Research Article
AMERICAN JOURNAL OF PHARMACY AND HEALTH RESEARCH
www.ajphr.com
2014, Volume 2, Issue 12
ISSN: 2321–3647(online)

Frequency and Temperature dependent dielectric study of unsaturated linseed (Linum usitatissimum)oil

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ABSTRACT

The dielectric constant (ε') and dielectric loss (ε'') of pure unsaturated Linseed (Linum usitatissimum) oil are measured at different temperatures and frequencies. X-band microwave bench operating in the frequency range 8.2-12.4 GHz is tuned to desired constant frequency. It is observed that the dielectric constant (ε') of linseed oil decreases with increase in temperature while the dielectric loss (ε") increases with increase in temperature. The dielectric constant (ε') of linseed oil decreases with increase in frequency, while dielectric loss (ε") increases with increase in frequency. The dielectric properties of oil samples are in good agreement with the earlier reported work.

Keywords: Microwave frequency**,** Dielectric constant, Dielectric loss, edible oils.

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Received 08 December 2014, Accepted 15 December 2014

Please cite this article as: Chaudhari HC, Frequency and Temperature dependent dielectric study of unsaturated linseed (Linum usitatissimum) oil. American Journal of Pharmacy & Health Research 2014.

INTRODUCTION

Healthy food works as fuel for our body and keeps us physically as well as mentally fit. Edible oil extracted from seeds or plant resource is important part of food of almost all peoples. They are key components of the diet and provide characteristics textures and flavors of foods. In India, different edible oils are used by the peoples of different regions as per the production of related seeds in the particular area; some of them are sunflower oil, soya bean oil, linseed oil, groundnut oil, safflower oil, mustard oil, almond oil, coconut oil etc. Edible oils have medicinal uses. Depending upon the requirement, different oils are used. In some case it becomes essential to use warm oils as they have special importance as Ayurvedic medicines. The botanical name for linseed is Linum usitatissimum[1]. Its Indian name is Alsi. Linseed is popular for its various medicinal qualities. These are anti-inflammatory, anti-arrhythmic, anti-hyperlipidemic, anti-arthritic, anti-atherosclerotic, anti-allergic activities. It also has anti-cancer property useful to prevent and cure many types of cancers. Linseed is developed for the seed, for the fibre, for seed and fibre. The oil is extracted from the seeds is used for medicinal and industrial purposes. Linseed oil, also known as flaxseed oil is a colorless to yellowish oil obtained from the dried, ripened seeds of the flax plant. Linseed oil is a triglyceride, like other fats. Linseed oil is distinctive for its unusually large amount of Alpha-linolenic acid (a particular form of omega-3 fatty acid), which has a distinctive reaction with oxygen in air. The fatty acids in a typical linseed oil are of the following types: The triply unsaturated α-linolenic acid (51.9-55.2%), saturated acids palmitic acid (about 7%) and stearic acid (3.4-4.6%), monounsaturated oleic acid (18.5-22.6%), doubly unsaturated linoleic acid (14.2-17%). Flax seeds contain lignans, a class of phytoestrogens considered to have antioxidant and cancer-preventing properties, although the extracted linseed oil, according to some, does not contain lignans found in flax seed and allegedly does not have the same antioxidant properties. Fresh, refrigerated and unprocessed, linseed oil is used as a nutritional supplement and is a traditional food, highly regarded for its hearty taste. It contains the highest level of the omega-3 fatty acid ALA among vegetable oils[1]. The microwaves have an ability to penetrate the food materials and dissipate heat in these materials. This is the reason why microwaves are used for several food processing operations. Interaction of microwaves with food materials depends on their dielectric properties. With this, it is possible to determine the extent of heating of a material when subjected to electromagnetic fields. Dielectric properties can be defined in terms of complex permittivity (ε^*). The complex permittivity (ε^*) is composed of a real part relative dielectric constant (ε') and an imaginary part dielectric loss (ε'') and is given by the equation $\varepsilon^* = \varepsilon' - j\varepsilon''$. Dielectric constant of material is measure of its ability to store electromagnetic energy, whereas dielectric loss factor is a measure of its ability to convert electromagnetic energy to heat. Researchers studying the dielectric properties of food material have determined the dielectric properties of different food products using the open-ended coaxial probe method. The wave guide cell method is used to find the dielectric properties of different edible oils by Agrawal Shilpi et al[2]. They have reported the dielectric properties of pure oils and mixture of mustard oil with coconut oil, groundnut oil, linseed oil in different volume percentage at a constant temperature. Kumar et al[4] measured dielectric properties of pumpable food products under continuous flow conditions at a temperature range of 20 ^{0}C to 130 ^{0}C. The frequency and temperature dependence of the dielectric properties of food materials are reported by Nelson et al[6]. The frequency dependence of the dielectric properties of milk are reported by Nunes et al[7]. Sipahioglu et al[8] used Open ended coaxial probe method is used for the determination of dielectric properties of vegetables and fruits as a function of temperature, ash and moisture content. Dielectric properties of selected vegetables and fruits are studied in the frequency range 0.1 GHz – 10 GHz[9]. Dielectric Properties of Vegetable Oils are studied by Shah et al[10]. Test objects, several types of vegetable oils, were measured in temperature range of 27^{0}C -45^{0}C, and frequency range of 10 MHz to 13 MHz[11]. Rudan-Tasic D et al[12] reported the Change in electric permittivity of edible oils with temperature. Chaudhari et al[13] reported temperature dependent dielectric study of some unsaturated edible oil at fixed microwave frequency. Chaudhari H.C[14] reported temperature dependent dielectric study of binary mixture of sunflower oil and groundnut oil with different proportion at constant frequency. Stauffer E[15] has made a review of the analysis of vegetable oils, also forensic approach to this study is used. Javed, M. Akram et al[16] studied the dielectric properties of cholesterol derivates. The frequencies and temperature dependence of permittivity are measured at lower frequencies[17]. The purpose of this paper is to report dielectric properties of unsaturated linseed oil as a function of frequency at temperatures from 30^{0}C to 70^{0}C.

