HORIBA Scientific

Application Note

Maximizing Soy Milk Quality Attributes through Particle Size Analysis

AN217

Soy milk is an increasingly important source of protein. As in cow's milk, particle size is important for customer acceptance. HORIBA laser diffraction analyzers can be used to characterize soy milk. Measurements with the HORIBA LA-960 laser diffraction particle size analyzer show significant differences in particle size distribution with soy milk price.

Introduction

Soy milk offers a good source of protein without the cholesterol, lactose, or A1 beta casein protein (a known food allergen) typically found in cow's milk. Beneficial effects of soy flavonoids on humans have also been reported. In this note, we will draw attention to the plant based milk sector with sales of 2.1 billion dollars and 14.4% growth [1]. Dairy beverages, in contrast, are projected to drop in sales [2].

For this reason, food and beverage companies are acquiring smaller plant-based milk facilities to bolster their market presence and to increase household penetration. Here we discuss particle size analysis of soy milk. As in the case of milk, fat droplet size has an effect on mouth feel, taste, and shelf-life. Therefore monitoring particle size is important to ensuring product quality.

Processing through the Lens of Particle Size

Soy milk is a liquid extract of soybeans composed of soybean oil, glycinin (11S) and β-conglycinin (7s) proteins, carbohydrates and other dry matter [3]. Production processes vary and are typically proprietary. A generic process is shown in Figure 1. Production starts with grinding to create soy milk slurry. During mixing of soy grind and water, an enzyme (lipoxygenase) naturally present in soy milk is triggered. Lipoxygenase catalyzes the oxidation of soybean oil, giving soy milk a raw flavor and paint-like aroma. In order to remove this unpleasant flavor, soy milk undergoes a heating step to deactivate the enzymatic activity. Whether milk production is carried out at high or low temperature, high or low pressure, homogenized or non-homogenized, heating plays a crucial role in influencing the size of soy protein-fat complexes.

Heating removes the undesirable flavor by destroying lipoxygenase. Heating also decreases particle size through protein denaturation and enhances mouth feel by increasing viscosity [5]. These mouth feel effects persist through and can be affected by subsequent processing. Most notably, homogenization is a high shear particle size reduction process that typically leads to smaller and more uniform fat particle sizes.

In this note, the final result of soy milk processing is evaluated with particle size analysis. Particle size results give a quantitative measure of the soy milk that can be used to ensure consistent production and product quality.

**The FDA has called for fortification such as vitamin D to take place prior to milk homogenization [4].*

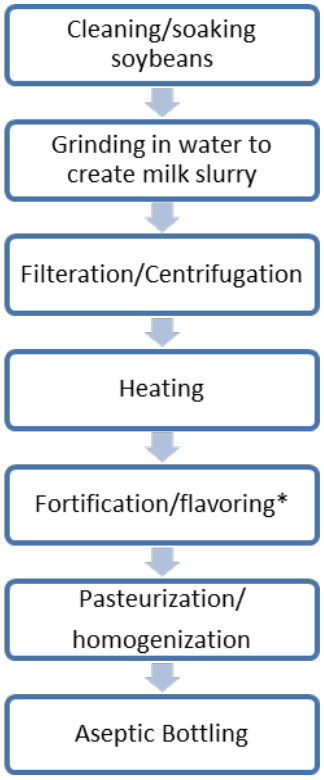

Figure 1 Typical Commercial Processing of Soy Milk

Materials and Methods

Two varieties of homogenized organic soymilk were purchased from a grocery store and tested. Both varieties were made from whole beans, rather than full fat soy flour or other alternatives. The HORIBA LA-960 laser diffraction particle size analyzer was used to determine the particle size with the following analytical test method:

Refractive Index: 1.46 | Imaginary (absorption): 0.001i
Dispersant: water (RI=1.333)
Stirring speed: 3 | No ultrasound

Each sample was mixed well by shaking the carton vigorously before sampling for measurement.

