

# Ultrasonic Velocity and Allied Parameters of Milk Powder Reconstituted with Water

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**ABSTRACT:** Velocity 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. Acoustic impedance, Bulk modulus and adiabatic compressibility were calculated. The velocity of ultrasound may be used to check the purity of milk. Any adulteration in the milk can be detected based on the velocity data. The present study throws light in understanding the variation in composition of milk.

**KEY WORDS:** Milk, Ultrasonic Interferometer, Ultrasonic Velocity, Compressibility, Bulk modulus, Acoustic Impedance, 1MHz.

## I. INTRODUCTION

Milk is the fluid secreted by female mammals for the purpose of nourishing their offspring. Milk is considered as complete human food. Milk contains several different carbohydrates including lactose, glucose, and other oligosaccharides. Both the fat globules and the smaller casein micelles contribute to opaque white color of milk. Milk often is homogenized, a treatment that prevents a cream layer from separating out of the milk. Milk fat globules are the largest particles in milk but they are also lightest. They have a lower density than milk serum, so the globules rise to the surface, which is how cream is formed. The density difference is used to separate milk fat from whole milk in high speed, continuous flow, and centrifugal separators. The homogenization process increases the shelf life of milk. Milk preserved by the UHT (Ultra high temperature) process does not need to be refrigerated before opening and has a much longer shelf life than milk in ordinary packing. Milk may be defined as the whole, fresh, clean, lacteal secretion obtained by complete milking of one or more healthy animals. Excluding that obtained 15 days before or 5 days after or such periods as may be necessary to render the milk practically colostrum free, containing legally prescribed minimum percentage of fat and Solids-not-fat (SNF). Milk is a complex product that contains more than 100 substances that are either in emulsion, suspension, or solution in water. Various factors like genetic, health status, stage of lactation and environmental factors are responsible for wide variation in milk compositions. The various fermented milk products (e.g., yogurt, lassi, curd, and cheese), concentrated milk (e.g., evaporated milk and sweetened condensed milk), dried milk, fat rich dairy products (e.g., cream, butter, and ghee), ice cream, heated desiccated products (e.g., khoa, rabdi) and heat-acid-coagulated products (e.g., paneer) are some of the typical milk products having different chemical compositions. The main purpose of manufacture of milk powder is to convert the liquid raw material into a product that can be stored without loss of quality for years. The reconstitution behavior of instant powder is one of the key quality parameter. Ultrasonic techniques have been implemented in non-invasive on-line measuring systems. They can avoid the important hazard of product contamination. In view of this, an attempt has been made to study ultrasonic velocity and its allied parameters of reconstituted milk powder, in order to check the purity of milk.

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## II. RELATED WORK

Mohanan et al [1] reported a new ultrasonic method for the detection of added chemical preservatives in branded milk. They observed the nature of variation and shift in the thermal response of the acoustic parameters such as specific acoustic impedance, adiabatic compressibility and Rao's specific sound velocity for different samples of branded milk as compared to the chemical added pure milk and explained as due to the presence of chemicals in branded samples. Luis Elvira et al [2] characterized ultrasonically adulterated milk and detected gross levels of melamine contamination. Sound speed and density measurements were made in skim milk as a function of melamine adulteration. An ultrasonic measurement technique to implement milk quality control was discussed. Herrera and Hartel [3] observed the effect of processing conditions on the micro structure of a milk fat model system further, they investigated different blends of high melting fractions in low melting fractions of milk fat by using CLSM and observed crystalline micro structure in a semi solid product. Ay and Gunasekaram [4] developed an ultrasonic system to employ a pulse-transmission method of measurement during coagulation of renneted milk. They transmitted ultrasonic waves through the milk after adding enzyme. They reported that the changes in ultrasonic attenuation during coagulation can be used to predict the coagulation time indicating the onset of coagulation. Scott Blair and Oosthuizen [5] and Scott Blair and Burnett [6] suggested measuring viscosity change in milk as an index of coagulation time. They showed that during the course of rennet action, viscosity first dropped to a minimum, then roused as incipient plotting started. Everson and Winder [7] measured the variation in velocity of ultrasonic waves passing through renneted milk during coagulation. They mentioned that the ultrasonic velocity of milk coagulum decreased at coagulation time.

