Reconstitutability of Spray-Dried Milk Products Containing 26 or 13% Fat

A. TAMSMA, F. E. KURTZ, A. KONTSON, and C. SUTTON
Dairy Products Laboratory
Eastern Regional Research Center[1]
Philadelphia, PA 19118[2]

ABSTRACT

The relationship of sinkability, dispersibility, and solubility was studied for regularly foamed, low foamed, and conventionally spray-dried milk powders each with two levels of two types of fat. The effect of five particle sizes of each powder on those characteristics was studied also. Foaming improved dispersibility and solubility but decreased sinkability. Large particle size improved sinkability and solubility but reduced dispersibility. Low fat was beneficial for all three properties while liquid fat was beneficial for sinkability and dispersibility but did not affect solubility. Carbon dioxide, compared with air at low foam in products with 26% fat, improved sinkability, adversely affected solubility, but did not affect dispersibility. The "instant type" powder, having the best overall properties (85% sinkability, 98% dispersibility, and .5 ml solubility index), contained 13% liquid fat and was prepared by spray drying after low foaming with carbon dioxide.

INTRODUCTION

The fat (26%) in dried whole milk (DWM) makes it more difficult than nonfat dry milk (NDM) to reconstitute with water. Milk fat contributes to flavor, but flavors of milks containing 1 or 2% fat score almost as high as milk containing 3% milk fat and considerably higher than skim milk with .1% fat (8). Dry milk products with fat lower than DWM reconstitute readily and have stable flavor (7).

We have compared low-fat dry products with full-fat products. Foamed DWM (7) is dried and reconstituted more easily than regular, nonfoamed DWM, but it has two disadvantages. Firstly, when added to water, the particles tend to float and do not dissolve without shaking. Secondly, because of its lower bulk density, foamed DWM requires a larger package than nonfoamed DWM. We rated reconstitutability on sinkability, dispersibility, and solubility as measured by solubility index (7). Because foaming increases dispersibility but decreases sinkability, there may be optimum foaming with respect to reconstitutability of DWM. Lowering the content and melting point of fat in dry milk improves reconstitutability. High homogenization pressure and use of CO_2 as the foaming gas are also beneficial. We developed low foamed "instant type" milk powder with 11% liquid milk fat (7).

In the present study, we compared effects of fat and foaming on regularly foamed, low foamed, and conventionally spray-dried powders. Regularly foamed DWM was used for all flavor studies and was the basis for a product that was scored initially as equal to fresh milk, and after 6 mo of storage as still acceptable as a beverage (3).

Our purpose was to determine effects of type and percent of milk fat, type and amount of foaming, and type of gas used for foaming on reconstitutability.

MATERIALS AND METHODS

Reconstitutability (sinkability, dispersibility, and solubility) was determined for 12 dry milk powders prepared by the 12 possible combinations of two types of milk fat, each at two levels and of two types of foaming with two foaming gases at low foaming. Properties of the 12 foamed powders were compared with those of 4 powders from conventional spray drying. A smaller spray nozzle was used than in the previous study (7) to assure low enough moisture for conventionally spray-dried powders.

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Regularly foamed spray-dried milk with low bulk density was included because of its dispersibility, solubility, and gas permeability although conventionally spray-dried milk with high bulk density has better sinkability and packaging economy. Low foamed products minimize foaming for optimum reconstitutability (1, 5, 7).

General procedures have been described (1, 3, 4). Milks dried to 26 and 13% fat powders were standardized to 3.3 and 1.4% fat, respectively. Liquid fat was prepared as described (7). All milks and recombined fluids were pasteurized at 77 C for 15 s, then homogenized at 367 atm and 63 C. Concentrates (45% total solids) were dried with a 1.06 mm nozzle in 132 C air. The dryer was equipped with carbon filters, and the powders were cooled with liquid N_2 (3). Regularly foamed products were foamed with air (6), and injected under high pressure between pressure pump and spray nozzle according to Hanrahan et al. (1). Low foamed products were foamed with air and with CO_2. For low foaming, gas was added just ahead of the high pressure pump at 3 atm and .35 liters/kg of concentrate, producing a powder with bulk density of about .4 g/ml (4, 7). Powders were held 7 days at 27 C (7); then physical properties were determined. Powders were separated into five fractions with ranges of particle size: over 710 μm, 710 to 500 μm, 500 to 250 μm, 250 to 105 μm, and below 105 μm (4). Parameters for original powders and each of the fractions were measured. All data were from duplicate experiments.