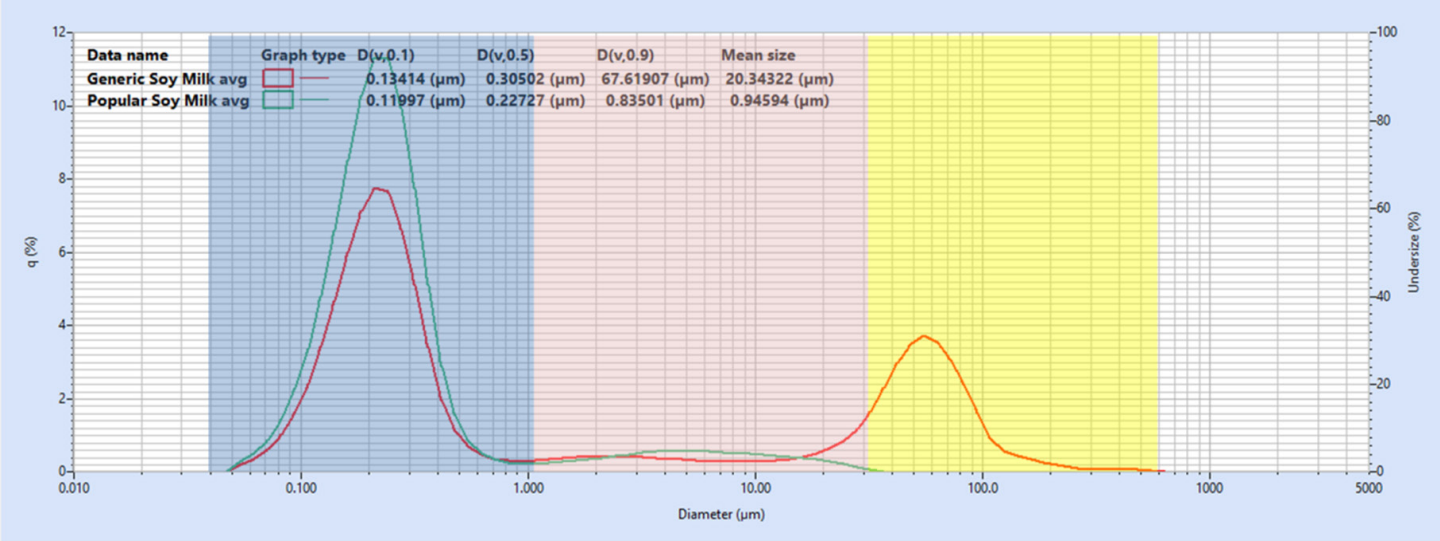

Figure 2 Particle size distribution of two soymilk brands determined with the LA-960 particle size analyzer

Results and Discussion

An overlay of a generic soymilk and market-leading soymilk particle size distribution is shown in Figure 2. The generic soymilk **(red)** shows a primary peak centered at 200 nm and a secondary peak centered at 55 µm. The market-leading soymilk **(green)** displays a single modal size distribution with the majority of its particle population at 200 nm, leading to a much smaller volume mean size (0.95 µm) than that of the generic soymilk (20.34 µm).

The result above can be separated into three particle size regions and is summarized below (Table 1):

Particle Size Range	Indication
40 nm – 1 µm	Size of soy proteins associated with dissociation, denaturation, and agglomeration after heating [5].
1 µm – 30 µm	Effect of heating and homogenization is pronounced in this region [3]. Further homogenization removes the tail extending to 30 µm, leading to particle size reduction.
> 30 µm	Traces of okara (soy bean fibers) remnants are detected [6]. Particle size in this range gives a "gritty and chalky" mouth feel. Better filtration or centrifugation should be considered.

Table 1 Particle size distribution of soy milk separated in three size regions.