Hueter et al [8] 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 Samal [9] 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. Mc Clements and Povey [10] studied the applications of ultrasound for the characterization of edible fats and oils. Pavic et al [11] made an attempt to establish the influence of the stage of lactation on the variability of chemical composition and physical properties of milk. Stefan meyer et al [12] studied with an objective to investigate five different types of milk powder qualities using the technique of ultrasound spectroscopy. Povey [13] related ultrasonic properties of biological materials to their physic-chemical properties. Vahid mohammadi et al [14] presented a comprehensive review on the potential applications of ultrasonic procedures and techniques in milk industry.

## III. MATERIALS & METHODS

Instant milk powder (Nestle Everyday) was reconstituted with water by adding to 10 ml of distilled water. A different concentration of reconstituted milk was prepared by mixing milk powder of mass ranging from 1gm to 6 gm in step of 1 gm. The solution was stirred by using magnetic stirrer. The stirring was performed very slowly to avoid any foaming. Milk was assumed to be homogeneous and isotropic, and the whole system, through which the sound wave passes, was considered linear. Density of milk samples was determined using specific gravity bottle. Velocity of ultrasound at the frequency of 1 MHz was measured by using Ultrasonic Interferometer (Mittal, M - 81) at the room temperature of  $30^{\circ}\text{C}\pm 1^{\circ}\text{C}$ . Knowing the ultrasonic velocity, its allied parameters such as acoustic impedance, bulk modulus and adiabatic compressibility were calculated using the formulae,

$$\text{Acoustic impedance, } Z = \rho v$$

$$\text{Bulk modulus, } K = \rho v^2$$

$$\text{Adiabatic compressibility, } \beta = 1/K$$

where,  $\rho$ : Density (or) Specific gravity ( $\text{kgm}^{-3}$ );  $v$ : Velocity of ultrasound ( $\text{msec}^{-1}$ );  $K$ : Bulk modulus ( $\text{Nm}^{-2}$ )

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**IV. RESULTS & DISCUSSION**

Table 1 presents data on velocity of ultrasound and its allied parameters at the frequency of 1MHz for different density of reconstituted milk. The parameters which shown in Table 1 are acoustic impedance, bulk modulus and adiabatic compressibility. Also, the content of milk powder in distilled water (%) is evident from the Table 1.

Table 1 - Data on density, ultrasonic velocity, acoustic impedance, bulk modulus and adiabatic compressibility in different concentration of milk

Milk powder content in distilled water (%)	$\rho$ (kg.m <sup>-3</sup> )	V (m.sec <sup>-1</sup> )	Z (x10 <sup>-6</sup> Kg.m <sup>-2</sup> .sec <sup>-1</sup> )	K (x10 <sup>10</sup> N.m <sup>-2</sup> )	B (x10 <sup>-10</sup> N <sup>-1</sup> .m <sup>2</sup> )
0	1007	1522	1.533	0.233	4.288
10	1101	1537	1.692	0.26	3.845
20	1202	1550	1.863	0.288	3.463
30	1301	1570	2.042	0.321	3.118
40	1402	1582	2.218	0.351	2.845
50	1504	1592	2.394	0.381	2.623
60	1602	1609	2.577	0.415	2.411

$\rho$ : density; v: velocity; Z: acoustic impedance; K: Bulk modulus;  $\beta$ : adiabatic compressibility

Fig. 1. depicts a plot between density of milk and velocity of ultrasound at a frequency of 1MHz. The plot is linear. It means velocity of ultrasound increase linearly with the density of milk. A significant increase in velocity of about 85 m/sec at the frequency of 1MHz for 60 % concentration of milk is shown graphically in Fig.1.

