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Physics

EFFECT OF IMPURITY ON DIELECTRIC PROPERTIES OF COOKING OILS WITH FREQUENCY AT DIFFERENT TEMPERATURES

Bachaspati Sunuwar, Prajwol Katwal, Tilak Bhandari, Neelam Baizalee, Bhojraj Bhandari and Bhadra Pokharel*
[1]*Department of Physics GoldenGate International College, Kathmandu, Nepal*
**Email: boydbhandari@gmail.com*

Abstract

Vegetable oils such as Mustard Oil, Sunflower oil, Olive Oil and Soyabean Oil are mostly used for cooking oil in our society. In most of the public eating places, oils are reused again and again until color of oil changes or foam appears on the surface of oil. We studied the effect of temperature in heating cycle and effect of impurity on the quality of oils at two frequencies: 1KHz and 120Hz. We measured the capacitance and loss factor for two frequencies by using the LCR meter and calculated the real and imaginary parts of dielectric constant of respective oils. The result obtained from experiment and calculation suggests that dielectric constant increases with the increase in heating cycle. In the case of adding impurity i.e. Dalda in each oil, the results revealed that dielectric constant of oil increased with increase in ratio of impurity to oil i.e. concentration of impurity up to certain critical value; further increasing the impurity caused the dielectric constant to decrease. The critical values of impurity for each oil are also determined. By the dielectric study of different edible oils, mustard oil was obtained as the best among them. It is also recommended that mustard oil, olive oil, sunflower oil and soya bean oil are better in order for cooking and frying foods.

Keywords: *Dielectric constant, cooking oil, Dalda, temperature, frequencies.*

Introduction

The nutritional quality of oil can be altered due to many factors. One of the major factors is due to the hydrolysis and oxidation. If the oil is deep fried, oxidation, hydrolysis and polymerization occur which may degrade the quality of oil (Fritsch et al 1979). The degradation depends on the factors, i.e. number of times that the oil is reused, quality/ nature of liquid vegetable oil i.e. high in polyunsaturated will deteriorate more quickly than hardened vegetable shortenings (Choe and Min 2007). In our Nepalese society, not only cheap impurities are mixed with oil for commercial purpose but also the same oil is reused for long times under many heating and cooling cycles. The oil is only dumped when the color is too dark, foams too much or smokes too much, when the odor of smoke becomes too strong, or the food has greasy texture or odor. When oil is heated, it oxidizes thereby causing change in dielectric property of the oil due to the introduction of polar groups in oil increasing the dielectric constant. This relation between the temperature and dielectric constant is used in our project to check the quality of oil. In our society, we use cooking oils such as mustard oil, olive oil, sunflower oil, soybean oil etc., for cooking vegetables and frying foods, and we use the oil by heating or frying for a long time. In order to intensify more researches on this topic we decided to choose topic similar to them.

Therefore, our project tried to answer questions whether there are effects of adding impurities like Dalda in dielectric constant of oil under different temperature scenario with many heating cycles.

Theoretical Background

To calculate real part of the dielectric constant, we used the relation for parallel plate capacitor,

$$\varepsilon' = \frac{Cd}{\varepsilon_o A} \qquad (1)$$

Here, C is capacitance, d is separation of the plates, A is the area of plate,
ε_o is permittivity of an air=8.85 x 10^{-12} Fm^{-1}
and, the imaginary part of the dielectric constant was calculated using,

$$\varepsilon'' = D\varepsilon' \;\; i.e.\; D = Tan\,\delta = \frac{\varepsilon''}{\varepsilon'} \qquad (2)$$

Where, D is loss factor or dissipation factor.
ε' is the real part of dielectric constant. C and D are obtained from experiment.

Materials and Method:

We collected four commercial oils from market. The oils are mustard oil, olive oil, sunflower oil and soybean oil of different trademarks. General laboratory thermometer is used to measure temperature with the accuracy ± 1^0C. Heater is used to heat the samples and TECPEL LCR 612 Meter is used to measure capacitance and loss factor with the accuracy of ±1pF and ±0.0005 respectively.

