Calculation of Adiabatic Thermoacoustic Properties of the Seed Oils.

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Abstract:
The thermoacoustic parameters, such as the 'Sharma constant' (S_0,) the 'isochoric temperature coefficient of internal pressure' (ITIP) and the 'isochoric temperature coefficient volume expansion' (ITVE), the decreased volume, the 'reduced compressibility', and the 'Huggins parameter' ($\dot{F}$) were calculated utilizing the coefficient of volume expansion $\dot{\alpha}$. The results show that the Sharma's constant has the characteristic value of 1.11±0.01 which establishes the constancy of S_0. The results of study are presented using graphs.

Keywords: Sharma's constant, Huggins parameter, isochoric temperature coefficients of volume expansion and internal pressure, seed oils.

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1. INTRODUCTION:

Oil is a viscous liquid that is neutral and non-polar in nature at room temperature. In nature, oil is both hydrophobic and lipotropic. Oils have a significant hydrogen and carbon concentration, as seen by their chemical composition. Seed oils are oils that are derived from seeds. Most edible oils are derived from plant seeds. Triglycerides are the building blocks of oils. The seed oils are either edible or unpalatable[1]. Edible oils are the most significant parts of the human diet because they provide food with distinctive nutrients, flavour, and textures. As a result, ultrasonic studies in edible oils have been a field of study for past few decades. For example, an implementation of ultrasonic technology in the high voltage liquid insulation sector to reduce the pour point of oilseed samples in order to use seed oils as fluid insulation on power transformers in cold climate zones was performed by Bakrutheen et.al., [2]. D. Julian Mc Clements et.al.[3], [4], utilized the low intensity ultrasound technique for the characterisation of edible oils and fats, they found the dynamic rheology, composition of oils, emulsions droplet size.

Sharma established the usefulness of the coefficient of volume expansion ($\dot{\alpha}$) in evaluating other thermoacoustic characteristics, such as the Sharma constant (S_0), in a variety of non-mesomorphic systems, such as polymers, rare earth alkali metals, polycrystalline solids, and so on. Sharma discovered that the Sharma constant, which is a characteristic constant, imparts a constant value of 1.11-0.01 in all these systems. Understanding intermolecular interactions and the molecular arrangement in the condensed phase may be aided by S_0. Y. Narasimha Murthy et.al.[5], have determined the Sharma's constant and other acoustic characteristics of natural oils/fats such as Sal seed fat and Mango kernel fat using the coefficient[1] of volume expansion and proved the Sharma parameter's constancy. The homologous sequence of alkoxy benzylidene butylanilines with for the values m=4 to m=7, to comprehend whether the thermoacoustic parameters are useful to realize the atypical behaviour at the phase transitional temperatures and pre-transitional effects on both sides of the transition was done by P.Venkatacharyulu et.al[6]

Inspired by these studies, an attempt is made in this research to estimate several thermoacoustic characteristics, including the Sharma constant. To understand the behaviour of the numerous thermoacoustic parameters in isotropic and nematic states, and near the phase transitional temperature, only one parameter, specifically the coefficient of volume expansion ($\dot{\alpha}$), was used.

2. THEORY:

A brief description of a theoretical approach for estimating various thermoacoustic parameters using the coefficient of volume expansion ($\dot{\alpha}$) is as below,

2.1. The volume expansion coefficient ($\dot{\alpha}$) can be defined as

$$\dot{\alpha} = \frac{1}{V_n}\left(\frac{dV}{dT}\right) \qquad (1)$$

Where,

$$dV = \dot{V}_2 - \dot{V}_1,\ dT = \dot{T}_2 - \dot{T}_1 \text{ and } V_n = \left(\frac{\dot{V}_1 + \dot{V}_2}{2}\right),$$

where $\dot{V}_2$ and $\dot{V}_1$ are the molar volumes at the

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temperatures $\dot{T}_2$ and $\dot{T}_1$ respectively.

