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The Production of a High Free-Fat Whole Milk Powder for the Chocolate Industry; The Spray Chilling Technology

A Thesis presented in partial fulfilment of the requirements for the degree of Master of Technology at Massey University.

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" I find the great thing in this world is not so much where we stand, as in what direction we are moving " O. W. Holmes

" There is always room at the top " Daniel Webster

ABSTRACT

Whole milk powder containing down to 80 percent free fat was manufactured by spray chilling suspensions of skim milk in milk fat, using a modified laboratory spray drier. Also, the pure unmodified milk fat, and the soft (SBF23), medium (SBF27) and hard (SBF42) fractions of the same were transformed into powder by spray chilling the molten samples. The effect of chilling with air and nitrogen was investigated. The powders were satisfactorily stable at 5°C, but were relatively unstable at ambient temperatures. The powders' particle size distributions ranged from 4.44 to 215.56 µm. The powder characteristics were influenced by the size of the nozzle, the atomising gas pressure, the chilling temperature, the feed flow rate, and to a lesser extent, the feed temperature.

The shelf life of the unmodified milk fat powders stored at 20°C, 5°C and -10°C was assessed. The powders chilled with air had excessively oxidised after one month of storage at all the temperatures, whereas powders processed with nitrogen were still usable after the same period of storage. Lower peroxide values were recorded for the powders stored at -10°C and 5°C, while significantly higher values were obtained for the samples stored at 20°C.

The powdered fats dry-blended successfully with skim milk and calcium caseinate powders at the ambient temperature. In comparison, the hard fraction mixed better than the other softer fractions. Up to 50 percent of the hard fraction, and just 30 percent of the softer fractions, could be blended with the skim milk powder. An upper level of 70 percent hard fraction, and of 50 percent for the softer fractions, were mixed with calcium caseinate. The repose angles of the skim milk and milk fat blends increased with the increasing fat content, and the blends containing up to 20 percent fat were free flowing. For the calcium caseinate and skim milk blends, the repose angle decreased with the increasing fat content, and all the blends were not free flowing. The bulk densities of the skim milk blends decreased with the increasing amount of fat, while those of the calcium caseinate blends increased with the increasing fat content.

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1 INTRODUCTION

Spray chilling is often regarded as the converse of spray drying (Lamb, 1987; Anon, 1970). Not surprisingly so because the two processes share the same basic operating principles. Perhaps the only notable difference is that spray chilling is achieved by circulating cold gas in the system, whereas spray drying is effected by circulating hot air.

Records describing spray chilling date as far back as the 1970s (Anon, 1970; Grolistch, 1975), but up to now widespread application of this technology has not followed, especially in the processing of food materials. By far, the slackness in the adoption of this process has been attributed to the processing difficulties (Grolistch, 1975; Lamb, 1987), in particular, the need for very low cooling temperatures, long product residence times in the crystallising chambers, and more importantly, poor physical properties of the spray chilled product during storage. However, research is now advancing the spray chilling technology, addressing these stumbling blocks by building into the system highly specific release properties (Lamb, 1987; BOC gases Ltd, 1995).

Despite the hampering factors, the envisaged application of the spray chilling process is very broad. Nevertheless, so far almost all the attention has been focused on lipid processing. By using this technology, the fat which is usually in block form or liquid can be handled as powder, ideal for incorporation into other ingredients by dry blending. Additional advantages associated with powdered fats include improved storage life at ambient temperatures (Claypool, 1984; Frede *et al* , 1991), enhanced handling properties which make storage and transportation more easier(Frede *et al*, 1991), and flexibility in product formulation, with subsequent potential for new product opportunities.

In the work discussed here, the potential for application of the spray chilling technique in manufacturing high-fat whole milk powders, specifically targeted for the chocolate

confectionery, was investigated. Moreover, it was sought to gain more insight into the operating parameters which have significant effect on the success of the spray chilling process *per se*, and therefrom, optimise the processing conditions for the purpose of manufacturing milk fat powders efficiently. The processing equipment used for this investigation comprised a converted laboratory spray drier, in which liquid nitrogen and blast-freezer-generated cold air were separately tested as the chilling media. Anhydrous milk fat and three different melting fractions of the same (soft, medium and hard fractions) were processed.

The actual production of the high-fat whole milk powder was approached in two strategies. The first tactic, which was derived from the work of Teo (1993), involved formulation of suspensions of skim milk powder in milk fat, which upon spray chilling gave powders whose particles were coated with milk fat. The second strategy entailed spray chilling pure anhydrous milk fat (AMF) to produce powders which were thereafter dry-blended with skim milk powder.

Following the production of the AMF powders, their physical and oxidative stability at three different storage temperatures were studied. The oxidation was assessed at intervals up to four months. In addition, the potential for the powdered fats to be dry-blended with other powders of differing physical properties was appraised.