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FTIR SPECTROSCOPY AND DIELECTRIC PROPERTIES OF RECONSTITUTED BUFFALO POWDERED MILK WITH WATER

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Abstract

Fourier transform infrared (FTIR) spectroscopy in the mid-infrared (400 - 4,500 cm-1) was carried out to investigate the conformation of chemical composition (proteins) in the present reconstituted buffalo powdered milk. Dielectric properties of milk play an important role when milk powder is reconstituted with water. Data on the analysis of dielectric properties, such as the dielectric constant, are reported in the paper, dielectric loss and electrical conductivity of reconstituted buffalo powdered milk with water at different concentrations of milk ranging from 0.5 to 5 gm/100ml were carried out at audible frequencies ranging from 100 Hz to 25k Hz, using digital LCZ meter.

Keywords: FTIR, Buffalo milk powder, Reconstitution, Dielectric constant, Dielectric loss, electrical conductivity, Impedance analyzer.

1. Introduction

In the last few decades, milk powders became the most essential food for human life. In general, the main objective of making milk powder is to transform a liquid raw material into a product that can be stored for a few years without experiencing a significant loss in quality. Like temperature and other physical and chemical conditions, dielectric properties also affect the storage of milk powder.

In nature, milk gives mammalian young nourishment and immunological protection. Humans have been consuming milk as nourishment from the beginning of time. The only food item in nature whose primary purpose serves food is milk. Milk has a high nutritious value. Another highly complex meal is milk, which contains a wide range of molecular species. Breed variations, herd-to-herd variations, nutrition considerations, seasonal variations, and geographic variations are just a few of the many variables that can impact the composition of milk.

William G. Griffin et al. [1] investigated on the ultrasonic attenuation in casein micelie aqueous solutions from cow milk. Researchers C.A. Miles et al. [2] looked into that ultrasound attenuates in milks and creams.

Stefan Meyer et al. [3] reported studies qualities of reconstituted milk powders by ultrasound spectroscopic technique.

Habib and Adeel Ahmad [4] Utilising a multifrequency interferometer, the velocity of ultrasound in various amounts of milk that had been reconstituted with water at a frequency of 1 MHz at room temperature was measured. A specific gravity bottle was used to measure the density of milk. Calculations were made for bulk modulus, adiabatic compressibility, and acoustic impedance. They reported that milk purity could be determined using an ultrasound velocity. With the help of the velocity data, any adulteration in the milk can be determined.

Habib and Adeel Ahmad [5] Utilising a multifrequency interferometer, the attenuation of ultrasound in various amounts of milk that had been reconstituted with water at a frequency of 1 MHz at room temperature was studied. A specific gravity bottle was used to measure the density of milk. They observed that when the density of the reconstituted milk increased, there was a corresponding increase in ultrasonic attenuation. This could be attributed to molecular rearrangement and relaxation brought on by the ultrasonic waves' propagation.

Habib and Adeel Ahmad [6] reported volume flow rate, surface tension, and coefficient of viscosity of reconstituted milk at various concentrations. They used a capillary viscometer, which was recently created, for this purpose. The capillary bore's radius was 0.045 cm. A specific gravity bottle was used to measure the density of milk. When the density of reconstituted milk increased, they saw a decrease in volume flow rate and an increase in viscosity and surface tension. They proposed using the rheological data to identify any adulteration in the milk.

Habib and Adeel Ahmad [7] conducted ultrasonic and viscometric tests to find verification of water adulteration in milk. Water was added in amounts of 2, 4, 6, 8, and 10 ml to each 10 ml of buffalo milk for utilize. Using a specific gravity bottle with a 10 ml capacity, the density of milk measured with water was determined as the initial stage. The Ostwald viscometer was used to calculate the coefficient of viscosity. Using an ultrasonic interferometer, the velocity and attenuation of ultrasound were measured at a frequency of 1MHz. They found correlations between these characteristics and the amount of water added to pure milk, and they came to the conclusion that monitoring viscosity and ultrasonic parameter was a simple way to identify water adulteration.

