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VELOCITY OF ULTRASOUND IN COMMONLY USED VEGETABLE OILS AT LOW FREQUENCIES

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Abstract: In the present study, velocity of ultrasound was measured in six vegetable oils at 1, 2, 3& 5 MHz frequencies using Ultrasonic Multi frequency Interferometer at a temperature of 30 ±0.1^{0}C. The present study throws light in understanding these oils with regard to their purity and data presented will be highly useful to identify the adulteration in oils.
Keywords: Ultrasound Velocity, Vegetable Oils.

1. Introduction

Oils are broadly classified into vegetable oils and animal oils. Depending upon the Physico - Chemical and dynamic properties of oils their applications vary. Vegetable oils play an important role in the diet. The Physico-chemical properties of oils are determined principally by the type and amount of triglycerides present in them.

A variety of techniques like X-ray diffraction, density, refraction measurements (RI), nuclear magnetic resonance (NMR), neutron scattering and differential scanning calorimetry (DSC) have been used to characterize oils.

Ultrasonic velocity studies in vegetable oils gives an insight into the Physico – Chemical and Dynamic properties of vegetable oils. In view of this the Ultrasonic studies have attracted the attention of number of scientists belonging to different disciplines. With the help of Ultrasonic compressibility data, fat content in solids was determined. Also Ultrasonic studies are extensively useful in phase transition studies in solids [1,2]. Ultrasonic velocity was measured in healthy and infected area of oil palm trunk and it is observed that Ultrasonic velocity of infected area is lower than healthy area [3]. Refined and unrefined Vegetable Oils were studied with Fluorescence Spectroscopy technique [4]. Ultrasonic study reveals that the dipole – dipole interaction is less at higher concentration of heavy fuel oil in the binary mixture [5]. Variation of Ultrasonic Velocity and Absorption with temperature and frequency in high viscous vegetable oils were measured and it is observed that Ultrasonic

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velocity of vegetable oils decreases with the increase of temperature [6]. Velocity of sound in various vegetable oils were studied [7]. Composition of fatty acid and degree of saturation of edible and medicinal Oils were studied with IR Spectroscopy [8].

2. Materials and Methods

Samples of six pure Vegetable oils (in unrefined state) are collected from their production units. The oils used with their scientific names are presented in Table 1. A variable path Ultrasonic Interferometer (Mittal Enterprises, Model M - 81) operating at the 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 taken into the interferometer chamber at room temperature 30 ± 0.1^0C. The interferometer consists of the following two parts:

1. The high frequency electronic generator.
2. The Ultrasonic measuring cell.

The high frequency electronic generator was used to excite the quartz plate fixed at the bottom of the measuring cell at its resonant frequency to generate Ultrasonic waves in the experimental sample kept in the Ultrasonic measuring cell. A micro-ammeter was provided on the high frequency generator to observe the change in current and two controllers for the purpose of sensitivity regulation and initial adjustment of micro-ammeter.

The measuring cell is a double walled cell for regulating the temperature of the sample during the experiment. The gold plated circular Quartz crystal of diameter 2.5cm, mounted at the bottom of the cell sends the Ultrasonic waves normal to its plane, which are reflected back by the movable metal reflector. A fine micrometer screw has been provided at the top which can lower or raise the reflector plate in the cell through a known distance (Fig 1).

The Ultrasonic measuring cell was connected to the output terminal of the high frequency generator through a shielded cable. The oil sample was introduced in the cell before switching on the generator.

The principle used in the measurement of velocity (V) of Ultrasound is based on the accurate determination of the wave length (λ) in the sample. 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. This acoustic resonance gives rise to an electrical reaction on the generator driving the quartz plate and the anode current of the generator becomes maximum (Fig 2).

The micrometer was slowly moved till the micro-ammeter on high frequency electronic generator showed a maximum. A number of maxima readings were passed on and their number ‘n’ was counted. The total distance (d) thus moved by the micrometer gives the value of wave length with the help of the following relation:

$$d = n\,\lambda/2, \text{ where } \lambda = 2d/n.$$

Therefore, the ultrasonic velocity in the oil sample is $V = \nu\,\lambda$ m/sec

where ν: frequency of Ultrasound, λ: wavelength of Ultrasound, d: distance between crystal and reflector for maximum current intensities I_1 and I_2 in the micro ammeter.