2.2. The isochoric temperature coefficient of internal pressure (ITIP) as derived by Harward and Parker[5] and denoted by $\tilde{X}$ can be calculated using $\dot{\alpha}$ as

$$\tilde{X} = \left[\frac{d\,ln\,P_i}{d\,ln\,T}\right]_V = \frac{-2[1+2\,\dot{\alpha}\,T]}{\tilde{V}^{C_1}} \qquad (2)$$

Where P_i is the internal pressure, $\tilde{V}$ is the reduced volume, $\tilde{\beta}$ is the reduced compressibility, C_1 is the dimensionless coefficient of bulk modulus as introduced by Moelwyn-Hughes[5]. These values can be obtained from α as follows

$$\tilde{V} = \left(\frac{V}{V^*}\right) = \left[1+\frac{\dot{\alpha}T}{3(1+\dot{\alpha}T)}\right]^3 \qquad (3)$$

$$\tilde{\beta} = \left(\frac{\beta}{\beta^*}\right) = \left(\tilde{V}\right)^{C_1} \qquad (4)$$

$$C_1 = \frac{13}{3} + \frac{1}{\dot{\alpha}\,T} + \frac{4\dot{\alpha}\,T}{3} \qquad (5)$$

Here V, V*, β, β* are the specific volumes and compressibilities, at absolute zero and temperature T.

2.3. The isochoric temperature coefficient of volume expansivity (X′) can be given [7], [8],

$$X' = -[1+2\dot{\alpha}T] \qquad (6)$$

2.4. The *Sharma's constant* (S_0) by means of the coefficient of volume expansion ($\dot{\alpha}$) ac be expressed as

$$\dot{S}_0 = \frac{-X'}{\tilde{\beta}}[3+4\,\dot{\alpha}\,T] = \frac{-S^*S_0^*}{\tilde{\beta}}[3+4\,\dot{\alpha}\,T] \qquad (7)$$

Where S* and S_0^* are the Sharma's parameters[7] given by

$$S^* = 1+\frac{4}{3}\dot{\alpha}T \quad \text{and} \quad S_0^* = \frac{1+2\dot{\alpha}\,T}{1+\frac{4}{3}\dot{\alpha}\,T} \qquad (8)$$

2.5. The *Huggin's Parameter* ($\dot{F}$) is expressed in terms of the Sharma's constant as

$$\dot{F} = 2\left[1+\frac{\dot{S}_0}{(3+4\dot{\alpha}T)}\right] - \frac{(3+4\dot{\alpha}T)}{3} \qquad (9)$$

Thus, from the above expressions of the thermoacoustic parameters imply the importance of the coefficient of volume expansion ($\dot{\alpha}$)

3. MATERIAL:

The specific volumes of palm seed oil and the Date seed oil, at various temperatures was calculated using the micro controller based Ultrasonic interferometer and for those data the adiabatic thermo-acoustic properties are calculated in this study.

1. **Palm seed oil**: Scientifically known as "***Elaesisguineesis***", it is obtained from the fruit pulp. This one among few highly saturated fats, semi solid at room temperature. The palm oil with less mono-diglycerides is said to be of good standard. Being one of the cheapest oils and having high oxidative strength is has wide range of utility in commercial food industry.

2. **Date Seed oil:** The scientific name of date seed oil is "***Phoenix dactylifera L***"**.** Being rich in "phenolic, tocopherols" compounds date seed oil is used in pharmaceutical and cosmetics, apart from having wide range of utility in food applications due to its high nutritional values.

4. RESULTS AND OBSERVATION:

Using the above mentioned formulae, the calculated values of different thermal parameters are mentioned in Table.1 and explained through the figures 1-3. When the system transitions from an isotropic liquid state to a mesomorphic state, i.e., from a completely disordered low-density isotropic liquid state to a more-ordered density state, the Sharma's constant assumes a lower value than the possible values only at and in the near vicinity of the transition temperatures. The constant reduces to a lower value than at any other temperature exactly at the transition temperature. Similar, type of result were given by M.S.R Subramanyam et.al[7] in their study of edible oils.

Figure.1 displays the variation of Sharma's constant with respect to various temperatures for the palm seed and date seed oil. From the figure it is evident that the Sharma's constant reaches it low expansivity at the transitional temperature which is 308^0K for palm oil and 328^0K for date seed oil.

The figure.2 displays the relation between the Huggin's parameter with that to the different temperature values. For liquid crystals, the MOELWYN-HUGHES parameter (F) provides the simplest scale for establishing the molecular ordering, structure, interactions, and harmonicity. At and near the transition temperature, the Huggin's parameter exhibits abnormal behaviour. For a given mesogenic liquid crystal, F is almost temperature independent. It explains liquid crystal interaction, molecular ordering, and harmonicity. The behaviour of the

F parameter in the nematic state is diametrically opposed to that of the thermal expansion coefficient. Thus, from the figure we can say that the transitional temperatures for date oil and the palm oil are 313⁰K and 328⁰K.

