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ULTRASONIC VELOCITY AND ABSORPTION IN MEDICINAL OILS AT LOW FREQUENCIES

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Abstract: The paper reports data on velocity and absorption of ultrasound in six medicinal oils of plant origin. The density of these oils was measured. From this data acoustic impedance and acoustic length were computed. The variation of ultrasonic velocity with frequency was also investigated. The study reveals that there is a significant variation of ultrasonic velocity among the oils studied. The ultrasonic velocity values may be used to fix the nature of the pure medicinal oils. Any adulterant in these oils can be detected based on the velocity data. The acoustic impedance of these oils is also useful for their identification.

Keywords: Ultrasonic velocity, ultrasonic absorption, density, acoustic impedance, medicinal oils.

1. Introduction

From good olden days the naturally occurring medicinal oils are being used for the improvement of health conditions. These medicinal oils are extracted from various plants by using standard procedures. Most of these oils act as pain reliving agents, when they are applied externally or taken internally. IR spectroscopic studies were carried out by Nazima Siddiqui et al [1] in some of the medicinal oils for identification, characterization, analysis, determination of degree of saturation of fatty acids and detection of adulteration. Studies were also made on viscosity, surface tension and volume flow rate in some of the medicinal oils to determine environmental influences, compositional, structural and physiological alterations and aging factors by Nazima Siddiqui, et al [2]. As ultrasonics is a versatile non destructive tool in fixing the purity and aging factor of the oils, an attempt is made to determine ultrasonic velocity, density and related parameters in six commonly used medicinal oils in the present work. Ultrasonic velocity studies were carried out by Mahammad Ali, et al. [3] in six commonly used Vegetable oils in their pure form. Several studies were made in

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medicinal oils to explore their composition. Fourier transform infrared spectroscopy (FTIR) was used by Safwan *et al* [4] to classify different medicinal oils. FTIR studies were done by Ersilia Alexa et al [5] to identify the adulteration of oils and found spectral differences in various types of pure and adulterated oils. An attempt is made to use FTIR spectroscopy as an effective analytical tool by Mariana-Atena Poiana et al [6] to access the adulteration of costly oils with cheaper oils and found that FTIR spectroscopy is a valuable tool to identify pure and adulterated oils. Ultrasonic studies like attenuation of ultrasound in commonly used Vegetable oils were done by Mahammad Ali et al [7] was helpful in fixing the purity and the percentage of adulteration of costly edible oils with cheap edible oils. Timms *et al* [8] studied physical properties such as density of pure and mixture of oils.

2. Material and Methods

The six medicinal oils, which were put to experimentation, were procured from an Ayurvedic Pharmacy, Hyderabad. Ultrasonic velocity was measured in six naturally occurring medicinal oils at 30 ± 0.1^0C by using a variable path multi frequency ultrasonic interferometer (Model No. M-81, Mittal Enterprises) with a least count of 0.0001cm of its micrometer by adopting a standard procedure [7]. Density was measured by using specific gravity bottle of 5ml capacity and a digital balance of accuracy 0.01gm at 30 ± 0.1^0C. Ultrasonic absorption was also determined at frequencies 1, 2, 3 and 5MHz by using ultrasonic interferometer. From the experimental data, acoustic impedance and acoustic length were also computed.

A brief account of the oils studied is furnished here under

1. Nilagiri Oil: The scientific name of the Nilagiri Oil is *Eucalyptus indica* and is prepared from the leaves of Eucalyptus. It has camphor like smell, insoluble in water and miscible with ether and chloroform. The boiling point is 176^0C and flash point is 49^0C. Eucalyptus is used in flavorings, fragrances and cosmetics. Eucalyptol is an ingredient in many brands of mouth washes and cough suppressant. An external application of this oil gives relief from pain.

2. Neem Oil: The scientific name of this oil is *Azardirachtaindica*. It is a medicinal oil extracted from the fruits and seeds of the Neem. It is an antiseptic, antifungal, antipyretic and antihistamine oil. Hence, it is largely used in organic farming and medicines. It consists of triglycerides and triterpenoid compounds which are responsible for the bitter taste. It also contains several sterols.

3. Hibiscus oil: Scientific name of this oil is *Chrysanthemum morifolium*. This oil is extracted from the Hibiscus flower and leaf. It has a lot of Ayurvedic importance. The Hibiscus flower and leaf extracts are used to regulate the menstrual cycle and to treat problems related to the

menstrual cycle in women. It also contains vitamin C and minerals. It acts as a natural diuretic. This oil is used as a mild medicine in the reduction of blood pressure. Polyphenol compounds were found to be ingredients of this oil. It also shows anti-inflammatory activities.