A search of literature reveals no information on dielectric properties of reconstituted buffalo milk with water.

2. Materials and Methods

Different concentrations of Nestle milk powder were reconstituted in double-distilled water. In 10 millilitres of distilled water, powder weighing 1, 2, 3, 4, and 5 grammes was combined. The milk was stirred at sufficiently low speed using magnetic stirrer. Care was taken to avoid foaming and milk becomes isotropic and homogeneous.

Fig. 1. LCZ meter

Fig. 2. Dielectric Cell

Using a digital LCZ metre, dielectric parameters including susceptibility, electrical conductivity, dielectric constant, and dielectric loss were measured at audible frequencies between 100 Hz and 25 k Hz (Fig. 1). For the dielectric measurements, a typical conductivity cell (Fig. 2) was utilised. The following formulas were used to compute the conductivity, dielectric loss, and dielectric constant.

Dielectric constant, $\varepsilon' = \frac{C_s}{C_a} = \frac{(C'_s - C_L)}{(C'_a - C_L)}$

where C_s: Actual cell capacitance using the sample; C_L: Lead capacitance; C_a: Actual air-filled cell capacitance; C'_s : measured the cell's capacitance using a sample; C'_a : measured the cell's capacitance in the lack of a sample, or with air.

Dielectric loss, $\varepsilon'' = \varepsilon' \tan\delta$,

where ε' is the dielectric constant and δ is the dissipation factor.

Electrical Conductivity, $K = \frac{GL}{A}$

where A is the plate area, G is conductance, and L is the distance between the cell's plates.

The conductivity measuring cell's lead capacitance is a frequency-dependent characteristic that has a negative impact on the dielectric measurements. Hence, one should determine the lead capacitance of the cell before making dielectric measurements of a sample. The lead capacitance acts in parallel combination with the capacitance of the measuring cell. It should be subtracted from the measured capacitance, in order to get actual capacitance. In the present investigation, capacitance of the parallel plate capacitor, when the space between two plates is filled with the sample was referred as sample capacitance (C_s). If the dielectric medium in the parallel plate capacitor is air, then its capacitance is called air capacitance (C_a). The air capacitance of the measuring cell was determined by considering the liquids of known dielectric constant such as water, acetone or alcohol. When a parallel plate capacitor is filled with a liquid with a known dielectric constant, the experimentally measured capacitance C's of the capacitor is,

$$C_s' = C_s + C_L$$

where, C_s= Actual sample capacitance

C_L = Lead capacitance

$$C_s = C_s' - C_L$$

In a similar way, the measured capacitance of a capacitor in which air represented as the medium between two plates,

$$C'_a = C_a + C_L$$

$$C_a = C'_a - C_L$$

The ratio of capacitance (Cs) in a cell with liquid as the dielectric medium to capacitance (Ca) in a cell with air as the dielectric medium is known as the dielectric constant (ε').

Therefore,

$$\varepsilon' = \frac{C_s}{C_a} = \frac{C'_s - C_L}{C'_a - C_L}$$

$$\varepsilon'(C'_a - C_l) = C'_s - C_L$$

$$C_L = \frac{\varepsilon' C'_a - C'_s}{(\varepsilon' - 1)}$$

the conductivity cell's measured capacitances at 1 kHz with and without a liquid that has a known dielectric constant, respectively, and ε' is the dielectric constant of distilled water. Lead capacitance was computed at frequencies between 100 and 25 kHz using knowing of C'a, C's, and ε'.

3. Results and Discussion

3.1. FTIR analysis

The FTIR spectra of different concentrations (1.0, 2.0, 3.0 ,4.0, 5.0 g) of reconstitutedbuffalo powdered milk mixed with 10 ml of waterin the mid-infrared region 400-4500 cm^{-1} are shown in Fig. 3 and the corresponding band assignments are tabulated in Table.1.

