DROPLET SIZE ANALYSIS OF MILK USING ACOUSTIC SPECTROSCOPY

Milk is an oil in water emulsion with a droplet size that can be unstable in its original state. Homogenization reduces the droplet size to product a stable emulsion. Acoustic spectroscopy is an attractive characterization technique for this process because it can measure the samples without dilution.

Introduction

Milk is a natural oil in water emulsion containing fat droplets surrounded by a layer of proteins and phospholipids. The fat content can range from 3-5 g of fat/100 ml for raw milk to 1 or 2% in low fat milks. The droplet size distribution in raw milk ranges from approximately 0.1 – 10 µm, which is often reduced through homogenization to 0.1 – 1 µm in order to extend the shelf life.

Monitoring the size distribution of the fat droplets is an important technique used to control the homogenization process. Acoustic spectroscopy has the proven ability to perform these droplet size measurements without sample dilution.

Acoustic Spectroscopy

Figure 1 illustrates the basic principles of the DT-1200 particle size analyzer used in this study. A piezo-electric transducer converts an input electrical tone burst to an ultrasound pulse of a certain frequency and intensity and transmits it into the sample. A range of frequencies and transmitter-receiver distances are used during the experiment. The intensity of this pulse decays as it passes through the sample due to interaction with the fluid.

A second piezo-electric transducer converts this weakened acoustic pulse back to an electric pulse and sends it to the electronics for comparison with the initial input pulse. The total intensity loss and time delay from the input to output transducer for each frequency and gap can be considered the raw data from which the particle size distribution is calculated.

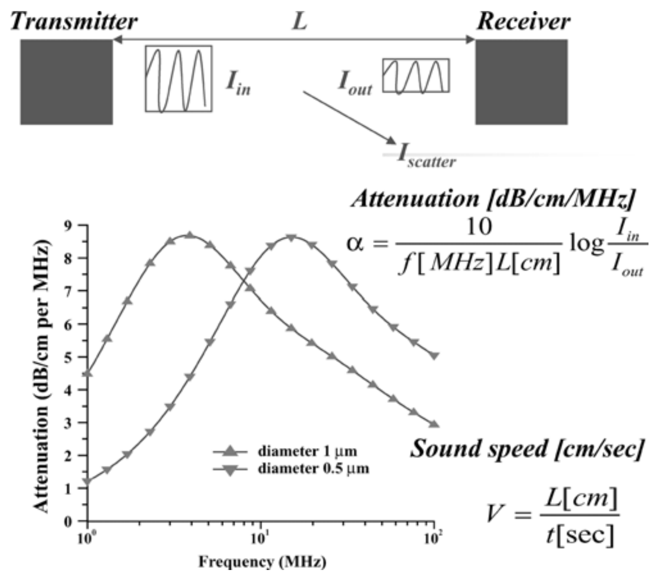

Figure 1

Materials and Procedures

One source of samples for this study was a local supermarket where we purchased various milks. The nutritional label on these product containers defined the product composition, including the fat, protein, and sugar content. In addition, we obtained two well-defined samples of whole milk from Carmen Moraru at the Department of Food Science, Cornell University (Ithaca, NY). One of these samples was homogenized, and both samples had the same composition: 3.9% fat, 3.25% protein, and 4.6% lactose. These two samples allowed us to verify the accuracy of the particle size calculation procedure.

No preparation or dilution was involved with any of the samples. Between 20 – 100 ml of milk was poured into the DT-1200 sample chamber. No mixing or pumping is required for measuring the attenuation of stable products that do not settle.

The DT-1200 does have a built-in magnetic stirrer, which can be used for mixing an unstable sample. For example, the stirrer was used for measuring the sound speed of a milk sample during a spoiling process, where the resultant agglomerates would otherwise settle without such continuous agitation.

Results

The measured attenuation spectra of the store-bought milk samples are shown in Figures 2 and 3. Figure 2 shows multiple measurements for the low-fat products, as well as a spectrum of plain water for comparison.

