RHEOLOGICAL CHARACTERISATION OF AGE THICKENING IN MILK CONCENTRATES

A THESIS PRESENTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN FOOD ENGINEERING AT MASSEY UNIVERSITY

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This project investigates the time-dependent rheological behaviour of fresh and reconstituted milk concentrates.

New experimental protocols, including sampling and measurement techniques, as well as equipment calibration and data analysis procedures were developed for both the industrial surveys and controlled rheology experiments.

The controlled rheology experiments were mainly carried out on reconstituted milk concentrates to minimise the variation in composition of fresh milk. A new recombination rig was built which could minimise the age thickening process by mixing at 35°C and recirculating at 40,000 s⁻¹ to break down the structure completely. This is the essence of this project, where age thickening is studied from a starting point of a fully broken down structure in contrast to past research. Using this method, the replicate milk concentrate samples had reproducible rheological behaviour, with a maximum reproducible error of 10%.

Age thickening involves two stages, a slow initial increase in apparent viscosity with storage time, followed by a sudden sharp rise which marks the onset of gelation.

The age thickening behaviour of milk concentrates is dependent on the processing variables prior to rheological measurement. These include solids content, shear rate and temperature during recombination, shear rate and residence time in the plate heat exchanger, and most importantly the raw material. The viscosity at the gelling point is an important characteristic of the age thickening process, and seems to depend mainly on the powder used, rather than the process treatments applied.

Industrial surveys exhibited similar trends, even under varying conditions that could not be completely controlled.

It is proposed that two types of age thickening phenomena can be distinguished: type I occurs below the temperature at minimum viscosity (65°C in this case), where weak
interactions take place between the casein micelles; type II occurs above the temperature at minimum viscosity, where additional stronger covalent bonds are formed, primarily due to the denaturation of whey proteins.

No mathematical model for the time-dependent rheology was developed. However, some important issues that must be taken into account during modelling were discussed.

The results showed that the age thickening process is more complex than had previously been envisaged. The knowledge of the interactions between the operating conditions, rheology of fresh concentrates and powder properties should be invaluable in the improvement of plant efficiency and quality control.
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<td>SCM</td>
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