From Fig 3, it is observed that the characteristic infrared spectral bands of the different concatenations were very similar. The absorption bands centered at 3269 to3279 cm^{-1}**,** 2012 to 2023 cm^{-1},1629 to 1636 cm^{-1}, and 1019 to 1027 cm^{-1} , respectively. It has been observed that the bands observed in the region 3269 to3279 cm^{-1} are due to the NH stretchingvibrations of absorption of amide A. The band in the region 2012 to 2023 cm^{-1} is due to the Diamond absorption (CO_2 affected) in this region and it may be neglected. The band in the region 2012 to 2023 cm^{-1} is due to the 1629 to 1636 cm^{-1}due to the C=O stretching vibrations of absorption of amide I.The band in the region 1019 to 1027 cm^{-1} may be due to the carbohydrate[8-10].

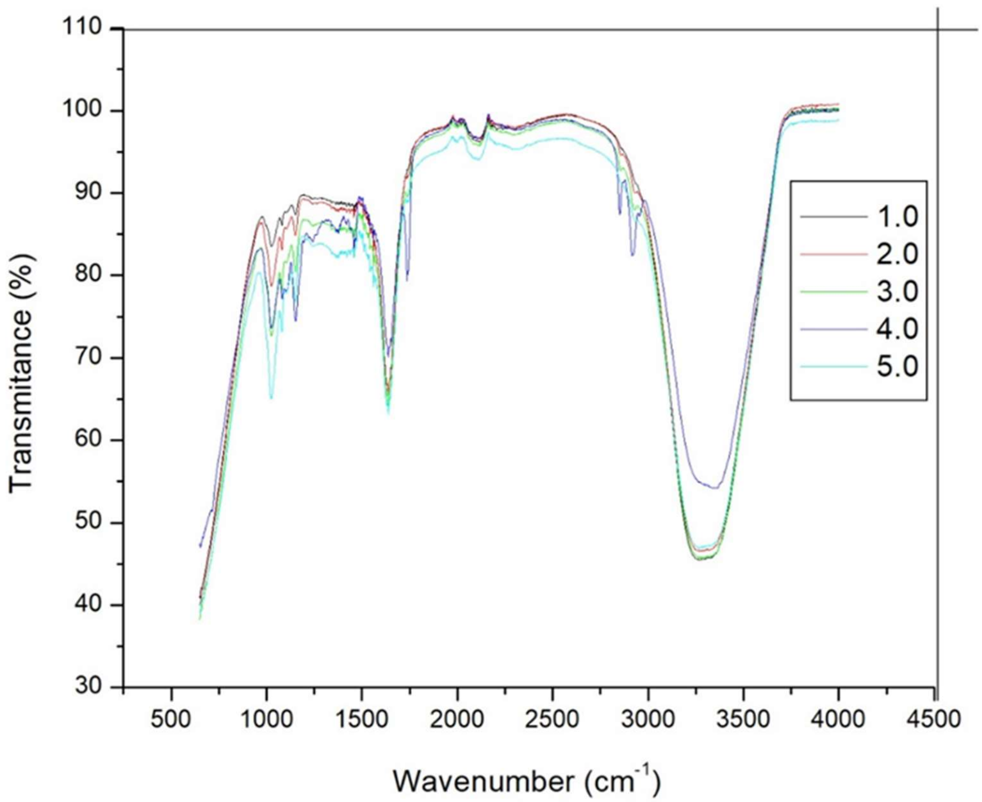

Fig. 3.FTIR spectra of different concentrations (1.0, 2.0, 3.0 ,4.0, 5.0 g) of reconstituted buffalo powderedmilk mixed with 10 ml of water at 250c.

Table 1. FTIR Spectral bands and their assignments for different concentrations of reconstituted buffalo Powdered Milk.

