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STUDIES ON RECONSTITUTION OF MILK FROM MILK POWDER DEPENDING ON WATER TEMPERATURE

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Key words: dry milk powder, wettability, dispersibility, solubility index.

Studies were carried out on the reconstitution of milk from milk powder depending on the temperature of water used (10-90°C, 10°C intervals). The temperature of water affected the reconstitution process as well as the final appearance of the milk. It was also found that wettability and dispersibility of the milk powders depended on the technical parameters of the powder production process.

INTRODUCTION

Reconstruction of milk from milk powder depends on the method of powder production, size of particles, agglomeration process, uniformity of lecithin distribution in case of whole milk powder, temperature of water used for the reconstitution, intensity of mixing etc. [4, 10].

Properly reconstituted milk should have a satisfactory appearance (no noticeable particles or sediment, and no fat coalescence), this being achieved only when the powder is of sufficient wettability, dispersibility and solubility [5, 8].

According to the accepted standards, milk powders should be reconstituted in warm, and the agglomerated products in cold water. In practice, however, these products are reconstituted in cold, warm or even hot water. Hence, it was decided to study the reconstitution of milk from milk powder with consideration given to water temperature.

MATERIAL AND METHODS

Studies were carried out in the Danish Government Research Institute for the Dairy Industry in Hillerod. The following products were used:

I. Agglomerated whole milk powder — 2 commercial brands (Ia and Ib) produced in Denmark.

II. Agglomerated whole milk powder produced in Denmark on a semi-commercial scale, the production parameters being as follows: pasteurization; temp.

85°C, time 15s, condensation 48% TS, homogenization; pressure 15 MPa, temp. 65°C, drying air temp.; inlet 180°C, outlet 78°C.

III. Agglomerated whole milk powder produced in Denmark on a semi-commercial scale, the production parameters being as follows: pasteurization; temp. 85°C, time 15 s, repasteurization; temp. 110°C, time 150 s, condensation: 48% TS, homogenization; pressure 15 MPa, temp. 65°C, drying air temp.; inlet 195°C, outlet 95°C.

IV. Whole milk powder — commercial brand produced in Poland.

V. and VI. Agglomerated skimmed milk powder — commercial brand produced in Denmark (V) and in Poland (VI).

VII. Granulated skimmed milk powder — commercial brand produced in Poland.

VIII. Skimmed milk powder — commercial brand produced in Poland.

IX. Buttermilk powder — commercial brand produced in Denmark.

X. Whey powder — commercial brand produced in Denmark.

All products were reconstituted using water of 10 to 90°C, at 10° intervals.

METHODS

Studies were based on the following analytical methods: wettability [12], dispersibility [11], solubility index [12], organoleptic estimates (appearance) [3].

RESULTS AND DISCUSSION

The samples differed as to their wettability (depending on the milk powder used) and temperature of water used for milk reconstitution. Wettability time decreased along with increasing water temperature for of the samples. The best wettability was noted for granulated skimmed milk powder irrespective of water temperature (Table 1). Wettability of this product amounted to 7 s when the temperature of water was 10°C, and to only 1,6 s at 90°C. Slightly worse results were obtained with agglomerated skimmed milk powder although the trend was similar. Wettability of agglomerated skimmed milk powder number VI improved already when temperature of water was raised from 10 to 20°C (from 44 to 21 s), and samples number V improved when the temperature was raised from 20 to 30°C (from 45 to 25 s).

Agglomerated full milk powder was characterized by a distinctly worse wettability. The best results were obtained at a water temperature of 60 to 80°C (14-36 s) (Table 1). Other temperatures, both higher and lower, gave worse results.

Also non-agglomerated whole milk powder was characterized by poor wettability. At a water temperature of 10-40°C this index amounted to over 3 min., and the obtained products did not conform to the standards. Only in temperatures over 50°C wettability of this milk powder improved noticeably (17-19 s).

