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BETTER PARTICLE SIZE SOLUTIONS

APPLICATION NOTE

Particle Size Analysis: Exploring the Impact of Homogenization on Soy Milk

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Abstract

To enhance the taste and stability of soy milk, homogenization, subjecting the liquid to intense shearing, breaking down large fat globules particle and protein clusters, is a crucial step in the manufacturing process. Bettersize can provide the soy milk particle analysis with the combination of two instruments: Bettersizer S3 Plus and BeVision S1, so as to ensure the overall quality of soy milk product and create a homogeneous liquid that effectively prevents fat floating and protein settling.

Keywords

Soy milk, protein, particle size, homogenization

Introduction

Soy milk is a serous liquid made from soaked soybeans and mainly contains protein, lipids, and carbohydrates. With comparable protein content to cow's milk, soy milk has become a popular substitute due to the absence of lactose and casein, which can cause allergic reactions and gastrointestinal symptoms. However, when soy milk is left undisturbed, it may undergo phase separation between solid and liquid components, which is prone to fat floating and increased sedimentation during storage. Additionally, the large size of plant proteins and fat globules in soy milk can result in reduced absorption rates in the human body.

To achieve a smoother texture and improve the bioavailability of soy milk, high-pressure homogenization is employed. Homogenization is a crucial step in the soy milk manufacturing process. Under pressures of up to 200 times atmospheric pressure, soy milk is forced through the narrow aperture of the homogenization valve. The combined forces of shear and impact can break down large fat globules, phospholipid and protein agglomeration, resulting in smaller and uniformly dispersed particles in the soy milk. Therefore, particle size of the components is the property in soy milk that can be used to track changes occurring during homogenization.

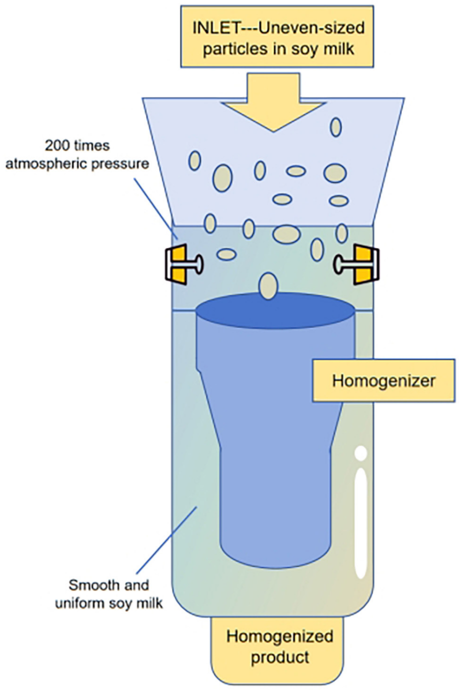


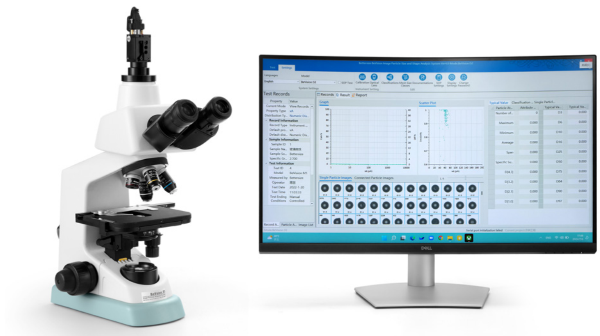
Figure 1. The simulated operation of a high-pressure homogenizer.

Materials and Methods

This experiment aims to analyze the impact of homogenization process on the particle size of soy milk components. The materials involved in the experiment include a homogenized soy milk (referred as sample 1) and an unhomogenized soy milk (referred as sample 2).

This application note showcases the utilization of the Bettersizer S3 PLUS and BeVision S1 for particle size distribution and shape analysis. The Bettersizer S3 Plus integrates laser diffraction and dynamic image analysis into one instrument to simultaneously characterize particle size, size distribution, and particle shape over a wide dynamic range. On the other hand, the BeVision S1 provides intuitive, accurate size and shape distributions of either powder or suspensions by combining light microscopy and image analysis.

Bettersizer S3 Plus



Bevision S1

Result and Discussion

Bettersizer S3 Plus result:

The results of these two samples are depicted in Figure 2. In the cases of homogenized soy milk, the median particle size is 0.355 microns, and the span of its particle size distribution is 2.833, indicating a uniform and finely dispersed mixture. However, the unhomogenized soy milk exhibits a significantly larger median particle size of 8.861 microns, with a wider span of 17.63, implying a more varied and less consistent distribution.