Wavenumber(cm^{-1})	Assignments
3269 - 3279	NH stretching vibrations of absorption of amide A
2012 - 2023	CO_2 affected in this region and is ignored
1629 -1636	C=O stretching vibrations of absorption of amide I
1019 - 1027	Carbohydrate stretching vibrations

3.2. Dielectric properties

Fig. 4.1. to .3. depict plots between dielectric constant (ε'), dielectric loss (ε'') and conductivity (G) of reconstituted milk on Y-axis and percentage of milk powder in reconstituted milk with water on X-axis. Interestingly, dielectric loss and dielectric constant show a significant nonlinear decrease, while an increase in conductivity as frequency increasesin the range of 100 Hz to 25 kHz for the milk sample of concentration rangingfrom 2.5 to 25 gm/100 ml. Here, any type of dielectric relaxation is observed in this frequency range.

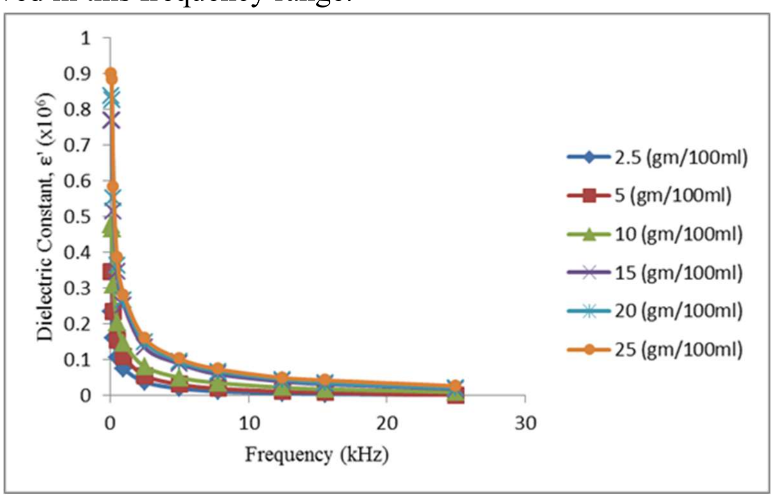

Fig. 4.1

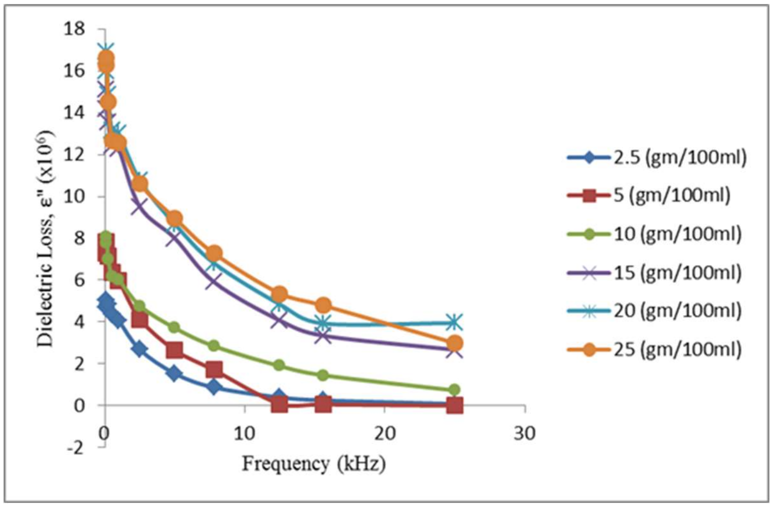

Fig. 4.2

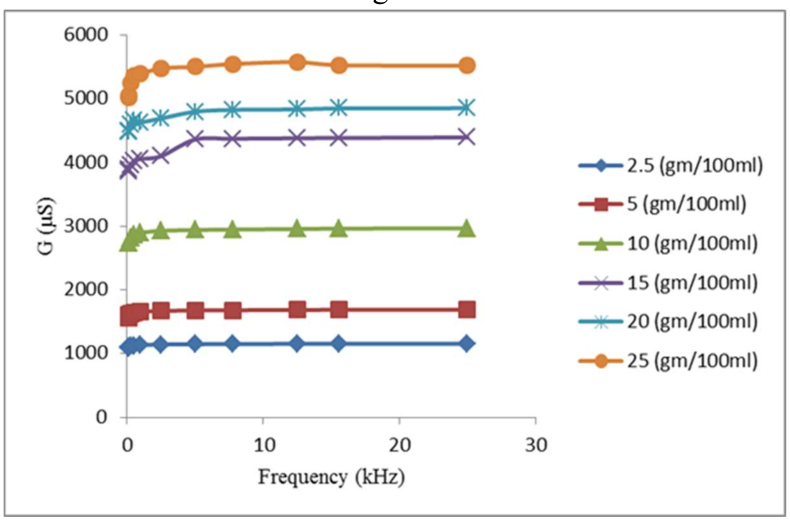

Fig.4.3.

