A Viscometric and Ultrasonic Study to Detect Water Adulteration in Milk

[1]Mohammed Habib Ali, [2]Adeel Ahmed
[1]Department of Physics, Dravidian University, Srinivasavanam, Kuppam-517426, India.
[2]Biophysics Research Laboratory, Department of Physics, Nizam College (Autonomous),
Osmania University, Hyderabad, India
Email - [1]habib4781@gmail.com, [2]dr_adeelahmad@yahoo.com

Abstract: *It is commonly observed that most of the milk vendors adulterate milk with water. The water adulteration in milk is assessed by using lactometer. But a large quantity of milk is required for this purpose. In view of this, it is thought to use the techniques of ultrasound and viscometry to assess the degree of water adulteration in milk.*

In the present investigation, the buffalo milk is adulterated with water by adding 2,4,6,8 and 10 ml to 10 ml of milk. As the first step density of water adulterated milk is measured using specific gravity bottle of 10 ml volume. The coefficient of viscosity is determined by using Ostwald viscometer. Velocity and attenuation of ultrasound are measured at the frequency of 1MHz employing ultrasonic interferometer. The relations are established for these parameters with respect to water added in pure milk. The paper concludes water adulteration can be detected accurately by measuring viscosity and ultrasonic parameter with ease.

Key Words: *Milk vendor, adulteration, Ostwald viscometer, ultrasonic interferometer, Viscosity, Ultrasonic velocity, Attenuation.*

1. INTRODUCTION:

Milk - A white fluid secreted by the mammary glands of adult females for the nourishment of their young, consisting of minute globules of fat suspended in a solution of casein, albumin, milk sugar and inorganic salts. There are many factors that can affect milk composition such as breed to breed variations, herd to herd variations, cow to cow variations, feed considerations, seasonal variations and geographic variations. Only an approximate composition of milk can be considered: 87.3% water (range of 85.5% - 88.7%); 3.9% milk fat (range of 2.4% - 5.5%); 8.8% solids-not-fat (range of 7.9% - 10.0%) including protein (3.25%), lactose (4.6%), minerals (0.65%) and acids (0.18%), enzymes, gases and vitamins. Milk of domestic animals considered as an important food source for humans. Milk is promoted by public education campaigns and doctors as a rich source of minerals. Doctors considered milk as an "indispensible" component of a child's diet.

2. LITERATURE REVIEW:

Hueter et al [1] measured ultrasonic absorption of homogenized and skimmed milk. They found that the ultrasonic absorption at 1MHz in homogenized milk was about 400 dB/m and in skimmed milk was about 200 dB/m. Saraf and Samal [2] studied velocity and attenuation of ultrasound in centrifuged and uncentrifuged samples of reconstituted powedred milk and fresh milk separately for comparative analysis of observing the effect of fat particles. McClements and Povey [3] studied the application of ultrasound for the characterization of edible fats and oils. Pavic et al [4] 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 [5] studied an objective to investigate five different types of milk powder qualities using the technique of ultrasound spectroscopy.

Guetouche et al [6] reported data on variation of composition of milk depending on various species. McClements and Fairley [7] found that a pulse echo technique can be used for measuring the velocity and attenuation and a reflection technique for measuring the impedance. It may also be used to determine various physical properties of liquid materials, such as temperature, density and the particle size and concentration of dispersed phases.
Miles et al [8] investigated that attenuation of ultrasound in milks and creams is due to the fat concentration. They also found that the attenuation of ultrasound in milk increases with decrease in size of fat globules. Del Grosso and Mader [9] studied sound speed in pure water and established sound speed equation of fifth order in temperature is fit with a standard deviation of 0.0028 m/sec for 148 observations between 0.001°C and 95.126°C on the T_{68} scale. Scott and Oosthuizen [10] made viscometric study on the breakdown of casein in milk by rennin and rennet. They plotted a graph between viscosity and fat content in milk and determined intrinsic viscosity.

3. MATERIALS AND METHODS:

Raw milk was collected from local vendors nearby mehdipatnam, Hyderabad. Since milk is a heterogeneous medium, stirring process is required to make it homogeneous medium. A specific gravity bottle of volume 10 ml and a digital balance (Fig. 1) was used to determine the density of milk. An Ostwald viscometer was employed to assess

viscosity of milk (Fig. 2). To measure time of flow of milk a digital watch of L.C. 0.1sec was used. A multi frequency ultrasonic interferometer (Model, M-81, Mittal Enterprises) with a least count of 0.001 cm was used to determine ultrasound velocity and 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. 3).

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.

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_0 and I were measured at two nodes separated by a distance "*x*", $\lambda = \frac{2x}{n}$ and the attenuation coefficient and ultrasound velocity was calculated.

Density of milk is calculated using the relation, $\rho_m = \frac{M-m}{V}$ Kg/m^3

ρ_m: density of milk, M: mass of specific gravity bottle with milk, m: mass of empty specific gravity bottle, V: volume of specific gravity bottle.

