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# Temperature dependent microwave dielectric study of some edible oils

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**Abstract :** The real (ε') and imaginary (ε'') parts of the complex dielectric constant (ε*) of unsaturated edible oils are measured at different temperatures ranging from 303K to 343Kat 7.0 GHz microwave frequency. Microwave J-band setup in the $TE_{10}$ mode with slotted section and crystal detector used for these measurements. The measured values of dielectric constant and dielectric loss show remarkable variation with temperature for all oils. It is observed that the dielectric constant (ε') of edible oils decreases with increase in temperature while the dielectric loss (ε")increases with increase in temperature. The variation in dielectric constant and dielectric loss with temperature may be due to their different physical and chemical properties.

The dielectric properties of oilsare in good agreement with those reported by earlier researchers.

**Keywords :** Microwave J-band**,** Dielectric constant, Dielectric loss.

## Introduction

Edible oils extracted from plant sources are important in foods and in various other industries. The proportion of various fatty acids, vitamin, moisture and other nutrient may vary with quality of seed, method of extraction, role of heat, pre processing and post processing etc. During extraction, purification and usage, oils undergo variety of processing operations, including heating, distillation and chemical modification, which may alter their properties. In this work, we have compiled some bulk parameters for different oils with special focus on temperature dependence of dielectric properties.

Microwaves has the ability to heat materials by penetrating and dissipating heat in materials. Microwaves have been used in the medicine, warming blood, thawing frozen tissues and tumor therapies. Microwaves have been used for several food processing operations including thawing, blanching, pasteurization, and sterilization, dehydration, baking, and roasting.Interaction ofmicrowaveswithdielectric materialsdependsontheir dielectricproperties, which determine the extent of heating of a materialwhen subjected to electromagnetic fields. Dielectric properties consist of dielectricconstant and dielectric loss factor. Dielectric constant is a measure of the ability of a material to store electromagnetic energy, whereas dielectric loss factor is a measure of the ability of a material to convertelectromagnetic energy to heat. Dielectric properties can be defined in terms of complex permittivity (ε*). The complex permittivity (ε*) is composed of a real partdielectric constant (ε') and an imaginary part dielectricloss (ε'') and is given by the equation $\varepsilon^* = \varepsilon' - j\varepsilon''$.

Quality food keeps human physically and mentally fit.Itis a fuel for human body. Edible oil extracted from fresh plant sources is an essential part of food. They are key components of the diet and provide characteristics flavors and textures of foods. Muyassaroh explained microwave distillation process to improve the quality of oil[1].In India,various oils used by the peoples of different regionsas per the production and availabilityof the seeds, in the respective area, some of them are soya bean oil, sunflower oil, groundnut oil, almond oil, safflower oil, coconut oil,mustard oil, etc. The dielectric constant and induced dipole moment of edible oils subjected to conventional heating are studied[2].Microwave dielectric properties of unsaturated edible oils at different temperatures using X-band microwave bench were reported by Chaudhari *et al*[3].

Jha S *et al.*[4]described the development and characterization of olive oil based pharmaceutical microemulsion system by using sophisticated physical techniques like differential scanning calorimetry studies.

Many researcher[5-9]studying the dielectric properties of food material have used open-ended co-axial probe method. Luque de Castro et al.[10] describe roll of the role of microwaves in the extraction of fats and oils. Hiromi Yoshida et al. [11]studied microwave roastingand for positional distribution of the fatty acids and suggest that unsaturated fatty acids are significantly protected from microwave roasting.

Number of studies determines the dielectric properties of food products using the open-ended coaxial probe method. Dielectric properties of 10 edible oils and 6 fatty acids were measured over the frequency range 100 Hz–1 MHz. The effects of temperature, moisture content and fatty acid component on dielectric properties of oils were investigated by Hu Lizhi et.al[12]. Shah et. al, reported dielectric properties of some vegetable oils[13]. Agrawal et al[14] have used the wave guide cell method to find the dielectric properties of different edible oils. They have reported the microwave 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. Sipahioglu et al[15]used the open ended coaxial probe method for the determination of dielectric properties of vegetables and fruits as a function of temperature,ash and moisture content. There is a need to study the impact of impurities due to addition of different oils, effect of temperature with microwave techniques. In the present paper, the microwave dielectric properties of different edible oils at single frequency with various temperatures is reported

## Materials and Methods

Samples of different edible oils collected from the market. These are used to measure physical, chemical and dielectric properties without further purification.The physical and chemical parameters are measuredat AGMARK approved laboratory. These parameters are in good agreement with earlier reported work[3] are in Table 1.

