Comparative dielectric study of binary mixtures of clove and cinnamon oil

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Abstract: The present paper deals with the dielectric study (dielectric constant, dielectric loss) of two medicinal oils, cinnamon and clove oil and their binary mixtures at different temperatures and frequencies. HP 4194A impedance gain/phase analyzer and temperature controller (Julabo, model number F-25, microprocessor controlled) were used for determination of dielectric parameters and maintaining the temperature of pure oils their binary mixtures.

Key Words: Clove Oil, Cinnamon Oil, Dielectric constant, Dielectric loss, Binary Mixture.

1. Introduction
Food is fuel for body and keeps our mind fit and working. Adulterated food products are responsible for an abundant loss both physically and mentally. With the development in the methods of identifying the adulteration, it becomes imperative that food we consume must be pure. For example, the mustard oil is used as the major cooking oil in India and it is highly recommended in food because it contains two essential fatty acids namely linolenic acid and α-linolenic acid which our body cannot make itself.

Edible oils are vital component of foods content either extracted from plant or from other sources. The edible oils give their characteristic flavors and textures to food. They are important in cosmetics, pharmaceuticals, lubricants and in various industries. They are made edible by purification and undergo variety of chemical and physical processes such as heating, distillation etc. before consumption.

Many semi-empirical equations have been developed to relate the physio-chemical properties of oils such as change in their density, viscosity, surface tension, etc. With the help of these semi-empirical equations, we can predict change in the properties of oils under various physio-chemical conditions.

The physio-chemical properties of oils depend on constituents of the oil, frequency, temperature, age, adulteration etc. In the present paper, we have reported dielectric properties of two medicinal oils (clove and cinnamon) and their binary mixtures. Various studies have already been done by researchers, the
dielectric properties of eleven fats and cooking oils at 300 MHz and at different temperature have been reported by Pace et al [1]. The Dielectric behaviour of edible unsaturated oils and their binary mixtures was reported by Shilpi Agarwal et al [2]. The dielectric study of many edibles oils and fatty acids were measured by Lizhi et al. over the frequency range of 100 Hz-1MHz [3]. The dielectric properties of oil used in engines and bone fatty oil were reported by other researchers [4]. The optical study of various oils has also been reported by our group [5]. Šegatin et al recently reported dielectric and dipole Moment study of edible oils after thermal treatment [6].

2. Material and Methods

The oils under investigation, clove and cinnamon, have been purchased from local market.

2.1. Clove Oil

Clove oil is extracted from cloves. It is rich in various minerals mainly iron, calcium, phosphorus, sodium, potassium, hydrochloric acid, and vitamin A and vitamin C. The main constituent of clove oil is Eugenol. This oil is used in aroma industry and as a local antiseptic and anesthetic medicine, for diarrhea, hernia, bad breath, vomiting, nausea, etc. intestinal gas [7]. It is also used in the manufacturing toothpaste, soaps, creams and lotions, perfumes etc. It is used as home remedy for dental care tooth ache, sore gums and mouth ulcers and provides relief from pain and stress.

The chemical structure of Eugenol is given in figure 1 below-

![Eugenol](image)

Eugenol (4-Allyl-2-methoxyphenol)

Fig. 1: Chemical structure of Eugenol

2.2. Cinnamon Oil

This oil is extracted from Cinnamomum verum and Cinnamomum cassia tree of Lauraceae family. The major constituents of this oil are eugenol, eugenol acetate, cinnamic aldehyde and benzyl benzoate. This oil is used to cure rheumatism, infection of the respiratory tract, arthritis and general pains and period pains. The chemical structures of the few constituents of cinnamon oil is given in figure 2 below-

![Chemical structures](image)
3. Experimental Details

The dielectric parameters of two medicinal oils, cinnamon and clove oils and their binary mixtures, dielectric parameters (\(\varepsilon'\) constant, \(\varepsilon''\) loss and \(\tan \delta\), loss tangent) between the temperature range 30\(^\circ\)C to 50\(^\circ\)C, and between the frequency 10 kHz to 10 MHz have been reported. The dielectric parameters were determined with the help of an impedance gain/phase analyzer HP 4194A and the temperature of oils was maintained with the help of a temperature controller Julabo F-25 (microprocessor controlled) and details of these devices have also been published in our previous papers [8-9]. All the samples investigated that is pure and binary mixtures have been designated as 1, 2, 3, 4 and 5, where sample 1 is pure oil (A), sample 2 is (75% oil A + 25% oil B), sample 3 is (50% oil A + 50% oil B), sample 4 is (25% oil A + 75% oil B), and sample 5 is 100% pure oil (B).

4. Results and Discussion

Figure (3) is representing the variation of \(\varepsilon'\) and \(\varepsilon''\) with \(\log_{10}\) frequency (Hz) at indicated percentage of impurity (the second oil is treated as impurity in first oil) and at constant temperature 30\(^\circ\)C for the pure and its binary mixtures (clove oil and cinnamon oil).

