International Journal of Science, Environment and Technology, Vol. 6, No 3, 2017, 1828 – 1832

ISSN 2278-3687 (O)
2277-663X (P)

ATTENUATION OF ULTRASOUND IN RECONSTITUTED MILK

Mohammed Habib Ali[1] and Adeel Ahmad
Biophysics Research Laboratory, Department of Physics, Nizam College (Autonomous), Osmania University, Hyderabad – 500 001, India
[1]Departmentof Physics, Dravidian University, Kuppam, India
E- mail: dr_adeelahmad@yahoo.com

Abstract: Attenuation of Ultrasound was measured in different densities of milk powder reconstituted with water at 1MHz frequency at room temperature, using multi frequency interferometer. Density of milk was measured by using specific gravity bottle. The ultrasound attenuation coefficient (α) of the milk is calculated by using the relation, $\alpha = \frac{1}{2x} \ln\left(\frac{I_o}{I}\right)$. It is observed that there is an increase in ultrasonic attenuation with increase in density of the reconstituted milk, which may be due to the molecular rearrangement and relaxation process due to the propagation of ultrasonic waves.

Keywords: Reconstituted Milk, Ultrasound absorption coefficient and relaxation process.

I. Introduction

Natural milk is a biofluid of complex nature. Chemically milk is a heterogeneous mixture which can be considered as a complex chemical substance in which fat is emulsified as globules, major milk protein *casein*. Some mineral matter in the colloidal state. Lactose combined with some minerals and soluble proteins, sugars in the form of solution. The composition of milk is inconsistent, varies even for the same individual animal, with the stage of lactation, nutrition, diet, season and climate. The main aim of preparation of milk powder is to convert the liquid raw material into a product that can be stored without loss of quality for many years. It is aimed to assess the quality of reconstituted milk using the technique of ultrasound.

Ay and Gunasekaram [1] developed an ultrasonic system by employing a pulse-transmission method of measurement during coagulation of rennetted milk. They transmitted ultrasonic waves through the milk after adding the enzyme. They reported that the changes in ultrasonic attenuation during coagulation can be used to predict the coagulation time indicating the onset of the coagulation. Hueter et al [2] measured ultrasonic absorption of homogenized and skimmed milk. They found that the ultrasonic absorption at 1MHz in homogenized milk was about 400dB/m and in skimmed milk was about 200dB/m. Saraf and

*Received May 14, 2017 * Published June 2, 2017 * www.ijset.net*

Samal [3] studied velocity and attenuation of ultrasound in centrifuged and uncentrifuged samples of reconstituted powdered milk and fresh milk separately for comparative analysis of observing the effect of fat particles. Griffin and Griffin [4] studied milk systems by making ultrasonic attenuation measurements. Miles et al [5] investigated ultrasonic attenuation in the frequency range of 1.5 to 7 MHz in milk and cream as a function of fat concentration.

2. Materials & Methods

Milk powder (Nestle powder) was reconstituted in distilled water. Different concentrations of reconstituted milk were prepared by adding 1,2,3,4 and 5gm of milk powder in distilled water of volume 10 ml. The milk was stirred by using magnetic stirrer. The stirring was performed very slowly to avoid any foaming. Then the milk was assumed to be homogeneous and isotropic. The whole system (reconstituted milk) through which the sound wave passes was considered to be linear. Density of milk samples was determined using specific gravity bottle. Attenuation of ultrasound at the frequency of 1 MHz was determined by using Ultrasonic Interferometer (Mittal, M-81) at the room temperature. Acoustic length, the reciprocal of coefficient of attenuation, was calculated.

A variable path multi frequency ultrasonic interferometer (Model, M-81, Mittal Enterprises) with a least count of 0.001 cm of its micrometer was used to measure attenuation coefficient. The instrument consists of a high frequency electronic generator and a measuring cell. The measuring cell is a double walled cell for regulating the temperature of the sample during the experiment. The gold plated circular quartz plate of diameter 2.5 cm, mounted at the bottom of the cell, sends the ultrasonic wave normal to its plane, which is reflected back by the moveable metal reflector plate in the cell through a known distance (Fig. 1).

The ultrasonic measuring cell was connected to the output terminals of the high frequency generator through a shielded cable. The milk sample was introduced in the cell before switching on the generator. If the separation between quartz plate and the reflector is exactly a whole multiple of one half the wavelength of ultrasound, standing waves are formed in the sample due to acoustic resonance, gives rise to an electrical reaction on the generator driving the quartz plate and anode current of the generator becomes maximum (Fig. 2).

The micrometer was slowly moved till the microammeter on high frequency electronic generator shows a maximum. A number of maxima readings were passed on and their number 'n' was counted and the corresponding maximum current intensities I_o and I were measured at two nodes separated by a distance "x" and the attenuation coefficient is calculated. The reciprocal of attenuation coefficient is acoustic length (α^{-1}).

