Preparation of a Foam Spray Dried Whole Milk Type Product with Good Sinkability, Dispersibility, and Solubility

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Abstract

Foam spray dried powder of whole milk type with good sinkability was prepared by combining three influential factors in the preparation procedure: (1) use of liquid milk fat, (2) high pressure homogenization, and (3) low foaming with carbon dioxide. A 26% liquid milk fat powder has somewhat adverse dispersibility and solubility, but lowering the fat content to 11% liquid milk fat provides a powder with instant type properties, 98% sinkability, 95% dispersibility, and .5 ml solubility index.

Introduction

Two desirable qualities of spray dried milk are good dispersibility and good sinkability. Dispersibility is the quality of separation upon mixing with water, forming a reconstituted milk equal in appearance to fresh milk. Sinkability is the quality of spreading the powder out with rapid wetting in water, with minimal formation of lumps or foam. Conventionally spray dried skim milk has some sinkability but poor dispersibility. Commercially, by an agglomeration process, the dispersibility of skim milk powder can be improved without adversely affecting the powder's sinkability. This commercial instantizing process cannot be applied successfully to whole milk powder. However, dispersibility of both types of powder can be improved by injecting gas into milk concentrates at a point before the spray nozzle.

Bell et al. (3) prepared skim milk powders foamed to a bulk density of about .33 with excellent dispersibility. Hanrahan et al. (5) prepared whole milk powders foamed to a bulk density of about .25 with good dispersibility. Foaming to these densities, however, has an adverse effect on a powder's sinkability. Whole milk powder, even without foaming, has poor sinkability. Solid fat crystallizes at the interface of the fat and contributes to formation of lumps when the milk is reconstituted (2, 4). Liquid milkfat contributes to sinkability because it mixes more readily with water. Tamsma et al. (9) prepared skim milk powders with both good sinkability and dispersibility by low foaming to provide higher bulk densities than in the earlier work. Utilizing the principle of low foaming, we have attempted to prepare powders containing milkfat with both good sinkability and good dispersibility. We are reporting the effects on these properties of substituting liquid milkfat for whole milkfat and of carbon dioxide foaming, nitrogen foaming, and homogenization pressure. Three parameters for dry milk reconstitution, dispersibility, sinkability, and solubility, were included in our study. Good solubility is a third desirable quality of spray-dried milk. Solubility is the quality of dispersing particles sufficiently small to minimize sedimentation after holding the reconstituted milk during practical periods or after moderate centrifugation. Free fat was also included because of its effect on dispersibility (8) and possible effect on sinkability and solubility.

Materials and Methods

General procedures were described (5, 9). Products obtained by drying concentrates of 45% total solids with a 1.19 mm nozzle were sieved through a 13 mesh screen. Liquid fat (mp 20 C) prepared by winterizing milkfat, was recombined with skim milk (7). Winterizing was done by holding liquid milkfat at 20 C during 3 to 5 days and removing the solid fraction with a basket centrifuge. Free fat (8), dispersibility (6), sinkability (4), and solubility (1), were determined by known methods.

Results and Discussion

Preliminary results were without sinkability data. Dried whole milks prepared without and with homogenization and foamed with CO_2 or N_2 to bulk density .4 (Table 1) showed the

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TABLE 1. Effect of homogenization and low foaming with CO_2 or N_2 on free fat, solubility, and dispersibility of spray dried whole milks. (Averages of 2 runs).

Homogenization pressure (atm)	0		167		367	
Foaming gas	CO_2	N_2	CO_2	N_2	CO_2	N_2
Bulk density (g/ml)	.39	.40	.40	.41	.42	.42
Free fat (%)	16.4	14.0	3.0	3.6	1.7	2.7
Solubility index (ml)	.7	.5	1.6	.9	1.5	.8
Dispersibility (%)	77	78	82	86	79	86

large effect that homogenization had in decreasing free fat. The decrease was somewhat more at 367 atm than that at 167 atm homogenization pressure. Solubility index was high, particularly for CO_2 foams, and was increased by homogenization. Dispersibility was improved by homogenization, slightly for CO_2 foams, more definitely for N_2 foams. Homogenization at 367 atm versus 167 atm did not affect solubility index or dispersibility. Dried whole milks were then compared with dried products prepared from recombined liquid fat and skim milk; moisture and sinkability data were included.