4. Amla Oil: Scientific name of this oil is *Phyllanthusemblica*. This is prepared from the dried and fresh fruits of the Amla plant. It contains high amounts of ascorbic acid (vitamin C) also it contains flavonoids, kaempferol, ellagic acid and gallic acid. Hence, Amla oil along with the other oils like Coconut and Sesame oil is used for hair and scalp massages.

5. Castor oil: Scientific name of this oil is *Ricinuscommunis*. It is a medicinal oil extracted from the seeds of the castor oil plant. Castor oil is colorless to very pale yellow liquid with a distinct taste and odor. Its boiling point is 313^0C and its density is 0.961 x10^3 Kgm^{-3}. Castor oil is a triglyceride in which 90% of fatty acids are ricinoleate. Castor oil and its derivatives are used in the manufacturing of lubricants like brake fluids, paints, dyes, coatings and soaps.

6. Clove oil: Scientific name of this oil is *Syzygiumaromaticum*. It is extracted from the clove. It is a natural analgaesic and antiseptic and hence is used for dental pain relief mainly toothache. It contains 85% volume/volume of Phenolic substances, chiefly eugenol ($C_{10}H_{12}O_2$) with regard to optical property. It is slightly levorotatory and the maximum angular rotation is 1.5^0. Its refractive index lies in between 1.527 to 1.535 at 20^0C nearly equal to glass, so widely used in microscope preparations as it is miscible with Canada balsam.

3. Results and Discussion

The density, ultrasonic velocity, and acoustic impedance of six medicinal oils at the frequencies 1, 2, 3 and 5MHz with their standard deviation values were presented in Tables 1 & 2.

Table 1: Data on density and ultrasonic velocity in medicinal oils

S No	Common Name	Scientific Name	Major ingredient	Ultrasonic Velocity (msec^{-1})				Density (x10^3 Kgm^{-3})
				1MHz	2MHz	3MHz	5MHz	
1	NilagiriOil	Eucalyptus Indica	Monoterpenoid	1358 ±2	1356 ±2	1354 ±1	1354 ±3	0.8655 ±0.01
2	Hibiscus Oil (Mandara)	Chrysanthemu Morifolium	Polyphenol	1445 ±1	1444 ±1	1443 ±2	1442 ±2	0.9075 ±0.003
3	AmlaOil	Phyllanthus Emblica	ascorbic acid	1446 ±1	1445 ±1	1444 ±2	1444 ±2	0.9175 ±0.005
4	NeemOil	Azardirachta Indica	triglycerides and triterpenoid	1444 ±2	1443 ±2	1441 ±1	1440 ±3	0.9185 ±0.006
5	Castor Oil	Ricinus Communis	Ricinoleic acid	1500 ±2	1500 ±0.5	1448 ±1	1448 ±1	0.965 ±0.005

6	Clove Oil	Syzygium Aromaticum	Phenolic substances, chiefly eugenol	1507 ±3	1505 ±3	1503 ±4	1502 ±2	1.0195 ±0.006

From the ultrasonic velocity data, it can be seen that there is a very good variation in velocity from Nilagiri oil with 1358m/sec to Clove oil i.e. 1507m/sec at 1MHz frequency. For other oils the velocity is in between the above two values. The significant change in velocity from one oil to other may be attributed to the different concentrations of various ingredients of which each oil is made up of.

In the case of Clove oil the main ingredient is a Phenolic substance i.e. eugenol ($C_{10}H_{12}O_2$). It can also be observed that the density of Clove oil is maximum when compared to other oils studied i.e. 1.019 ($X10^3$ Kgm^{-3}) which can be attributed to Phenolic substance namely eugenol in the Clove oil. The observed higher ultrasonic velocity in clove oil may be attributed to its main ingredient and also the density factor. The ultrasonic velocity observed in Castor oil is 1500m/sec at 1MHz frequency which is higher than the other oils studied except Clove oil in which the ultrasonic velocity is 1507m/sec at 1MHz frequency. The main ingredient in the Castor oil is Ricinoleicacid, the density is 0.965($X10^3$ Kgm^{-3}). The observed higher ultrasonic velocity in castor oil may be attributed to its main ingredient and also the density factor which is higher when compared to other system of medicinal oils studied (except Clove oil).

