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BETTER PARTICLE SIZE SOLUTIONS

Application Note

Particle Size Analyzing of Milk Powder by Laser Diffraction

Fangfang Zhang, Zhibin Guo, Shelly Zhang

Application Research Laboratory, Bettersize Instruments Ltd.

Introduction

Milk powder is an important product from the processing of milk and it is widely used in the production of ice-cream, cultured milks and yogurts, chocolate, confectionery, bakery products, soups, and sauces. As people's living standards continuously improve in many parts of the world, their consumption and requirements of dairy products, such as the flavor profiles and sensory characteristics, also gradually increase. As we know, milk powder composition, and physical and sensory properties of milk powder are easily affected by production, packaging, transportation, storage and other processes. For example, different manufacturing parameters in the production process of milk powder, such as homogenization, spray drying, and sieving, are likely to affect the particle size distribution of the milk powder, thus affecting its final flavor and sense. Generally, in order to improve the flavor and taste of milk powder, proper homogenization is required to break up large fat particles during the production process. However, a balance has to be achieved in the homogenization process. On the one hand, a significant amount of fat particles will attach to the surface of the protein particles to form larger aggregates, if the homogenization of fat particles is insufficient the stability and flow ability of milk powder will be reduced. On the other hand, with excessive homogenization, the specific surface area of fat particles will significantly increase, which in turn will lead to flocculation of milk powder or acceleration of the fat oxidation, thus weakening the flavor and stability of the product. Therefore, it is very important to monitor the size change of milk powder particles during the production process.

Particle sizing of milk powder

The particle size distribution of milk powder has a great impact in packaging, storage, quality of the product and its final application. Therefore, it is essential for milk powder manufacturers and relevant equipment manufacturers to check the size distribution of milk powder during the production process frequently. Generally, milk powder sizing methods include microscopy, sieving, image analysis and light scattering. In particular, laser diffraction is widely applied by milk powder manufacturers, because its advantages include ease of use, high accuracy and precision. In this note, the Bettersizer 2600 laser diffraction particle size analyzer, with the dry dispersion module, was used to determine the particle size distribution of milk powders under the air pressure of 0.25 MPa. The Bettersizer 2600 adopts the combination technology of Fourier and Inverse Fourier design to simultaneously detect the scattered light signals of the sample in the forward, lateral and backward direction. Meanwhile, an inclined sample cell is utilized in order to diminish the effect of total internal reflection and have a wider measuring range. This innovative technology provides high resolution and accuracy. Therefore, the Bettersizer 2600 is a useful sizing tool especially for investigating the size distribution of fat and casein particles, as well as their interactions.

Particle size analysis of skimmed milk and full-fat milk powder of different brands

The effect of different production techniques and fat content on the particle size distribution of milk powder was investigated by selecting different brands of skimmed milk powder and full-fat powder (Brand A and B).