The powders were examined fresh and after 2 and 7 days of storage at 4 or 27 C because sinkability of fresh dry whole milk decreases after short storage coinciding with crystallization of the fat (2, 4). Both types of products were homogenized at 167 and 367 atm and foamed with CO_2 or N_2 to bulk density .4. Moisture contents varied from 3.0 to 4.5% which is high (Table 2). Free fat and solubility index, in fair agreement with the preliminary data (Table 1), did not change during the 2 to 7 days holding of the powders at 4 or 27 C. No effect of free fat on sinkability or solubility could be established. Initial dispersibility was higher for N_2 foams as compared to CO_2 foams, in good agreement with preliminary results (Table 1). The data indicated a slight decrease in dispersibility during the holding period with no difference between 4 or 27 C holding temperatures. The decrease was slightly more for N_2 foams (averaging 4%) as compared to CO_2 foams (averaging 2%).

Sinkability of the fresh dry whole milks was high and was maintained well at 4 C, poorly at 27 C. This is like Bullock and Winder's re-

TABLE 2. Effect of homogenization pressure and low foaming with CO_2 or N_2 on free fat, solubility, dispersibility, and sinkability of spray dried whole milks and products recombined from liquid milkfat and skim milk. (Averages of 2 runs, 26% fat in the dry powders).

Homogenization pressure (atm)	Whole milks				Lquid fat products			
	167		367		167		367	
Foaming gas	CO_2	N_2	CO_2	N_2	CO_2	N_2	CO_2	N_2
Bulk density (g/ml)	.40	.37	.42	.40	.41	.40	.41	.39
Moisture (%)	3.2	3.0	4.4	4.2	4.2	3.4	4.5	3.8
Free fat (%)*	3.0	3.1	1.9	1.7	4.5	4.7	1.7	1.7
Solubility index (ml)*	1.6	1.0	1.6	.8	1.0	.8	1.4	.9
Dispersibility (%)								
Initially	82	88	79	87	80	83	78	81
2 days 4 C	82	86	78	78	79	82	80	82
7 days 4 C	80	85	79	79	75	78	76	83
2 days 27 C	83	82	79	79	81	82	80	82
7 days 27 C	80	81	76	79	78	79	77	79
Sinkability (%)								
Initially	98	95	99	98	100	100	100	99
2 days 4 C	90	86	99	95	100	99	100	94
7 days 4 C	94	78	100	96	96	89	100	92
2 days 27 C	83	18	49	29	100	85	98	91
7 days 27 C	34	19	50	26	95	80	100	94

* No change during 7 days holding at 4 or 27 C.

sults (4). Homogenization at 367 atm compared to 167 atm and CO_2 foaming compared to N_2 foaming improved sinkability during holding. Liquid fat was beneficial for good sinkability, particularly after holding at 27 C. Combination of these three important factors, liquid fat, homogenization at 367 atm, and foaming with CO_2 produced a product which maintained 100% sinkability after holding at 27 C (Table 2).

Foaming with CO_2 as compared to N_2 resulted in better sinkability, but poorer solubility and dispersibility. Further study indicated that undissolved protein, as demonstrated by high solubility index after reconstituting the powder and centrifugation by standardized procedures, was not denatured in the sense that it was permanently insoluble. The reconstituted milk held at 38, 27, and 4 C before centrifugation improved in solubility index, rapidly at 38 C, (in 2 to 3 h to .2) and more slowly at lower temperatures.

The dispersibility and solubility of products with excellent sinkability (prepared with liquid milk fat, 367 atm homogenization, and CO_2 foaming) were improved by reducing fat. Sinkability, dispersibility, and solubility index determined after 2 days of holding at 27 C were 98, 88, and 1.0 at 19% fat; 98, 95, and .5 at 11% fat in the dry product. Dispersibility of 95% is very good as compared to commercial instantized skim milk which was 97% dispersible (9). Solubility index .5 is satisfactory for extra grade quality.

Future Work

A product with lower deodorized liquid milk fat has good economic and nutritional feasibility. It has good reconstitution properties and also good flavor stability (7). The physical properties and flavor stability of such products in comparison with full fat products, foaming higher and conventional spray drying, will be reported later.

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