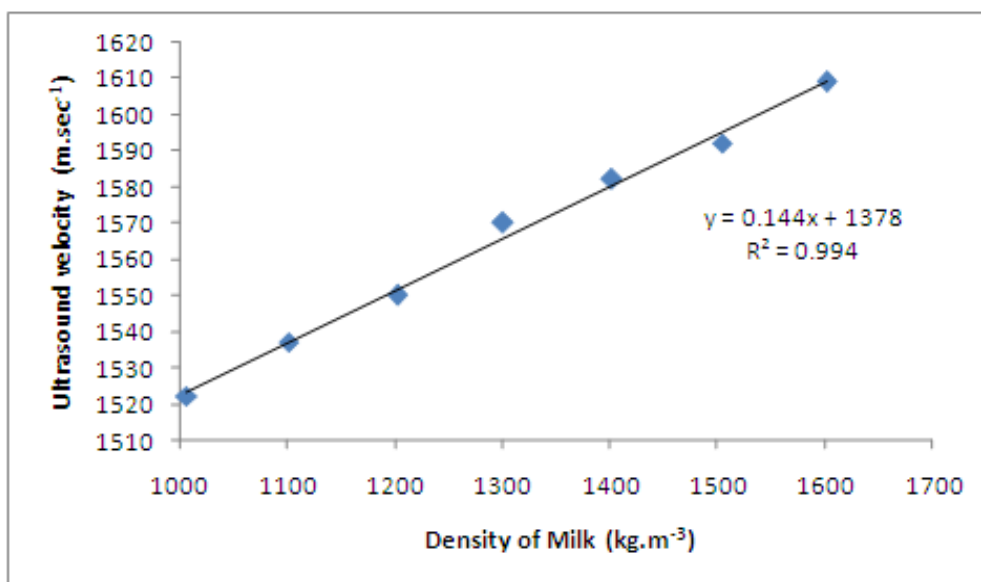


Fig. 1. Variation of ultrasonic velocity with density of milk

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Fig. 2. Shows the graph between acoustic impedance and density. Acoustic impedance is the parameter which measures the opposition to the acoustic flow that a system offers. This parameter increases from  $1.544 \times 10^{-6} \text{ Kg. m}^{-2} \text{ sec}^{-1}$  to  $2.584 \times 10^{-6} \text{ Kg. m}^{-2} \text{ sec}^{-1}$ , when density increases from  $1007 \text{ Kg.m}^{-3}$  to  $1604 \text{ Kg.m}^{-3}$ . The increase is linear (Fig. 2).

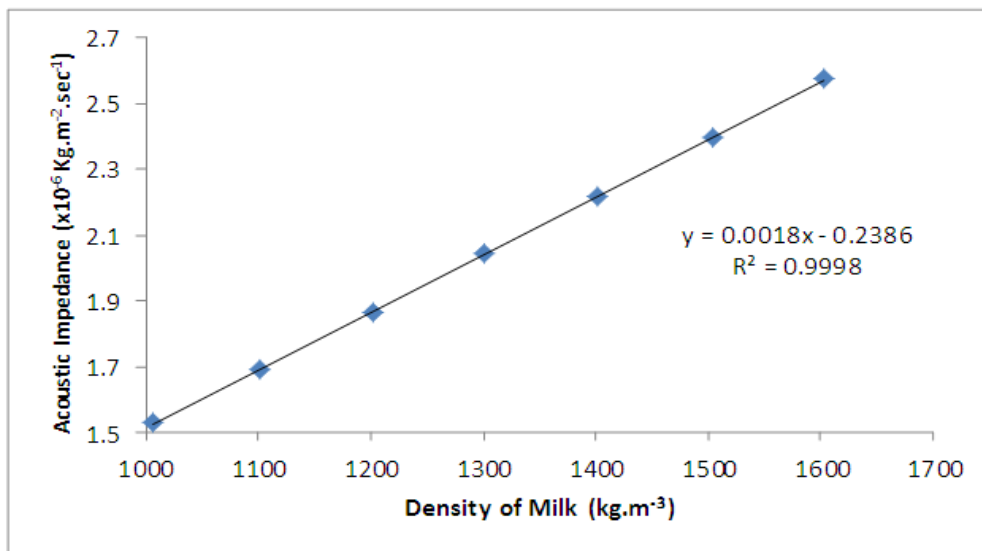


Fig. 2. Variation of Acoustic Impedance with density of milk

Fig. 3. Is a straight line graph between bulk modulus and density of milk. The bulk modulus of reconstituted milk increases with the increase in its density as evident from Fig. 3.