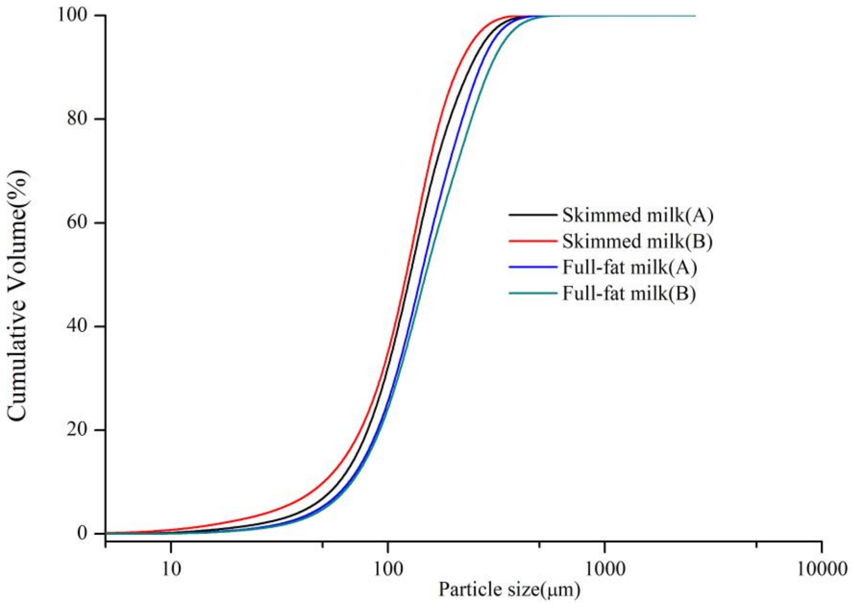

Figure 1. Cumulative volume versus size distributions of skimmed milk and full-fat milk of Brand A and B

As shown in Figure 1, the average particle size of full-fat milk powder is significantly larger than that of the skimmed milk powder. Besides, Brand A's skimmed milk powder had a larger average particle size than Brand B. However, the full-fat milk powders are larger in particle size from Brand B instead of Brand A.

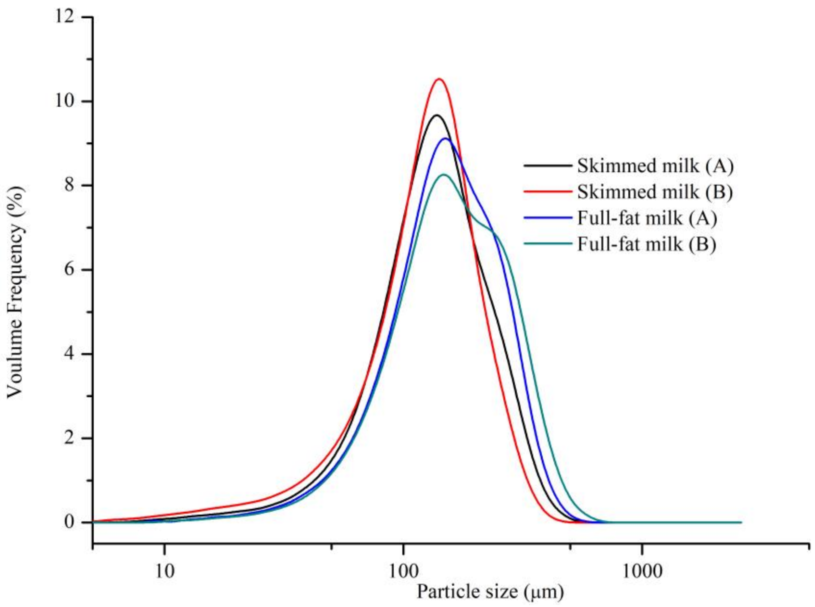

Figure 2. Particle size distributions of skimmed milk and full-fat milk of Brand A and B

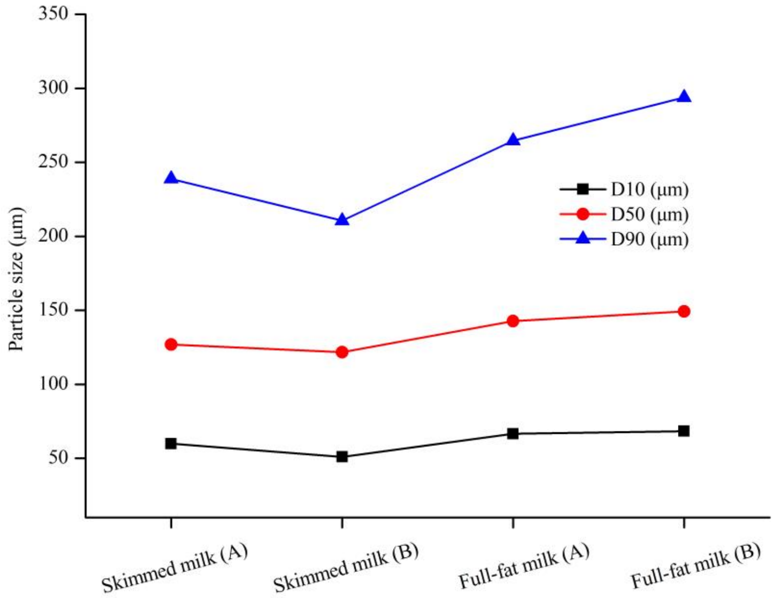

Figure 3. Particle size distributions of skimmed milk and full-fat milk of Brand A and B