MATERIALS AND METHOD

Linseed oil is purchased from the retail market and is used without further purification. The physical and chemical parameters of oil are measured at Shri. Venkatesh food laboratories, approved by AGMARK, Ministry of Agriculture, Department of Agriculture and Co-operation (Government of India).

Iodine Value (IV): The iodine value (IV) of an oil is a direct representation of the degree of unsaturation of the oil. Iodine is used to halogenate the double bonds present in unsaturated fatty acids. The IV is expressed in the number of centigrams of iodine absorbed per gram of sample.

Saponification Value (SV): The saponification value (SV) is a measure of the amount of alkali necessary to saponify all the triglycerides present in the sample. It is expressed as the amount (in milligrams) of potassium hydroxide (KOH) required to saponify one gram of the sample.

Acid Value: The acid value is a measure of the amount of free fatty acids present in the oil. It is determined as the amount (in milligrams) of potassium hydroxide (KOH) necessary to neutralize the FFA's in one gram of sample. This value is then converted to the percentage of FFA's in the sample. The quantity of sample needed varies from about 0.1 to 20 g, depending on the expected acid value.

The wave guide cell method is used for measurement of dielectric properties of Linseed oil. These measurements are carried out using a microwave bench operating in X-band frequencies tunable at desired constant frequency. The X-band experimental setup for measurement of dielectric properties consist of a reflex klystron 2K25 as the microwave source, with maximum output power of 25 mW and frequency range 8.2-12.4 GHz. A broadband isolator is connected to avoid the interference between source and reflected signals. The isolator is followed by a variable attenuator, to control the microwave power at desired level. A frequency meter with high Q-factor and with 5 MHz resolution is used to measure the signal frequency. To detect the output power diode detector, with square law characteristics having VSWR better than 2:1, is used. A micro ammeter is used for measurement of power. The liquid cell is connected to slotted section. The liquid cell is equipped with movable short plunger with scale division 0.001cm. The bench is tuned to a desired constant frequency and is kept undisturbed throughout the experiment. For accurate measurement of wavelength, the probe carriage is mounted with a dial gauge having least count of one micron. The water bath and a thermostat have been used to maintain the constant temperature within ± 1^0C, accuracy limit. Liquid sample cell is surrounded by a heat-insulating container, through which water of constant temperature is circulated. The temperature of oil at the cell is monitored and recorded using a thermometer. The experimental arrangement for measuring the dielectric properties of a liquid is as shown in Figure-1. The dielectric constant and dielectric loss of oil are determined by following relations:

$$\in' = \left(\frac{\lambda_0}{\lambda_c}\right)^2 + \left(\frac{\lambda_0}{\lambda_d}\right)^2 \left[1 - \left(\frac{\alpha_d}{\beta_d}\right)\right]^2 \qquad \in'' = 2.\left(\frac{\lambda_0}{\lambda_c}\right)^2 \left(\frac{\alpha_d}{\beta_d}\right)$$

Here, λ_0, λ_c and λ_d are the free space wavelength, cut-off wavelength and wavelength in the dielectric sample (oil), respectively. α_d is attenuation constant of the material measured in nepers per meter and β_d is phase shift per unit length of the material measured in radians per meter. These are calculated by following relations.

$$\alpha_d = \frac{2.302}{2L}.\log\left[\frac{\sqrt{x_1}}{2\sqrt{x_2} - \sqrt{x_1}}\right] \qquad \beta_d = \frac{2\pi}{\lambda_d}$$

x_1 and x_2 are output power readings without and with sample length L in waveguide.