Coefficient of viscosity was calculated using the relation, $\eta_m = \eta_w \frac{\rho_m t_m}{\rho_w t_w}$ Poise

η_m: viscosity of milk, η_w: visosity of distilled water(0.008 Poise), ρ_m: density of milk, ρ_w: density of water(1003 Kg/m^3), t_m: time of flow of milk, t_w: time of flow of water.

Ultrasound velocity and Attenuation was determined using the relations, $v = \nu\lambda$ m/sec and $\alpha = \frac{ln\left(\frac{I_o}{I}\right)}{2x}$ neper/m

v: ultrasound velocity, λ: ultrasound wavelength, *ν:* ultrasound frequency, n: number of oscillations, I_o*:* initial intensity *I:* final intensity, *x:* distance travelled in the medium by ultrasound waves.

Figure 1 Digital balance

Figure 2 Oswald viscometer

Figure 3 Ultrasonic interferometer

4. RESULTS: Table 1 Data on density, viscosity, velocity and attenuation of ultrasound of milk

Water (%)	Density, ρ_m (Kg/m^3)	Viscosity, η_m (Poise)	Velocity, v (m/sec)	Attenuation, α (neper/m)
0	1028 ± 4	0.0145 ± 0.00071	1524 ± 3	21 ± 3
20	1024 ± 5	0.0136 ± 0.00073	1520 ± 4	20 ± 2
40	1019 ± 3	0.0133 ± 0.00075	1515 ± 4	15 ± 4
60	1017 ± 4	0.0104 ± 0.00069	1512 ± 5	14 ± 3

80	1013 ± 6	0.0098 ± 0.00076	1510 ± 5	13 ± 4
100	1011 ± 4	0.0093 ± 0.00070	1506 ± 3	11 ± 2

