Milk Homogenization

AN135

Homogenization of Milk

Milk is the drink of champions. And think of all the permutations. Chocolate milk, strawberry milk, and of course, lattes and cappuccinos. What would we do without it? But without homogenization, the milk's quality and consistency are sacrificed. Milk is an emulsion that is often homogenized to reduce the average particle size. That improves its consistency and extends its shelf life. The homogenization process is expensive, but careful control of the process can improve quality, and thus, reduce operating costs. That's where particle characterization comes in.

Background

Milk is an oil-in-water emulsion. It contains essential nutrients such as calcium, magnesium, selenium, riboflavin, vitamin B12 and pantothenic acid. About 3 to 4 percent of cow's milk is fat, 3.5 percent is protein (casein micelles), and 5 percent is lactose[1]. Fat content varies depending on the dairy breed.

The particle size of fat, in particular, plays a crucial role in determining key quality characteristics, including shelf life, taste, and mouthfeel. When left to stand, fat globules in whole, raw milk will agglomerate, or collect and form into a larger group which rises to the surface to create a layer of cream on top. This causes the milk to taste greasy.

When kept at the optimal temperature of 36-38°F (2-4°C), the shelf life of non-homogenized milk can extend to about seven days. Homogenized milk can last for more than double that. Homogenization also allows mixing of milk from different cowherds. For that reason, almost all commercial milk we find in supermarkets is homogenized.

Homogenization Process

Conventional homogenization is a two-stage mechanical, as opposed to chemical, process. It reduces fat globules into smaller droplets by forcing milk through a tiny orifice under high pressure (Figure 1).

The first stage typically aims to reduce fat globules to sizes ranging from 0.2 µm to 2 µm. While size reduction improves taste and prevents creaming, over-processing leads to instability of the emulsion. That is, the particle size of a fat droplet is greatly reduced and the total surface area is greatly increased.

Instability happens when there is not enough protein to cover the total surface area of the fat droplets. In this circumstance, proteins begin to interconnect, causing flocculation (aggregation) or coalesce of fat droplets, forming a mass[2].

The second stage of the homogenization process is employed to separate clusters from individual fat globules. A high-shear fluid processor is a more commonly used homogenizer. It allows users to have greater pressure control when scaling up from testing-laboratory to production. In both cases, experts recommend scientists monitor particle size reduction to gain processing control.

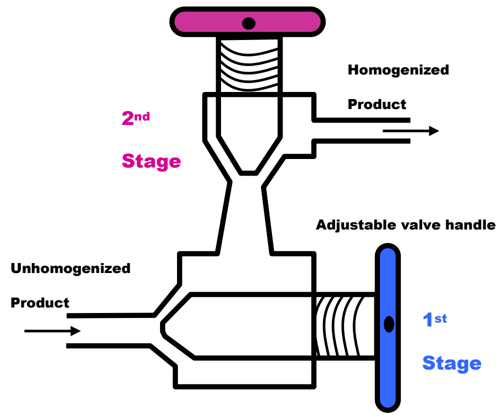

Figure 1: Conventional two-stage homogenizer

Materials and Method

A laser diffraction analyzer is used to measure the size of the particles. The distribution below represents an overlay of store-bought non-homogenized whole milk and homogenized whole milk using the Partica Mini LA-350 laser diffraction analyzer. The LA-350 offers a single laser light source at 650nm, allowing the system to measure from 0.1 µm to 1000 µm.

As seen in Figure 2 below, particles of non-homogenized milk range from 1-10 µm, with a mean size of 3.79 µm. Homogenized whole milk ranges from 0.2-2 µm with a mean size of 0.73 µm. Particle distribution mean (or average), obtained by the LA-350, is a critical parameter used by milk manufacturers when setting product quality specifications.

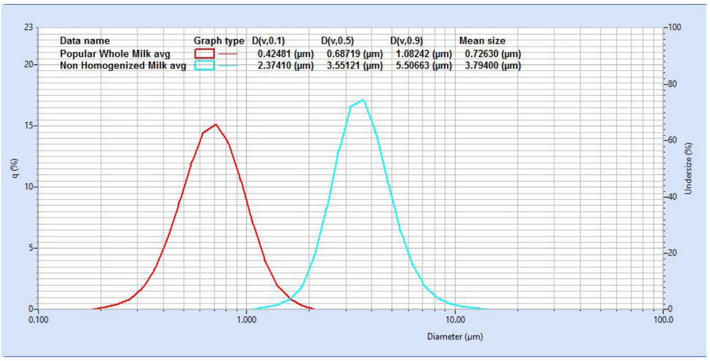

Figure 2: Homogenized Whole Milk (red) and Non-homogenized Whole Milk (blue) showing critical quality parameter for fat globules during homogenization process. Measurements made using the LA-350.

Laser diffraction can also easily detect changes in the fat content. The particle size distribution of whole milk (approximately 3.6 percent fat), 2 percent milk, 1 percent milk and fat-free milk shift incrementally smaller as the amount of fat is removed (figure 3 below). Since fat-free milk lacks the emulsified fat globules, the distribution is made up primarily of the protein caseins, which make up about 82 percent of milk protein.

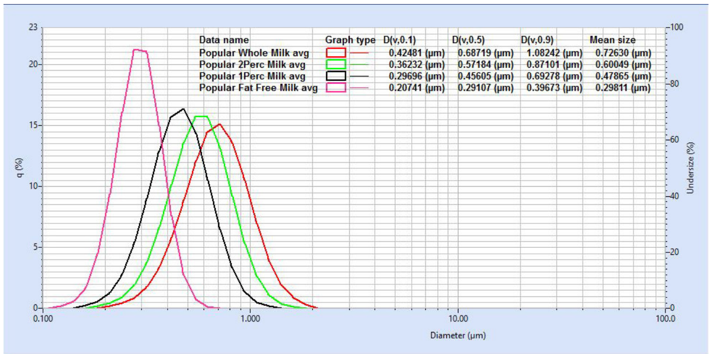

Figure 3: The LA-350 effectively tracks changes in size distribution for Whole, 2 percent, 1 percent, and fat free milk

Summary

The particle size of milk influences its microstructure and defines shelf life, taste and mouth feel. The presence of particles ranging between 0.2 μm to 2 μm is a critical quality parameter for fat globules during the homogenization process. When the homogenization process is not carefully controlled, clumping due to protein bridging or creaming due to undispersed fat globules may occur. These issues are seen in many other commercially available milk products. Laser diffraction to measure the particles in milk is, therefore, an ideal instrument for quality control.

References

1. http://www.fao.org/agriculture/dairy-gateway/milk-and-milk-products/milk-composition/en/#.V2rX_ORdE5s
2. Lakkis, Jamileh M., Encapsulation and Controlled Release Technologies in Food Systems. Wiley-Blackwell; 2 edition (March 9, 2016). http://books.google.com
3. ISO13320-2009 Section A.7

Analytical test method

Refractive Index: 1.46 | Imaginary (absorption): 0.001i
Dispersant fluid – Deionized water
Pump speed – Gentle pump speed at 1-3 to avoid disruption of emulsions

LA-350