Table 1. Wettability (s) of dried concentrates depending on water temperature

Kind of production / Temp. of water °C	Whole milk powder — agglom.				Whole milk powder non-agglom.	Skimmed milk powder				Buttermilk powder non-agglom.	Whey powder non-agglom.
						agglom.	agglom.	granul.	non-agglom.		
	Ia	Ib	II	III	IV	V	VI	VII	VIII	IX	X
10	> 3 min.	> 3 min.	> 3 min.	> 3 min.	> 3 min.	49	44	7	> 3 min.	> 3 min.	> 3 min.
20	96	> 3 min.	> 3 min.	> 3 min.	> 3 min.	45	21	6	> 3 min.	> 3 min.	> 3 min.
30	47	> 3 min.	> 3 min.	> 3 min.	> 3 min.	25	12	5	> 3 min.	> 3 min.	48
40	25	43	32.3	> 3 min.	> 3 min.	21	10	4	62	67	27
50	18	36	17	> 3 min.	64	11	4	3	31	27	15
60	14	21	12	> 3 min.	19	10	3.5	2.5	14	12	14.3
70	17	18	13	> 3 min.	18	6	3.3	2.3	11	11	9
80	36	15	93	> 3 min.	17.5	5	3.2	2.0	7	8	7.9
90	53	19	> 3 min	> 3 min.	17	4	3.0	1.6	6	7	6

Wettability of the agglomerated full milk powder produced on a semi-commercial scale (products II and III) was largely differentiated. Product II, obtained with a less strict technological regime, was characterized by almost similar wettability as commercial milk powder. Noticeably lower values were obtained for product III which was produced from repasteurized milk and using higher temperatures of inlet and outlet air (Table 1). Wettability of the latter amounted to over 3 min. irrespective of water temperatures.

It seems that the differences in wettability of the agglomerated whole milk powders were due the different rate with which water penetrated the pores of milk particles. According to Kreveld [5] this rate depends on the free fat, particle size, relative volume of the pores, their diameter, distribution and angularity. Rate of internal wetting may decrease also due to increased hydrodynamics resistance caused by pore clogging as well as to increased viscosity, the latter resulting from an uneven rate with which particular milk components are dissolved in water. Studies by Jensen et al. (4) revealed favourable wettability in 15-50°C only for agglomerated skimmed milk powder. These authors concluded that wettability of milk powder does not necessarily determine its final solubility.

Dispersibility of the milk powders was slightly different than wettability. The agglomerated products gave satisfactory results already when water temperature amounted to only 10°C. The highest dispersibility was observed when the milk powders were reconstituted at 60°C. For all samples (with the exception of whey powder) the dispersibility decreased with increasing water temperature in the range above 60°C (Table 2).

Kreveld (5), Woodhams and Murray [9] stated that the unsatisfactory dispersibility of milk powder was due to low density, high air content, low particle size and low wettability. Lascelles and Baldwin [7] observed that milk powder reconstituted in water of 55-65°C was characterized by the highest dispersibility. Lower dispersibility at 45°C was caused by low wettability, while in temperateres over 70°C large particles of low wettability were formed.

Our studies showed that the temperature of water used for milk reconstitution had no major effect on the solubility index. This effect was noticeable only in extreme temperatures as well as in case of the product III regenerated in 10-30°C (0.40-1.35 ml) (Table 3).

Jensen et al. [2] did not notice clear effect of milk pasteurization (65-125°C for 15-200 s) on the solubility of the milk powder (0.11-0.27 ml). It was concluded that this property was affected by air parameters during milk drying. This suggestion was confirmed by DeVilder et al. [1]. These authors found that the solubility of a full milk powder was affected by the temperature of inlet (180-195°C) and outlet (80-90°C) air, the respective values being 0.25 for lower and 0.45 ml for higher temperature. Kreveld and Verhoog [6] observed a considerable effect of water temperature (within a range of 15 to 25°C) on the solubility of milk powder. Hovewer, their, studies were based on the C.C.F. test and cannot be fully compared with the results obtained with the ADMI method.