Figs. 5.1. to 5.3. are the plots drawn between ε', ε" G of reconstituted milk and percentage of milk powder added to water. These parameters pertaining to reconstituted milk incease linearly with the percentage of milk powder added to the water at a constant frequency of 1 MHz. The linear regression equation and coefficient of correlations are evident from thefigure.

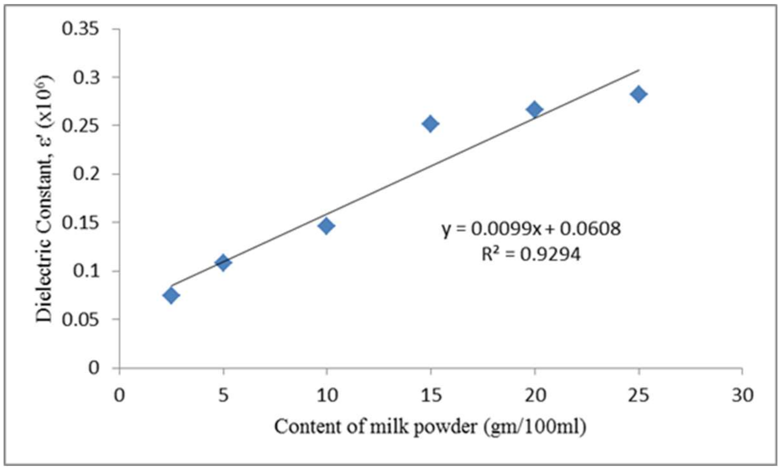

Fig. 5.1

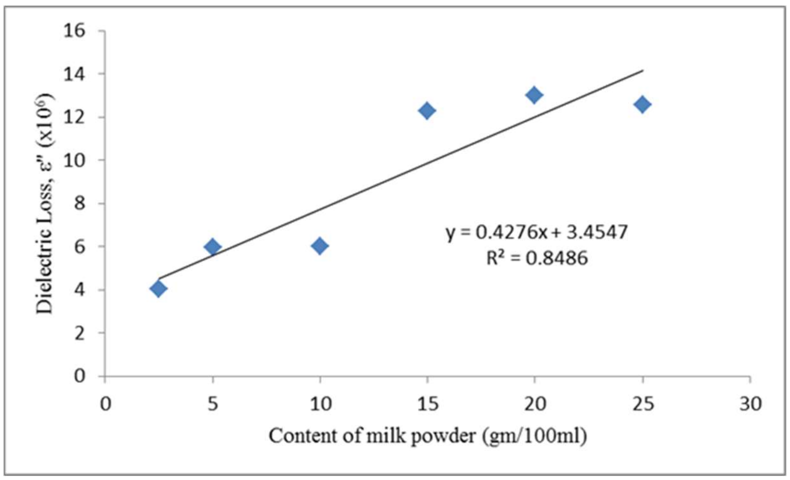

Fig. 5.2

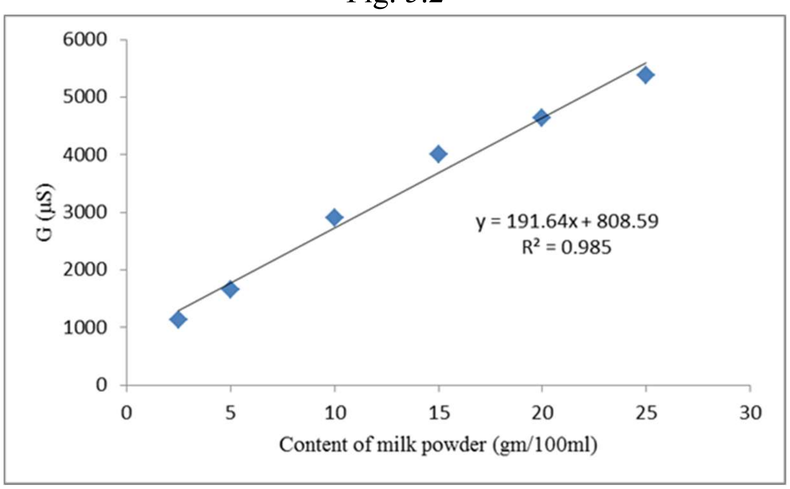

Fig. 5.3

Milk constitutes proteins which include casein and whey protein. The casein in the milk exists in micelles. The fat of both saturated and unsaturated fatty