Similarly the velocity variation in other oils studied may be attributed to the main components present in a particular medicinal oil. In the case of Hibiscus oil the ultrasonic velocity is 1445m/sec at 1MHz frequency and its density is 0.9075($X10^3$ Kgm^{-3}) which is less when compared to Clove oil. The main component in Hibiscus oil is Ployphenol compounds associated with ascorbic acid. In case of Neem oil the ultrasonic velocity is 1444m/sec at 1MHz frequency which is very close to the velocity of Hibiscus oil. The ingredients of Neem oil are triglycerides and triterpenoids. The density of Neem oil is 0.9185($X10^3$ Kgm^{-3}) which is slightly more than the Hibiscus oil. From this it can be observed that the response of Neem oil to ultrasonic wave propagation is same as that of Hibiscus oil. In the case of Amla oil the ultrasonic velocity is 1446m/sec with a density of 0.9175 ($X10^3$ Kgm^{-3}), the main ingredient of Amla oil ascorbic acid i.e. vitamin C which got very high medicinal values. In the range of oils studied Nilagiri oil (Eucalyptus Indica oil) the ultrasonic velocity is found to be minimum i.e. 1358m/sec at 1MHz frequency. Eucalyptus oil is a natural organic compound which is a colour less liquid. It is a mixture of cyclic ether and monoterpenoid formed due to

biochemical modification such as oxidation or rearrangement of monoterpenes. The observed ultrasonic velocity of Eucalyptus which is the least of the six oils studied may be attributed to the low density of the oil i.e. 0.8655(X10^3 Kgm^{-3}). Variation of ultrasonic velocity with density of six medicinal oils at 1MHz frequency is shown in figure no.1. Ultrasonic velocities in these systems of medicinal oils are also studied at 2,3 and 5MHz frequencies. In almost all the oils the ultrasonic velocity has marginally decreased with increase of frequencies which may be attributed to the relaxation time of the medium. The values of acoustic impedance presented in table no. 2 (which is a product of velocity and density) also support the above discussion. Variation of ultrasonic acoustic impedance with density of six medicinal oils at 1MHz frequency is shown in Fig. 2.

Table 2: Data on Acoustic Impedance of Medicinal Oils

S. No.	Common Name	Scientific Name	Major ingredient	Absorption coefficient(m^{-1})				Density (X10^3 Kgm^{-3})
				1MHz	1MHz	1MHz	1MHz	
1	NilagiriOil	Eucalyptus Indica	*Monoterpenoid*	5.1 ±0.5	14.5 ±0.9	19.6 ±1.0	43.3 ±3.4	0.8655 ±0.01
2	Hibiscus Oil (Mandara)	Chrysanthemum Morifolium	*Polyphenol*	6.0 ±0.4	10.04 ±0.4	15.6 ±0.5	31.3 ±0.7	0.9075 ±0.003
3	AmlaOil	Phyllanthus Emblica	*ascorbic acid*	5.24 ±0.5	11.7 ±0.5	13.8 ±1.1	29.9 ±1.4	0.9175 ±0.005
4	NeemOil	Azardirachta Indica	*triglycerides and triterpenoid*	5.0 ±0.2	11.4 ±0.5	20.8 ±2.0	24.4 ±2.9	0.9185 ±0.006
5	Castor Oil	Ricinus Communis	*Ricinoleic acid*	3.8 ±0.3	8.3 ±0.1	17.6 ±1.1	78.3 ±0.7	0.965 ±0.005
6	Clove Oil	Syzygium Aromaticum	*Phenolic substances, chiefly eugenol*	5.0 ±0.3	10.9 ±0.6	15.9 ±0.32	25.7 ±2.3	1.0195 ±0.006

The ultrasonic absorption determined in oils of the present investigation at 1, 2, 3 and 5MHz frequencies and are presented with their standard deviation values in Table 3. Variation in absorption coefficient of these systems of oils may be attributed to their main ingredients. The values of absorption coefficient of these oils were found to be increasing with increase of frequency (as shown in Fig.3) which may again may perhaps be due to the relaxation process of the medium which it under goes because of the propagation of low frequency ultrasonic waves and to the relaxation times. Variation in absorption coefficient at different frequencies of six medicinal oils is shown in Fig. 4. Acoustic length which is an inverse factor of absorption coefficient is also computed and is presented with their standard deviation values in the Table. 4. Variation of acoustic length at various frequencies of six medicinal oils is shown in Fig.5.