As seen from Figure 2 and Figure 3, the D50 of full-fat milk powder is in the range of 142 μm-149 μm, and the D50 of skimmed milk is in the range of 121 μm-126 μm. Therefore, the average particle size of full-fat milk powder is greater than that of the skimmed milk powder. It might be due to the fact that the full-fat milk powders of Brand A and Brand B contain 48% of fat, and the fat particles in the full-fat milk powders are easily aggregated on the surface of casein particles, forming particle agglomerates with larger diameters. Furthermore, it can be clearly observed from Figure 2 and Figure 3 that the average particle size of skimmed milk powder of Brand A is larger than that of Brand

B, while the average particle size of full-fat milk powder of Brand A is smaller than that of Brand B. The reason for this difference probably lies in the diverse parameter settings used when producing the same type of milk powder from different brands. Different settings in the spray drying process (air inlet and outlet temperatures, nozzle air pressure and rotational speed) impact the particle size of the milk powder. In addition, homogeneous mixing speed and pressure also contribute to the particle size distribution of the milk powder. If the homogenous speed is low or the homogeneous time is short, some overly large fat particles might not be broken, leading to the larger powder particle size.

Particle size analysis of milk powders adjusted for different age groups

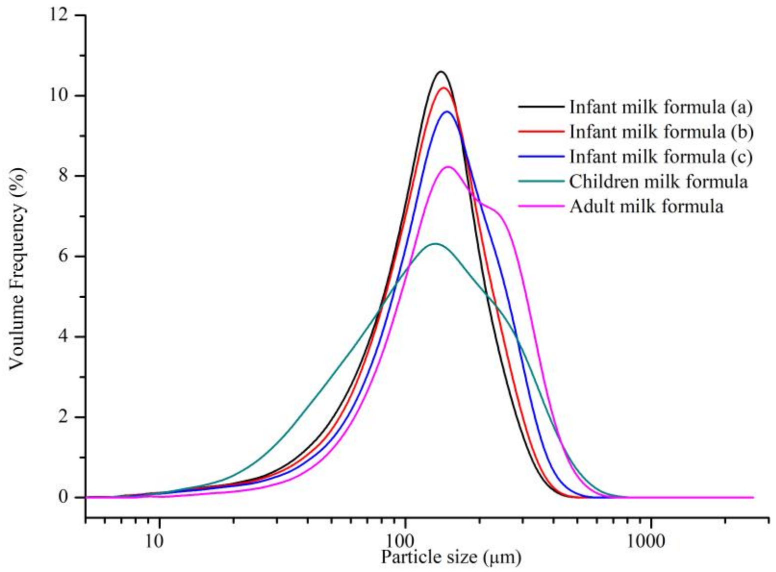

Figure 4. Particle size distribution of milk powder for different age groups

Note: Infant milk powder (a), suitable for infants from 0 to 6 months. Infant milk powder (b), suitable for infants from 6 to 12 months. Infant milk powder (c), suitable for infants from 12 to 36 months.