**Table1: Physical and Chemical properties of edible oils.**

| Name of the oil | Refractive index ($313^0$K) | Specific gravity ($303^0$K) | Saponification value | Iodine value | Acid value | Unsopinable matter (%) |
|---|---|---|---|---|---|---|
| Safflower oil | 1.468 | 0.916 | 189.43 | 141.32 | 0.18 | 0.40 |
| Mustard oil | 1.465 | 0.909 | 171.28 | 106.36 | 1.52 | 0.48 |
| Coconut oil | 1.449 | 0.918 | 267.90 | 8.70 | 1.10 | 0.47 |
| Seaseme seed oil | 1.466 | 0.917 | 190.52 | 110.40 | 1.43 | 0.53 |

For measurement and estimation of dielectric properties of oils, the wave-guide cell method is used. The experimental set-up consists of a microwave source for J-band operating in the frequency range 5.85-8.2 GHz. A broadband isolator with minimum isolation and minimum insertion loss is used to avoid the interference between source and reflected signals. To control the power at desired level, a variable attenuator connected after the isolator. A frequency-meter is used to measure the signal frequency. The diode detector with square law characteristics with VSWR better than 2:1 used to detect the output power. A micro ammeter is used for measurement of output power. The liquid cell connected to slotted section.The liquid cell is equipped with movable short plunger with scale division 0.001cm. The bench tuned to frequency 7.0 GHz and kept undisturbed throughout the experiment. Accuracy of measurement of real (ε') and imaginary (ε'') parts of the complex dielectric constant (ε*) is $\pm 0.001$ and $\pm 0.001$ respectively.

The water bath and a thermostat areused to maintain the constant temperature within the accuracy limit of ±1$^0$C. The sample cell surrounded by a heat-insulating container, through which the water of constant temperature can be circulated. The constant temperature of the cell recorded using a thermometer.

The dielectric constant and dielectric loss of pure oils at various constant temperatures at microwavefrequency 7GHz are determined by applying 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, $\lambda_0$, $\lambda_c$and $\lambda_d$ are the free space wavelength, cut-off wavelength and wavelength in the dielectric sample, respectively. $\alpha_d$ and $\beta_d$ are attenuation constant of the material measured in nepers per meter and phase shift per unit length of the sample measured in radians per meter, respectively and are calculated by following relations :

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

$$\beta_d = \frac{2\pi}{\lambda_d}$$

$x_1$and $x_2$ are output power readings without and with sample length L in the wave-guide.

## Results

The values of dielectric constant (ε') and dielectric loss (ε") for different oils are measured at different constant temperatures. The variation of dielectric constant and dielectric loss with temperature for oils areshown in fig.1 and 2 respectively. The dielectric constant of edible oils decreases with increase in temperature. The dielectric loss increases with increase in temperature. The dielectric constant and dielectric loss for these edible oils have different values at the same temperature; this is due to their physical and chemical properties. These results are in good agreement with the earlier reported work.

The dielectric constant is maximum for mustered oil and minimum for safflower oil at 343K. (Fig.-1 andFig-2).

