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Acoustics Impedance Studies in Some Commonly Used Edible Oils

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Abstract

In the present work Ultrasonic velocity is measured in six basic forms (unrefined) of some commonly used Edible Oils at various frequencies by using Multy frequency Ultrasonic Interferometer. Density of the Oils was determined by using a Specific Gravity bottle of 10ml capacity at 30 ±0.1^{0}C. Using Ultrasonic velocity (V) and Density (ρ), Acoustic impedance (Z) was computed. These values of Acoustic impedance and their variations in the systems of oils studied may be taken as standard values for calibration purpose and can be used to check if oils are adulterated.

Key words - *Ultrasonic Velocity, Density, Acoustic impedance, Edible Oils.*

1. Introduction:

Ultrasonic techniques have been widely used to study a number of the physical properties of oils. Bhattacharya et al (1981) used ultrasonic techniques for the estimation of adiabatic compressibilities and the investigation of phase transitions in coconut oil [1]. Hussein et al (1984) determined the solid fat content in solidifying fat oils by employing Acoustic studies [2]. Rao et al (1980) studied the temperature dependence of the velocity of ultrasonic waves to detect adulteration in a number of animal and vegetable Oils [3]. Mc Clement et al (1990) used ultrasonic methods for characterization of food emulsion [4]. Jaafar et al (1993) employed an ultrasonic technique to determine the oil content in a homogeneous solution of crude palm oil and hexane (michella) [5]. They proposed that the three main parameters affecting the velocity of ultrasonic waves in the solution were density, acoustic impedance and temperature. M. M. K. Najmie et al (2011) measured Ultrasonic velocity in healthy and infected area of oil palm trunk and it is observed that Ultrasonic velocity of infected area is lower than healthy area[6]. Sobahan Mial et al (2010) used Ultrasound to measure properties such as food composition, structure, flow rate, physical state, and molecular properties [7]. Nikoolic Biban D et al (2012) studied the parameters such as Ultrasonic velocity, Bulk modulus and density of liquid fuels to predict the fuel injection process in diesel engines [8]. SIDEK et al (1996) determined the dynamic compressibility, kinematic viscosity and acoustic impedance of oils as well as particle distribution in emulsions using ultrasonic technique [9]. The aim of the present work is to characterize quantitatively some commonly used edible oils, using an ultrasonic technique in order to obtain a valuable insight into their dynamic properties. The sound velocity and attenuation coefficient are closely related to the physico-chemical properties of oils through which sound waves propagate and can therefore be used to provide information about these properties.

2. Materials and Methods:

In the present study, samples of Six commonly used pure Edible oils (In unrefined state) are collected from their production units. A variable path Ultrasonic Interferometer (Mittal Enterprises – New Delhi, Model No. M 81) operating at various frequencies of 1,2,3&5 MHz with a least count of 0.0001cm of its micrometer was used to determine the velocity of Ultrasound in these oil samples at temperature 30 ±0.1^{0}C by adopting standard procedure. Densities of the samples were measured by using a Specific gravity bottle of 10ml capacity and a digital balance of accuracy 0.01 X 10^{-3} Kg at a temperature of 30 ±0.1^{0}C. From the value of Ultrasonic velocity and Densities of oils, Acoustic impedance is computed by using standard formula Z=Vρ Nsec/m ^{3} , Where V – Velocity of Ultrasound, ρ – Density of oils.

2. Results and Discussion:

The values of Ultrasonic velocity of various Edible Oils at 1,2,3 and 5MHz frequency is shown in Table 1. It is observed that there is a marked difference in Ultrasonic velocity in all the Edible oils studied at 1MHz frequency . The variation of Ultrasonic velocity ranges from 1401.1 m/sec in Coconut oil to 1436.8 m/sec in Groundnut oil. A significant increase in velocity is clearly observed as we proceed from Coconut oil to Groundnut oil to an extent of 35m/sec at 1MHz frequency. At 2MHz frequency the Ultrasonic velocity was found to be more in all the oils than at 1MHz. Thus a clear increase in Ultrasonic velocity is observed with increase of frequency from 1MHz to 2MHz. The observed increase in velocity is about 6m/s or more in the oils studied except sunflower oil in which the velocity remained almost the same when the frequency changed from 1MHz to 2MHz. The Ultrasonic velocity studies at 3MHz frequency showed an increase of velocity by about 1to 2 m/s in Coconut, Sunflower and Groundnut oils where as there is decrease in velocity in the case of Cotton and Till oils. There was no change of velocity in Palm oil and Groundnut oil as the frequency is increased from 2 to 5MHz. At 5MHz frequency it is observed that there is a decrease in velocity of about 2m/s in Coconut, Cotton and Till oils where as there is an increase in velocity in Sunflower oil. The variation of Ultrasonic velocity of these samples with frequencies is shown graphically in fig 1.

