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Arunee Srichantra

STUDIES OF UHT-PLANT FOULING BY FRESH, RECOMBINED AND RECONSTITUTED WHOLE MILK

EFFECTS OF PREHEAT TREATMENTS

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

BY

ARUNEE SRICHANTRA

2008

Abstract

The objective of this study was to investigate the effects of preheat treatments on fouling by fresh whole milk (FWM), recombined whole milk (RCB) and reconstituted whole milk (Recon) in the high-temperature heater of indirect UHT plants.

Various preheat treatments prior to evaporation during milk powder manufacture were applied to skim milk powder (SMP, 75 °C 2 s, 85 °C, 155 s and 95 °C, 155 s) and whole milk powder (WMP, 95 °C, 33 s). These preheat treatments were so-called "evaporator preheat treatments". Skim milk powder (SMP) and whole milk powder (WMP) were derived from the same original batch of pasteurised FWM to remove the effects of the variation in milk composition between different milk batches. These SMPs were recombined with anhydrous milk fat and water to prepare RCB, and WMPs were reconstituted with water to prepare Recon. Then, (homogenized) FWM, RCB and Recon were subjected to various preheat treatments (75 °C, 11 s, 85 °C, 147 s and 95 °C, 147 s) prior to UHT processing. These preheat treatments were so-called "UHT preheat treatments". Temperature difference (hot water inlet temperature – milk outlet temperature) was taken as a measure of the extent of fouling in the high-temperature heater. The slope of the linear regression of temperature difference versus time (for two hours of UHT processing) was taken as fouling rate (°C/h).

Increasing both evaporator and UHT preheat treatments resulted in increasing fouling rate and total deposit weight for all three whole milk types for several milk batches. In the case of FWM, there was no reduction in fouling rate with increasing UHT preheat treatment whether FWM was homogenized then preheated, preheated then homogenized or not homogenized at all. These findings, which are wholly consistent and well replicated, are in apparent conflict with the results of most previous comparable studies. Possible reasons for this are explained.

Further investigations of the effects of homogenization relating to the role of whey protein on the surface of the fat globules showed that whey protein associated with the membrane covering the surface of fat globules for homogenized then preheated FWM, RCB and Recon and that association increased with increasing heating process stage. The increasing association of whey protein with the milk fat globules membrane with increasing severity

of heating process stage became faster when preheat treatment was more severe: the association of whey protein plateaued on intermediate temperature heating when the milks were preheated at 75°C, 11 s and on preheating when the milks were preheated at 95°C, 147 s.

In the case of FWM, the thickness of the membrane covering the surface of fat globules for homogenized then preheated FWM, which increased with the severity of heating process stage, was greater than the thickness of the membrane in preheated then homogenized FWM. Preheating then homogenization resulted in the greater interfacial spreading of small molecules on the surface of fat globules, i.e. whey protein or small molecules from the disintegration of casein micelles during preheating.

Possible basic mechanisms for UHT fouling in the high-temperature heater include: the reduction in the solubility of calcium phosphate and the deposition of protein as fat-bound protein and non-fat-bound protein. When non-fat-bound protein in milk plasma deposited, it could be a carrier for the deposition of mineral, such as, the precipitate of calcium phosphate in the casein micelles or the deposition of complexes between whey protein and casein micelles.

Acknowledgements

I wish to express my sincere gratitude to my chief supervisor Dr. Owen McCarthy for his long and patient guidance throughout the project. I am thankful for the kindness of Dr. David Newstead who has had his peace disturbed by me during his retirement. Many thanks for sharing your soul as a dairy scientist with me. I also wish to thank Associate Professor Tony Paterson for the encouragement and sharing of your soul of positive leadership and help through my PhD.

I am indebted to the staff of the milk powder pilot and the UHT plants at Fonterra, Palmerston North. Thanks to Dennis Dugmore and Geoff Paterson for the setting up and running of the UHT plant who showed lots of patience with me. Special thanks to Gordon Groube for his fabulous support, guidance and assistance in making every trials happen at the UHT plant. Many thanks to Paul Mason for your awesome work for both recombining and UHT plants. Sincere thanks to Adam Duker for delivering your best on every fouling trial at the UHT plant and all hard work to dismantle the plate heat exchanger.

I would like to thank for the team of milk powder plant ; Colin Knight, John Grant, Dennis Dugmore, Bill Barnes and Sue Adams. Thanks for lots of laughs and the friendship that you gave to me.

Many thanks to the staff of the Analytical Chemistry section for the analyses they carried out. In particular, Errol Conaghan and Freya Gwynne for their patience and assistance on the analysis of milk samples. Thanks for Aiqian Ye for his generous discussion and Amy Ye for her kindness of the analysis for milk samples.

I am thankful to Diana Mackereth for her training on work of Gel Electrophoresis and to Raewyn McRedmond on work of fat-bound protein. Many thanks to Alan Baldwin, who gave his booking to proceed my fouling trials. Special thanks to Dr. Skelte Anema for your expertise on PAGE analysis and dairy science.

I would like to thank Barbara Kuhn-Sherlock (Fonterra), Robert Crawford (Fonterra) and Dr. Nigel Grigg (Massey) for their helps in statistics. Thanks to Liza Zhang, Cheese laboratory, for her patience and support to my milk samples.

Thanks to Fonterra, Palmerston North (formerly the New Zealand Dairy Research Institute) for access to unpublished internal reports on trial work. Also, thanks to the Foundation for Research, Science and Technology, Wellington, New Zealand and the Royal Thai government who gave me financial support for my PhD.

Finally, thanks to Mum, Dad and my sisters (Amornrat and Pattara) for your support and patience on my long journey. Thank you to my husband, Wisanu, and my lovely daughter, Amy Srichantra, who always accept my roles and support me throughout my PhD.

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