Table 1

S. No.	Common name	Scientific Name of Sample
1	Coconut oil	Cocus nucifera
2	Cotton Seed oil	Gossypium herbaceum
3	Till oil	Sesammum indicum
4	Palm Oil	Elaeis guineensis
5	Sunflower oil	Helianthus annuus
6	Groundnut oil	Arachis hypogaea

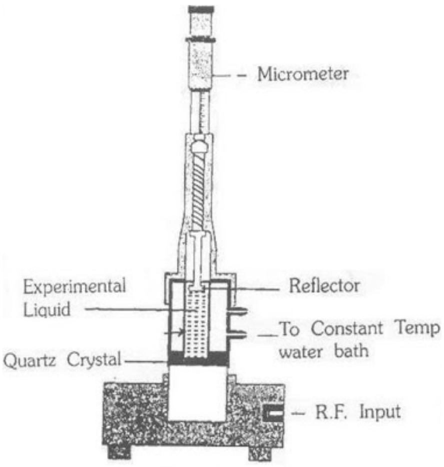

Fig 1. Ultrasonic interferometer

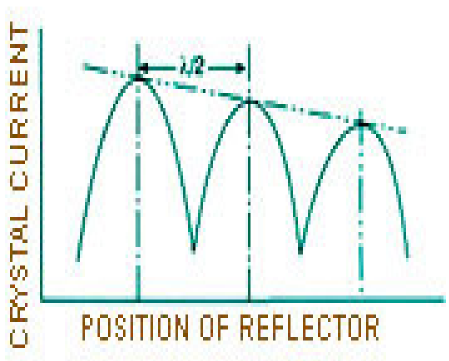

Fig 2. Crystal current vs position of the micrometer in cm

3. Results and Discussion

The values of Ultrasonic velocity with standard deviation of various Vegetable Oils at 1MHz frequency is shown in Table 2. It is observed that there is a marked difference in Ultrasonic velocity in all the vegetable oils studied at 1MHz frequency. The variation of Ultrasonic velocity ranges from1401.1 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 the extent of 35m/sec at 1MHz frequency is shown graphically in Fig 3. The variation of Ultrasonic Velocity with standard deviation at various frequencies (1, 2, 3 & 5MHz) of each vegetable oil is shown in Table 3. 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 seed 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 seed and Till oils where as there is increase in velocity in Sunflower oil. The variation of Ultrasonic velocity of these samples with frequencies is shown graphically in Fig 4.

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 2 MHz i.e. at 3 and 5 MHz.

Table 2: Data on velocity of ultrasound in vegitable oils under study at 1 MHz frequency

S. No	Common name of Sample	Scientific name of Sample	Velocity (m/sec)
1	Coconut oil	Cocus nucifera	1401±0.94
2	Cotton Seed oil	Gossypium herbaceum	1411±3.24
3	Till oil	Sesammum indicum	1410±0.83
4	Palm oil	Elaeis guineensis	1414±2.44
5	Sunflower oil	Helianthus annuus	1424±1.90
6	Groundnut oil	Arachis Hypogaea	1437±2.65

Table 3: - Data on velocity of ultrasound in vegetable oils under study at different frequencies

S. No.	Common Name of Sample	Scientific Name of Sample	Frequency (MHz)	Velocity (m/s) with standard deviation
1	Coconut	Cocus nucifera	1	1401±0.93
			2	1406±1.42
			3	1408±0.91
			5	1406±1.00
2	Cotton Seed	Gossypium herbaceum	1	1411±3.24
			2	1418±1.51
			3	1416±1.65
			5	1415±0.96
3	Till	Sesammum indicum	1	1411±0.83
			2	1422±2.14
			3	1421±1.15
			5	1422±1.00
4	Palm Oil	Elaeis guineensis	1	1414±2.43
			2	1420±0.94
			3	1420±1.28
			5	1419±2.42
5	Sunflower	Helianthus annuus	1	1424±1.90
			2	1424±1.06
			3	1426±1.59
			5	1432±1.91
6	Groundnut	Arachis hypogaea	1	1437±2.65
			2	1442±1.80
			3	1443±1.73
			5	1444±2.31

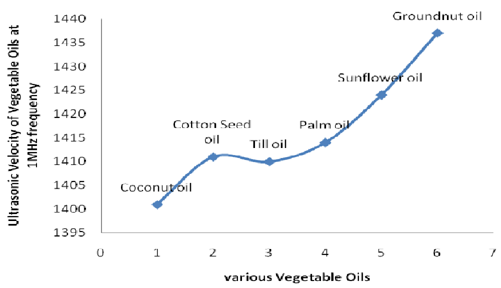

Fig. 3. Ultrasonic velocity of various Vegetable Oils at 1 MHz

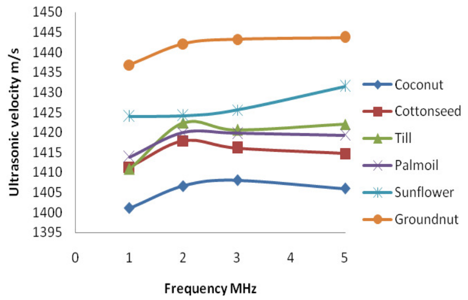

Fig 4. Ultrasonic velocity of various Vegetable Oils at various Frequencies.

Conclusions

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 3 and 5 MHz. Hence in the frequency range studied, it can be concluded that these edible oils responded very well at 1 and 2 MHz frequencies than at 3 and 5MHz. Perhaps the ultrasonic velocity at 1 and 2 MHz may be taken as the base values and can be used to detect any adulteration component if these pure oils are adulterated.

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