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Granulation of Whole Milk Powder

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Gary Field-Mitchell B.Eng (Hons)

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Abstract

High-shear granulation is an attractive alternative to spray drying for producing dried milk products. The capital cost of a granulation circuit is likely to be much less than a spray drying circuit which will reduce the manufacturing costs of milk powders. This work investigated the high-shear granulation of milk powder using milk concentrate as a binding agent in order to determine the feasibility of granulation as an alternative to, or and improvement on, the spray drying process. This research has laid the groundwork for further investigation into milk granulation by defining the conditions for which granulation is achieved and describing the effects of processing parameters on granulation for a pilot-scale mixer granulator. The technical feasibility of granulation is shown by proving that granulation does not affect the quality of the milk. Designs for perceived continuous granulation circuits are included to aid in further milk granulation research.

Successful granulation occurs at a total moisture content of approximately 11 % (± 1 %). This was found to be suitable using either reconstituted or evaporated milk concentrated binder at between 20 and 50 % total solids. The time of granulation affects the size distribution of the granules and the granule yield at the end of the process. A narrower size distribution with increasing granule sizes and a reduction in the granule yield is observed for longer granulation times.

Granules were found to have better handling qualities than spray dried milk powders. Granules performed better in many functional tests having a higher bulk density, less change in bulk density during handling, better flowability and less fines. Granulation does not affect the chemical quality of the milk providing the granules are dried immediately after granulation. However, it was found that extended exposure of dried milk solids to a moisture content of 11 % results in an unacceptable amount of insoluble material forming. Granules are well suited as a product for reconstitution but did not perform adequately in wettability tests, suggesting that their use as an instantised product would require further study and improvement.

Further research is required to understand the role of lactose crystallisation and the generation of insoluble material to ensure scaling up of granulation will be successful. An investigation into continuous granulation would be useful for further milk granulation work.

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Chapter 1 – Introduction

1.1 Background

The New Zealand dairy industry produces over 1.2 million tonnes of powders manufactured from milk each year (NZMP, 2001). Powders have low transport cost and can be stored for an extended time due to their low water activity. The handleability and flowability are important physical properties for powders as well as the ease of reconstitution when being used by the consumer. These are influenced by the composition of the powder, the particle size distribution and the surface area.

Dairy powders are almost universally produced by spray drying (Caric, 1994) due to the short drying time and the adaptability of the equipment to manufacture different products. The disadvantages are the high capital costs of the spray drying equipment, the high-energy load required for the evaporation and the generation of fines. This necessitates further handling and recycling during manufacture, as well as an increased possibility of product loss during packaging and end-use of the product.

This project looks at granulation as either an alternative or an improvement to the spray drying process for producing whole milk powder. Granulation is a method used to improve the physical properties of powders by increasing the size of the powder particles (Hounslow et al, 1988). Granulation typically improves the flowability and wettability of powders, producing larger, more spherical particles. In addition, fines are eliminated and the bulk density is less likely to change during storage and transport (Jones, 2001). Granulation can be achieved in a batch, semi-batch or continuous process using a high-shear or low-shear system. High-shear mixer granulation was identified as being the most suitable process for whole milk powder due to the capability of the process for handling sticky materials.

1.2 Project Objectives

The objectives of this research were to:

- granulate milk using a high-shear granulator in a batch process
- investigate the physical changes that may occur to the milk during granulation
- design and simulate a continuous granulation process that will be able to granulate milk using milk concentrate as the sole ingredient.

1.3 Thesis Outline

This thesis aims to investigate the high-shear granulation of whole milk powder and seeks to provide an understanding of the subsequent effects of granulation on the functional quality of dried milk.

Chapter 2 reviews the literature and summarises the knowledge relevant to granulation of milk powders. The scope of the project limits the review primarily to

the particle technology aspects of granulation. As the project progressed there was a lot of knowledge outside the field of particle technology that was relevant. The knowledge of other issues, such as milk chemistry and surface science, are extensive but are herein only covered in summary.

Chapter 3 describes the equipment used for this research. Chapter 4 describes the alterations undertaken of a current batch high-shear granulation rig and the development of suitable experimental conditions for achieving milk granulation.

Chapter 5 describes a series of experiments performed to analyse the optimal process conditions to achieve successful granulation. The effects of varying process conditions on granule physical properties and the efficiency of the granulation are also covered.

Chapter 6 looks at the physical and functional effects of granulation on the granules produced in order to test the technical feasibility of milk granulation. A comparison between the original spray dried milk powder used as feed for the granulator and the final granules is given.

Chapter 7 investigates continuous granulation of milk powder. The results of a simulation of a continuous granulation process are presented. This determines whether continuous granulation is technically feasible. Process block diagrams are proposed for likely continuous granulation circuits, and their merits are discussed. The chapter also summarises suggested further work that is recommended.

The thesis finishes with a final chapter describing the major conclusions and recommendations.