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Results and Discussions:

We have carried out the dielectric measurements of four different cooking oils as mentioned above as a function of temperature at two frequencies 120HZ and 1KHz using Dalda as an impurity. The result are mentioned below:

Room Temperature Study:

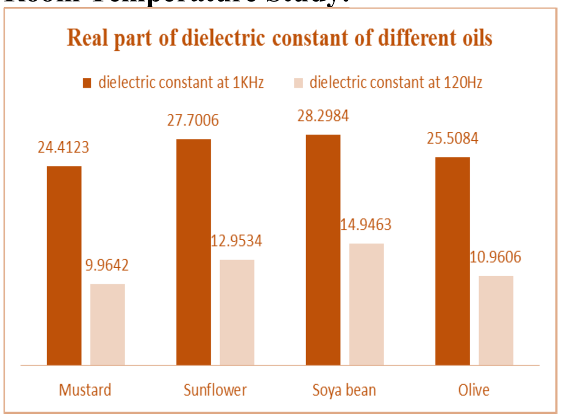

Figure 1: *Comparison of real part dielectric constant of different oils at frequencies 1 KHz and 120 Hz*

Figure 1 represents the plot for comparison of real part of dielectric constant of sample oils as a function of temperature for two frequencies 1 KHz and 120 Hz at room temperature. The above bar diagram reveals that at both frequencies 1 KHz and 120Hz, dielectric constant of mustard oil is lowest than other samples we used and dielectric constant of soya bean is highest than others samples i.e. sunflower oil which in turn greater than that of olive oil at room temperature. That is, dielectric constant of soya bean oil is highest than other samples we used which is the measure of impurity.

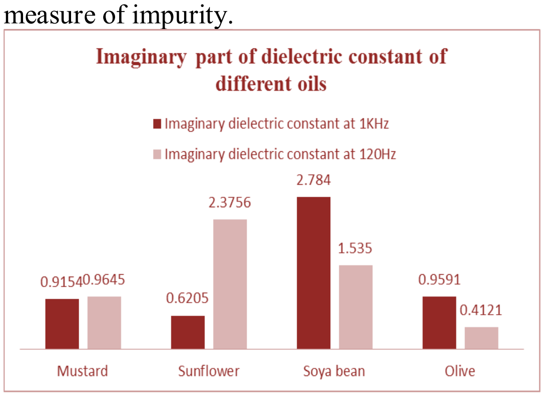

Figure 2: *Comparison of imaginary part of dielectric constant of different oils at frequencies 1 KHz and 120 Hz*

Fig 2 represents the plot for comparison of imaginary part of dielectric constant of the samples oils at frequency 1 KHz and 120 Hz. The above plot reveals that imaginary part of dielectric constant of soya bean oil and olive oil has higher values at 1KHz than at 120 Hz, but in the case of mustard oil and sunflower oil, the imaginary part of dielectric constant is maximum at 120Hz than at 1 KHz which is due to the presence of different polar groups.

Dielectric Study of Mustard Oil:

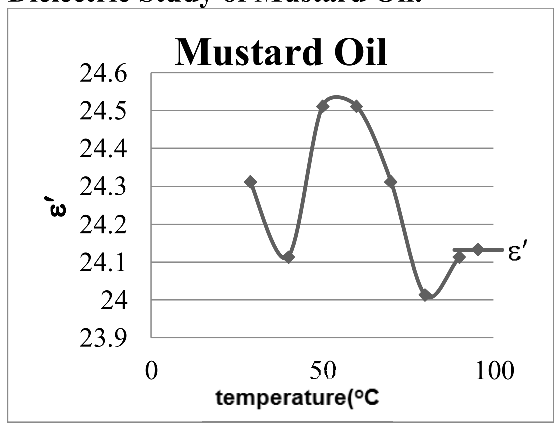

Figure 3:*ε′ vs. temperature of mustard oil at frequency 1 KHz.*

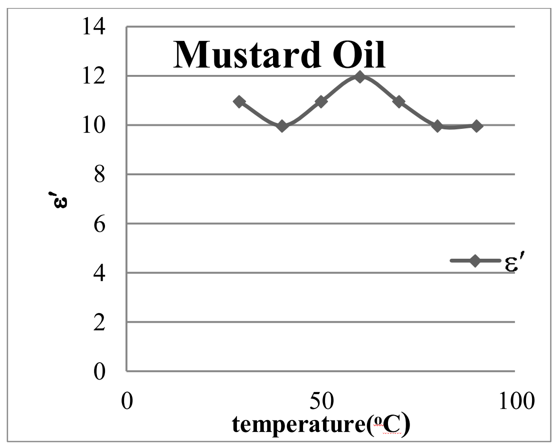

Figure 4:*ε′ vs temperature of mustard oil at frequency 120 Hz*

Figure 3 and 4 represent the plot of the real part of dielectric constant of mustard oil as a function of temperature for two frequencies 1 KHz and 120Hz. Overall, the graphs divulge that dielectric constant decreases with the increases in temperature up to 40^{o} C in both frequencies and then increases up to 60^{o}C. The dielectric constant decreases afterwards obeying negative temperature coefficient of resistance (NTCR). This result is similar to reported by (Suresh 2016).

