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**Effect of Processing and Storage on the  
Reconstitution Properties of Whole Milk and  
Ultrafiltered Skim Milk Powders**

THESIS  
PRESENTED IN PARTIAL FULFILMENT OF THE REQUIREMENT  
FOR THE DEGREE OF  
DOCTOR OF PHILOSOPHY IN FOOD TECHNOLOGY

BY  
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2000

# SUMMARY

Concentrated and dry milk products have a longer storage stability than fresh milk because of a lower water activity and they are therefore desirable in regions with unsuitable climates for fresh milk production and distribution.

During the manufacture of spray dried milk products, there are processing steps that cause interactions between the various components in milk that influence powder functionality. These processes include pasteurisation, homogenisation, concentration, heating, atomisation and the spray drying conditions.

Whole milk powders (WMP), particularly those sold directly to the consumer, are required to disperse rapidly in water and to be quickly and completely soluble *i.e.* form a stable colloidal suspension of fat and protein leaving little or no visible residue suspended in the water or coated to the inside surface of the container. Spray dried ultrafiltered skim milk containing 85% protein (UFSMP85) is used for a wide range of applications including protein fortification of liquid milks, nutritional foods and cheese milks. The UFSMP85 should have good solubility in water and milk for it to be used successfully in these applications.

The main objective of this work was to further our knowledge about the influence of processing factors on component interactions during the manufacture of WMP and UFSMP85, using microscopy as a major investigative tool. Evaluation of the influence of milk component interactions on the functional characteristics of the powders was an integral part of the work and provided important insights towards improving the reconstitution properties of these powders.

The development of confocal laser scanning microscopy methodology for WMP proved valuable for the localisation of fat globules, lactose crystals and a phospholipid-based surface wetting agent.

Major structural changes in the fat globules, casein micelles and whey proteins occurred during the manufacture of WMP. Preheating resulted in the formation of hair-like structures on and between casein micelles onto the fat globule surface. Upon further heating the adsorbed protein on the fat aggregated with other micelles to form a chain-like network. Reduction in the whey protein concentration of the concentrated milk appeared to reduce the number of hair-like structures, aggregation and the extent to which this network formed upon heating.

A study of instant-WMP products, obtained from the marketplace, indicated that WMP with poor functional properties (solubility in coffee and hot and cold water, and dispersibility) generally had been manufactured using high preheating conditions, had a high fat globule protein load (excessive shear during processing) and exhibited a high degree of protein-protein interactions. The instant-WMP sample with the most favourable functional properties (good solubility in hot and cold water and coffee, excellent dispersibility and good agglomerate structure) was manufactured using low preheating conditions and exhibited fewer protein-protein interactions as observed by transmission electron microscopy (TEM).

In the manufacture of UFSMP85 there were changes that occurred during membrane

concentration and evaporation that predisposed the concentrated milk to protein-protein and protein-mineral interactions upon drying. The extent of these protein interactions increased with an increase in protein content of the UFSMP. It was considered that these interactions gave UFSMP85 a solubility of only 40% when it was reconstituted in water at 20°C. The solubility was approximately 98% when UFSMP85 was reconstituted in water at 60°C. Determination of the location of  $\beta$ -lactoglobulin and  $\kappa$ -casein by immuno-gold labelling and TEM showed that these components may be associated with the formation of an aggregated matrix that 'sets' upon drying thus influencing particle solubility.

Storage of UFSMP85 at temperatures  $\geq 20^\circ\text{C}$  caused a "skin" to develop at the particle surface that reduced water penetration. This skin eventually (after 6 months of storage) decreased the powder solubility even in water at 60°C. The application of shear at approximately 14.50 MPa was required to break down these poorly soluble reconstituted UFSMP85 particles.

Changes in the pH of milk prior to ultrafiltration and a reduction of temperature during drying and storage of the powder may result in some incremental improvements in the solubility of the UFSMP85.

# ACKNOWLEDGEMENTS

My first acknowledgement is to my beloved, Lee, who still loves me! Over the duration of this work you endured more hardship than I did. I Promise it won't happen again!!! Thanks and love to my children Rachel (10), Thomas (8), Rory (6) and Megan (3) who were as patient as could be and still call me Dad.

To my parents, Kevin and Marlene, for your love and support always. To my grandmother, Alelia, thanks for making a family out of us all.

I am appreciative of my supervisor Professor Harjinder Singh for his support, friendship and guidance.

Thanks to Professor Peter Munro (co-supervisor), who encouraged me to undertake this work and bared the brunt of many day to day enquiries.

Special thanks to Brian Brooker (co-supervisor, Institute of Food Research, UK) who graciously took me into his fold and provided expert guidance in microstructure preparation and analysis. To Mrs Peg Brooker (passed away on the 7th August 1999). You are an inspiration to my family and I. We remember you with great warmth - "we'll meet with a kiss when we walk through the gate".

Thanks to the New Zealand Dairy Research Institute who generously supported my doctorate. To my friends and colleagues from the Institute, thank you for your encouragement and technical assistance. To Dr Terry Thomas and Dr Jeremy Hill for supporting this work. Thanks to Mrs Robyn Hirst for providing excellent assistance and for competently taking over operation of the microscopy unit. To Dr Ranjan Sharma, Dr Skelte Anema, Mr Richard Lloyd, Dr Steven Euston, Ms Chris Thompson, Dr Satyendra Ram, Mrs Suzie Finnigan, Dr Claire Woodhall, Ms Andrea Cooper and Mr Donald Love for expert assistance, advice and personal support. Thanks to Dr David Newstead for teaching me (with patience) to document my thoughts. Thanks to Dr John Smith and Dr Steve Haylock for being good sports.

Sincere thanks to associate Professor Donald McMahon and Mr Bill McManus from Utah State University who gave their time for training me in immunogold labelling techniques.

Finally, thanks to my friends of the Christian Community Church in Palmerston North, in particular Nigel & Carolyn Dixon, Andy & Ruth Smith, Mark & Trish Gunning, Steve & Margie Jones, Malcolm & Janice Hardy and Matt & Suzie Finnigin. You've been great support, thanks.

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