Table 3: Data on Ultrasonic Absorption coefficient of Medicinal oils

S. No.	Common Name	Scientific Name	Major ingredient	Absorption coefficient(m^{-1})				Density ($X10^3$ Kgm^{-3})
				1MHz	1MHz	1MHz	1MHz	
1	NilagiriOil	Eucalyptus Indica	*Monoterpenoid*	5.1 ±0.5	14.5 ±0.9	19.6 ±1.0	43.3 ±3.4	0.8655 ±0.01
2	Hibiscus Oil (Mandara)	Chrysanthemum Morifolium	*Polyphenol*	6.0 ±0.4	10.04 ±0.4	15.6 ±0.5	31.3 ±0.7	0.9075 ±0.003
3	AmlaOil	Phyllanthus Emblica	*ascorbic acid*	5.24 ±0.5	11.7 ±0.5	13.8 ±1.1	29.9 ±1.4	0.9175 ±0.005
4	NeemOil	Azardirachta Indica	*triglycerides and triterpenoid*	5.0 ±0.2	11.4 ±0.5	20.8 ±2.0	24.4 ±2.9	0.9185 ±0.006
5	Castor Oil	Ricinus Communis	*Ricinoleic acid*	3.8 ±0.3	8.3 ±0.1	17.6 ±1.1	78.3 ±0.7	0.965 ±0.005
6	Clove Oil	Syzygium Aromaticum	*Phenolic substances, chiefly eugenol*	5.0 ±0.3	10.9 ±0.6	15.9 ±0.32	25.7 ±2.3	1.0195 ±0.006

Table 4: Data on Acoustic length of Medicinal oils

S No	Common Name	Scientific Name	Acoustic Length (m)			
			1MHz	2MHz	3MHz	5MHz
1	NilagiriOil	*Eucalyptus Indica*	0.195 ±0.022	0.068 ±0.004	0.050 ±0.002	0.023 ±0.002
2	Hibiscus Oil(Mandara)	*Chrysanthemum Morifolium*	0.163 ±0.010	0.099 ±0.004	0.063 ±0.002	0.031 ±0.007
3	AmlaOil	*PhyllanthusEmblica*	0.190 ±0.020	0.084 ±0.003	0.072 ±0.006	0.033 ±0.001
4	NeemOil	*AzardirachtaIndica*	0.191 ±0.010	0.087 ±0.004	0.044 ±0.026	0.040 ±0.005
5	Castor Oil	*RicinusCommunis*	0.261 ±0.020	0.120 ±0.002	0.056 ±0.003	0.012 ±0.012
6	Clove Oil	*SyzygiumAromaticum*	0.181 ±0.011	0.091 ±0.005	0.062 ±0.001	0.038 ±0.003