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Dielectric Study of Sunflower Oil:

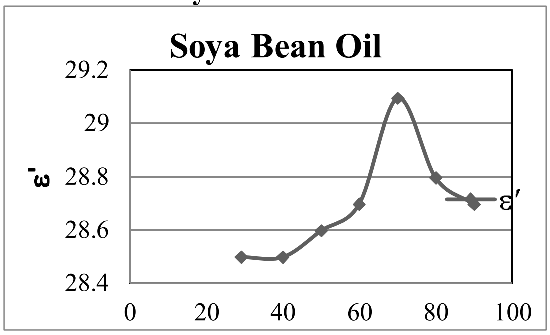

Figure 5:*ε' vs. temperature of sunflower oil at frequency 1 KHz*

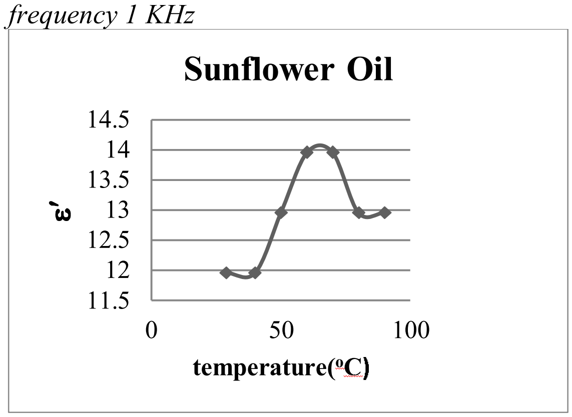

Figure 6:*ε' and temperature of sunflower oil at frequency 120 Hz.*

Figure 5 and 6 represent the plot of real part of dielectric constant of sunflower oil as the function of temperature for two frequencies 1KHz and 120Hz. Above graphs reveal that dielectric constant increases on increasing the temperature up to 70°C. The dielectric constant decreases afterwards obeying negative temperature coefficient of resistance (NTCR). This result is similar to reported by (Houhoula 2001).

Dielectric Study of Olive Oil:

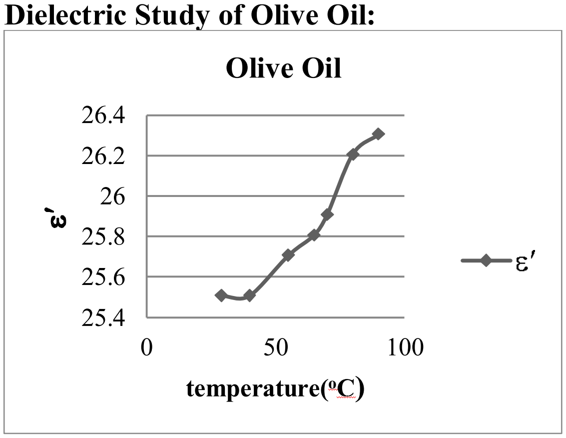

Figure 7:*ε' vs. temperature of olive oil at frequency 1 KHz*

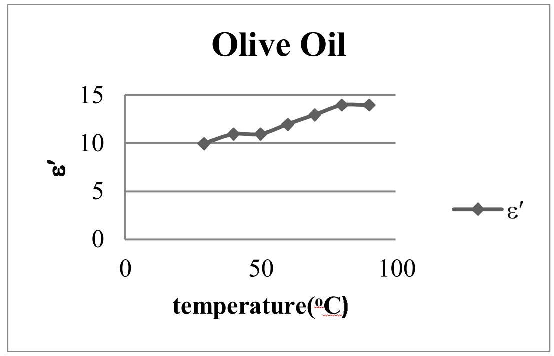

Figure 8:*ε' vs. temperature of olive oil at frequency 120Hz.*

Figure 7 and Figure 8 represent the plot of real part of dielectric constant of olive oil as function of temperature for two frequencies 1 KHz and 120 Hz. Overall the plots reveal that in both frequency, on increasing the temperature, the dielectric constant increases. In both frequencies, dielectric constant is minimum at room temperature and maximum at 90^{O}C. This result is similar to reported by (Houhoula 2001).

