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International Dairy Journal 15 (2005) 85–91
INTERNATIONAL DAIRY JOURNAL
www.elsevier.com/locate/idairyj

The contribution of milk fat towards the caking of dairy powders

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Received 1 September 2003; accepted 10 May 2004

Abstract

Milk fat has a role in the caking of dairy powders during storage. The cohesiveness of six powders was studied by exposing the powders to temperature fluctuations whilst keeping the amorphous lactose component stable. It was found that caking was related to the amount of crystallised surface fat present on the powder. There was no measurable increase in the cohesiveness of the powders when only liquid fat bridging was present. An increase in cohesiveness was only found when the fatty liquid bridges were able to partially solidify due to a decrease in powder temperature. It is important to avoid elevated temperatures in bulk packed powders if the surface fat levels are above 13% (w/w), corresponding to a total fat content of 41% (w/w). Heating and subsequent cooling of such powders results in significant caking problems.
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Keywords: Milk fat; Surface fat; Caking; Sticking

1. Introduction

High fat powders, such as cream powders and cheese powders, have been known to experience sticking and caking problems during processing and storage. During processing, high fat powders cause smearing, where the powder builds up on the inside of the dryers, cyclones and fluidised beds. During storage, lumps of powder, which can be very difficult to break up, form. Sometimes a free flow agent is added to these powders; however, flowability problems often still persist.

Amorphous lactose is generally present in high fat powders and can contribute to flowability problems. However, these problems also arise under conditions (water activity and powder temperature) where the amorphous lactose is stable. This indicates that milk fat also contributes to caking. Milk fat has been stated as the cause of caking in a number of studies (Buma, 1971c; Peleg, 1977; McKenna, 1997). Peleg (1977) stated that viscous liquid bridges may cause flow difficulties in fat-containing powders. It was noted that if the temperature is increased during storage or processing, some fat may melt forming liquid bridges of fatty composition. If the temperature drops later on, the fat can resolidify, resulting in a lumpy product. At ambient temperature, ~20°C, a significant percentage, 77% (MacGibbon & McLennan, 1987), of the total milk fat is in a fluid-like state and is able to flow over the particle surfaces and contribute to caking if the temperature is subsequently reduced. The mechanism for sticking and caking due to milk fat is given in Fig. 1.

In some studies, increases in the free fat content were observed in caked powders (King, 1965; Saito, 1985; Munns, 1989; Roos & Karel, 1992; Fäldt & Bergenståhl, 1994, 1996a, b). However, these powders were stored under conditions favouring amorphous lactose crystallisation. King (1965) stated that milk powders consist of spherical particles of amorphous lactose containing embedded casein micelles and fat globules. Roetman (1979) stated that the structure of the powder particles is changed when the amorphous lactose undergoes crystallisation. When this happens, the protein, minerals and fat are excluded from the ordered structure of the lactose crystals and are expelled to the powder surface. Therefore, the increase in free fat is due to the crystallisation of the amorphous lactose. Furthermore,

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doi:10.1016/j.idairyj.2004.05.005

it is the crystallisation of amorphous lactose that is likely to have caused the caking problems and the increase in free fat may just compound the problem. In these cases, preventing the crystallisation of amorphous lactose is likely to control caking problems.

Sticking and caking are surface related phenomena, therefore it is necessary to relate these flowability problems to the composition of the powder surface. Free fat (non-encapsulated fat) originates from four different sources, as defined by Buma (1971c). These include surface fat, outer layer fat, capillary fat and dissolution fat. Surface fat is present as pools or patches of fat on the powder particle surface, particularly in surface folds and at contact points between the particles. Outer layer fat consists of fat globules in the surface layer of the powder particles, which can be reached directly by fat solvents. Surface fat and some outer layer fat are therefore likely to contribute to fatty bridging and caking. Fat held in capillaries and bulk phase fat embedded deeply in the powder particle are less likely to contribute to caking.

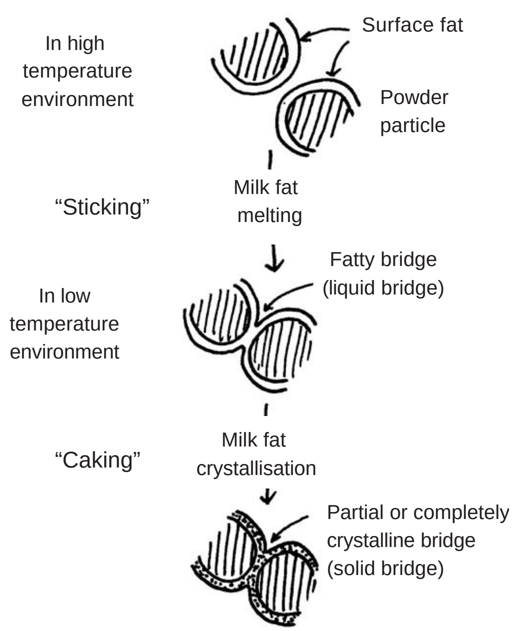

Fig. 1. Fat sticking of powder particles and powder caking mechanism.

This work investigates flowability problems during storage of six different dairy powders, as a result of fatty liquid bridging and fat solidification arising from temperature fluctuations, and the relationship between these flowability problems and the surface fat content. This was achieved by investigating the sticking and caking behaviour of high fat dairy powders in conditions where the amorphous lactose fraction of the powder is stable. A method for estimating the surface fat content of a powder is also discussed.

2. Materials and methods

2.1. Materials

Table 1 outlines the compositions of the powders used in this work. All powders were obtained from the New Zealand Dairy Board (Wellington, New Zealand). The moisture and fat contents of the powders were measured using the techniques described below. Lactose and protein contents were supplied by the manufacturer.

2.2. Moisture content measurements

The free moisture content was measured gravimetrically by desiccation over phosphorous pentoxide for 3 weeks.

2.3. Fat content measurements

The surface fat content was measured by taking 8 g of dry powder (1 month desiccation over phosphorous pentoxide) and washing in 100 mL petroleum spirit (40–60 °C boiling point) for 10 s at room temperature. The powder and petroleum spirit were then filtered through Whatman No. 1 filter paper. The glassware was then washed with 25 mL petroleum spirit, which was

Table 1
Composition and specific surface area data of dairy powders obtained from different dairy companies in New Zealand

Powder	Number of samples	Moisture (% w/w)	Lactose[a] (% w/w)	Protein[a] (% w/w)	Total fat (% w/w)	Surface fat (% w/w)	Specific surface area ($m^2 g^{-1}$)
High fat cream powder	2	1.51	12	11	65.0	34.1	0.075
Low fat cream powder	2[b]	1.90	23	16	54.5	12.6	0.064
Cheese powder 1	2	ND[c]	28	19	41.0	23.5	0.116
Cheese powder 2	2	ND[c]	34	20	31.0	4.1	0.158
Whole milk powder	2	ND[c]	37	27	28.0	2.0	0.049
Buttermilk powder	2	ND[c]	46	35	8.7	0.09	0.132

[a] Not measured, taken from powder specification sheets supplied by the manufacturer.
[b] Four samples of LFCP were used for surface fat measurement.
[c] Not determined.

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