EFFECT OF HOMOGENISATION ON MILK FOULING IN A TUBULAR HEAT EXCHANGER

A Thesis presented in partial fulfilment for the requirements for the Degree of

Masters of Food Engineering

Massey University
Palmerston North
New Zealand

Monica Martinez-Sanchez

2004

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.

Acknowledgements

This work and its completion would not have been possible without the help and support of people who have, in different ways, contributed to the thesis and to my life during this time. It is with pleasure that I express my gratitude to them.

My supervisors, Dr. Tuoc Trinh and Ms Carol Ma deserve special praise. I appreciate the generous way in which they shared their time, knowledge, experience and wisdom, and provided me with intellectual challenges, guidance and encouragement throughout the project. I have received their immediate and thoughtful attention when I most needed them. I shall always be grateful to you both.

My thanks also go to I.T support technicians Bryden Zaloum, Guy Defryn and Peter Jeffery for their assistance with implementation of computer software and general computer enquires. Steve Glasgow for his assistance with chemical tests and texture analysis; Byron McKillop for helping me to build the experimental fouling rig and Gary Radford for organising milk transport bookings and steam for the pilot plant.

I am also grateful to my fellow students Mark Downey, Kheng-Huat Lim, Richard Croy, Hayden Bennett and Binh Trinh for answering my questions and for helping me with heavy pilot plant jobs.

Heartfelt thanks to my kiwi family Julie, David, Allie and Michael Blackwood for their immense moral support, company, generosity, kindness and for sharing so many early-afternoon teas with me; I could not have found a better place to live, indeed.

I thank my parents and sisters; without their endless trust, encouragement and constant phone calls, this work would have been more difficult and the accomplishment less enjoyable. My warmest thanks to my friend Fiona Chowdhury for her constant good advise, practical expressions of support and good humour. My special thanks to my friend Mr. Ainul Islam for his patience, kindness and valuable help.

Finally and most of all I am profoundly grateful to my husband Jahid, an inexhaustible source of help, patience, love and understanding. I am lucky to have you in my life.

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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.