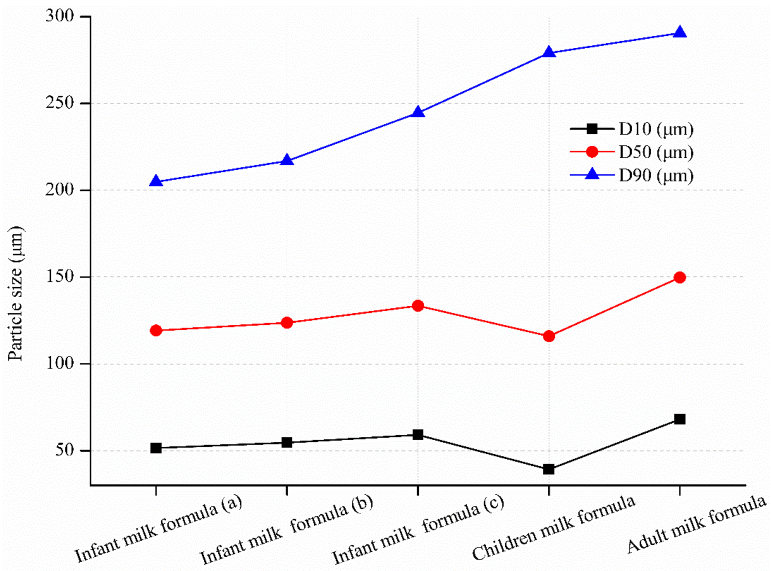

Figure 5. Particle size distribution of milk powder for different age groups

(1) Particle size analysis of infant milk powders

As shown in Figure 4 and Figure 5, there are differences in particle size between infant milk formulas at different stages of infancy. The formula milk powders have ascending particle sizes in the following order: infant milk formula (a) (suitable for infants from 0 to 6 months), infant milk formula (b) (suitable for infants from 6 to 12 months), infant milk formula (c) (suitable for infants from 12 to 36 months). The increase in particle size of the milk powders may be due to the increase of infants' digestive ability and satiety needs with the increase in the infants' life. Therefore, it is necessary to change the nutritional composition ratio of infant milk formula according to age. Meanwhile, in order to imitate breast milk at different stages, the nutritional ratio of infant milk formula will be adjusted accordingly. Generally, the proportion of whey protein in infant milk formula between 6-12 months and infant milk formula between 12-36 months will gradually decrease, while the content of casein will steadily increase. On the one hand, most of the casein in infant milk formula exists in micellar form, and it is fully attached by the fat particles to form large particle masses, thus affecting the particle size distribution of the milk powder. On the other hand, interactions between casein micelles and whey proteins may increase the diameter of casein micelles in the milk powder during the evaporation and drying stages, due to the aggregation of casein micelles or the binding of whey proteins to micelles.

(2) Particle size analysis of milk powder of different stage group

As shown in Figure 5, the average particle size distribution of adult milk formula is significantly larger than that of infant milk formula and children milk formula at all stages. This may be related to the larger fat content of adult milk formula than that of infant milk formula and children milk formula. Meanwhile, a large amount of casein in adult milk formula attach to the surface of the fat particles and form more stable large particles, which leads to the larger particle size of adult milk formula.

It can be seen from Figure 5 that the D90 of infant milk formula, children milk formula and adult milk formula gradually increases, which indicates an increase in the coarse content particles of milk powder. The reason for this result is due to the gradual increase of casein content in milk powder formula with the increase of age stages.

Figure 5 indicates that the D50s of infant milk formula, children milk formula and adult milk formula are ranging from 119 to 133 μm, 116μm, and around 150 μm, respectively. However, the D10 and D50 of the children milk powder are lower than those of infant milk powder and adult milk powder. This could be related to mechanical wear of the agglomerated particles during processing, packaging and transportation. When the milk powder particles collide with each other or with the container wall, it is easy to cause the particle breakage, which reduces the particle size and flow performance of the powder.

Conclusion

In the production and application process of milk powder, the particle size of milk powder directly affects its final taste, sensory properties and quality characteristics. The Bettersizer 2600 can be used by milk powder manufacturers or relevant equipment manufacturers to accurately monitor the size changes of milk powder during production, packaging, storage and application process, as well as to better understand the relationship between dairy product formulation and quality.

Further information on the technique of laser diffraction can be found at

https://www.bettersizeinstruments.com

Bettersize Instruments Limited

Address: No. 9, Ganquan Road, Jinquan Industrial Park, Dandong, Liaoning, China

Postcode: 118009

Tel: +86-415-6163800

Fax: +86-415-6170645

Email: info@bettersize.com