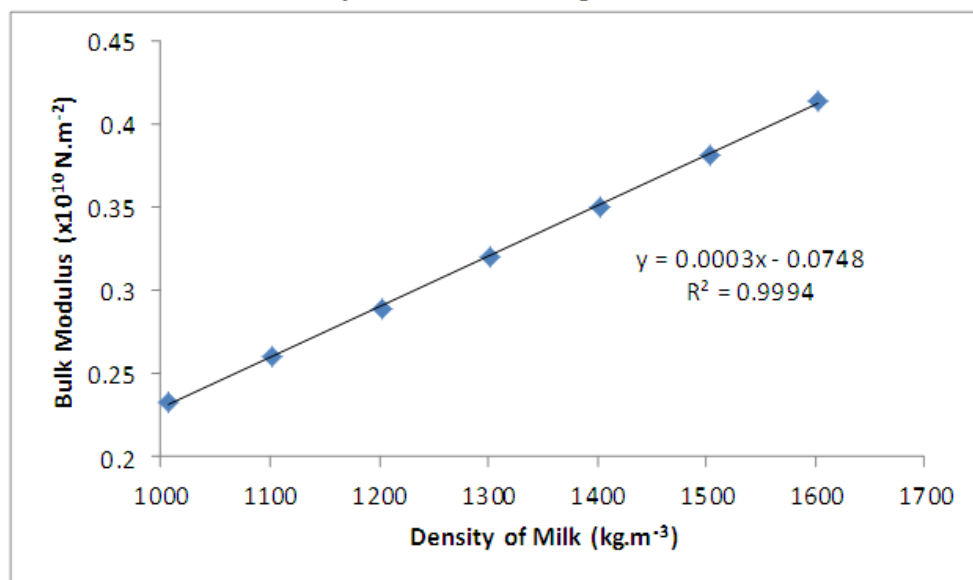


Fig. 3. Variation of Bulk modulus with density of milk

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Fig. 4. is a plot between adiabatic compressibility and density of milk. It can be noted that adiabatic compressibility decreases non-linearly with the increase in density of milk, because of the fact that it is reciprocal of bulk modulus.

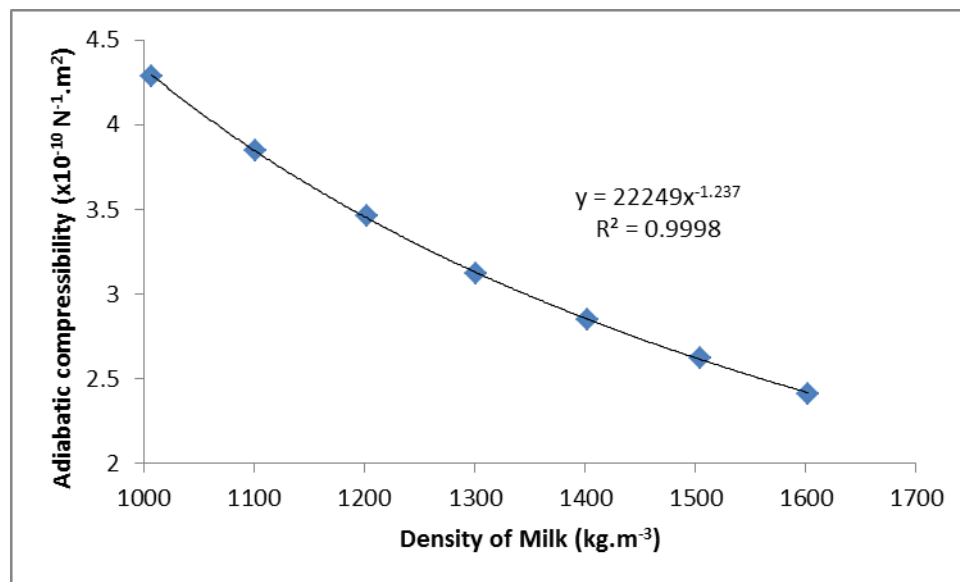


Fig. 4. Variation of Adiabatic compressibility with density of milk

It is observed that when instant milk powder is mixed with water, the product resembles fresh milk. But dissolved particles found were at the surface and also in the bulk of the product. The particles found at the surface are formed by clustered liquid-fat aggregates. The particles found in the bulk are small particles composed of a protein gel. Milk is a complex liquid, whether it is natural or reconstituted, consists of fat globules of different sizes suspended in aqueous medium as a natural emulsion, proteins in the colloidal state and sugars in true solution [9]. The increase in the velocity of ultrasound measured in reconstituted milk of the present study could be explained by the solid part of the matrices, which is the presence of either of fat or lactose crystals. The presence of these lactose crystals changes the compressibility of the matrix drastically. But this is not the case, because of the fact that the matrix contains both liquid and solids. Therefore it can be concluded that the high value of ultrasonic velocity in milk, in comparison with water, may perhaps be due to the modification of compressibility, which is definitely due to solid material in the matrix. The contribution of lactose crystals in changing the acoustic parameters may not be the determining factor to assess the reconstitution quality of a milk powder.

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