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***RHEOLOGY AND MICROSTRUCTURE
OF ACID MILK GELS : The Role of
Fat Globule Membrane***

A THESIS
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ABSTRACT

The objectives of this study were to investigate the effects of different compositions of fat globule membranes as well as heat treatment of reconstituted skim milk, on the properties of acid milk gels. Rheological and microstructural properties of acid milk gels were determined.

Recombined milks were made by mixing reconstituted skim milk with homogenised (20.7 and 3.5MPa, first and second stage pressures, respectively) emulsions which were stabilised by low-heat, medium-heat or high-heat skim milk powder, sodium caseinate, whey protein concentrate, heated (80 °C for 30 min) whey protein concentrate, Tween 60 or the native fat globule membrane of whole milk. To study the effect of milk heat treatment, unheated reconstituted skim milk or milk heated at 80 °C for 30 min was used for making recombined milk. Gels were formed by acidification of recombined milk with glucono- δ -lactone by incubating at 30 °C for 16 h.

Each type of emulsion was characterised by determining the size distribution of fat globules, protein load and composition of fat globule membrane. The average fat globule size in the emulsion systems varied from 0.66 to 0.48 μm . Emulsions made with low-heat skim milk powder had the highest protein load (7.05 mg/m^2), because of the adsorption of large particles (casein micelles) on to fat globules. In contrast, emulsion systems made with whey protein concentrate had the lowest protein load (1.13 mg/m^2). The membrane of emulsions stabilised by skim milk powder solutions contained both caseins and whey proteins while whey protein concentrate stabilised emulsions had both β -lactoglobulin than α -lactalbumin

adsorbed onto the fat globule surface. The membrane of Na caseinate stabilised emulsions contained all caseins at the surface.

The rheological properties of recombined milk during acidification were determined by low amplitude oscillation using a Bohlin Rheometer and a penetration test using the Instron. The storage modulus (G') of acid gels made from recombined milk that was made from heated skim milk were in the range ~ 180 to 530 Pa, whereas acid gels made from recombined milk made from unheated skim milk systems produced gels with G' values in the range ~ 20 to 90 Pa. The G' of acid gels made from recombined milk containing fat globules stabilised by different materials was in the order: heated whey protein concentrate > sodium caseinate > skim milk powders > Tween 60, unheated whey protein concentrate or natural membrane material (fresh cream). The results of the penetration test were variable and did not fully agree with the trends from the oscillation tests.

For all recombined milk systems both the pH of gelation and the gelation time were influenced by the heat treatment of reconstituted skim milk, i.e. heating increased the pH of gelation and decreased the gelation time.

The microstructure of the acid gel network was determined by confocal scanning laser microscopy. Acid gels made from unheated reconstituted skim milk appeared to be formed from irregular clusters and strands, interspersed with fat globules whereas more crowded structure was observed from unheated systems. Recombined fat globules appeared to be embedded in the matrix. Differences in microstructures between gels containing different types of fat globule membranes were not very clear. Acid gels made from Tween 60 and whole milk were different from the other fat systems; the fat globules in the Tween 60 stabilised

milk appeared to be very small while in contrast those in whole milk were much larger probably because whole milk was not homogenised.

Possible mechanisms have been proposed which explain the effects of heat treatment on gel properties and the role of fat globule membrane material in gel structure and stiffness.

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