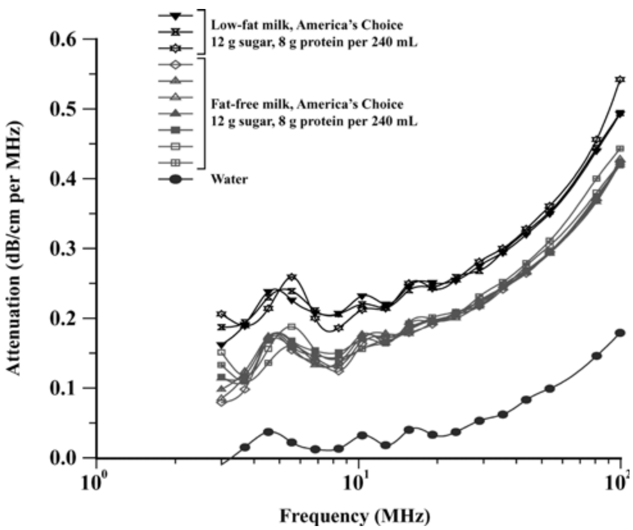

Figure 2

Figure 3 shows the attenuation spectra for the two milk samples from Cornell University. The samples are identical in composition but different in terms of homogenization (and therefore one would also expect different in the fat droplet size distribution).

The distinctive difference in the attenuation spectra between these two milk samples is itself proof that acoustic spectroscopy can be used to characterize differences in the particle size of dairy products.

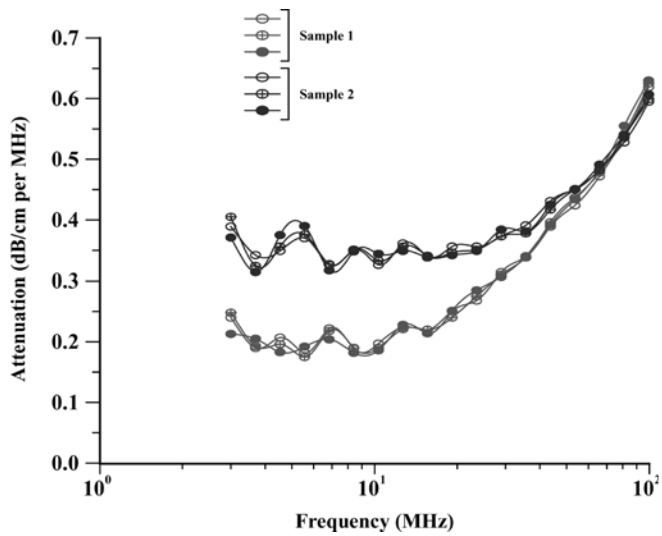

Figure 3

Figure 4 shows the droplet size distributions calculated from the attenuation spectra shown in Figure 3.

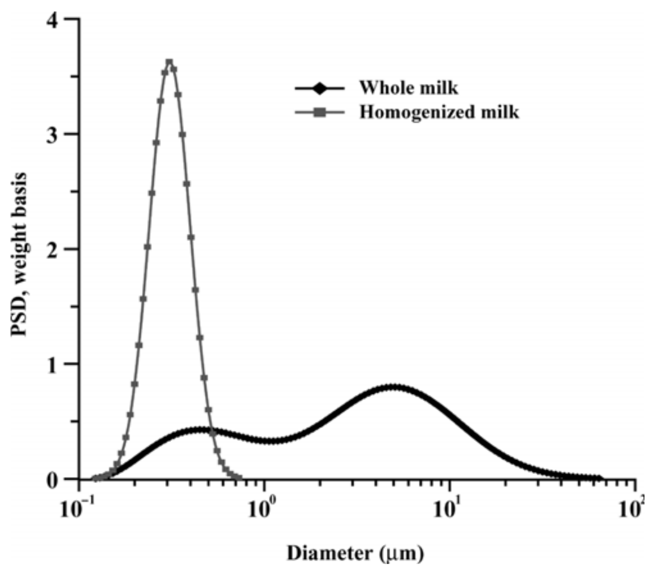

Figure 4

Conclusions
The reduction in droplet size excepted after homogenization is clearly seen in the results in Figure 4. Acoustic spectroscopy provides the droplet size measurements without dilution, making this an ideal technique for food emulsions.

Acoustic spectroscopy also has the ability to provide a wealth of additional information about these types of samples. Fat content, characterization of chemical reactions when milk is spoiling, and water droplet size in butter are examples of the range of capabilities of the DT-1200.

The team of Dispersion Technology and HORIBA Instruments supplies the technology and assistance to solve application problems and provide worldwide support.

The DT-1200 Acoustic Spectrometer

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