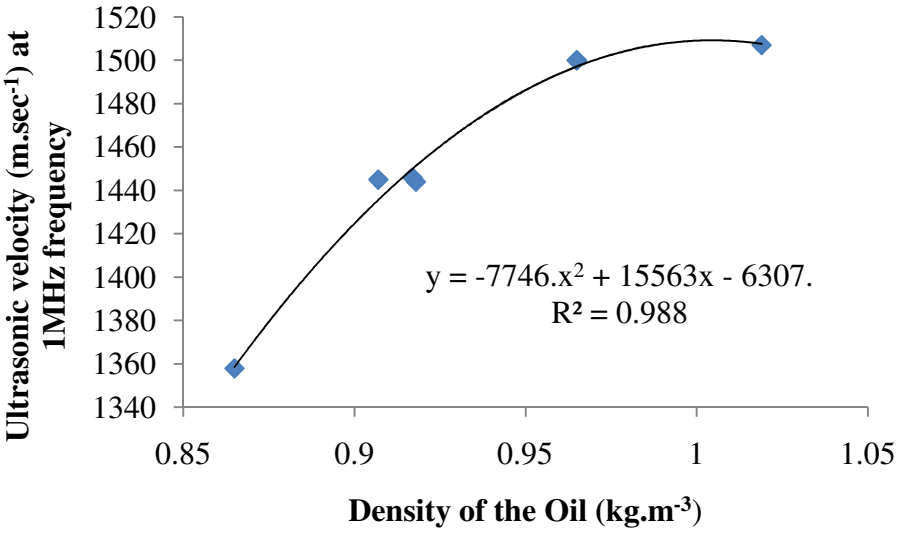

Fig. 1. Variation of ultrasonic velocity with density

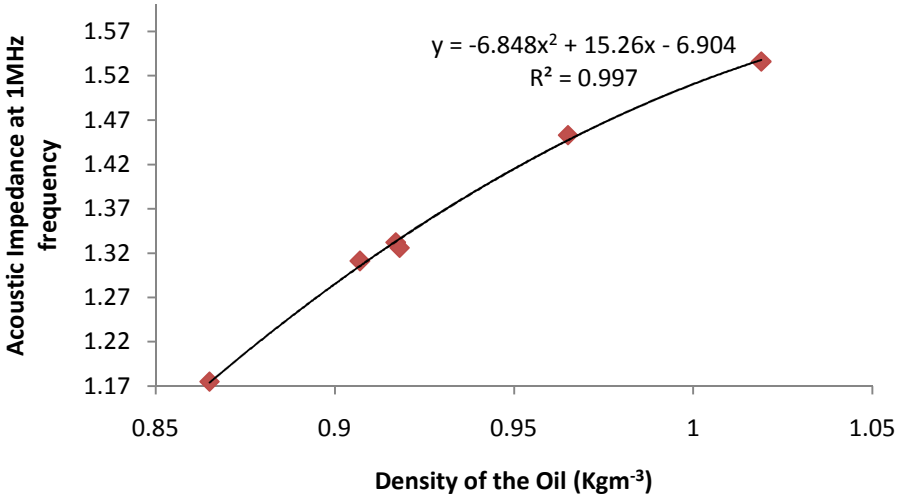

Fig. 2. Variation of ultrasonic acoustic impedance with density

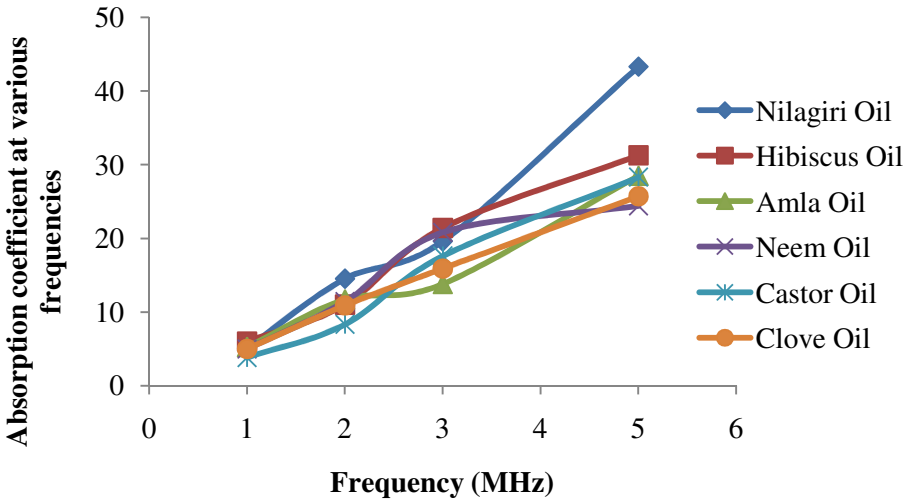

Fig. 3. Variation of ultrasonic absorption coefficient at various frequencies

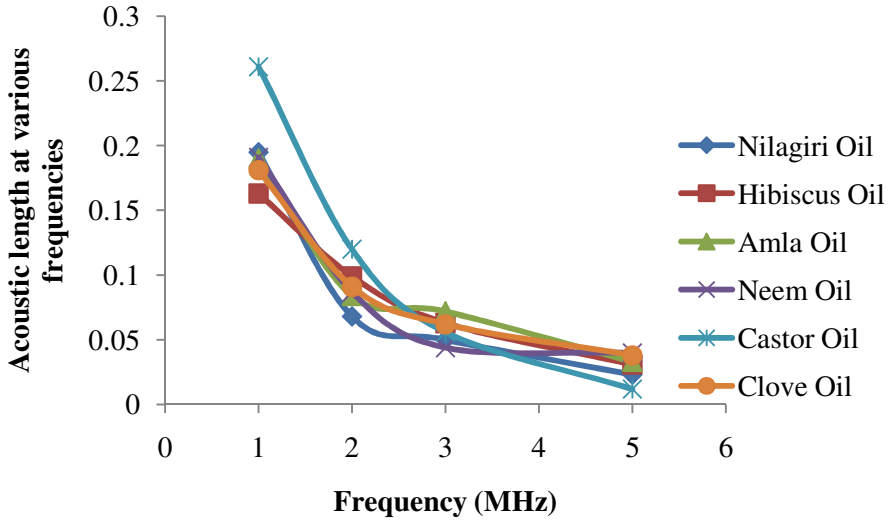

Fig. 4. Variation of ultrasonic acoustic length at various frequencies

It can be concluded that Ultrasonic velocity can be considered as a useful parameter for the characterization of medicinal oils. The velocity data also helps in finding any adulteration in these oils. Most of these oils are used as external application agents on the skin, which will have different action on the skin system, depending upon the major ingredients possessed by them.

It is a matter of interest, to study various combinations of these medicinal oils for a better advantage of the mankind as in the case of combination medicines of Allopathic system of medicine.

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