Dielectric Study of Soya Bean Oil:

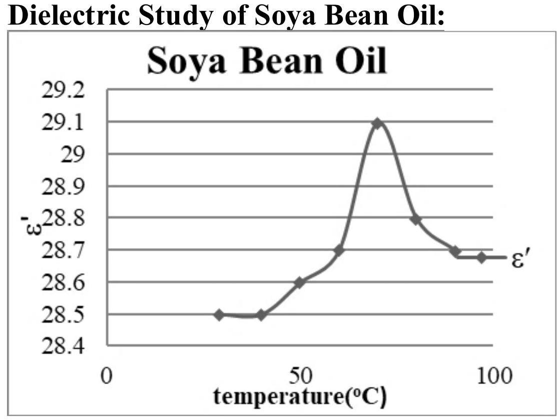

Figure 9:*ε ' vs. temperature of soya bean at frequency 1 KHz.*

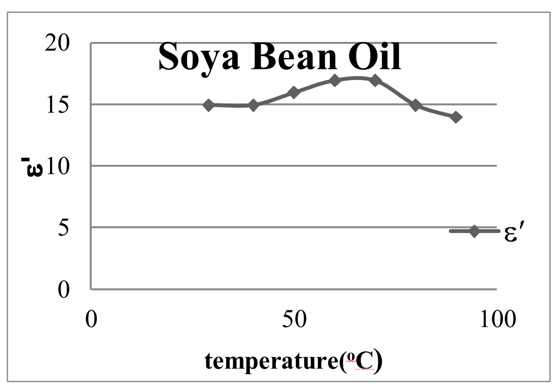

Figure 10:*ε' vs temperature of soya bean at frequency 120Hz.*

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Figure 9 and 10 represent the real part of dielectric constant of soya bean oil at 1 KHz and 120 Hz respectively. Figure 10 divulges that dielectric constant is increased gradually up to 60^{o} and increases sharply up to 70^{o}C. The dielectric constant decreases afterwards obeying negative temperature coefficient of resistance (NTCR). Similarly figure 23 reveals that dielectric is increased up to 60^{o}C seems as a transition or peak temperature. The dielectric constant decreases afterwards obeying negative temperature coefficient of resistance (NTCR). Overall the plots also reveal that dielectric constant of soya bean oil has higher at higher frequency and lower at lower frequency. In both frequencies, dielectric constant is increased with increased in temperature up to 70^{O}C which is similar to reported by (Houhoula 2001).

Heating Cycle of different oils at 1 KHz:

Heating and cooling cycles degrade the quality of the oils. Due to lack of proper knowledge in this field people reused it.

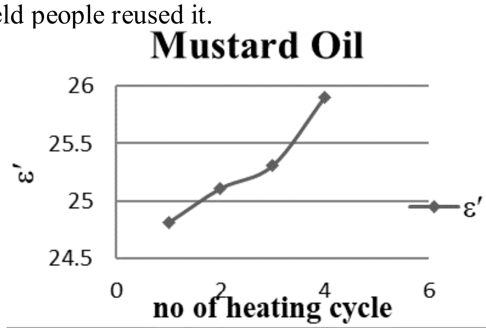

Figure 11:ε' vs.no of heating cycle of Mustard oil at frequency 1 KHz

Fig 11 represents the plot of real part of dielectric constant of mustard oil against number heating cycles at frequency 1 KHz. The dielectric constant is low at first heating cycle and rises gradually with the increase in number heating cycles of the oil. The results were similar for both frequencies. This result was similar to result of study reported by (Choe 2007) and (Fritsch 1981).

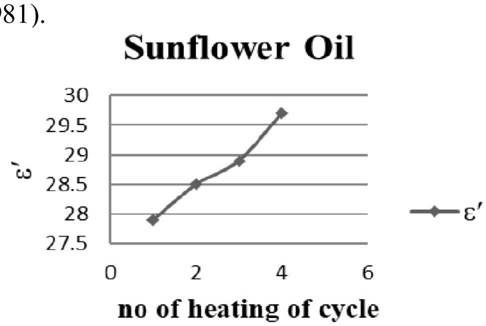

Figure 12:ε' vs.no of heating cycle of soya bean oil at frequency 1 KHz

Fig 12 represents the plot of real part of dielectric constant of sunflower oil against number heating cycles at frequency 1KHz.The dielectric constant is low at first heating cycle and gradually increases with increasing the number of heating cycles. This result is similar to both frequencies 1 KHz and 120 Hz. This result is similar to the result of study reported by (Choe 2007).

