Rheological Behavior of Skim Milk Concentrates at Different pH

Anders Ola Karlsson[1], Richard Ipsen[1], Ylva Ardö[1], Karsten Bruun Qvist[2]

[1]Dairy Technology, Department of Food Science, TheRoyal Veterinary and Agricultural University, Copenhagen, Denmark
[2]Danisco A/S, Copenhagen, Denmark

Caseins constitute the largest proportion of the protein in skim milk. At pH 6.7 and 30 °C almost all caseins are present in the casein micelles, which at those conditions can be considered as interacting hard spheres. When the pH of milk is decreased, a proportion of the caseins will no longer be bound within the casein micelles. When the concentration of dry matter is increased in milk, viscosity increases and the concentrated milk begins to exhibit non-Newtonian behavior. In the present work, skim milk concentrates with different pH values was characterized over a broader shear rate interval than previously done in order to elucidate the state of the casein micelles. Attempts were made to fit the data to the model of Carreau and Yasuda.

Skim milk was concentrated by ultrafiltration. The concentration factor regarding to casein was 7.25. Concentrate was acidified with glucono-δ-lactone. Viscometric measurements (couette flow) were preformed using $0.000105 < \dot{\gamma} < 1500$ s^{-1}.

At pH 6.5 the whole flow curve fitted well to the Carreau-Yasuda model with a Newtonian region at lower shear rates and indications of one at the highest shear rates. Thus, the concentrate did not show a yield stress. In the pH interval 6.2-5.5, the flow curves exhibited indications of a yield stress at the very low shear rates. Thus, only parts of the flow curves could be fitted to the Carreau-Yasuda model. The yield stress can indicate the presence of polymers, i.e. free caseins, in the serum resulting in bridging flocculation between micelles. Near or after acid coagulation of the caseins (pH 5.2), the samples once again showed no yield stress. This flow could, however, not be well predicted by the Carreau-Yasuda model due to the appearance of two shear thinning regions characterized by different flow behavior indexes, *n,* in the shear-thinning regime. This indicates the occurrence of larger aggregates due to the acid coagulation.