RESULTS AND DISCUSSION

Data of Table 1 indicate that the product with 13% liquid fat low foamed with CO_2 had optimum characteristics: sinkability 85%, dispersibility 98%, and solubility index .5 ml. Low fat was beneficial for sinkability, dispersibility, and solubility of all products and brought dispersibility of foamed products close to that of instant NDM (4). Low fat improved sinkability most for products with normal fat, conventionally spray-dried, and low foamed with CO_2. Low fat improved solubility to "extra grade" (.5 ml) for all products except those conventionally spray-dried. Liquid fat was beneficial for sinkability and dispersibility. Regularly foamed DWM improved most in dispersibility

TABLE 1. Effect of fat and foaming on reconstitutability of dry milk products.

	Normal fat						Liquid fat					
	26%			13%			26%			13%		
	Sinkability (%)	Dispersibility (%)	Solubility index (ml)	Sinkability (%)	Dispersibility (%)	Solubility index (ml)	Sinkability (%)	Dispersibility (%)	Solubility index (ml)	Sinkability (%)	Dispersibility (%)	Solubility index (ml)
Air foam, regular	7	83	.1	12	99	0	30	94	.1	34	97	0
Air foam, low	7	81	.7	20	92	.4	27	86	.8	40	94	.3
CO_2 foam, low	14	81	2.0	61	95	.3	54	86	2.0	85	98	.5
Conventionally spray-dried	22	73	2.7	77	90	1.9	99	74	3.3	99	88	1.8

from use of liquid fat (from 83 to 94%) bringing it into the dispersibility range of instant NDM. With 26% liquid fat, sinkability was 99% for the conventionally spray-dried product, 54% for the product low foamed with CO_2, and 27 and 30% for the other two foamed products. Sinkability for an 11% liquid fat product low foamed with CO_2 was 98% (7). However, that product, which had been sprayed with a wider nozzle, contained larger particles that tend to have better sinkability. Effect of particle size will be discussed later.

Foaming improved dispersibility and solubility, but at 26% fat, low foaming with CO_2 reduced solubility as compared to foaming with air. Better sinkability resulted from low or no foaming and from low foaming with CO_2 as compared to air (Table 1). Dispersibility was improved by foaming, less fat, and liquid fat. Solubility was improved by foaming and less fat. Sinkability and dispersibility of conventionally spray-dried milk with 26% fat were much lower than for instant NDM which was close to 100% for both sinkability and dispersibility (4). Regularly foamed DWM had solubility (.1 ml solubility index) but low sinkability (7%) which resulted from air incorporated in the particles. Dispersibility, 83%, seemed low as compared to the 89% reported by Hanrahan et al. (1). However, they manually stirred the powder in ice water for 1 min. We used the method of Kontson et al. (2), who improved reproducibility of the dispersibility method by replacing hand stirring by controlled mechanical mixing. A 30-s period adopted produced lower values than a 60 s period but gave more differentiation between various highly dispersible samples.

Bulk densities (data not shown) were similar for products with the four types of fat but were affected by foaming: .21 to .24 for regularly foamed, .37 to .42 for low foamed, and .50 to .56 for conventionally spray-dried products.

Foaming, as expected, produced more coarse and less fine particles. Low fat produced more fine and less average size and coarse particles (Table 2). Fraction distribution differed little between powders with normal and liquid fat (data not shown). Large particle size generally improved sinkability and reduced solubility index but adversely affected dispersibility (Table 3). Liquid fat improved sinkability and dispersibility of the fractions, especially among coarse fractions. Liquid fat reduced solubility of conventionally spray-dried milk fractions but generally had little effect on other fractions (Table 3). Effects on fractions of powders with 13% fat were similar (data not shown).