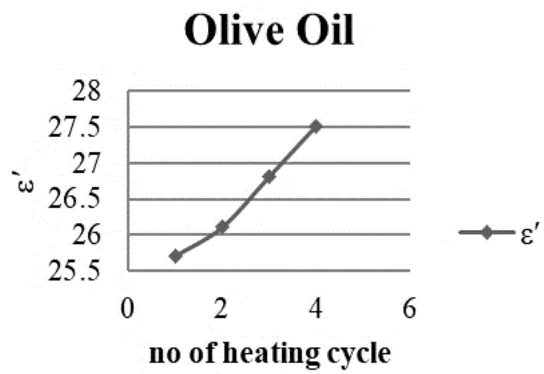

Figure 13:ε' vs.no of heating cycle of olive oil at frequency 1 KHz

Figure13 represents the plot of real part of dielectric constant of olive oil against number heating cycles at frequency 1 KHz. The dielectric constant is low at first heating cycle and rises gradually with increase in number of heating cycles of the oil. Similar nature of the curve are observed in both frequencies. Similar result was also reported by (Choe 2007).

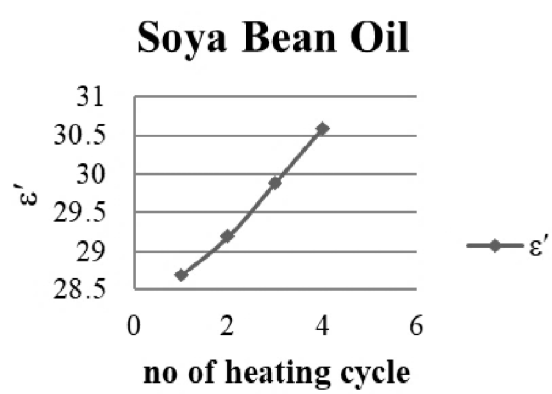

Figure 14:ε' vs.no of heating cycle of soya bean oil at frequency 1 KHz

Fig 14 represents the plot of real part of dielectric constant of soya bean oil against number of heating cycles at frequency 1 KHz. The dielectric constant is low at first heating cycle and rises gradually with the increase in number of heating cycles of the oil. This result is similar with the result reported by (Choe 2007).

Impurity (dalda) effect on Different Oil:

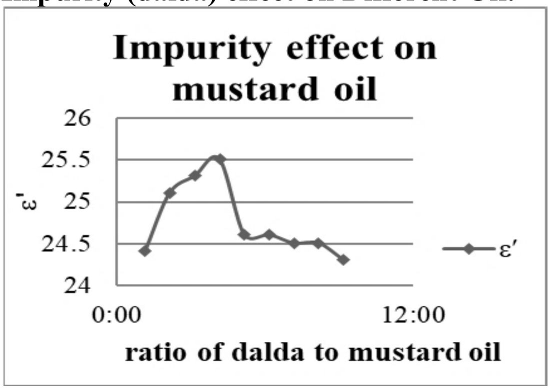

Figure 15:*ε' vs. ratio of dalda to mustard oil at frequency 1KHz*

Figure15 represents the plot of real part of dielectric constant of mustard oil against the ratio of dalda (which is used as impurity in our study) to mustard oil at frequency 1 KHz. The dielectric constant of mustard oil increases gradually on adding the impurity up to 4:10 representing the peak value or critical value at frequencies 1 KHz. Afterward, on adding the impurity more in the mustard oil, dielectric constant of mustard oil goes in decreasing in both frequencies. This study confirms that the critical value i.e.4:10 ratio of impurity to mustard oil is harmful to human health than other proportions. Graph also reveals that in proportion of 1:10 and proportion of 9:10, dielectric constants are lower which may not be harmful to human health comparatively than other proportions.