Fig. 1 Ultrasonic interferometer **Fig. 2** Magnetic stirrer

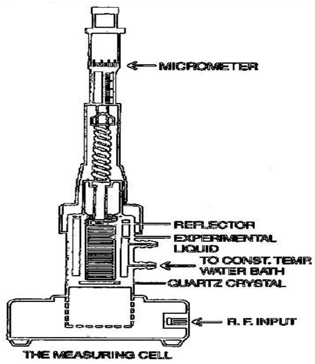

Fig. 3 Block diagram of Ultrasonic interferometer

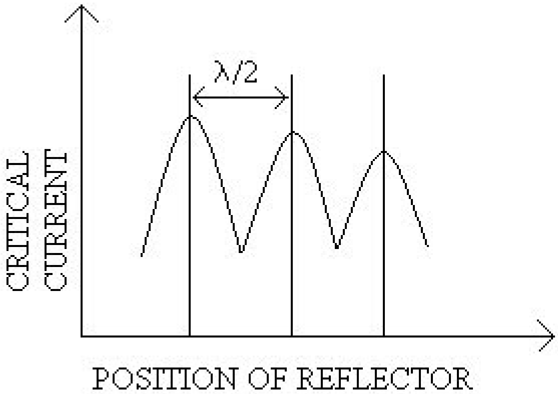

Fig. 4 Current vs Position of reflector

Table 1 presents the data on coefficient of attenuation and acoustic length along with density of milk. A significant increase in coefficient of attenuation is about 90% when density of milk increases to 50%. Similarly acoustic length decreases to about 50% with 50% increase in density.

Fig. 5 shows a plot between coefficient of attenuation on y-axis and density of milk on x-axis. It is a straight line with positive slope. Similarly Fig. 6 presents a plot between acoustic length and density, which reveals that acoustic length non linearly with the increase of density.

Table 1: Data on coefficient of attenuation and acoustic length in reconstituted milk at 1MHz frequency

Milk powder Added (%)	Density (Kg.m^{-3})	Attenuation Coefficient (m^{-1})	Acoustic Length (m)
0	1007	17	0.060
10	1101	18	0.055
20	1202	21	0.047
30	1301	23	0.043
40	1402	30	0.033
50	1503	32	0.031

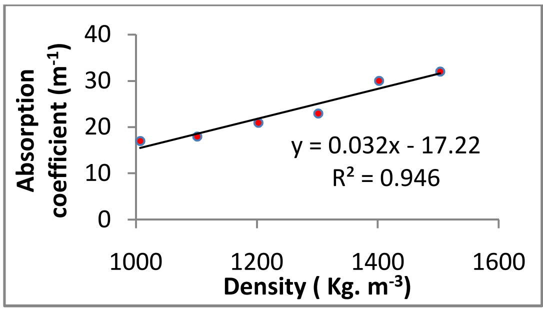

Fig.5. A plot between α and ρ

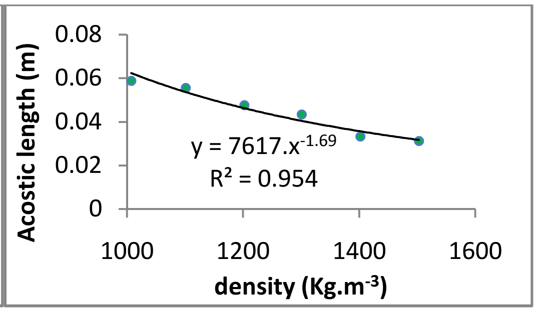

Fig.6. A plot between 1/α and ρ

Milk is a heterogeneous complex fluid, whether it is natural or reconstituted. It contains emulsified lipid globules, colloidal proteins and dissolvable sugars also, milk contains lactose crystals. Hence it is a mixture of macromolecular components, which are not separable. The attenuation coefficient measured in reconstituted milk could be explained by the solid part of the matrices, the presence either of fat or lactose crystals. No doubt the presence of crystals changes the compressibility in turn attenuation. But it is not the case, because of the fact that liquid and solids present in the milk. The higher attenuation in comparison with that of water may perhaps be due to the size of particles and also concentration rather than the presence of crystals and air in the matrix. These two factors are determining factors. Therefore, the measure of ultrasonic attenuation may characterize and assess the reconstitution quality of a powder. In sum the study suggests that the parameter ultrasonic attenuation can be used comfortably to detect adulteration either in the form of addition of water or chemical treatment. As attenuation coefficient is a sensitive parameter can be extended to study composition, molecular assembly, physiological changes and lastly the quality of reconstituted milk of different brands.

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