The Effects of Shear and Thermal History on Whey Protein Fluid Gel Microstructures

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The role that fats play within food with respect to texture and physical properties is vital for consumer satisfaction. However, a high concentration of fat in an everyday diet is a risk factor for obesity and other health related diseases associated with a poor diet. Fluid gels may function as suitable fat mimetics as they can be prepared to mimic the physio-mechanical properties of fat components in foods.

Fluid gels are semi-solid materials formed of gelled particles suspended within an un-gelled medium[1]. The term fluid gel can be further subcategorised into two areas; Shear gels and microgels. Shear gels are produced when gelation occurs within a shear field, preventing a complete network to form, producing smaller gel particles. Microgels on the other hand use a two-step emulsion route[2] to form spherical gel beads within a droplet. The beads can then be removed from the continuous phase and redispersed in water. In both cases however, particle size and microstructure can be controlled by changing the parameters in the preparation stage.

This has lead to an investigation into the effects of particle size and microstructure by varying;

- **Shear Rate**
- **Heating and Cooling Rate**
- **Holding Time**

The application of varying shear rates to the gelling system has confirmed that there is a correlation between shear rate and particle size (fig.1). The gelling of whey protein is a two-step method. The first step consists of denaturing the whey globules leading to the unfolding and exposing of the hydrophobic groups[3]. This is then followed by an aggregation step forming structured particles[4]. Therefore by changing the processing environment for instance the heating and cooling rate, holding time and level of shear, the aggregate structures can be controlled producing tailored microstructures. This allows the physio-mechanical properties to also be controlled.

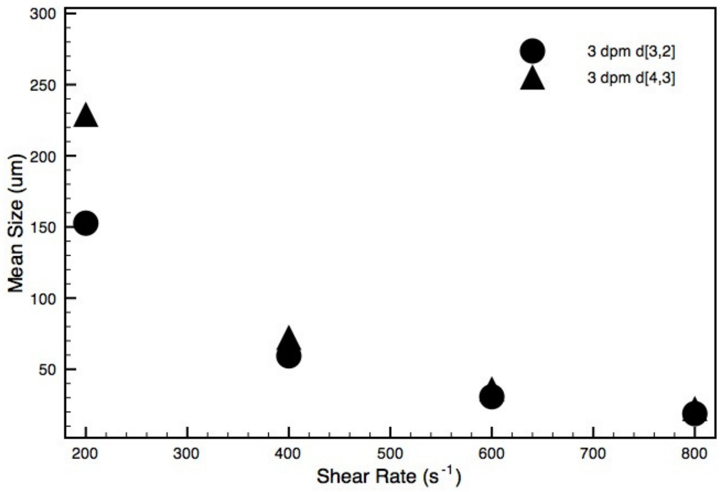
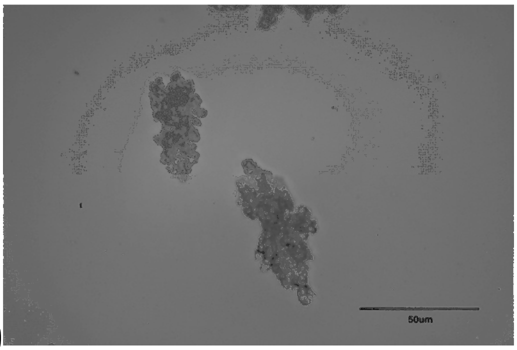


Figure 1: Relationship showing exponential decrease in particle size with increasing shear. (●) Represents surface weighted means (d[3,2]) and (▲) represents volume weighted means (d[4,3]).

The results obtained from the initial experiments investigating the effects of shear rate on particle size (fig.1) have shown an exponential decrease in the size with increasing the shear rate. Optical light microscopy of the fluid gel particles has also been used to determine their morphology (fig.2).

(a)


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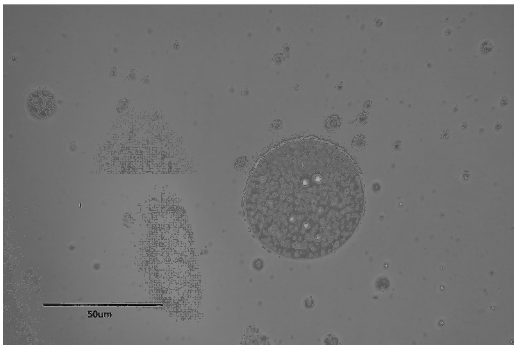

Figure 2: Optical microscopy of fluid gel particle produced via shear (600s^{-1}) (a) and via emulsion route (b) at 40x magnification.

Light microscopy (fig.2) shows the difference in morphology between shear and microgel particles in both cases consisting of aggregates. However, the use of an emulsion route has controlled the protein particle structure to be spherical. These results have therefore shown the ability to control both size and particle shape of protein based fluid gels. In the future we will investigate the changes in rheology and tribology arising from the changes found in the microstructure.

1. G. Cassin, I. Appelqvist, V. Normand, and I. T. Norton, *Colloid & Polymer Science*, 2000, **278**, 777–782.
2. S. Matsumoto, Y. Kita, and D. Yonezawa, *Journal of Colloid and Interface Science*, 1976, **57**, 353–361.
3. W. H. Sawyer, *Journal of Dairy Science*, 1968, **51**, 323–329.
4. E. R. Morris and D. a Rees, *British medical bulletin*, 1978, **34**, 49–53.