The observed lower Ultrasonic velocity at 1MHz in Coconut oil may be attributed to the % of unsaturated fatty acid (UFA) and saturated fatty acid (SFA) contained by it. Coconut oil contains 8% UFA and 86% SFA. As the % of UFA increases i.e. 70 to 85% and SFA decreases i.e. 10 to 25% the Ultrasonic velocity is found to be of the higher order as in the case of Cotton, Till, Sunflower and Groundnut oils.

From the data presented, it can be clearly seen that when the % of UFA and SFA are almost of the equal order as in the case of Palm oil there is no change in Ultrasonic velocity at various frequencies.

In general the studies at 2,3 and 5MHz reveal that in all the systems the Ultrasonic velocity is found to be maximum at 2MHz, which may be attributed due to the uniform response of all the system to the Ultrasound.

A significant increase in Ultrasonic velocity of almost 6m/s in all the vegetable oils when the frequency is changed from 1 to 2MHz may be attributed to their response equally. However the increase in Ultrasonic velocity in the systems studied is marginal beyond 2MHz i.e. at 3 and 5MHz.

From the data of Acoustic impedance(Z) presented in Table 2, Acoustic impedance of Coconut and Palm oil are found to be increasing up to 3MHz and there after a slight decrease is observed. In Cotton seed and Till oil the Acoustic impedance (Z) is found to be increasing up to 2MHz and there after it decrease marginally. In the systems namely Sunflower and Groundnut oil the Acoustic impedance (Z) is found to be increasing with increase of frequency as shown in Fig2. From the values of Acoustic impedance (Z) (Table 2) it can be clearly seen that the Acoustic impedance of Palm oil is minimum and the Acoustic impedance of Cotton seed and Coconut oil is maximum at 1MHz frequency in the systems studied. These variations of Acoustic impedance of the systems studied may be attributed to the densities of the oils studied. The density of Palm oil is $0.9145X10^3$ kg/m^3. In the case of Cotton seed and Coconut oil the densities are $0.941 \text{ X } 10^3$ kg/m^3 and $0.947 \text{ X } 10^3$ kg/m^3. In the case of Ground nut oil and Till oils the density values fall between Palm oil and Coconut oils values. When an Ultrasonic wave is propagating in the given oil medium, the molecules of the medium vibrate causing variation of pressure in the medium which can be understood in terms of Acoustic impedance.

4. Conclusion:

The study clearly reveals that the Ultrasonic velocity depends on the % of UFA and SFA contained by the various Edible oils. For an initial increase of frequency from 1MHz to 2MHz there is a significant increase of Ultrasonic velocity in all the samples studied. No significant change in Ultrasonic velocity was observed in the frequency range 3and 5MHz. Hence in the frequency range studied, it can be concluded that these Edible oils responded very well at 1 and 2MHz frequencies than at 3 and 5MHz. Perhaps the Ultrasonic velocity at 1 and 2MHz may be taken as the base values and can be used to detect any adulteration component if these Edible oils are adulterated. In the present system studied the values of Acoustic impedance are less in Palm oil and is more in the case of Cottonseed and Coconut oil with an in between values for Sunflower, Groundnut and Till oils. These values of Acoustic impedance and their variations in the systems of oils studied may be taken as standard values for calibration purpose and can be compared to check if oils are adulterated.