Dispersibility of the coarse fraction in regularly foamed DWM had been low and was improved when the coarse fraction was crushed and recombined with other fractions (2). For regularly foamed DWM, the procedure improved dispersibility from 83 to 89%. For other air foamed and conventionally spray-dried products, the increase ranged from 0 to 5 percentage points and averaged 3.2. There was no increase for products low foamed with CO_2. Other possibilities for improving the reconstitutability of products by manipulation or elimination of fractions are not apparent from the data.

In less soluble products, fine particle fractions had the highest solubility indexes (Table

TABLE 2. Effect of fat content and foaming on particle size distribution[a] of dry milk products.

	Normal fat									
	26%					13%				
Fat content fraction no.[b]	1	2	3	4	5	1	2	3	4	5
Air foam, regular	20	23	40	16	1	18	23	37	21	1
Air foam, low	16	20	47	13	4	13	17	34	28	8
CO_2 foam, low	11	18	55	13	3	9	19	37	26	9
Conventionally spray-dried	14	17	38	24	8	7	13	37	29	14

[a]Weight percentages of the 5 fractions.

[b]Fraction 1 = over 710 μm, fraction 2 = 710 to 500 μm, fraction 3 = 500 to 250 μm, fraction 4 = 250 to 105 μm, fraction 5 = below 105 μm.

TABLE 3. Effect of type of fat, foaming, and particle size on reconstitutability of fractions of dry milk products.

	26% Normal fat					26% Liquid fat				
Fraction no.[a]	1	2	3	4	5	1	2	3	4	5
Sinkability (%)										
Air foam, regular	7	9	9	7	7	26	31	31	19	17
Air foam, low	9	11	9	5	5	50	33	31	18	16
CO_2 foam, low	19	16	16	11	7	86	75	74	19	13
No foam	16	21	25	19	17	100	100	98	99	99
Dispersibility (%)										
Air foam, regular	72	86	94	95	95	82	97	100	100	99
Air foam, low	71	81	90	89	85	81	90	94	93	95
CO_2 foam, low	66	79	83	84	85	78	84	87	86	91
No foam	61	73	76	77	81	72	73	78	80	84
Solubility index (ml)										
Air foam, regular	.1	.1	.1	0	0	.1	.1	.1	.1	.1
Air foam, low	.5	.5	.8	.9	.7	.6	.8	1.1	1.0	.8
CO_2 foam, low	1.4	1.8	2.2	2.8	2.1	1.6	2.0	2.4	2.7	3.1
No foam	2.1	2.4	3.0	3.3	4.5	2.9	3.1	3.9	4.2	4.8

[a]Fraction 1 = over 710 μm, fraction 2 = 710 to 500 μm, fraction 3 = 500 to 250 μm, fraction 4 = 250 to 105 μm, fraction 5 = below 105 μm.

3). During the drying process, fine particles apparently receive more heat exposure. Solubility can be improved by reducing air temperature of the dryer (9). With air at 120 C, conventionally spray-dried milk with 13% fat was obtained with a solubility index .5 ml, sinkability 99%, and dispersibility 87%; however, moisture increased to 6.6%. With a smaller nozzle (.77 mm diameter), a fine powder was produced. The moisture content was 3.6%; bulk density, .66%; solubility index, .2 ml; sinkability, 50%; and dispersibility, 85%.

Conventionally spray-dried milks were reconstituted and dispersed 98 to 100% in 60 s with an electric blender. A heavy powder is an advantage in packaging economy, which might dominate for some applications, if mechanical mixing devices are available. Instant-type powders are generally desirable for convenience foods and preferable for beverage-type milks. Results of this and previous work (7) show that good quality instant-type products can be produced with low liquid milk fat and low foamed with CO_2.

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