27.72	0.69

TABLE S2 *Yield stress (σ_y), consistency index (K) and flow behaviour index (n) of 0.3 to 1% PGPR added to 26% fat chocolate, predicted by fitting the Herschel-Bulkley model to viscosity measurements. Note: PGPR added = mass of PGPR/(mass of PGPR + mass of chocolate).*

PGPR added (w/w)	**σ_y (Pa)**	**K (Pa.s)**	**n**
0 % (no PGPR)	25.1	27.72	0.69
0.3 %	9.7	11.68	0.82
0.4 %	10.4	9.33	0.87
0.7 %	1.5	6.15	0.93
1 %	0.4	5.59	0.95

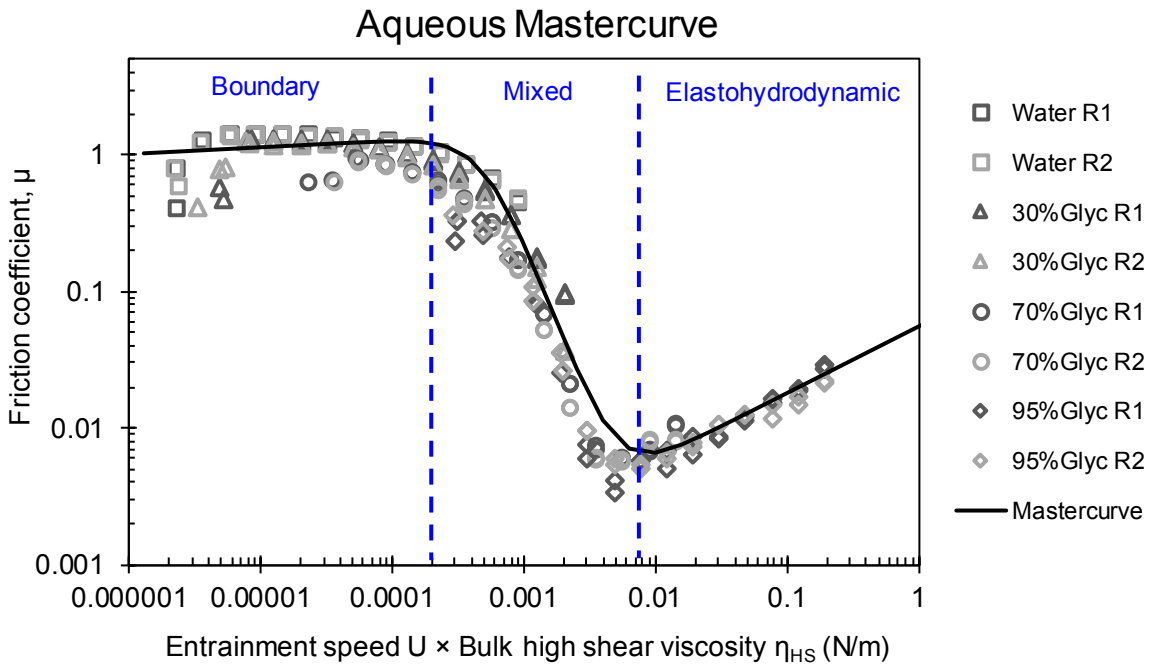

FIGURE S1 *Empirical mastercurve generated from friction measurements on water and glycerol solutions between the same smooth hydrophobic surfaces used to test all chocolate samples. The mastercurve demonstrates the typical Stribeck curve for a single-phase aqueous Newtonian liquid across all three lubrication regimes: boundary, mixed and elastohydrodynamic lubrication. Film thickness decreases with decreasing speed, such that elastohydrodynamic friction depends on fluid viscosity (thick film) and boundary friction depends on properties of the surfaces (thin film).*

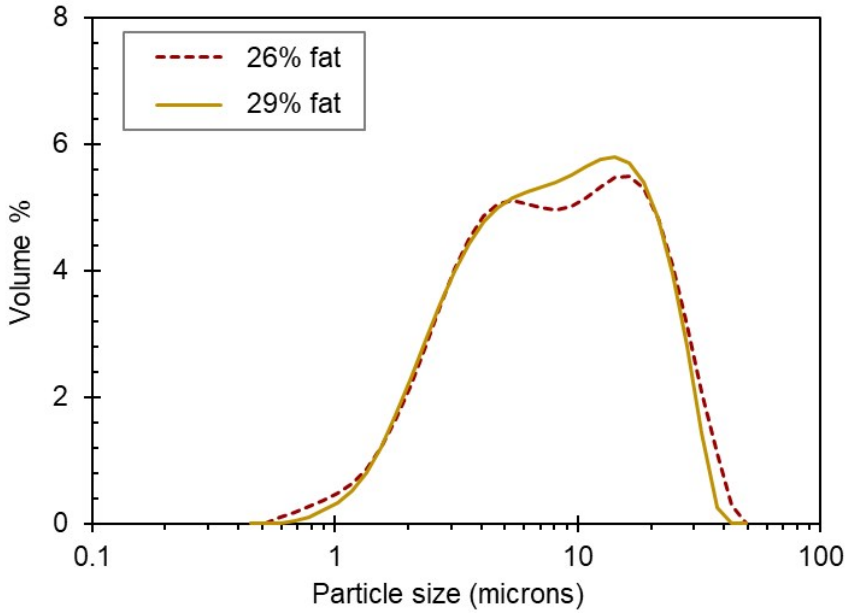

FIGURE S2 Particle size distribution for 26 and 29% fat chocolates. Corresponding values of (a) volume-weighted mean diameter, D[4,3] = 10.79 μm (26% fat) and 10.33 μm (29% fat); (b) surface-weighted mean diameter, D[3,2] = 5.22 μm (26% fat) and 5.44 μm (29% fat). Particle size was measured with on a Malvern Mastersizer 2000. Chocolate was melted and dispersed in sunflower oil at 40 °C. The refractive index used for sunflower oil and chocolate were 1.469 and 1.59, respectively.

