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**EFFECT OF HOMOGENISATION ON MILK FOULING IN A
TUBULAR HEAT EXCHANGER**

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Abstract

Fouling of equipment surfaces in milk processing has been a costly problem for many years. In spite of an increasing body of knowledge of the fouling mechanism, the problem is not fully understood yet. Recent investigations suggest that the role of fat in whole milk fouling seems to be very important. The state and form of the fat globules, processing conditions as well as the orientation of heating surfaces may affect the fouling mechanism.

Homogenisation of milk is known to cause disruption of fat globules and prevent creaming. The present work aimed to investigate the effect of homogenisation on the rate of fouling, composition and structure of fouling layers.

Homogenised and un-homogenised milk were used as test fluids. Milk was heated from 4 °C to 60 °C in a plate heat exchanger then to 70 °C and 80 °C in a double pipe heat exchanger consisted of a horizontal and a vertical tube. The fouling rate in the double pipe heat exchanger was calculated and expressed as the rate of increase of the overall resistance to heat transfer, normalised using the initial heat transfer coefficient at the beginning of the run.

Composition analysis of fouling layers was carried out using standard methods of moisture, ash, fat and protein tests. Resistance to deformation analysis was performed using texture tests; coverage measurement was determined by digital image analysis.

Within the experimental conditions used in this work, the effect of homogenisation on the fouling rate could not be ascertained conclusively because of large variations in the values obtained but it had a significant effect in the composition of fouling layers. In all experimental runs, the amount of fat in the fouling layer was higher for un-homogenised milk compared to homogenised milk. In fact, the fat contents of fouling layers were found to be very high (between 30%-60% on a dry weight basis), which agrees with observations of other researches in New Zealand.

The coverage and thickness of fouling layers were more influenced by the orientation of heated surfaces than by homogenisation. The strength of fouling layers is affected by their thickness, which decreases with increasing milk temperature.

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Chapter 1 Introduction

Liquid milk is a major food item in all developed dairying countries, representing 30% of total milk production (Fox and Guinee, 2000). The remainder is processed into one of several thousand products, making dairy products the most diverse and flexible group of food products. The flexibility of milk as a raw material resides in the chemical and physico-chemical properties of its constituents, many which are unique and therefore, there is the need for specific knowledge of milk constituents and the effects of various processing treatments on them.

In fresh whole milk the fat is present in the form of globules that are surrounded and stabilised by their own membranes. This membrane can be altered during processing, e.g. by homogenisation, where the newly created fat surface is coated by adsorbed proteins, mainly caseins (Walstra and Oortwijn, 1982; McCrae *et al.*, 1994).

Homogenisation lies at the heart of dairy processes. It improves the mouth-feel of consumer milk and distributes the cream throughout the milk, thus preventing the formation of a cream line.

Milk fouling in heat exchangers is a very important issue for the dairy industry. Fouling reduces the rate of heat transfer from the heating medium to milk and increases the pressure drop across the heating equipment used. In addition, fouling layer can act as a harbour for bacteria growth, potentially compromising milk product's sterility and safety (Hinton *et al.*, 2002). Plant cleaning involves the use of expensive chemicals and combined with the reduced process run times, means that high rates of fouling can have a significant economic impact for the milk processor.

The fouling deposit mainly consists of fat, proteins and minerals. The composition of fouling layers in most overseas studies is dominated by proteins (β -lactoglobulin) and minerals (calcium phosphate). However, recent studies (Truong *et al.*, 1996; Fung, 1998 and Ma and Trinh, 1999) have shown that fouling layers from New Zealand milk contain considerably more fat, between 40% and 60%, than overseas (4% -8%). The reason of this difference is still being studied.

Previous studies have shown that fat plays an important role on fouling. The rate of fouling increases with the increasing amount of fat present in milk (Ma *et al.*, 1999) as well as the amount of damage to the fat globule membrane (Fung, 1998). However it is still unclear how homogenisation could affect the fouling behaviour.

The objective of this work was to investigate whether the changes caused by homogenisation in the structure of fat globules does have an effect on milk fouling. Two areas of study were included: effect of temperature and effect of orientation of heating surfaces. The rate of fouling, composition and strength of fouling layers were used as parameters of measurement of fouling.

This work is divided into five sections. Chapter one outlines the fouling problem and its implications in the dairy industry. Chapter two gives a general assessment of the effect of heating on the different milk components as well as the role of milk fat globules in the formation of fouling deposits. Chapter three describes the resources and methodology used for the development of this research. Chapter four shows and explains the results obtained in this work. Final conclusions and recommendations for further work are given in chapter five.