SHIMADZU
Excellence in Science

Application News

No. AD-0197

SALD-2300 / Milk / Food Analysis

Characterisation of Casein Micelles and Fat Globules in Milk by Particle Size Laser Diffraction Method

Ai Ming Chua, Joyce Lim, Zhen Hao Lee
Application Development & Support Centre, Shimadzu (Asia Pacific) Pte Ltd, Singapore

❑ Introduction

Milk is a natural occurring oil-in-water emulsion, in which the fat globules are dispersed in a continuous phase of milk plasma containing lactose, protein, vitamins and minerals. The main structural components of milk are fat globules and casein micelles as shown in Figure 1. The fat globules are surrounded by the milk fat globule membrane which acts as an emulsifying agent that prevents aggregation and coalescence of milk fat [1]. The particle size distribution of these fat globules ranges from 1 µm to 10 µm, depending on the cow breed and seasons. On the other hand, casein protein in the form of spherical micelle structure are mostly in the range of 40 nm to 300 nm in diameter [2].

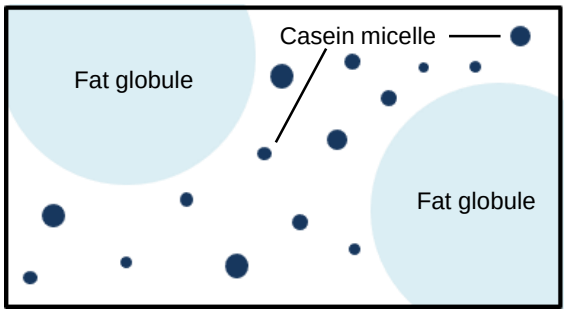

Figure 1: Main structural components of milk

The size of fat globules can be altered through mechanical treatment such as homogenization process where milk is passed through a tiny orifice under high pressure. This would decrease the size of the fat globules to an average diameter of about 1 µm which improves the stability of emulsion and shelf life of the milk. The size of fat globules and casein micelles in milk is important as it contributes greatly to the texture, flavour and creaming stability of the milk. Therefore, it is important to monitor the particle size distribution of fat globule from homogenization process of milk to ensure the quality and consistency of the end product. One method to determine the particle size distribution in milk is by laser diffraction method. This application news introduces the particle size distribution measurement of milk using SALD™-2300 particle size analyzer.

❑ Experimental

Four different types of commercially available milk were purchased from local markets: unhomogenised fresh milk (4.1% fat), homogenised fresh milk (4.1% fat), low fat milk (1.1 % fat) and skimmed milk (0.1% fat). The SALD-2300 laser diffraction particle size analyzer (Figure 2) was used for the measurement.

Milk sample was added into the batch cell (Figure 3) containing deionised water. The solution in batch cell was dispersed with stirring plate to obtain a homogenous solution during measurement. Each sample was measured three times. The measurement conditions are shown in Table 1.

Table 1: Instruments and analytical conditions

Instrument	:	SALD-2300, BC23 Batch Cell
Refractive index	:	1.50 – 0.50i
Solvent (dispersion medium)	:	Pure water
Dispersant	:	None
Dispersion method	:	Only stirring

Figure 2: SALD™-2300 laser diffraction particle size analyzer

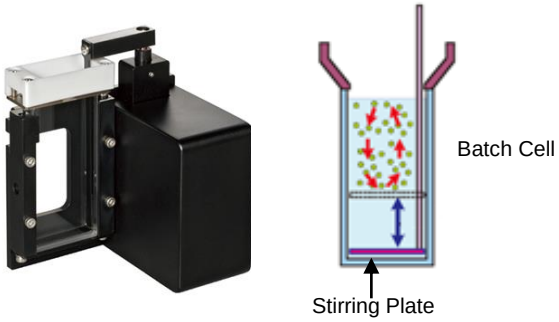

Figure 3: Batch cell (left), schematic diagram of batch cell (right)

