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Milk: Particle Size and Zeta Potential with the Litesizer™ 500

Keywords:

Dynamic light scattering, electrophoretic light scattering, zeta potential, particle size, milk

1 Introduction

Milk is an emulsion of butterfat globules within an aqueous solution of carbohydrates, minerals, fat droplets and casein micelles, the latter being the largest dissolved components in milk[1]. There are four types of casein micelles, which vary in diameter from about 100 to 200 nm[2]. The aim of this study is to use the Litesizer 500 to measure the particle size and the zeta potential of milks, both whole and skimmed; and to investigate the influence of salt concentration on zeta potential.

2 Experimental

Whole (3.5 % fat) and skimmed (0.5 % fat) milks were acquired from a local supermarket. For particle-size measurements, the milk was diluted 1:200 (v/v) with deionized water, and then filtered (Whatman; pore size 5 µm). Particle size was measured by using dynamic light scattering, which was performed in back-scattering mode at 20 °C. The number of runs, the focus position and the attenuation were all automatically optimized by the instrument.

For zeta-potential measurements, four solutions were prepared, each containing milk diluted 1:200 (v/v) and a different concentration of NaCl (0, 10, 20 and 40 mM) in deionized water. Zeta-potential measurements were made by using electrophoretic light scattering at 25 °C. The applied power and the number of runs were both automatically optimized by the instrument.

3 Results and Discussion

The skimmed milk showed only a single peak in the intensity size distribution (Fig. 1), corresponding to a hydrodynamic diameter of 175 nm, with 2.5 % standard deviation for 5 repetitions. It is very likely that filtration through 5 µm pores removed the larger fat particles, leaving the casein micelles as the dominant particles, which typically have diameters of 100 to 200 nm[3].

Different phenomena were observed for the whole milk during DLS measurements (Fig. 2). Two peaks appear in the intensity size distribution, indicating a bimodal distribution, with the average particle sizes being 135 nm and 527 nm with standard deviations (based on 5 repetitions) of around 10 %. The small particles are likely to be casein micelles, whereas the large particles are probably the remaining middle-sized fat particles. Compared to the skimmed milk, the whole milk not only has more fat but also probably contains fat particles in a broader size range.

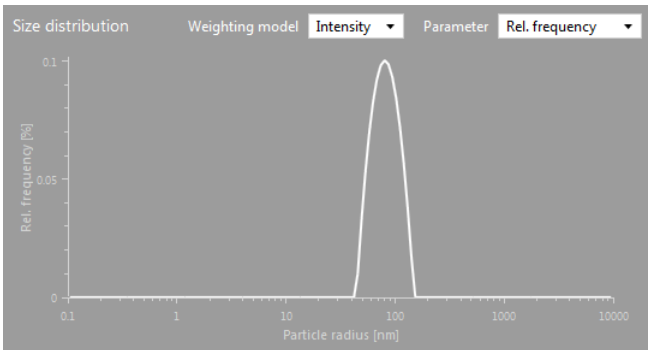

Fig. 1 DLS intensity size (radius) distribution of skimmed milk

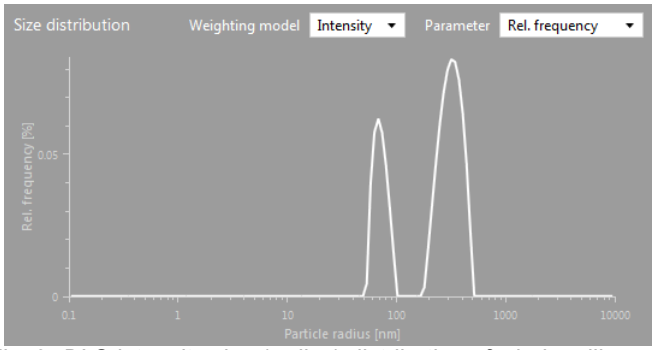

Fig. 2 DLS intensity size (radius) distribution of whole milk

The results of the zeta-potential measurements are shown in Fig. 3. Both the skimmed and whole milk samples were measured at four different salt concentrations (0, 10, 20 and 40 mM). The zeta potential values were -42.0, -37.2, -32.7 and -27.6 mV, respectively, for the skimmed milk, and -38.9, -35.9, -31.9 and -27.0 mV for the whole milk. The standard deviations for all data points (5 repetitions at each data point) are within 1.5 %. The two milks show a decrease in the magnitude of the zeta potential with increasing salt concentration. This result is not unexpected, since a higher salt concentration is known to reduce the particle's Debye double-layer and therefore also its zeta potential. Also, the skimmed milk has a higher-magnitude zeta potential than the whole milk at each concentration, although the difference narrows as the salt concentration increases.

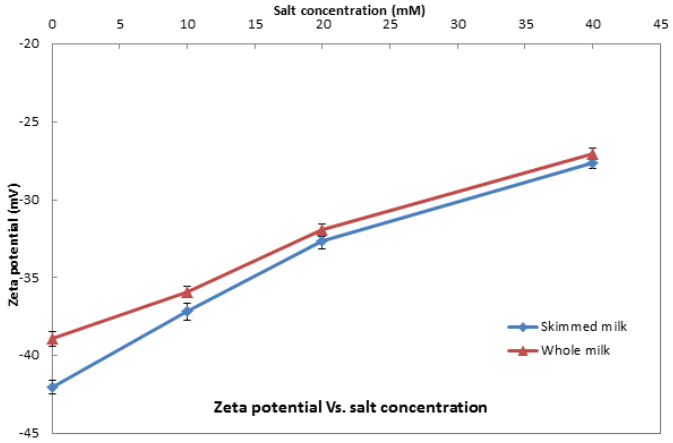

Fig. 3 Zeta potential vs salt concentration for skimmed milk (blue) and whole milk (red)

4 Conclusions

Using the Litesizer 500, we have successfully measured particle size and zeta potential for skimmed and whole milk.

5 References

[1] Jost, R. Milk and Dairy Products, Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH, Weinheim 2002.

[2] Fox, P.F. Advanced Dairy Chemistry, Vol.3: Lactose, Water, Salts and Vitamins. 2nd ed. Chapman and Hall: New York 1995.

[3] Mootse, H., Pisponen, A., Pajumägi, S., Polikarpus, A., Tatar, V., Sats, A., Poikalainen, V. Agronomy Research 2014, 12(3), 753-758.

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