The measurements suggest a processing difference between two manufacturers and demonstrate why one brand commands a higher price than the other. When the market-leading soymilk is compared to the most sought-after (highest consumption) fluid milk product, 2% milk [7], the small difference in particle size distribution bolsters the claim that particle size is a reliable measure of customer acceptance rate (Figure 3). The majority of the particle population for both 2% milk and soy milk has a diameter 1 µm with a Dv50 of roughly 200 nm for the primary peak. In this range, milk products taste smooth and clean.

Customer acceptance often depends on familiarity and awareness. This data shows that the market-leading soy milk is produced with the understanding that consumers use the taste of reduced fat milk as a frame of reference when transitioning from dairy to non-dairy products.

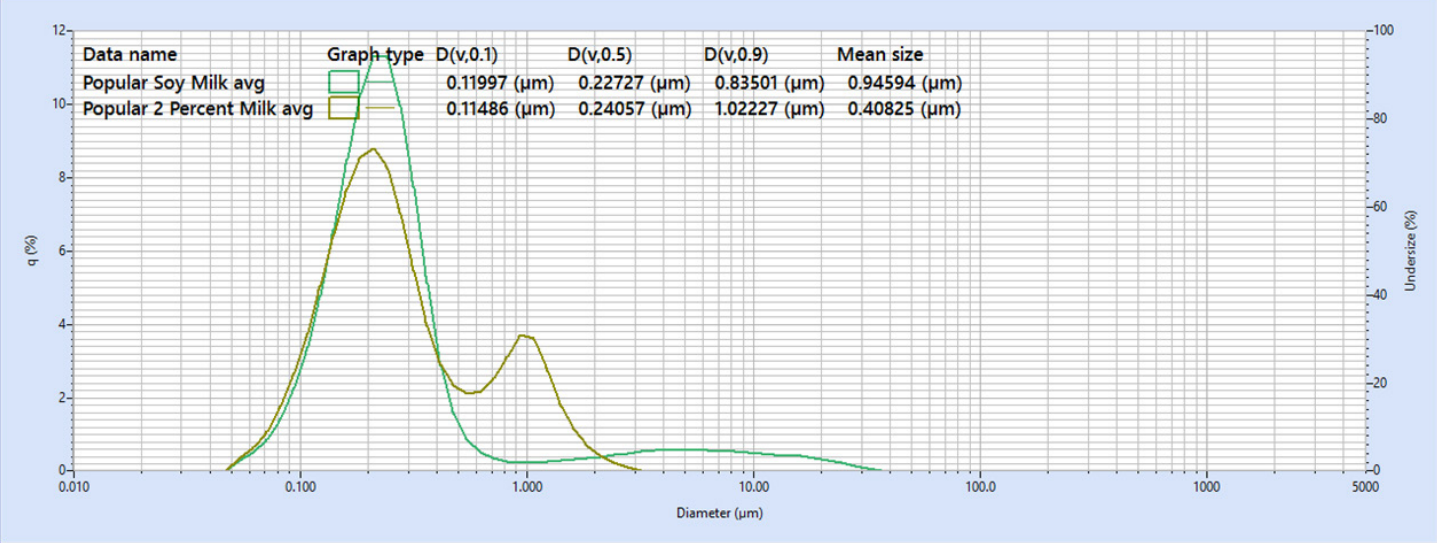

Figure 3 Particle size of market-leading soymilk mimics the particle size of the most widely accepted dairy milk.

Summary

In this note, we have demonstrated that the laser diffraction technique is a reliable tool to track the particle size of soy milk. Analysis results indicate that more expensive soy milk has a similar particle size distribution to reduced fat milk. Furthermore, the analysis results indicate the presence of possible agglomerates and leftover okara. Particle size distribution is an important parameter for tracking changes that take place during processing as well as sensory attributes and storage time. Particle size distribution in these products can be effectively measured with the HORIBA LA series laser diffraction instruments.

References:

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