Variation of Ultrasonic Velocity and A Few Acoustic Parameters as A Function Frequency in Some Commonly Used Edible Oils

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Abstract
In the present investigation an attempt is made to find out whether ultrasonic velocity and acoustic parameters vary as a function of frequency by using the ultrasonic technique. Ultrasonic velocities of commercially available edible oils were various frequencies by using Ultrasonic Multi-frequency Interferometer at room temperature**.** The density of the oils was determined by using a specific Gravity bottle of 10ml capacity at 30±0.1ºC. The present study gives information about the ultrasonic velocity changes as a function of frequency and the data of Ultrasonic Velocity and density obtained will be highly useful in estimating various acoustic parameters such as Acoustic impedance (Z), Bulk Modulus (K), and Adiabatic Compressibility (βad). Acoustic parameters and their variation in the systems of oils studied. The variation of ultrasonic velocity is critically discussed as a function of frequency and the data presented in the present work will be highly useful in identifying the adulterationin oils.

Keywords: Ultrasonic Velocity, Density, Acoustic Impedance, Bulk Modulus, Adiabatic Compressibility, and Edible Oils**.**

1. Introduction
Edible oils are basically fats that are liquid at room temperature. Edible oil is the third most important class of food type required in the human diet. Most of the vegetable oils are obtained from the seeds or fruits. Some of the richer vegetable sources of nutritional fats are nuts soybeans, seeds, peanuts, and olives. Mainly these oils used in cooking, fuels for cosmetics, for medicinal purposes and for other industrial purposes.
Ultrasonic dispersion studies oils provide valuable information about their physicochemical properties. The majority of information can be obtained by measuring Ultrasonic velocity as a function of frequency and temperature or a fixed frequency and temperature depending on the information required. Various 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 for many decades. The chemical constitution of the edible oils is more complex, consists of triglycerides, i.e., mixtures of esters and three fatties

(saturated and unsaturated) acid molecules [1].
Measuring the Ultrasonic velocity at a single frequency of different edible oils [2, 3] can be used to study the degree of crystallization that has been reported in the literature. The ultrasonic studies in edible fats and oils are useful to estimate various acoustic parameters such as Acoustic impedance (Z), Bulk modulus(K), and Adiabatic Compressibility(β) are estimated using the results of the above measurements. Indeed, ultrasonic velocities are even used to estimate the composition and adulterationof the oils [4], and these studies of edible oils were used to study the physical properties of these oils [5]. In this article, we report our experimental investigations on ultrasonic velocity and density in some ofthe most common domestic-used oils in the Rayalaseema region.

2. Materials and Methods

All the Edible oils samples were acquired from local distributors who are supplying the cold pressed oils, getting directly from the wooden cold pressed extraction machine (Chekka Ganuga) without any further purification. Since these oils are healthier because these oils keep more nutrients. In this investigation the following six commonly used and available in our region (Rayalaseema in AP) were studied they are listed in the table 1 along with their scientific names. Mean molecular weights of all the selected oils are calculatedfrom the relation given in [1]

$$M = 3 \times 56108 \times 1/SV \quad (1)$$

Saponification value (SV) of all the oils have been experimentally determined by using chemical volumetric titration method [6]. Mean Molecular Weights (M) and SV values are also mentioned in the table 1. Ultrasonicvelocities of the selected edible oils as a function of frequency at room temperature measured using Multi frequency Ultrasonic Interferometer (Model: M-81(B "MITTAL MAKE") with a least count of 0.0001cm on its micrometer.
The experimental procedure adopted for the determination of ultrasonic velocities has been given in detail [7,8]. The principle used in the measurement of velocity (v) is based on the accurate determination of the wavelength (ʎ) in the medium. Ultrasonic waves of known frequency (f) are produced by a quartz plate fixed at the bottom of the cell. The waves are reflected by a movable metallic plate kept parallel to the quartzplate. If the separation between these plates is exactly a whole multiple of the sound wavelength, standing waves are formed in the medium.
The acoustic resonance gives rise to an electrical reaction on the generator driving the quartz plate and the anode current of the generator become maximum. If the distance is now increased or decreased and the variation is exactly one-half wavelength (ʎ /2) or multiple of it, anode current again becomes maximum. Fromthe knowledge of wavelength (ʎ) the velocity (v) can be obtained by the relation:
Velocity = Wavelength x frequency

$$V = ʎ \times f \quad (2)$$

Table.1. Saponification values and mean molecular weights of the edible oils

S.No	Common name of thesample	Scientific name of the sample	% of SFA	% of USFA	onification Value	Mean Molecular weight(g)
1	**Coconut Oil**	**Cocus nucifera**	92	08	244.64	688.05
2	**Sesame Oil**	**esammumindicum**	14	86	186.73	901.43
3	**Palm Oil**	**Elaeis guineensis**	50	50	194.23	866.62
4	**Castor Oil**	**Ricinoleic acid**	05	95	186.45	902.80

		triglyceride				
5	**Sunflower Oil**	**elianthus annuus**	13	87	183.54	917.10
6	**Groundnut Oil**	**Arachis hypogaea**	22	78	188.35	893.68

To obtain the good reproducibility and to minimize the errors, the velocity measurements were repeated several times on each of the sample collected and their average value were taken to be the measured ultrasonic velocity at each frequency.