Figure (4) is showing the variation of \(\varepsilon'\) and \(\varepsilon''\) with percentage impurity contents at indicated frequencies and at constant temperature of 30\(^\circ\)C while figure (5) shows the variation of \(\varepsilon'\) and \(\varepsilon''\) with temperature at indicated percentage of impurity and at constant frequency 50Hz for the pure and binary mixtures of clove oil and cinnamon oil.
Fig. 3: Frequency dependence of dielectric constant $\varepsilon'$ and dielectric loss $\varepsilon''$ of clove oil and cinnamon oil at indicated impurity (in percentage) and at temperature 30$^\circ$C.
Fig. 4: Variation of dielectric constant $\varepsilon'$ and dielectric loss $\varepsilon''$ with percentage impurity of clove oil and cinnamon oil at indicated frequency and 30°C.

Fig. 5: Temperature dependence of dielectric constant $\varepsilon'$ and dielectric loss $\varepsilon''$ of clove oil and cinnamon oil at indicated impurity (in percentage) and at frequency 50 kHz.
4.1. Dielectric Properties of Pure Oils and their Binary Mixtures

4.1.1 Frequency Dependence

Figure (3) is showing the variation of dielectric constant and dielectric loss with log_10 frequency at a constant temperature 30°C for clove oil and cinnamon oil. It can be seen from the figure (3), that the dielectric constant value of pure clove oil is less than the cinnamon up to certain frequency then reverse effect is seen. For all the samples, pure and binary mixtures, the nature of the dielectric constant curve is almost same i.e. it decreases with increase in frequency. For the samples 2, & 4 the value of dielectric constant is more than the dielectric constant of pure oils while for the sample 3 it is less than the dielectric constant of pure oils. This type of behaviour was reported by Sorichetti et al [10] in 2005.

Figure (3b) is showing the variation of dielectric loss $\varepsilon''$ with natural log of frequency at constant temperature 30°C for the clove oil and cinnamon oil. The dielectric loss value for the samples 2, 3 and 4 are in between the dielectric loss value of sample 1 and sample 5. The dielectric loss value for the samples 4 is almost zero. The dielectric loss value for sample 1 decreases sharply up to 50 kHz frequency then it decreases slows down. Similar type of nature has also been reported by Saraev et al [11].

4.1.2 Composition Dependence

Figure (4a) is presenting the variation of dielectric constant with percentage impurity at a constant temperature 30°C for frequency (5kHz, 10kHz, 30kHz, 50kHz, 130kHz, 330kHz, 2MHz, 4MHz, and 10MHz) for the said oils and their binary mixtures. The dielectric constant decreases sharply initially with small impurity addition. When percentage of second oil increases up to 50% then the rate of decrease for dielectric constant is very slow with impurity addition. Therefore, we can say that the dielectric constant values decrease with increase in impurity with very slow rate. The similar nature of the curve for binary mixture of edible unsaturated oils at 300 kHz has been reported by other workers [2]. Figure (4b) is presenting the variation of dielectric loss with percentage impurity at a constant temperature 30°C for frequency (5kHz, 10kHz, 30kHz, 50kHz, 130kHz, 330kHz, 2MHz, 4MHz, and 10MHz) for the selected oils and their binary mixtures. The dielectric loss values are also decreasing with increase in percentage impurity. The value of dielectric loss up to 10% decreases sharply at all the shown frequencies and then its decrease slows down with increase in percentage impurity.

4.1.3 Temperature Dependence

The variation of $\varepsilon'$ with temperature at a frequency of 50 kHz is presented in figure (5a) for the said oils and their binary mixtures. It can be seen that the dielectric constant decreases with increase in temperature for all the samples. From the figure (5a) it is also observed that the dielectric constant values for sample 1
are quite high as compared to the sample 5 and rest of the samples, the dielectric constant values are in between sample 1 and sample 5. This type of behaviour has also been reported by Tasic et al [12].

The variation of dielectric loss with temperature at a frequency of 50 kHz are presented in figure (5b) for the said oils and their binary mixtures, it is observed that the dielectric loss values for all the samples decreases with increase in temperature. Again, it can be seen that in figure (5b) the dielectric loss values for samples 1 are moderately high as compared to the sample 5. The changes can be attributed to constituents of the oils which consist of mixtures of esters of the trihydric alcohol i.e. glycerol and fatty acids.

5. Conclusions

The dielectric constant and dielectric loss of all the oils are showing decreasing tendency with increase in applied frequency, while the dielectric constant is found to decrease with increase in temperature and the dielectric loss is found to increase with increase in temperature. It can also be concluded that the dielectric constant and dielectric loss of binary mixtures of oils is showing unpredictable behavior. The type of study can also be applied to explore the purity of any liquid sample for example, fluoride content in water.

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