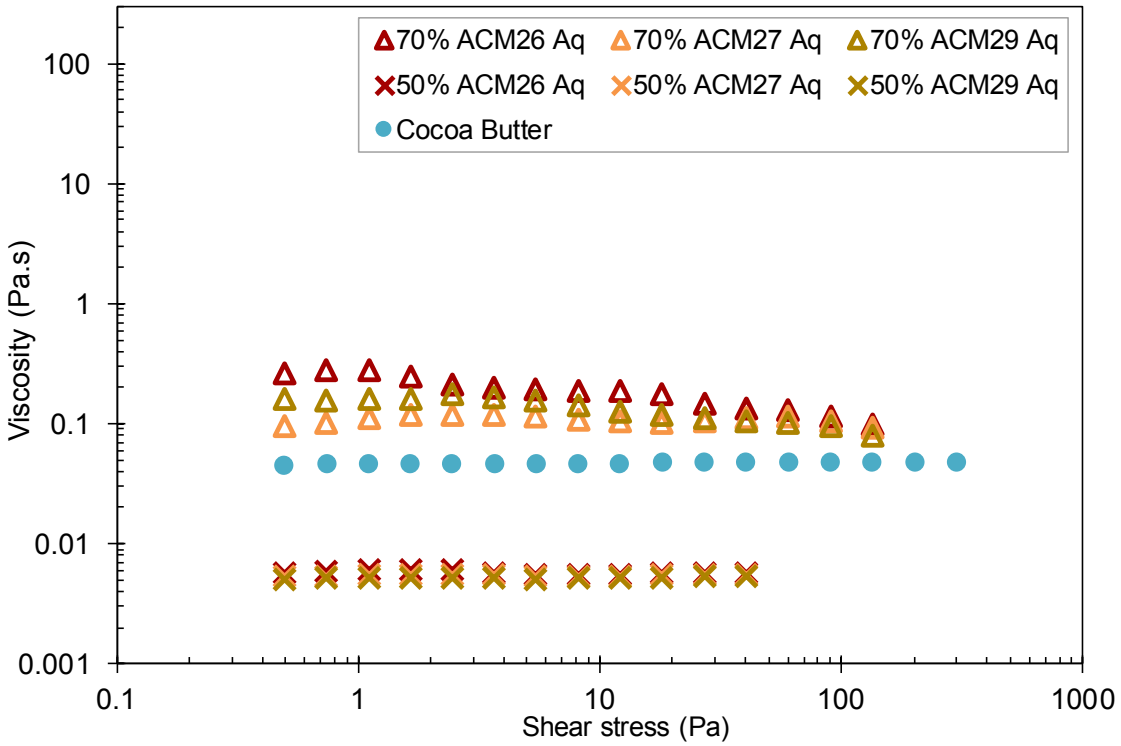

FIGURE S3 *Viscosity of liquid phases in model bolus systems, obtained by centrifuging chocolate-PBS mixtures. % indicates the mass of chocolate/(mass of chocolate + mass of PBS), 26F, 27F and 29F represent 26, 27 and 29% fat.*

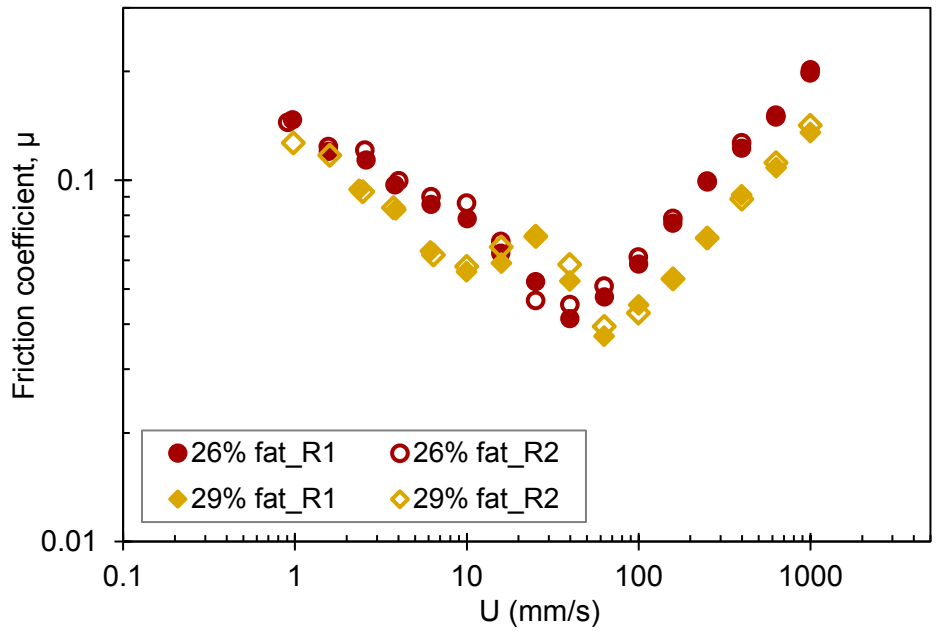

FIGURE S4 *Example of variation between repeated measurements, shown for molten chocolate with 26% and 29% fat. Friction coefficient was measured between the same smooth, hydrophobic PDMS tribopair to ensure a fair comparison.*