Table.1. Tabulated values of the obtained thermo acoustic parameter values of seed oils.

Temperature T^0K	α x 10^{-3} K^{-1}	$\dot{X}$	$-\dot{X}'$	$\dot{V}$	$\tilde{\beta}$	$\dot{S}_0$	S^*	S^*_0	$\dot{F}$
1.Palm seed oil									
298	0.062050	-0.6852	1.124114	1.05957	3.28075	1.113	1.08274	1.03821	1.6025
303	0.045848	-0.6979	1.091697	1.04448	3.12832	1.111	1.06113	1.02880	1.6368
308	0.034931	-0.7066	1.069861	1.03413	3.02786	1.109	1.04657	1.02225	1.6601
313	0.283258	-0.5415	1.566516	1.23737	5.78536	1.119	1.37767	1.13707	1.1639
318	0.161308	-0.6147	1.322615	1.14543	4.30316	1.120	1.21507	1.08850	1.3996
323	0.260081	-0.5544	1.520163	1.22092	5.48319	1.120	1.34677	1.12874	1.2077
328	0.317972	-0.5229	1.635943	1.26118	6.25698	1.117	1.42396	1.14886	1.0990
2.Date seed oil									
298	0.0413	-2.1651	1.0826	1.0402	3.0860	1.1103	1.0550	1.0261	1.647
303	0.0839	-2.3354	1.1677	1.0794	3.4920	1.1153	1.1118	1.0503	1.557
308	0.0426	-2.1703	1.0851	1.0414	3.0980	1.1105	1.0568	1.0269	1.644
313	0.3942	-3.5767	1.7884	1.3102	7.3763	1.1096	1.5256	1.1723	0.959
318	0.0997	-2.3989	1.1995	1.0935	3.6505	1.1168	1.1330	1.0587	1.524
323	0.2084	-2.8337	1.4168	1.1826	4.8448	1.1211	1.2779	1.1087	1.307
328	0.5547	-4.2189	2.1094	1.4009	10.1549	1.0841	1.7396	1.2126	0.676

