Role of water structure in the presence of sugars and its effect on emulsion formation and properties

Amir K Asghari[a,b], Ian Norton[a], Fotios Spyropoulos[a], Thomas Mills[a], Richard Greenwood[a], Peter Sadd[b]

[a.] School of Chemical Engineering, University of Birmingham, Edgbaston B15 2TT
[b.] Premier Foods Central Technical, The Lord Rank Centre, High Wycombe, HP12 3QS

Emulsifiers are primarily used in the manufacture of cakes because it is believed they aid foaming, emulsification, and batter stability. Further benefits include the homogeneous dispersion of fat in the batter, greater tolerance to recipe formulation changes, and the possibility of changing from multistage mixing to an all-in mixing method (Sahi, 2008). However they are perceived as artificial ingredients by consumers, so alternative ways of getting the same benefits are of interest.

For the purpose of this study the effect of three different sugars (glucose, sucrose, and maltodextrin) on emulsion formation and properties has been investigated.

Along with the effect on emulsion properties, the effect on the interfacial properties (interfacial tension - IFT) has also been measured, to assess the effect of these (poly) saccharides on emulsifier functionality.

The emulsions were produced using a high shear static mixer and were studied by analysing the droplet diameters and the apparent viscosity of the continuous phase (viscosity of the continuous phase as a function of shear rate).

Three different phase volumes of oil (10, 20 & 40 wt. %) and three different concentrations of emulsifier Tween 60 (0.1, 1 & 5 wt. %) have been studied at seven different sugar concentrations (0-60 wt. %).

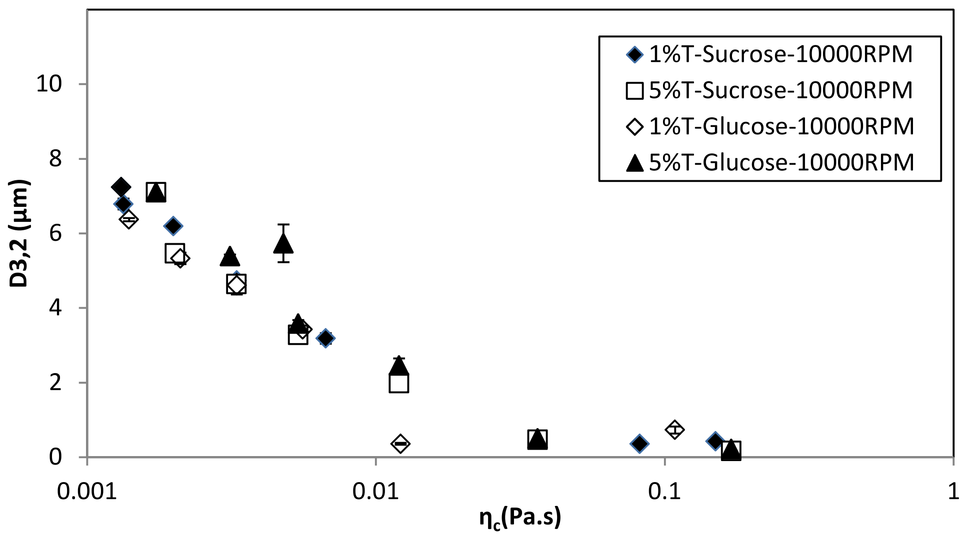

Figure 1- Comparison of the evolution of the droplet size as a function of the apparent viscosity using sucrose and glucose at 1 & 5 wt.% Tween 60 (all produced at 10000 RPM)

Figure 1 shows the effect of η_c (continuous phase viscosity) on the droplet diameter. The plot shows that although η_c has a clear effect on the droplet diameter it is not the determining factor as droplet diameters of <1μm can be achieved for $0.01 \leq \eta_c \geq 0.1$. The increase in the viscosity does mean higher energy dissipation rates around the mixer head; hence the higher break-up rates observed, however the trend is not linear as expected.

The static interfacial tensions of oil-water interface with increasing sugar concentrations were determined using the Wilhelmy plate method.

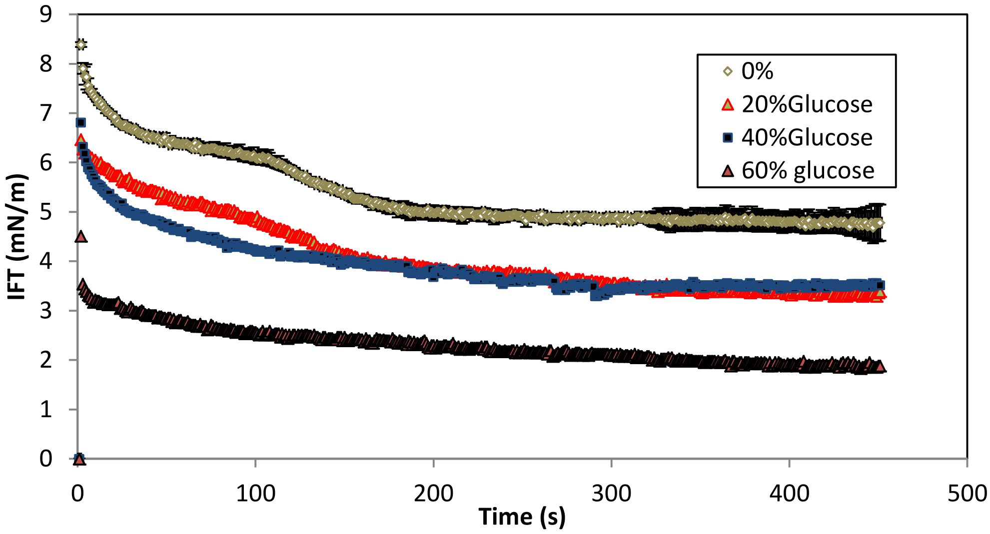

Figure 2 - The reduction in the Oil-Water Interfacial Tension with increasing glucose concentration (all measurements conducted at room temperature)

With increasing concentration of glucose in the presence of 5wt% Tween 60, the asymptotic interfacial tension was lowered significantly from ~5mN/m down to ~2mN/m. It must be noted that at 0, 20 and 40 wt.% glucose the interfacial tensions observed above are very comparable to those of 1% Tween and glucose solutions. The differences in the interfacial tension observed at different concentrations of different sugars are discussed as a function of the water structure within the presentation and its effects on the Tween functionality.

In conclusion it is clear that emulsifier functionality can be affected by additional ingredients such as different sugars. In this case the sugar is thought to affect water structuring which, can be interpreted as a depletion of the solute molecules at the water-oil interface. This combined with the presence of Tween leads to a reduction of IFT.

References

Sahi, S. S. (2008). Cake Emulsions. In S. G. Sumnu, & S. Sahin, *Food Engineering Aspects of Baking Sweet Goods.* Boca Raton, FL: Taylor & Francis Group.