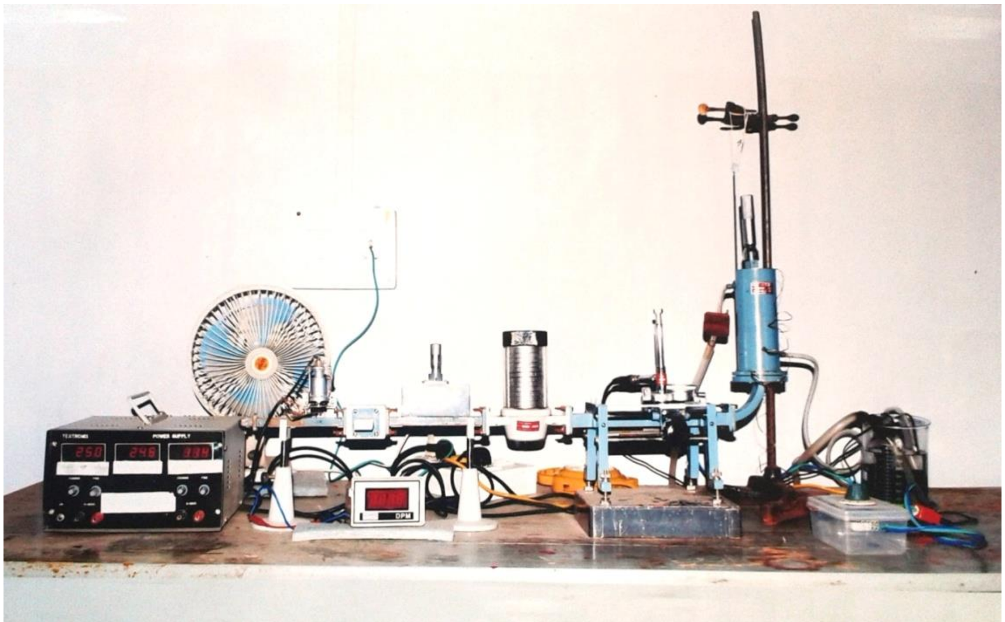

Figure 1: Experimental set-up for measuring dielectric constant and loss of a liquid, when sample length is in multiple of λ_d.

RESULTS AND DISCUSSION

The physical and chemical parameters are given in Table 1. These properties are compared with the literature values. It is observed that these values are in very good agreement with literature values. This oil sample is best suitable as per PFA standard.

Table1. : Physical and Chemical properties of unsaturated edible Linseed oil.

Properties	Linseed oil		
	PFA standard[18]	Measured	Literature[2]
Refractive index at 40 ^{0}C	1.4720-1.4750	1.4733	1.473
Specific gravity	0.923 -0.928	0.924 (at 30 ^{0}C)	-
Saponification value	188-195	190.20	188
Iodine value	Not less than 170	174.30	-
Acid value	Not more than 4.0 %	1.41	-
Unsoponifiable matter %	Not more than 1.50%	0.51	-

The values of dielectric constant (ε') and dielectric loss (ε") for Linseed oil with four different frequencies are measured at different constant temperatures from 30 ^{0}C to 70 ^{0}C. The variation in dielectric constant and dielectric loss with temperature for Linseed oil for four different frequencies are shown in Figure 2 and 3 respectively. It is observed that the dielectric constant ε' of linseed oil decreases with the increase in frequency. The dielectric loss ε" of linseed increase with increase in frequency. For linseed oil, dielectric constant decreases with increase in temperature while dielectric loss increases with increase in temperature. The temperature dependence of the dielectric constants shows that the value of ε' decreases with increasing temperature, indicating the presence of a definite dipole moment, i.e. the oils are not purely non-polar. Also, this temperature dependence of oil could be assumed that, as the temperature increases, viscosity of oil decrease, relaxation times decrease leading to an increase in dipole moment and a decrease in the dielectric constant ε'. The dielectric loss ε″ for insulating materials used in electrical equipment are constituted by two different components: the losses related to conduction processes and those related to the polarization phenomena. The decrease in the dielectric constant for linseed oil as a function of temperature measured for different frequencies of the applied electric field is observed. This behavior is normal for almost all materials, because at higher frequencies there is insufficient time for the molecule to rotate, i.e. the orientation polarization decreases with a tendency to disappear; therefore, at these frequencies, only the polarizability term contributes to dielectric constant[11]. The increase in dielectric loss with increase in frequency at a constant temperature may be due volume conductivity. These results are in good agreement with the earlier reported work[10, 11, 13].