Comparing these two samples, it is evident that the homogenized soy milk yielded a decrease in average particle size of fat globules and protein, with a narrower size distribution, proved that a finer and more uniform liquid can be achieved by homogenization process. Additionally, in the range from 1 to 11 microns, which represents the dominant particle size range of sample 2, sample 1 exhibits tailing phenomena, indicating the presence of incompletely homogenized particles. These findings imply that further homogenization would lead to a smoother soy milk with a more refined consistency.

Furthermore, the particle size distribution of sample 2 displays two significant peaks. The primary peak is centered at 5.07 microns, suggesting a prevalent particle size in that range. There is a second peak centered at 154 microns, signifying the presence of larger particles within the mixture.

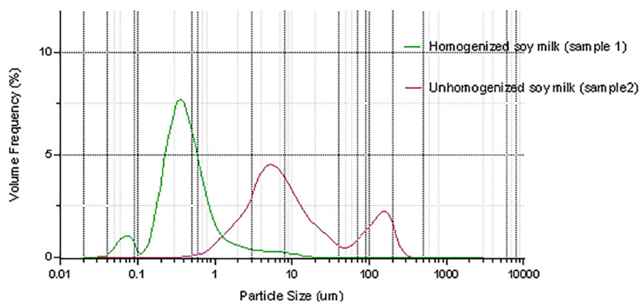


Figure 2. Particle size distribution of homogenized and unhomogenized soy milk

Table 1. Typical particle size values of soy milk samples

Samples	Homogenized soy milk (sample 1)	Unhomogenized soy milk (sample 2)
Dv10(μm)	0.152	2.763
Dv50(μm)	0.362	8.861
Dv90(μm)	1.161	159.0
Span	2.782	17.63
D[4,3](μm)	0.928	45.10

With dynamic image analysis technique based on counting, the Bettersizer S3 Plus is capable of easily identifying these oversized globules and protein particles. This capability is achieved by examining each particle individually or by analyzing the size and shape data parameters of all particles collectively, resulting in the creation of number-based distribution and multiple other essential parameters, as shown in Figure 3.

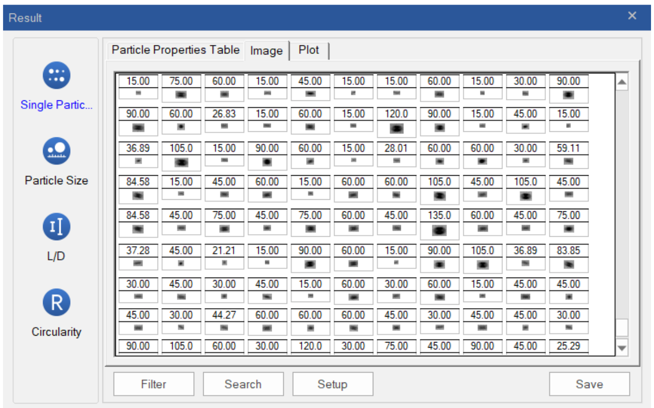


Figure 3. The result from the dynamic image analysis of Bettersizer S3 Plus

BeVision S1 results :

To cross-verify the components of particles presenting in the dynamic image analysis, BeVision S1 provides more precise and detailed magnified images, as presented in Figure 4.

Under the BeVision S1, the large particles with sizes of approximately 30 microns exhibit a diverse array of intriguing shapes and structures, according to Figure 4 A/B/C. These bodies, which are arranged in a spatially organized pattern within the cellular matrix, thus can be defined as the aggregation of soybean protein particles. The globular protein aggregation bodies, mainly comprising glycinin and β-conglycinin, resemble spherical entities with internal small pores or channels, forming network-like structures that demonstrate organized and regular patterns. However, Figure 4D displayed a relatively blank microcosm of homogenized soy milk with a few small particles , which substantiates its tailing phenomenon from 1 to 10 microns as shown in Figure 2. These results manifest that BeVision S1 is able to offer a glimpse into the complex and dynamic nature of soybean protein aggregation at the microscopic level.