Reconstituted skimmed milk, buttermilk and whey were characterized by

Table 2. Dispersibility (%) of dried concentrates depending on water temperature

Kind of production / Temp. of water °C	Whole milk powder — agglom.				Whole milk powder non-agglom.	Skimmed milk powder				Buttermilk powder non-agglom.	Whey powder non-agglom.
						agglom.	agglom.	granul.	non-agglom.		
	Ia	Ib	II	III	IV	V	VI	VII	VIII	IX	X
10	94.54	85.56	82.07	64.10	70.79	95.12	94.02	90.24	80.62	80.01	83.56
20	97.17	91.79	93.06	81.18	61.73	96.13	95.38	92.91	86.84	87.58	93.64
30	97.30	94.46	95.05	89.44	91.63	96.19	95.23	93.54	93.01	92.13	93.81
40	97.01	95.84	98.55	98.11	96.38	96.34	95.16	94.05	97.73	93.88	93.97
50	97.20	96.81	98.61	98.16	95.70	96.98	95.07	90.89	94.52	94.33	94.07
60	97.89	97.19	98.79	98.48	95.64	96.97	95.42	96.48	95.23	88.56	94.35
70	97.57	96.73	98.41	98.13	95.54	96.89	95.14	95.49	94.76	83.64	95.53
80	96.53	96.54	96.49	96.36	90.85	96.05	94.37	93.65	91.24	78.14	96.87
90	94.35	96.39	93.15	94.41	85.26	92.89	91.87	88.49	90.40	63.51	97.08

Table 3. Solubility index (ml) of dried concentrates depending on water temperature

Kind of production / Temp. of water °C	Whole milk powder — agglom.				Whole milk powder non-agglom.	Skimmed milk powder				Buttermilk powder non-agglom.	Whey powder non-agglom.
						agglom.	agglom.	granul.	non-agglom.		
	Ia	Ib	II	III	IV	V	VI	VII	VIII	IX	X
10	0.08	0.60	0.06	1.35	0.06	0.10	0.05	0.07	0.06	0.07	0.10
20	0.05	0.20	0.05	0.60	0.06	0.05	0.05	0.07	0.05	0.05	0.10
30	0.05	0.11	0.05	0.40	0.05	0.05	0.05	0.06	0.05	0.05	0.09
40	0.05	0.08	0.05	0.07	0.05	0.05	0.05	0.06	0.05	0.05	0.08
50	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.05	0.08
60	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.05	0.05	0.07
70	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.05	0.09	0.06
80	0.05	0.05	0.06	0.06	0.06	0.05	0.06	0.06	0.05	0.05	0.10
90	0.06	0.06	0.06	0.07	0.06	0.06	0.07	0.07	0.06	0.06	0.11

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Table 4. Characteristic of milk appearance (scores) reconstituted from dried concentrates depending on water temperature

Kind of production / Temp. of water °C	Whole milk powder — agglom.				Whole milk powder non-agglom.	Skimmed milk powder				Buttermilk powder non-agglom.	Whey powder non-agglom.
						agglom.	agglom.	granul.	non-agglom.		
	Ia	Ib	II	III	IV	V	VI	VII	VIII	IX	X
10	11.5	9	10.5	5.5	6.5	12.5	12	12.5	12	12.5	13
20	9	9	10.5	7	5.5	12.5	12	12.5	12	13	13
30	7.5	8	9.5	8	5.5	13	12	12.5	12	13	13
40	11	7	11.5	10	8	13	12.5	12.5	12.5	13	13
50	13	10	11.5	11	11.5	13	12	12.5	12.5	13	13
60	13	10.6	12	11	12	13	12.5	12.5	12.5	13	13
70	13	10.6	12.5	11	12	13	12.5	12.5	12.5	13	13
80	13	11	12.5	11.5	12	13	12.5	12.5	12.5	13	13
90	13	11.5	13	12	9	13	12.5	12.5	12.5	13	13

very satisfactory appearance independently of the temperature of water used. All of these products were given a score of 12-13 points out of the 15 possible (Table 4). Much worse results were obtained with whole milk powders. When the temperature of water used for the reconstitution was 10-40°C, the products were given a score of only 7.0-11.5 points (with the exeption of product III). Non-agglomerated whole milk powder was given only 5.5-8.0 points. Appearance of the reconstituted milk was improved in higher water temperatures.

The results point to the importance of water temperature in milk powder reconstitution. Its effect was noticeable not only during the reconstitution but also as regards the final appearance of the regenerated milk.

CONCLUSIONS

1. Wettability of milk powder improved already when the temperature of water was raised to 30°C or 60°C. Most satisfactory wettability was noted for granulated skimmed milk powder irrespective of the water temperature.
2. The highest dispersibility was observed when the milk powders were reconstituted at 60°C.
3. Temperature of water used for milk reconstitution had no greater effect on the solubility index.
4. Reconstituted skimmed milk, buttermilk and whey were characterized by wery satisfactory appearance independently of the temperature of water used. Much worse results were obtained with whole milk powders.