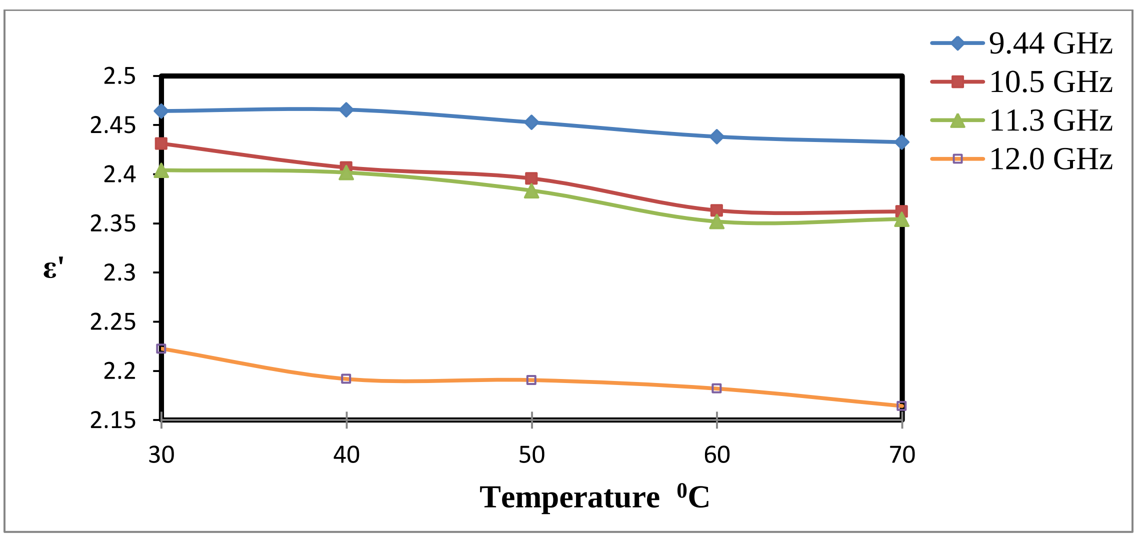

Figure 2: Variation in dielectric constant (ε') with temperature for Linseed oil for different frequencies.