Density ρ measurements of all the oils have been measured by gravimetric method and specific volumes, V_{sp} estimated as $V_{sp} = 1/\rho$.

Using the specific volume, V_{sp}, ultrasonic velocity, v, and average molecular weight data a few thermodynamic parameters such as Acoustic impedance, Z, bulk modulus, K and adiabatic compressibility β were computedby using standard formulae.

Acoustic impedance $Z = \rho U$ (3)

Bulk modulus $K = \rho U^2$ (4)

Adiabatic compressibility, $\beta = 1/K$, (5)

Where U: Velocity of Ultrasound ($msec^{-1}$); ρ = Density (kgm^{-3}); K: Bulk modulus (Nm^{-2})

3. Results and Discussion

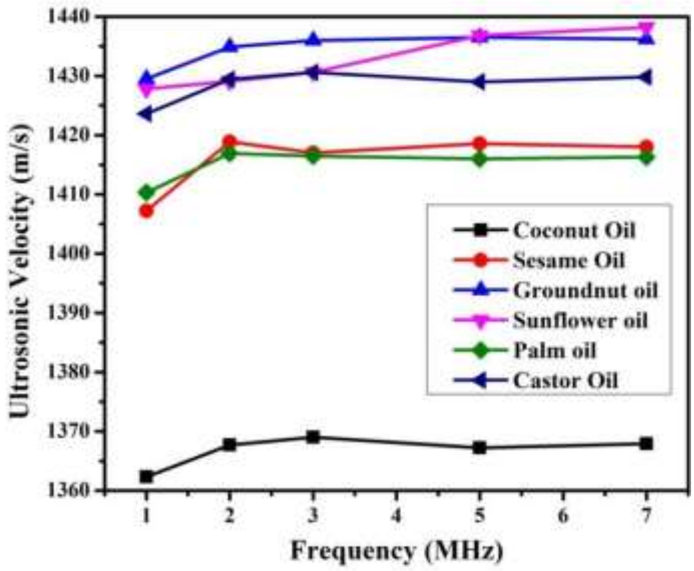
The density, ultrasonic velocity values measured as a function of frequency of all the selected edible oils arepresented in the table -2 and a few acoustic parameters such as acoustic impedance, bulk modulus, and adiabatic compressibility was computed by the researcher in the present investigation are listed in the table.3.

Table.2. The density, and ultrasonic velocity values measured as a function of the frequency of all the selected edible oils.

S.No	The common name of the sample	The scientific name of the sample	Densities (ρ) Kg/m^{-3}	Freq. in MHz	Ultrasonic Velocity m/s
1	**Coconut Oil**	**Cocos Nucifera**	0.9368	1	1362.3
				2	1367.7
				3	1369.0
				5	1367.2
				7	1367.9
2	**Sesame Oil**	**Sesamum indicum**	0.9252	1	1407.2
				2	1418.9
				3	1417.0
				5	1418.6
				7	1418.0
				1	1410.3
				2	1416.9

3	**Palm Oil**	**Elaeis guineensis**	0.9156	3	1416.5
				5	1416.0
				7	1416.3
4	**Castor Oil**	**icinoleic acidtriglyceride**	0.9648	1	1423.6
				2	1429.4
				3	1430.6
				5	1429.0
				7	1429.8
5	**nflower Oil**	**Helianthus annuus**	0.9260	1	1427.8
				2	1429.1
				3	1430.6
				5	1436.8
				7	1438.2
6	**oundnut Oil**	**Arachis hypogaea**	0.9232	1	1429.5
				2	1434.9
				3	1436.0
				5	1436.5
				7	1436.2