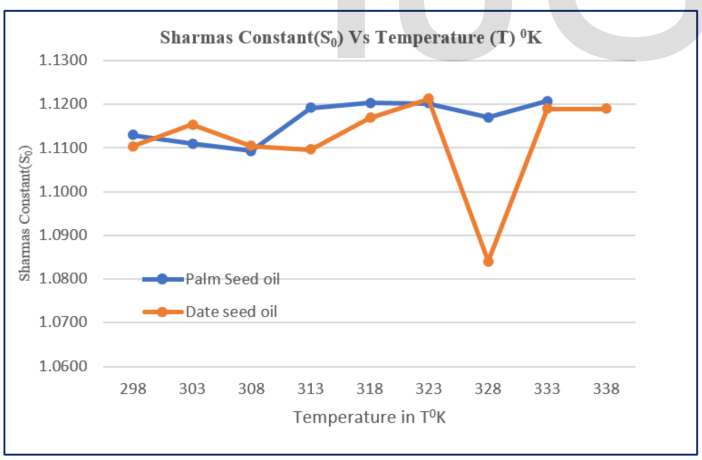


Figure.1 . Sharmas Constant (ṡ₀) vs temperature (T) ⁰K

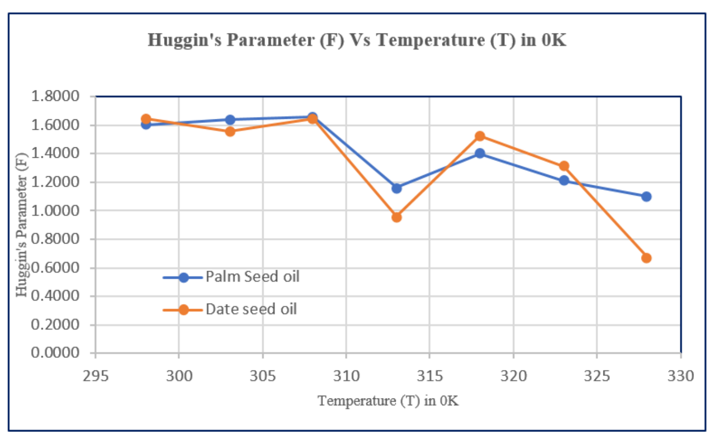
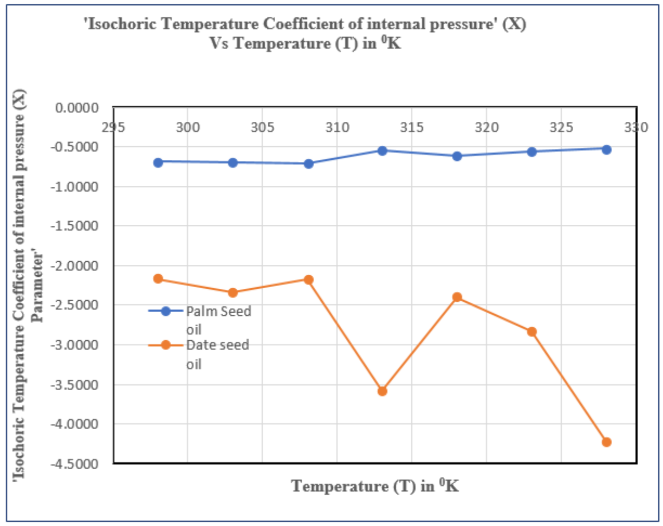


Figure.2.Huggins's parameter Vs Temperature(T) ⁰K

Figure.3. X Vs Temperature (T) ⁰K



From Figure.3 we can observe that the adiabatic internal pressure (X) is invariant for plam oil where as a small variation can be observed at the transitional for the date seed oil.

5. Conclusions:

The various adiabatic acoustic properties for the palm and date seed oils have been calculated. The results validate the characteristic nature of the Sharma's constant and other properties except at the transitional temperature.

6. References:

[1] I. R.JEEVANKUMAR, E.REKHA ,Department of Physics, Sri Krishnadevaraya University, Ananthapuram, Andhra Pradesh, "DENSITIES, ULTRASONIC STUDIES AND A FEW ACOUSTIC PARMETERS IN SOME EDIBLE OILS," *J. Interdiscipl. Cycle Res.*, vol. XII, no. VII, pp. 43–54, 2020.

[2] M. Bakrutheen and W. Siluvairaj, "Impact of ultrasonic treatment process on pour point of vegetable oils based liquid insulation," *Ultrason. Sonochem.*, vol. 71, p. 105380, Mar. 2021, doi: 10.1016/j.ultsonch.2020.105380.

[3] D. J. McClements and M. J. W. Povey, "Ultrasonic analysis of edible fats and oils," *Ultrasonics*, vol. 30, no. 6, pp. 383–388, 1992, doi: 10.1016/0041-624X(92)90094-3.

[4] R. Chanamai and D. Julian McClements, "Ultrasonic attenuation of edible oils," *JAOCS, J. Am. Oil Chem. Soc.*, vol. 75, no. 10, pp. 1447–1448, 1998, doi: 10.1007/s11746-998-0198-1.

[5] R. N. V. R. R. Y. NARASIMIIA MURTHY, V. RAMA MURTHY, "Coefficient of Volume Expansion and Thermoacoustic Parameters in Two Natural Oils," *Cryst. Res. Technol*, vol. 13, pp. 921–927, 1996, doi: 10.1002/crat.2170310720.

[6] K. S. R. Prasad, A. Kasturi, and N. V. L. N. Prasad, "Coefficient of volume expansion and thermoacoustic parameters in certain alkoxy benzylidene butylanilines — IB," vol. 25, no. 4, 1990.

[7] M. S. R. Subrahmanyam, H. S. Vedanayagam, and P. Venkatacharyulu, "Estimation of the sharma constant and thermoacoustic properties of vegetable oils," *J. Am. Oil Chem. Soc.*, vol. 71, no. 8, pp. 901–905, 1994, doi: 10.1007/BF02540471.

[8] B. K. Sharma, "Nonlinearity parameter and its relationship with thermo-acoustic parameters of polymers," *J. Phys. D. Appl. Phys.*, vol. 16, no. 10, pp. 1959–1965, 1983, doi: 10.1088/0022-3727/16/10/020.