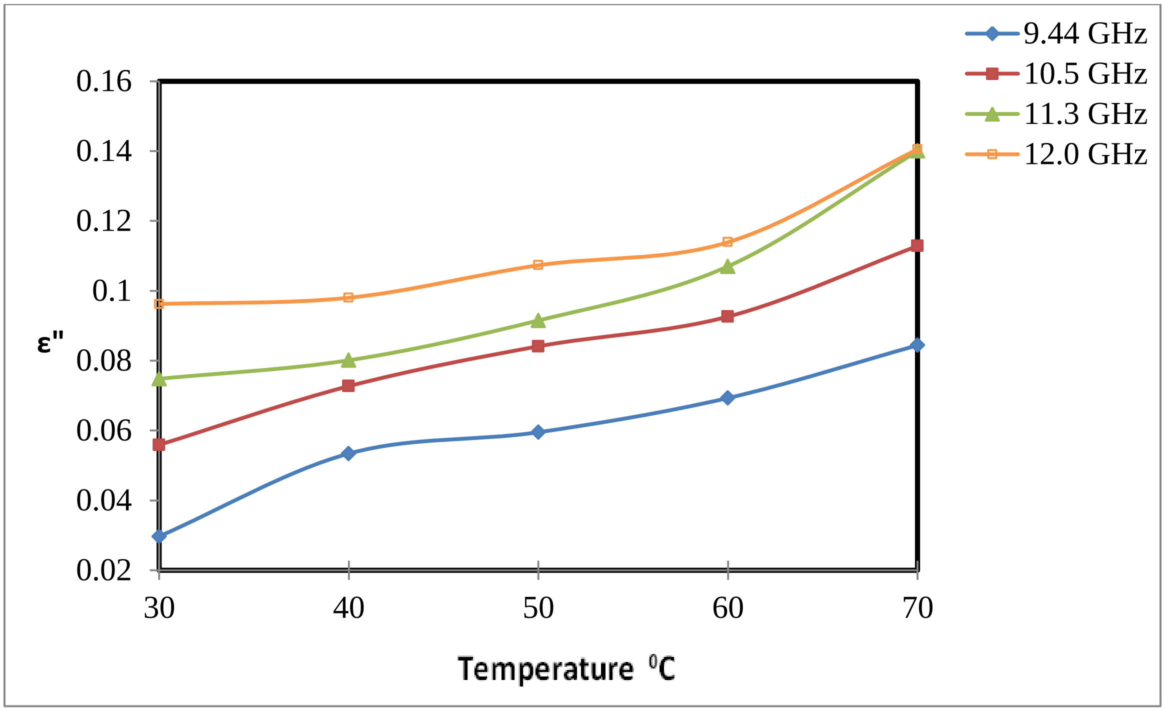

Figure 3: Variation in dielectric loss (ε") with temperature for Linseed oil for different frequencies.

CONCLUSION

Microwave dielectric properties of unsaturated edible oil varies with frequency of applied field also these properties varies with temperature of oil. Dielectric properties can be used for preparation of scales which may be used to find the quality of unsaturated oils. The data obtained from such study can be correlated with physical and chemical properties of oils which may provide the information weather available products in market are suitable for consumption or not.

ACKNOWLEDGEMENT

Author thanks Principal R.S.Agrawal, J.E.S. College, Jalna for providing laboratory facilities and valuable support during this work.

REFERENCES

1. http://en.wikipedia.org/wiki/Linseed_oil#Chemical_aspects
2. Agrawal S and Bhatnagar D., Dielectric study of binary mixtures of edible unsaturated oils, Indian Journal of Pure and applied Physics, 2005; 43(8) :624-9.
3. Guan D, Cheng M, Wang Y and Tang J., Dielectric properties of mashed Potatoes relevant to microwave and radio-frequency pasteurization and sterilization processed. J Food Science, 2004; 69 (1):30-7.

4. Kumar P, Coronel P, Simunovic J, Truong V D, and Sandeep K P., Measurement of dielectric properties of pumpable food materials under Static and continuous flow conditions, Journal of Food Science, 2007;72 (4):177-83.
5. Nelson SO, Forbus WR Jrand Lawrence KC. Microwave permittivity's of fresh Fruits and vegetables from 0.2 to 20 GHz., Transactions of American Society of Agricultural Engineers, 1994; 37(1):183-9.
6. Nelson SO and Bartley PG., Frequency and temperature dependence of the dielectric properties of food materials, Transactions of American Society of Agricultural Engineers, 2002; 45(4):1223-7.
7. Nunes AC , Bohigas X and Tejada J. Dielectric study of milk for frequencies between 1 and 20 GHz., Journal of Food Engineering. 2006; 76(2):250-5.
8. Sipahioglu O, Barringer SA. Dielectric properties of vegetables and fruits as a function of temperature, ash, and moisture content. J Food Science, 2003 ; 68(1):234-9.
9. Tran VN , Stuchly SS, Kraszewski A . Dielectric properties of selected vegetables and fruits 0.1–10.0GHz. J Microwave Power, 1984; 19 (4):251-8.
10. Shah Z. H. and TahirQ. A., Dielectric Properties of Vegetable Oils. J. Sci. Res. 2011; 3 (3), 481-92.
11. Margareta Pecovska-Gjorgjevich, Aleksandar Andonovski, Julijana Velevska, Dielectric constant and induced dipole moment of edible oils subjected to conventional heating, Macedonian J Chemistry and Chemical Engineering, 2012; 31(2), 285-94.
12. Rudan-Tasic D. and Klofutar C., Characteristics of vegetable oils of some Slovene manufacturers, Acta Chim. Slov., 2012; 46(4), 511-1.
13. Chaudhari Harish C, Sarda Swapnil R. and Shinde Vijay J., Microwave dielectric properties of unsaturated edible oils at different temperatures, Am J PharmaTech Res 2014; 4(5) 453-1.
14. Chaudhari H. C. Temperature dependent dielectric study of binary mixture of unsaturated edible oils. J Deccan Current Science, 2014:9(2): 278-82.
15. Stauffer E. A Review of the analysis of vegetable oil, residues from fire Debris samples: spontaneous ignition, vegetable oils, and the forensic approach. J. Forensic Sci., 2005; 50, 1–10.
16. Javed, M. Akram, M. I. Shafiq, Dielectric properties of cholesterol derivates, Rom. J. Phys., 2006; 51, 819–26.

17. Pecovska-Gjorgjevich M, Andonovski A, J. Velevska J., Measuring frequency- and temperature dependent permittivities of vegetable oils, Physica Macedonica, 2010, 59, 77–89.

18. http://www.agmarknet.nic.in/vogmrule.htm#linseed%20oil