Graph 1. Variation of Ultrasonic velocity vs frequency



The measured ultrasonic velocity in the frequency range of 1- 7MHz of all the oils increases with increase of frequency, which can be confirmed from the graph-1 drawn for the variation of ultrasonic velocity with temperature. This observation in ultrasonic velocity of oils is in good agreement with results obtained inedible oils [9]. It is found that there is a marked difference in Ultrasonic velocity in all the selected edible oils studied at 1MHz frequency. The variation of Ultrasonic velocity ranges from 1362.3m/sec in Coconut oilto 1429.5 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 67.2m/sec at 1MHz frequency is shown graphically in graph 1. The variation of Ultrasonic velocity of each edible oil studied in the present investigation is also shown in thegraph 1. From the table -2 and graph -1 it can be noticed that the Ultrasonic velocity value at 2MHz is more increase in all the samples than at 1MHz. It is very clear that increase in Ultrasonic velocity increased with the increase of frequency from 1MHz – 2MHz. The observed increase in the value of Ultrasonic velocity is around 5m/s or more in edible oils studied except Sesame oil in which the velocity increased more than 10m/swhen the frequency changed from 1 to 2MHz. The Value of Ultrasonic velocity at 3MHz frequency is increased about 1 to 2m/s in all the samples except Palm oil in which the increase is very minute it is less than0.5m/s. There is no significant change in the velocity of all the oils as frequency increased from 3 to 7 MHz frequency except sunflower oil the increase in velocity is around 2m/s. The variation of Ultrasonic velocity of all the samples a function of frequency is graphically shown in the graph 1. From the table-1 it is found the density value of castor oil is more means it is more viscous means strong intermolecular interaction exists between the triglyceride molecules which are due to the presence of hydroxyl groups within the fatty acid chains in castor oil [10]. In general, the-reason for increase in velocity with frequency mainly because inter atomic distance decreases with frequency and in turn increases the ultrasonic velocity as the frequency increases.

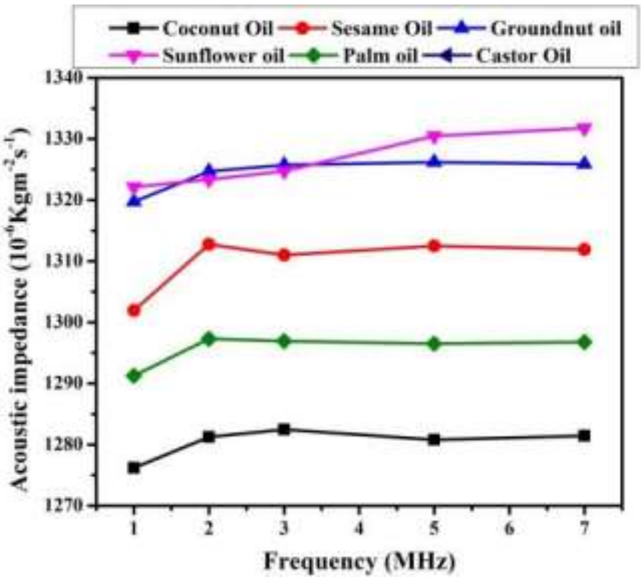
The measured ultrasonic velocity and specific volume data and a few acoustic parameters such as Acoustic impedance, Z Bulk modulus, K and adiabatic compressibility, β_{ad} were computed by the researcherin the present investigation which is shown in the table 3.

Table.3 Acoustic parameters of edible Oils

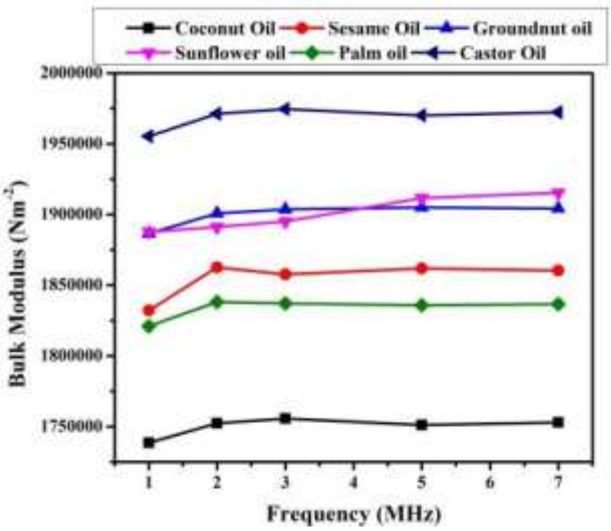
S. No	Name of the sample	Specific volume,Vsp $(m^3kg^{-1})x10^{-3}$	'req. in MHz	Ultrasonic Velocity ms^{-1}	Acoustic impedance Z= ρV $10^{-6}kgm^2s^{-1}$	Bulk Modulus $K=\rho V^2x10^{10}$ $N.m^{-2}$	Adiabatic Compressibility $\beta ad=1\backslash K$ $10^{-10}m^2N^{-1}$
	Coconut Oil	1.06746	1	1362.3	1276.2026	1738570.85	$5.7518 x10^{-7}$
			2	1367.7	1281.2613	1752381.16	$5.7065x10^{-7}$
			3	1369.0	1282.4792	1755714.02	$5.6956 x10^{-7}$
			5	1367.2	1280.7929	1751100.13	$5.7106x10^{-7}$
			7	1367.9	1281.4487	1752893.70	$5.7048x10^{-7}$
2	**Sesame Oil**	1.08084	1	1407.2	1301.9414	1832091.99	$5.4582x10^{-7}$
			2	1418.9	1312.7662	1862684.07	$5.3685x10^{-7}$
			3	1417.0	1311.0084	1857698.90	$5.3830x10^{-7}$
			5	1418.6	1312.4887	1861896.49	$5.3708x10^{-7}$
			7	1418.0	1311.9336	1860328.4	$5.3754x10^{-7}$
3	**Palm Oil**	1.09217	1	1410.3	1291.2706	1821079.04	$5.4912x10^{-7}$
			2	1416.9	1297.3136	1838163.69	$5.4402x10^{-7}$
			3	1416.5	1296.9474	1837125.99	$5.4432x10^{-7}$
			5	1416.0	1296.4896	1835829.27	$5.4471x10^{-7}$
			7	1416.3	1296.7642	1836607.25	$5.4448 x10^{-7}$
4	**Castor Oil**	1.03648	1	1423.6	1373.4892	1955299.33	$5.1143x10^{-7}$
			2	1429.4	1379.0851	1971264.27	$5.0728x10^{-7}$
			3	1430.6	1380.2428	1974575.46	$5.0643x10^{-7}$