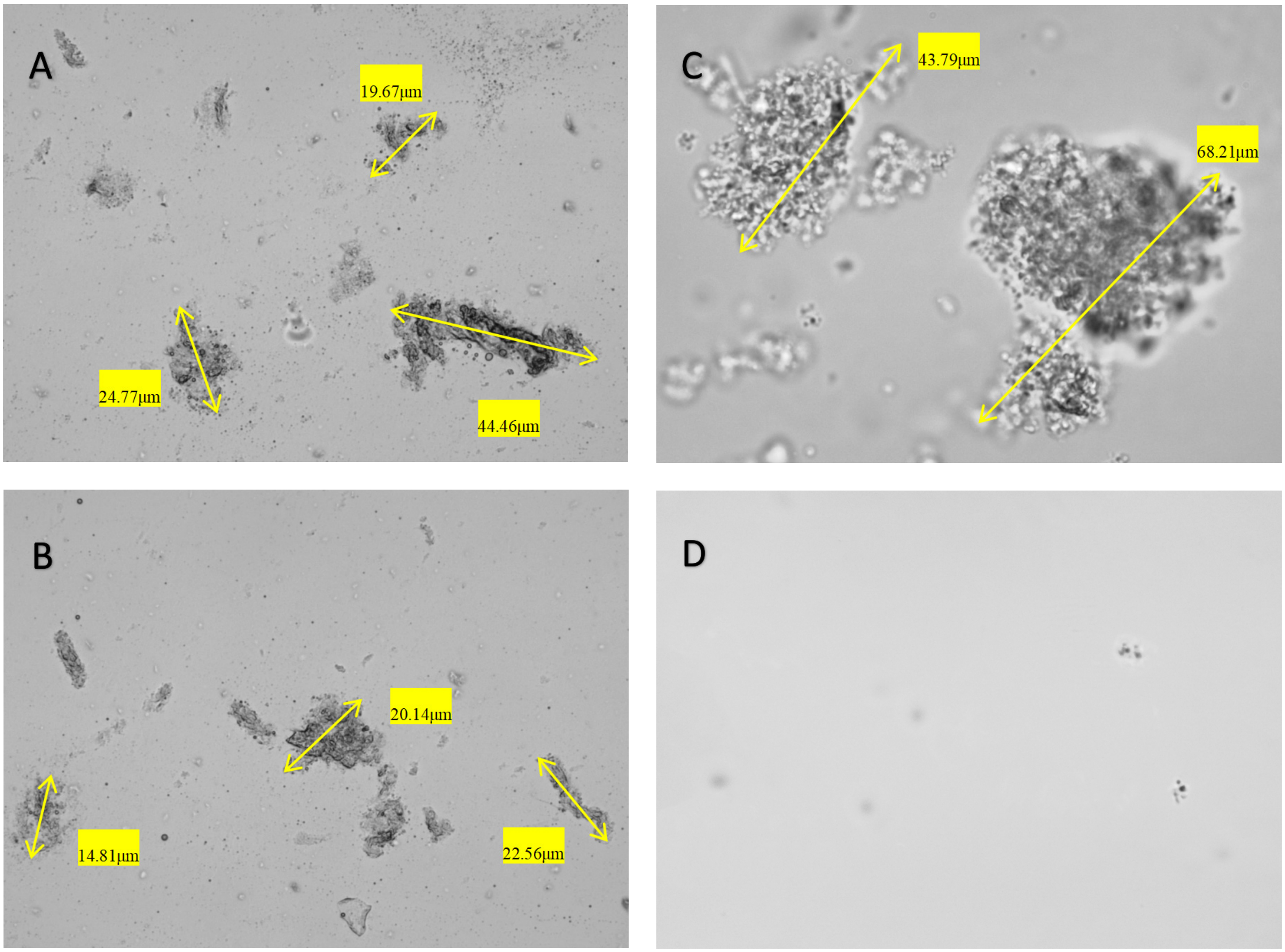


Figure 4. Examples of the microscopic results from BeVision S1. A&B: Results of unhomogenized soy milk under 10x objective. C: Zoom-in results with oversized particles of unhomogenized soy milk under 40x objective. D: Results of homogenized soy milk under 40x objective

Normally the particle size of undissolved soy bean protein monomer is from 40nm to 2 microns. According to figure 2, the particle size of sample 1 is mainly under 2 microns and sample 2's particles are highly above 2 microns. With the image analysis provided from BeVision S1, these overly large particles are further proved to be protein agglomeration in sample 2. Therefore these results revalidate that unhomogenized soy milk is more prone to protein aggregation. On the other hand, the homogenization process effectively decreases the overall particle size of components and disrupts large aggregates of soy proteins, leading to improved bioavailability of soy milk in the human body.

Conclusions

Homogenization plays a pivotal role in breaking down large fat globules and protein aggregates, resulting in smaller and more uniformly dispersed particles in soy milk, which contributes to improved texture, stability, and overall product quality. By understanding the particle size distribution, manufacturers can track the homogenization process to achieve desired sensory attributes, such as creaminess and mouthfeel, as well as consistency in the final product.

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