acids is present in globules. There is specific sugar referred as lactose and usually called milk sugar. Apart from these some minerals inorganic compounds and ions are emulsified in water. The contribution of milk sugar lactose in changing dielectric parameters may not be determining factor. The milk powder content in water that reconstitute the milk, in other words density of reconstituted milk is directly proportional to the content of protein and fat. Hence, dielectric parameters linearly vary with protein and fat contents as evident from Fig 6. and Fig. 7 respectively.

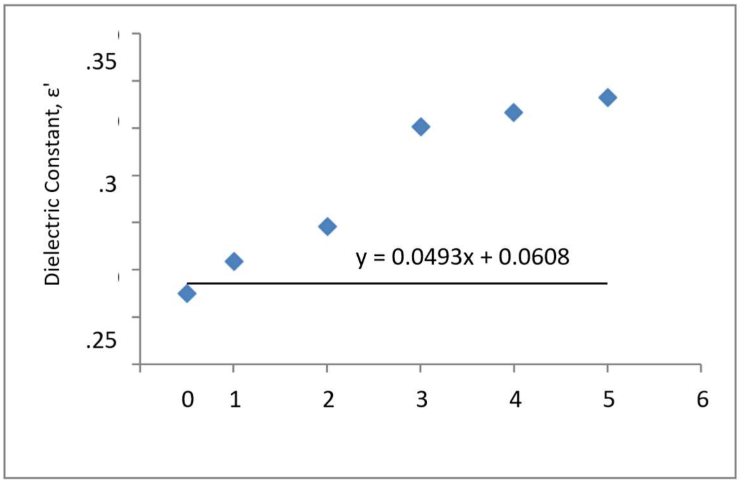

Fig. 6.1.

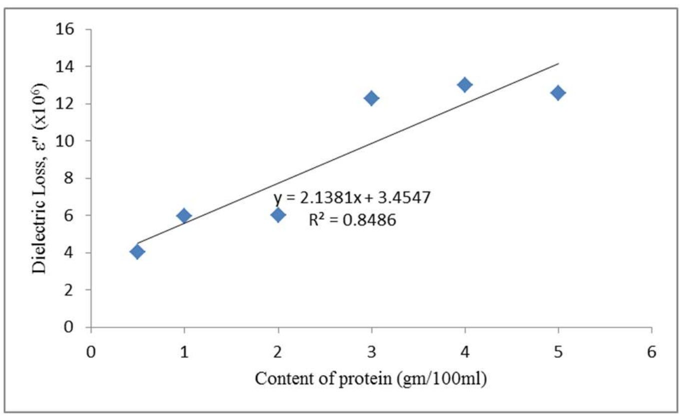

Fig. 6.2.

