THE EFFECTS OF WATER ACTIVITY, PARTICLE SIZE DISTRIBUTION AND FREE FAT CONTENT ON FLOWABILITY OF GRATED AND DRIED PARMESAN CHEESE

A THESIS PRESENTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF TECHNOLOGY IN FOOD TECHNOLOGY AT MASSEY UNIVERSITY

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2000

ABSTRACT

A study was made of the effects of water activity, particle size distribution and free fat content on flowability of Grated and Dried Parmesan cheese made by Greenwood Valley Cheese Company (GVC) and by Kraft. The three parameters were modified to span a wide range around the original level of each.

Water activity (A_w) was decreased / increased through water sorption. A range of particle sizes for each of the samples was obtained by separating the samples into two fractions and then combining them together to different levels. Samples were sieved through a stack of sieves with different mesh sizes and particle size was expressed in terms of median particle size. A range of free fat levels was obtained by spraying samples with anhydrous milk fat (AMF). The response of flowability to changes in these parameters was assessed. Flowability was measured by using a rotating drum.

The results in the preliminary study showed that flowability increased with increasing moisture content from 18 to 22%, which is in contradiction to the normal expectation from the literature. Therefore, the hypothesis: flowability increases with increasing moisture content / A_w was proposed.

To test the validity of the hypothesis, several trials were conducted. The results in the first trial showed that flowability increased with increasing A_w from 0.66 to 0.79 for both GVC and Kraft products. The results also revealed a possible critical A_w between 0.79 to 0.83 at which the products could have their optimum flowability.

In the next trial, additional values in the A_w range between 0.79 to 0.83 were included. The results showed that flowability increased with increasing A_w from 0.67 to the critical A_w value and dropped down above this value. The critical A_w values for GVC products were determined at 0.80 ± 0.01. Kraft' s product did not show this increasing trend or the critical A_w value.

A series of commercial samples with different A_w levels from two of each of GVC products were chosen to test the hypothesis. Variation in water activity naturally occurred during processing due to the slight changes in drying conditions. The results obtained on these commercial samples showed flowability increased with increasing A_w from 0.69 to 0.77. Therefore, the hypothesis has been proven.

The study on the effect of particle size shows flowability also increased with increasing median particle size for both GVC and Kraft products. Of the methods chosen to plot cumulative undersize versus sieve size, linear regression is suggested rather than simply joining the points. This is because all the points are taken into account when linear regression is used.

The study conducted on the effect of free fat shows that flowability decreased with increasing free fat levels from 16.8 to 26.3%. The sieve analysis results on the samples with different free fat levels show that median particle size increased from 721 to 1476 μm with increasing free fat levels from 16.8 to 26.3%. This was presumably caused by particle aggregation. The results show that the positive effect of particle size on flowability could not counteract the negative effect of free fat. Further study is required to confirm the net effect of free fat and particle size.

ACKNOWLEDGEMENTS

I gratefully acknowledge my chief supervisor, Mr Rod Bennett, for arrangement of this project and the research collaboration with the New Zealand Dairy Research Institute. I am in debt for his support and encouragement throughout my study. Also, I would like to thank my supervisor Mr Rohan Wewala, from the New Zealand Dairy Research Institute, for his invaluable ideas, guidance, and encouragement throughout the project. It was my honour to work with them. Special thanks to both of them for their diligence, persistence, professional suggestions in the finalisation of this thesis and their tolerance and patience in editing the manuscript of the thesis.

My gratitude extends to Mr Stephen Gregory, for organising the financial issues in this study. Special thanks to Dr. Stephen Dybing from New Zealand Milk Products (North America) for his technical support and endless patience on editing of my thesis.

I wish to record my gratitude to the New Zealand Dairy Research Institute for allowing my attendance at this M.Tech course and for providing the opportunity to work with the experienced scientists. Special thanks are also extended to Mr. Allan Main (Cheese Food Portfolio Manager), Dr Russell Wilson (Consumer Application Section Manager), Dr. P. K. Samal, Dr. Justin Bendall, Dr. Rob Crawford, Dr. Frank Visser, Allan Dodge, Angela Veale, Ivan Simpson, Kathy Davidson, Peter Elston, and all other staff at New Zealand Dairy Research Institute for their great support and friendship to complete this project successfully.