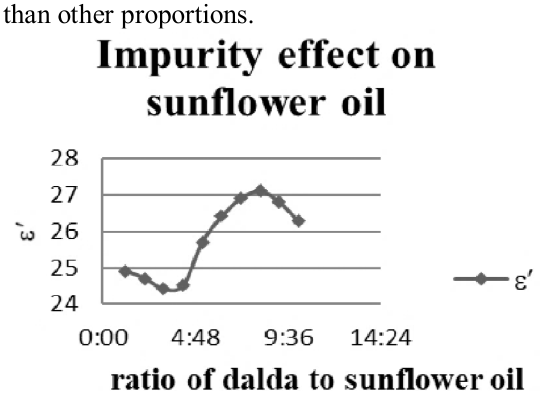

Figure 16*ε' vs. ratio of dalda to sunflower oil at frequency 1KHz*

Figure16 represents the plot of real part of the dielectric constant of impure sunflower oil at frequencies 1 KHz. Overall figure reveals that in the case of sunflower oil, firstly on increasing the small amount of dalda up to 4:10, the dielectric constant of sunflower is decreased and afterward on increasing the concentration of dalda, the dielectric constant of sunflower oil is increased. But on adding the dalda in the ratio of 8:10, dielectric constant becomes maximum called critical ratio. On further increase in concentrations of dalda in sunflower oil, cause the dielectric constant to decrease. In this case critical ratio is 8:10 which is more harmful to the human health than other proportions as per impurity addition.

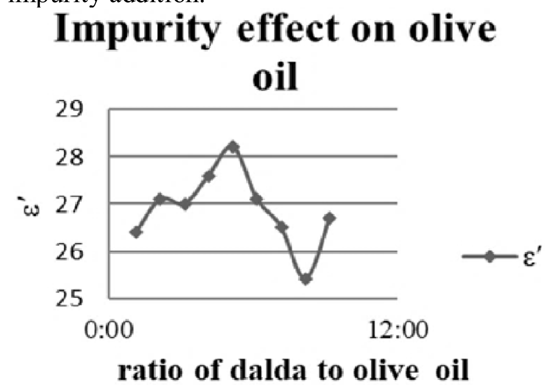

Figure 17:*ε' vs. ratio of dalda to olive oil at frequency 1KHz.*

Figure17 represents the plot of real part of the dielectric constant of impure olive oil at frequency 1 KHz. Fig 17 reveals that on increasing the concentrations of dalda in olive oil up to 5:10, real part of dielectric constant is also increased up to 28.54. But on further increasing the concentration of dalda in olive oil, dielectric data of olive oil is decreased. Similarly, in the case of frequency 120Hz, figure reveals that on increasing the concentration of dalda in olive oil up to 5:10, firstly the dielectric constant of olive oil is increased and on further increasing the concentration of dalda in olive oil, the dielectric constant of olive oil is gradually decreased. The critical proportion i.e. 5:10 proportion is harmful to human health. Graph also reveals that, dielectric constant is lower when concentration of impurity is 9:10. So on adding an impurity in the ratio of 9:10 is less harmful to human health.

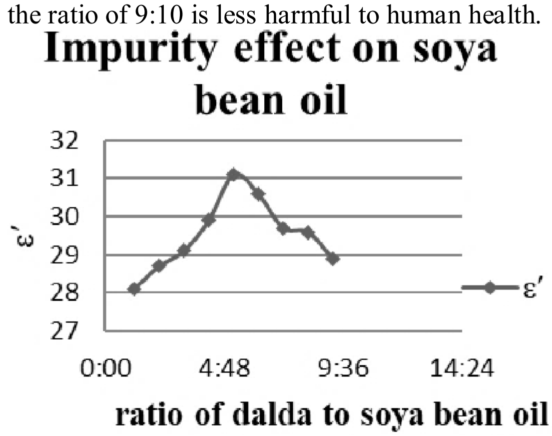

Figure 18:*ε' vs. ratio of dalda to soya bean oil at frequency 1KHz*

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Figure18 represents the plot of real part of the dielectric constant of impure soya bean at frequency 1 KHz. Overall figure reveals that, the dielectric constant increases on adding the impurity in the soya bean up to 5:10 representing peak value or critical value and on further adding the impurity in soya bean oil, the real part of dielectric constant of soya bean oil decreases. This result is similar with the result of olive oil and sunflower oil. In the case of soya bean oil, the critical ratio is 5:10 which is harmful to human health.

Conclusion

Among all the oils studied here, dielectric constant of soya bean oil is very high and dielectric constant of mustard oil is low. On increasing the temperature of samples, both real and imaginary part of dielectric constant increase in both frequencies and the degree of deterioration of oils is high at 90°C and low at room temperature. The dielectric constant of all samples increases with increase in the number of heating cycles. It is concluded that mustard oil is better than other oils for cooking and frying foods.

Acknowledgements.

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