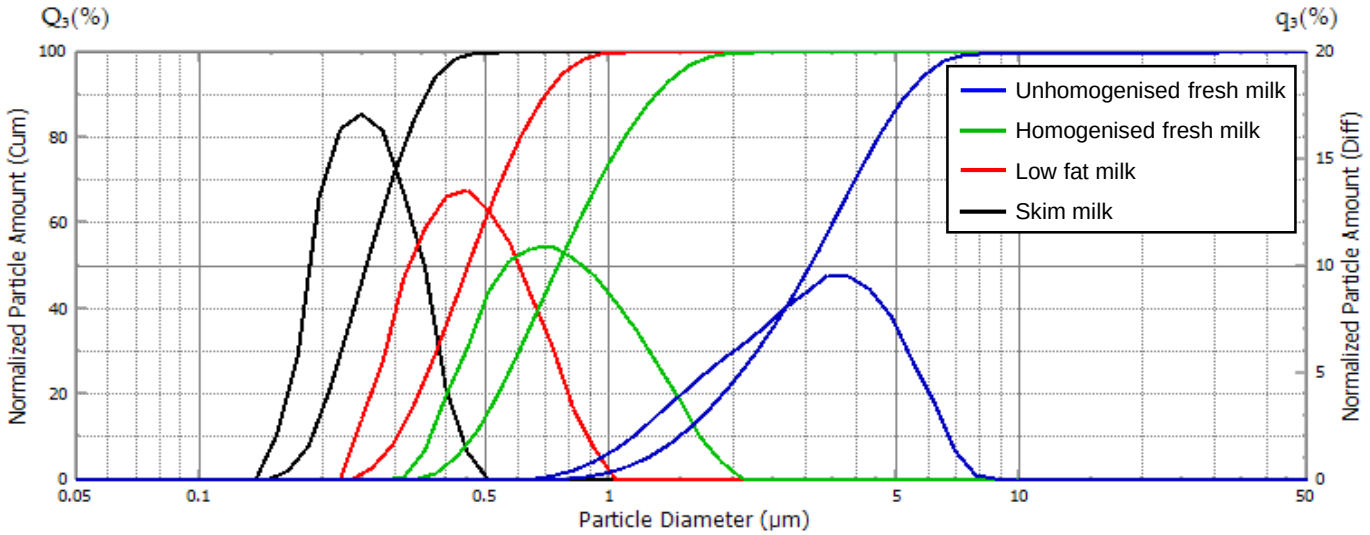

Figure 4: Particle size distribution of different types of milk

Table 2: Fat content and particle size statistic of different types of milk

Milk Sample	Fat Content (%)	Median Diameter (µm)	Modal Diameter (µm)	Mean Diameter (µm)
Unhomogenised fresh	4.1	3.058	3.596	2.907
Homogenised fresh	4.1	0.744	0.680	0.758
Low fat	1.1	0.449	0.422	0.453
Skim	0.1	0.254	0.262	0.256

❑ Results and Discussion

Figure 4 and Table 2 show the particle size distributions of the four milk samples. The particle size in unhomogenised fresh milk has a range of 0.6 µm to 10 µm due to the large fat globules present in the milk. In homogenised fresh milk, the distribution shifted to a smaller range of 0.3 µm to 2.5 µm even though the fat content is the same for both unhomogenised and homogenised fresh milk. This demonstrate the effect of homogenisation process where fat globules are reduced in size.

Most of the fat globules are removed in low fat milk, resulting in a decrease for the ratio of fat globules to protein casein micelles. This is reflected in the measured particle size distribution of low fat milk as shown in the red graph in Figure 4. The particle size distribution for skim milk ranges from 0.1 µm to 0.5 µm and a median diameter at around 0.2 µm. This is because skim milk has predominantly protein casein micelles and near absent of fat globules.

❑ Conclusion

The particle size distribution of different types of milk depends on both protein casein micelles and fat globules. Using SALD-2300 particle size analyzer, the changes that occur in particle size during the homogenisation process of milk can be monitored by measuring the particle size distribution as demonstrated in this application news.

❑ References

1. Walstra, P. and Jenness R. (1984). Dairy Chemistry and Physics, New York, USA: John Wiley & Sons, p. 106.
2. Walstra, P., Wouters, J. T. M. and Geurts, T.J. (2006). Dairy Science and Technology, 2nd Ed.. Boca Raton, FL: Taylor & Francis Group, LLC (CRC Press), p. 141.

SHIMADZU
Shimadzu Corporation
www.shimadzu.com/an/

First Edition: Jun. 2019