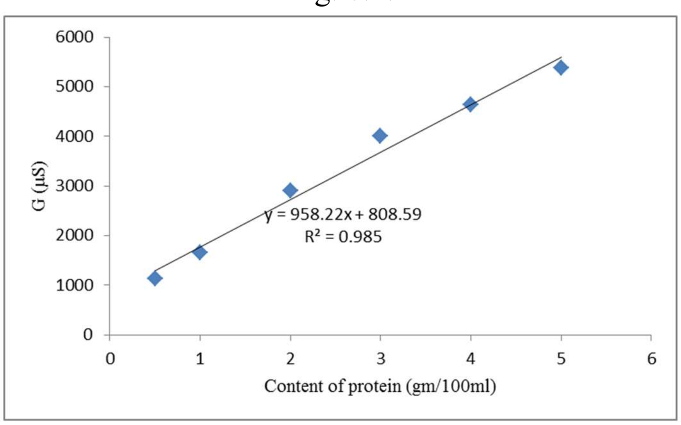

Fig. 6.3.

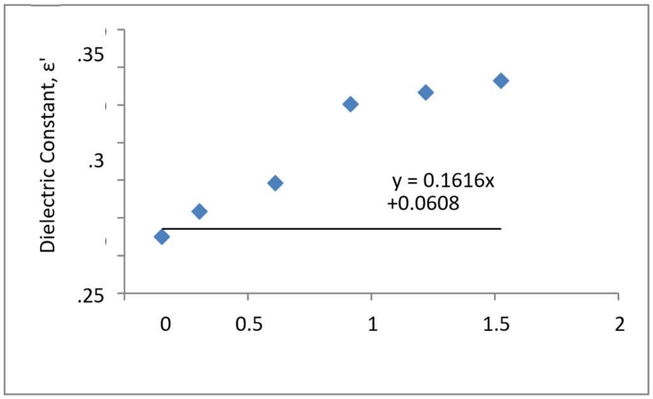

Fig. 7.1

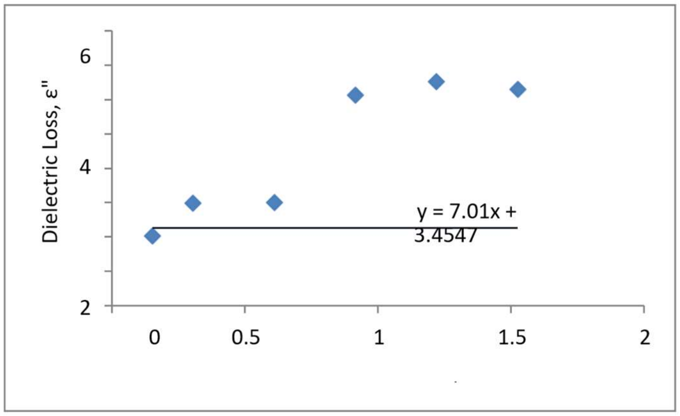

Fig.7.2

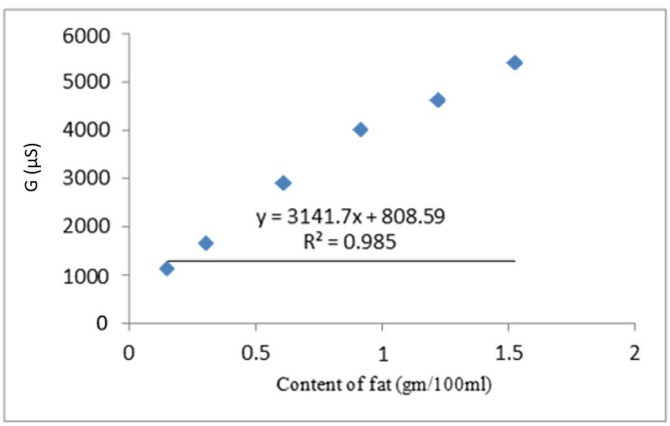

Fig.7.3

4. Conclusion

Food's dielectric characteristics, such as its electrical conductivity, dielectric dispersion, loss, and dielectric constant, are significantly impacted by water. The presence of proteins affects the directrices properties and was confirmed by FTIR spectra. The study suggests that biological fluids such as milk possesses very high dielectric constant, dielectric loss as well as electrical conductivity because of water. Another peculiar feature is that high dielectric constant is coupled with high dielectric loss in contrast to usual non biological materials. Hence, the results the conclude that the feature and storage of milk depends on the dielectric properties.

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