			5	1429.0	1378.6992	1970161.15	5.0757×10^{-7}
			7	1429.8	1379.4710	1972367.69	5.0700×10^{-7}
5	**Sunflower Oil**	1.07991	1	1427.8	1322.1428	1887755.49	5.2972×10^{-7}
			2	1429.1	1323.3466	1891194.62	5.2876×10^{-7}
			3	1430.6	1324.7356	1895166.74	5.2765×10^{-7}
			5	1436.8	1330.4768	1911629.06	5.2311×10^{-7}
			7	1438.2	1331.7732	1915356.21	5.2209×10^{-7}
6	**Groundnut Oil**	1.08318	1	1429.5	1319.7144	1886531.73	5.3007×10^{-7}
			2	1434.9	1324.6996	1900811.57	5.2609×10^{-7}
			3	1436.0	1325.7152	1903727.02	5.2528×10^{-7}
			5	1436.5	1326.1768	1905052.97	5.2491×10^{-7}
			7	1436.2	1325.8998	1904257.35	5.2513×10^{-7}

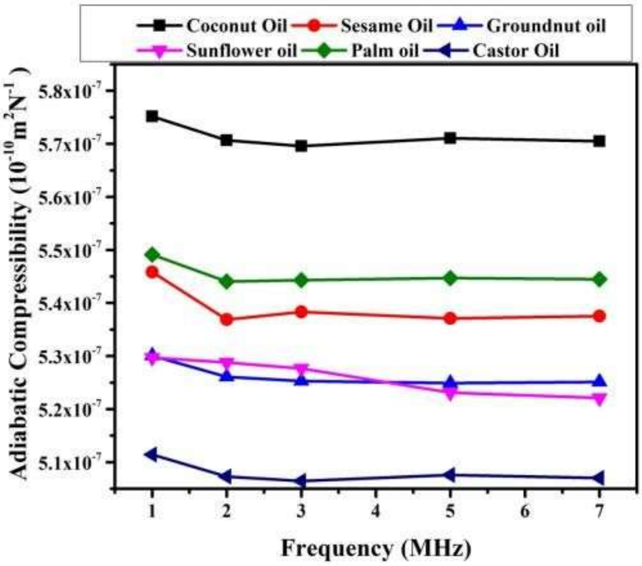
Graph.2 Variation of Acoustic Impendence and Frequency



Graph 3. Variation of Bulk Modulus with Frequency



Graph 4. Variation of adiabatic compressibility with frequency



From the table.3 and graphs 2,3 and4, it is found that the estimated acoustic parameters such as Acoustic impedance (Z) and bulk modulus (K) are increase as increase the frequency, but the Adiabatic Compressibility (β) decreases with the frequency increase. This indicates the increased pitch of the sound waves with frequency.

4. Conclusions

The variation of Ultrasonic velocity with frequency ranges from 1 to 7MHz for the commonly used edibleoils in this region were selected in the present study, are not increasing perfectly linear. Ultrasonic velocity value at 2MHz is more increased in all the samples than at 1MHz. Acoustic impedance (Z), Bulk modulus

(K) and Adiabatic Compressibility (β) are estimated using the data of ultrasonic velocity and density. Acoustic impedance (Z), Bulk modulus (K) are increasing with an increase of frequency Adiabatic Compressibility (β)of oils are decreasing with temperature. All these variations may be due to breakages of weak polar bonds between the polar ends of triglyceride molecules. The results obtained are critically discussed as function of temperature.

5. Acknowledgment

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6. References

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