Finally, many thanks to my parents and my brother, for encouragement and support shown during the study.

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CHAPTER 1

INTRODUCTION

Parmesan is the name commonly used to describe a group of very hard cheese varieties that originated in the Po River valley of Italy. Locally, these cheese varieties are generally called Grana, or specially named after the city of manufacture (i.e. Parmesan comes from Parma, Reggino from Reggio, etc.). These cheeses are characterized by a granular texture, sharp flavour, hard body, very small eyes, long shelf life and excellent shipping properties (Sanders, 1953).

The traditional Italian manufacturing methods have been gradually and continuingly modified for commercial production as follows (Anonymous a, 1973):

- The cheese is manufactured by some producers on a continuous basis using pasteurised or heat treated and standardised milk.
- The cheese is produced by using various starters in addition to whey starters.
- The size of the cheeses generally ranges from 10 to 12.7 kg rather than the traditional 27 kg on average.
- Ripening is controlled by mechanical refrigeration.
- The cheese is coated with wax rather than oil or grease.
- The cheese is cured for 10 to 14 months rather than 16 to 24 months in the traditional method and a shorter curing method with only 6 months is being trialed (Anonymous b, 1999).

Parmesan production in the United States is a growing segment of the cheese industry. For example, the production of Parmesan and similar cheese varieties increased from 30,750 tonnes in 1979 (Ferris, 1981) to about 68,000 tonnes in 1997 (Anonymous c, 1999). Kraft is a major manufacturer of Parmesan in the U.S. with production of about 27,200 tonnes annually, followed by Sartori at 12,700 tonnes per year (S. Dybing, personal communication).

Parmesan cheeses are marketed in four basic forms: as pieces cut from larger wheels by local retailers in grated form, in shredded form, or as an ingredient of another food (Anonymous a, 1973). Parmesan is normally consumed as a table cheese in very small quantities, so virtually all Parmesan is grated before it is consumed. Most of the Parmesan purchased by consumers is either grated, dehydrated and packaged or shredded and packaged at the higher moisture level (Anonymous a, 1973). After being grated and dehydrated, the so-called Grated and Dried Parmesan or Grated Parmesan is packed into consumer sized canisters (eg. 227g). Dehydration reduces the moisture content of the product to 12 – 18%, an average 17.7% as shown in Table 1.1.

Table 1.1 The compositions of Hard and Grated and Dried Parmesan

	Hard (mature) Parmesan (%)	**Grated and Dried Parmesan (%)**
Moisture	29.2	17.7
Total solids	70.8	82.3
Fat	25.8	30.0
Total protein	35.8	41.6
Carbohydrates (by difference)	3.2	3.7
Ash (Includes added salt)	6.0	7.0

(Kosikowski and Mistry, 1997:69)

Drying to these moisture contents greatly enhances the shelf life, allowing Grated Parmesan to be widely marketed in canisters (e.g. 227g) for use on soups, salads, pizza and pasta. At 12 to 18% moisture there is a problem of clumping or agglomeration of the grated cheese product, which hinders consumers' acceptability. Clumping is easily observed in the canister and constitutes a serious defect. Aggregates range from small clumps to large lumps. The small clumps may be disrupted and eliminated when shaking the canister. However, some lumps aggregate into hard pieces that cannot be broken apart with acute shaking. These lumps hinder the flowability of product out of the canister during shaking. Therefore, flowability is an indirect measure of clumping. Also, flowability is a major criterion by which consumers determine product quality. Hence, flowability constitutes a vital product characteristic, which is even more important than clumping.

The overall objective of this study is to determine the fundamental factors affecting flowability in Grated and Dried Parmesan cheese. The production of Grated Parmesan cheese creates a food powder. Therefore, the theories presented in the literature review should describe the factors that control flowability in this powder product. Three major factors known to significantly affect flowability in food powders include the water activity (A_w) of the particles, the particle size distribution and the amount of free fat present on the particle surface. This is a fundamental study on the flowability of Grated and Dried Parmesan cheese. The study was divided into three sections to specifically focus upon the following factors:

- Determining the effect of A_w on flowability
- Investigating the effect of particle size distribution on flowability
- Illustrating the influence of free fat on flowability

Other properties such as porosity of powders and storage conditions are not included in this study.