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Table 1

S. No	Common name of Sample	Scientific name of Sample	Freq in MHz	Velocity m/s
1	Coconut	Cocus Nucifera	1	1401.1
			2	1406.6
			3	1408
			5	1406
2	Cotton Seed	Gossypium Herbaceum	1	1411.32
			2	1417.9
			3	1416.15
			5	1414.75
3	Till	Sesammum Indicum	1	1410.84
			2	1422.4
			3	1420.66
			5	1422
4	Palm Oil	Elaeis Guineensis	1	1413.88
			2	1419.93
			3	1419.73
			5	1419.33
5	Sunflower	Helianthus Annuus	1	1423.96
			2	1424.2
			3	1425.6
			5	1431.5
6	Groundnut	Arachis Hypogaea	1	1436.83
			2	1442.08
			3	1443.2
			5	1443.66

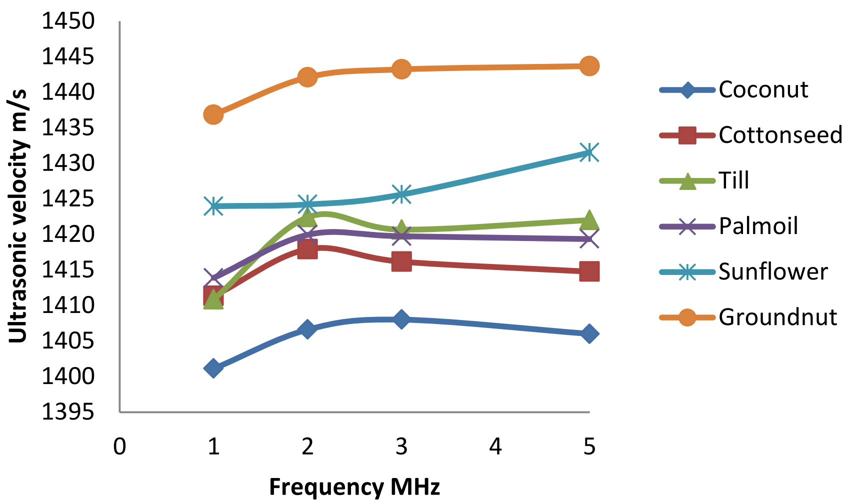

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Fig 1. Ultrasonic velocity of various Vegetable Oils at vs Frequencies.

Table 2

S. No	Common name of Sample	Scientific name of Sample	Freq in MHz	Density ($X10^3 Kg/m^3$)	Acoustic Impedance Zp=Vρ ($X10^6 N\ sec/m^3$)
1	Palm Oil	Elaeis Guineensis	1	0.914	1.292
			2		1.298
			3		1.298
			5		1.297
2	Sunflower	Helianthus Annuus	1	0.916	1.304
			2		1.3047
			3		1.3058
			5		1.311
3	Groundnut	Arachis Hypogaea	1	0.92	1.321
			2		1.326
			3		1.327
			5		1.328
4	Till	Sesammum Indicum	1	0.922	1.3007
			2		1.312
			3		1.299
			5		1.311
5	Cotton Seed	Gossypium Herbaceum	1	0.941	1.33
			2		1.334
			3		1.332
			5		1.331
6	Coconut	Cocus Nucifera	1	0.947	1.327
			2		1.331
			3		1.333
			5		1.331

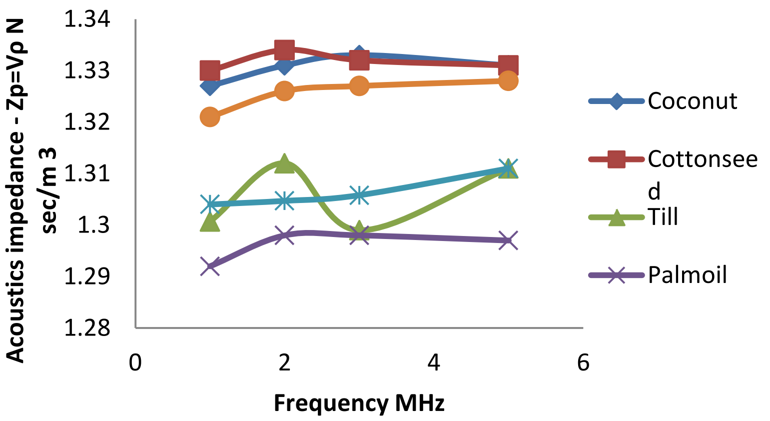

Fig 2. Acoustics impedence vs Frequency