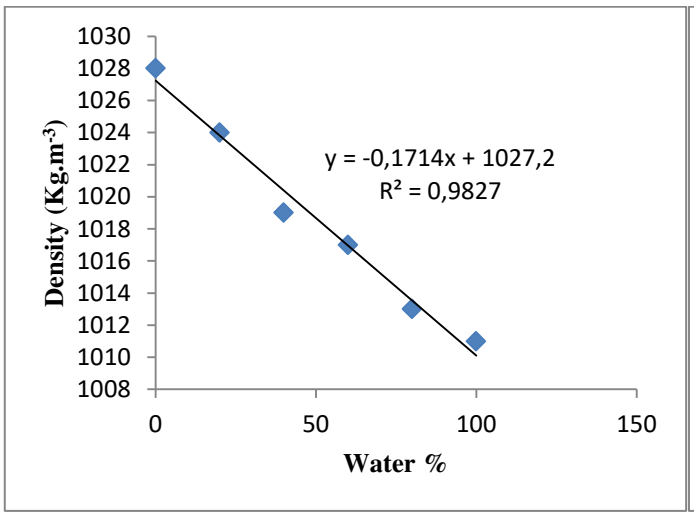

Figure 5: water % vs. density of milk

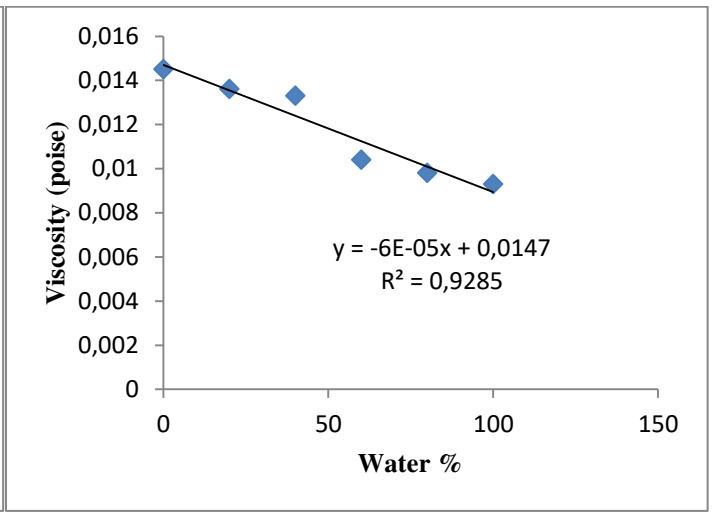

Figure 6: water % vs. viscosity of milk

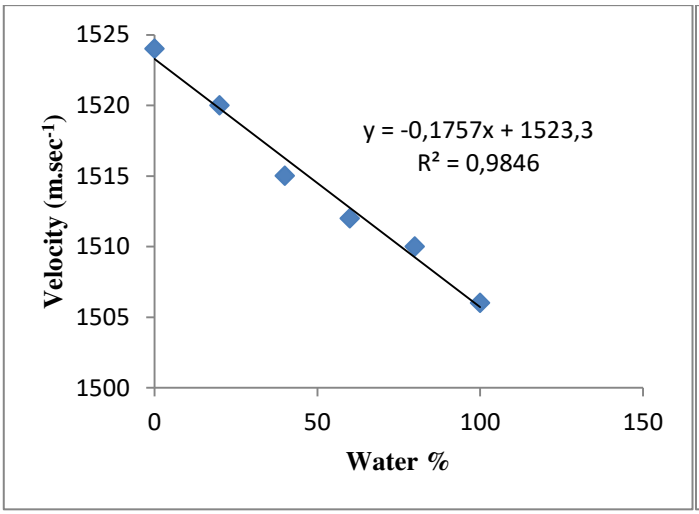

Figure 7: water % vs. velocity of milk

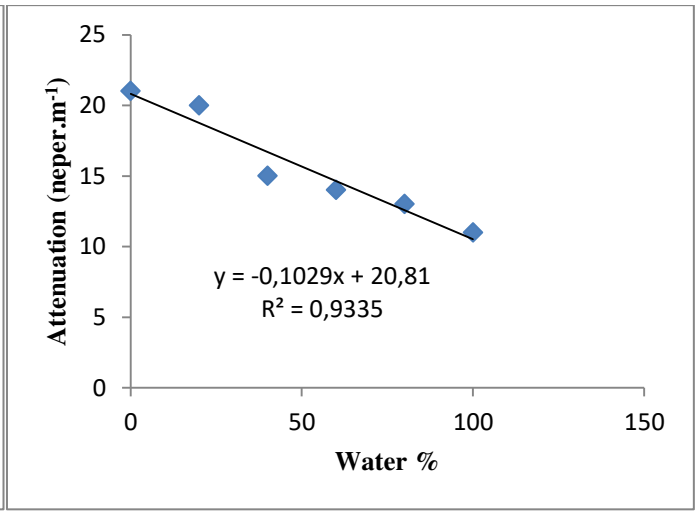

Figure 8: water % vs. attenuation of milk

Table 1 reveals the data on coefficient of viscosity of adulterated milk with water. The data cleared that the viscosity of milk decreases with increase in % of water content in pure milk. Similar trend is followed in the values of ultrasound velocity and attenuation coefficient. The plots between % of water and density, viscosity, ultrasound velocity, attenuation clearly shows the variation of parameters with highest correlation coefficient (R^2) values.

5. DISCUSSION:

The density of milk is not a constant but it varies. The density of milk decreases linearly with % of adulteration with water. The same is true for other parameters such as viscosity, ultrasonic velocity and utrasonic attenuation (Table 1). The relationship between parameters understudy and % water adulterated to milk is strong as R^2 value is more than 0.9 in all the cases. The decrease in rheological and ultrasonic paprameters with increase in adulteration of milk with water can be attributed to the fact that the major constituent of milk is fat. Further the fat is in the form of globules whose density is very less and they float. On the other hand casein plays major role in the coagulation of milk. When water added to the milk, fat globules seperate apart and hence their concentration decreases. It can be concluded that decrease in concentration of fat globules and coagulation of casein may cause decrease in density, viscosity, ultrasonic velocity and ultrasonic attenuation ; when milk is adulterated with water.

As is known in practice lactometer is being used to detect water adulteration in milk. But it requires large quantity of milk and does not work for small sample of milk. But the parameters under study serve the purpose for the small quantity of milk samples to be tested for water adulteration. It is interesting to note from the present study that

ultrasonic parameters such as velocity and attenuation are very much sensitive than rheological parameters like density and viscosity to detect water adulteration in pure milk in a small level.

REFERENCES:

1. Hueter T. F., Morgan H., and Cohen M. S., (1968): Ultrasonic attenuation in biological suspensions: *J. Acoust. Soc. Am.*, 26(2), 1200-1201.
2. Saraf B. and Samal K., (1984): Ultrasonic velocity absorption in reconstituted powdered milk: *J. Acoustic*, 56(1), 61-66.
3. McClements J.D. and Povey M.J.W., (1992): Ultrasonic analysis of edible fats and oils: *J. Ultrasonic*, 30(6), 383-388.
4. Pavic V., Antunac N., Mioc B., Ivankovic A., and Havranek J. L., (2002): Influence of stage of lactation on the chemical composition and physical properties of sheep milk: *J. Anim. Sci*., 47(2), 80-84.
5. Stefen Meyer, Vijaya S., Rajendram and Malcolm J. W. Povey, (2006): Characterization of reconstituted milk powder: *J. Food Quality*, 29, 405-418.
6. Guetouache, Mourad, Guessas, Bettache and Medjekal Samir, (2014): Composition and nutritional value of raw milk: *J. Issues boil. Sci. Pharm. Res*., 2(10), 115-122.
7. McClements D.J., and Fairley P., (1991): Ultrasonic pulse echo reflectometer: *J. Ultrasonics*, 29, 58-62.
8. Miles C.A., Shore D., and Langley K.R., (1990): Attenuation of ultrasound in milks and creams: *J. Ultrasonics*, 28, 394-400.
9. Del Grosso V.A., and Mader C.W., (1972): Speed of sound in pure water: *J. the Acoustical Society of America*, 52(5) (part 2), 1442-1446.
10. Scott Blair G.W. and Oosthuizen J.C., (1961): A viscometric study of the breakdown of casein in milk by renin and rennet: *J. Dairy Res*., 28(165), 165-173.