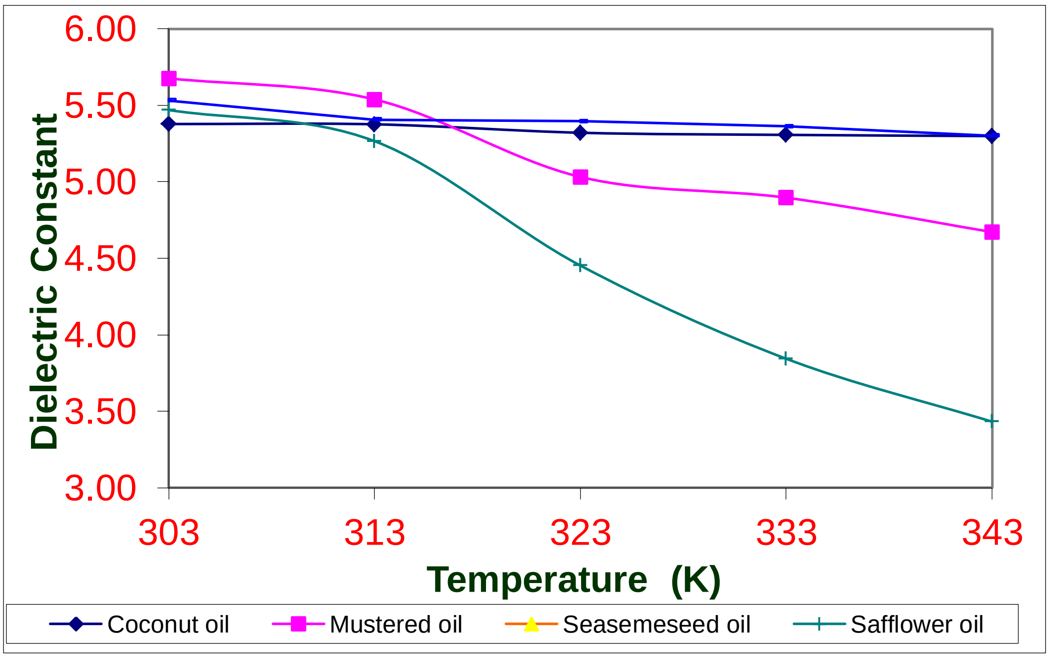


**Fig. 1 : Variation of dielectric constant with temperature for oils.**

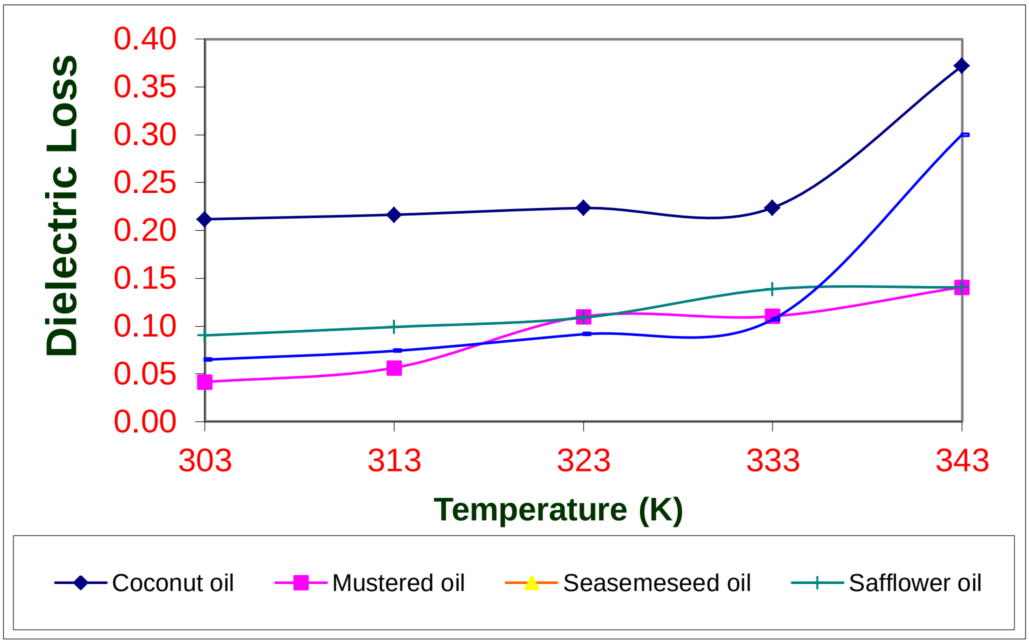


**Fig. 2 : Variation of dielectric loss with temperature for oils.**

## Conclusion:

The data obtained from microwave dielectric study of oils can used to estimate the parameters like dipole moment, relaxation time, conductivity. The thermodynamic parameters such as entropy, enthalpy of liquid.With help of these dielectric properties,different scales can be prepared;this studymay beuseful to find the amount of impurities in unsaturated oils. Themicrowave dielectric data from this study can be correlated with physico-chemical properties of oils. This may provide the information whether a particular oil,available in market,is suitable for consumption or not.

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