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LITERATURE

1. De Vilder J., Martens R., Naudts M.: Milchwiss., 1976, 31 (7), 396.
2. Jensen G. K., Hansen P. S.: Statens Forsøgsmejeri, Beretning 1972, 195.
3. Jensen G. K., Hansen P. S.: Statens Forsøgsmejeri, Beretning 1973, 202.
4. Jensen G. K., Hansen P. S., Rutkiewicz W.: Statens Forsøgsmejeri, Beretning 1974, 219.
5. Kreveld A.: Neth. Milk Dairy J., 1974, 28 (1), 23.
6. Kreveld A., Verhoog J.: Neth. Milk Dairy J., 1963, 17 (3), 209.
7. Lascelles D., Baldwin A.: New Zeland J. of Dairy Sc. and Technology 1976, 11 (7), 283
8. Pisecki J.: The Australian J. of Dairy Technology 1980, 35 (9), 95.
9. Woodhams D., Murray M.: New Zeland J. of Dairy Sc. Technology 1974, 9 (4), 172.
10. Żbikowski Z., Kisza J., Rybka J., Żbik H.: Przegl. Mlecz., 1976, 25 (8), 12.

11. American Dry Milk Institute, Inc. ADMI: Standards for Grades of Dry Milks including Methods of Analysis. Bulletin 916. revised 1971.
12. Niro-Atomizer A/S: Analytical Methods for Dry Milk Products. Copenhagen, Denmark 1987.

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BADANIE STOPNIA ODTWORZENIA MLEKA Z ROZPYŁOWEGO PROSZKU MLECZNEGO W ZALEŻNOŚCI OD TEMPERATURY WODY

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Streszczenie

Przeprowadzono badania nad wpływem temperatury wody (w zakresie10-90°C w przedziale co 10°C) na stopień odtwarzania mleka z rozpływowego proszku mlecznego. Analizowane próbki charakteryzowały się zróżnicowaną zwilżalnością w zależności od rodzaju proszku oraz temperatury wody używanej do regeneracji. W większości analizowanych próbek wraz ze wzrostem temperatury następowało wyraźne skrócenie czasu zwilżania. Najlepszą zwilżalnością, niezależnie od temperatury wody, charakteryzował się granulowany odtłuszczony proszek mleczny. Nieco gorzej kształtowały się te wartości w aglomerowanym odtłuszczonym proszku mlecznym, choć tendencje tych zmian były dla obydwu produktów podobne. Znacznie natomiast gorszą zwilżalnością w porównaniu z poprzednio analizowanymi produktami charakteryzował się aglomerowany i nie aglomerowany pełny proszek mleczny. Poprawę zwilżalności tych produktów uzyskano dopiero przy użyciu wody o tem. 60-80°C (14-36 s). Przyczyn tak niskiej zwilżalności pełnego proszku mlecznego należy upatrywać w sposobie produkcji, zawartości wolnego tłuszczu, aglomeracji i w równomierności rozprowadzenia lecytyny.

Nieco inaczej kształtowały się wyniki rozpraszalności proszku mlecznego, choć w większości próbek były one zgodne z wymogami. Najwyższą rozpraszalnością charakteryzowały się próbki proszku mlecznego regenerowane w wodzie o tem. 60°C. W niniejszych badaniach stwierdzono niewielki tylko wpływ temperatury wody używanej do regeneracji proszku na kształtowanie się wskaźnika rozpuszczalności. Zregenerowane mleko odtłuszczone, maślanka i serwatka, niezależnie od temperatury użytej wody charakteryzowały się bardzo dobrym wyglądem, uzyskując 12-13 punktów (na 15 możliwych). Natomiast wyraźnie gorszym wyglądem charakteryzowały się próbki mleka odtwarzanego z pełnego proszku mlecznego. Uzyskane wyniki wskazują na znaczny wpływ temperatury wody na przebieg procesu odtwarzania rozpyłowego proszku mlecznego. Wpływ ten uwidocznił się zarówno w samym przebiegu procesu regeneracji, jak i wyglądzie mleka odtworzonego.