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MOISTURE DEPENDENT DIELECTRIC PROPERTIES OF INDIAN RICE SEEDS

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Abstract:- The moisture dependent dialectical properties of Gandhsala and Sona masuri rice seeds have been reported in the present paper. The dielectric constant, dielectric loss and conductivity have been measured for these two rice varieties over the temperature range 30° C- 48°C at varying frequency i.e. from 5 KHz to 2 MHz. The measurements have been carried out using Hewlett-Packard (HP-4194A) impedance gain phase analyser. The electrical properties were found to decrease with increase in frequency and increase with moisture content. The electrical properties for Gandhsala and Sona Masuri seed have depicted graphically. This provides information not only on typical values of the dielectric properties, but also on their dependence on such variables.

Index Terms — **Dielectric constant, Dielectric loss, frequency, Moisture content.**

1. INTRODUCTION

The dielectric properties of foods and agro-based products are important in food engineering and technology. These properties are used to describe the behavior of materials when exposed to high- frequency electro-magnetic fields and also important in the design of equipments for radiofrequency or microwave dielectric heating applications and as indicators of their use for instantaneous non-destructive method of determining moisture content. Through the last years, many potential agricultural applications of electromagnetic heating for foods have emerged such as grain drying, seed treatment to improve seed germination and insect control in stored grain using high-frequency and microwave electric field. Preservation, moisture content determination, dry fruits by selective heating, preparation of microwaveable food, dielectric heating, sorting of food grains etc. can be achieved by valuable information of dielectric properties[1]. Factors that influence electrical parameters i.e. dielectric constant, dielectric loss and conductivity have been evaluated. Dielectric data has also been utilized for measuring the oil content in Soya bean and Sunflower[2] and study of metabolic mechanism[3]. Funebo et al. find out those dielectric properties of fruits and vegetables also depends upon the temperature and moisture content as well as on frequency of the applied field[4].

The dielectric properties of coarse-cereal grains are helpful in studying the viable test[5], metabolic mechanism of grains[6], furthermore in the designing of moisture sensing equipments for monitoring of moisture using electrical methods. The electrical parameters for many agricultural materials are affected by ionic conductivity[7], and water retention of cell[8]. Although a lot of work has been done on the dielectric properties of food grains outside India, there are very few reports of dielectric study of food grains of Indian variety. Therefore, it was considered to be of importance to study dielectric properties of food grains cultivated in India. The present paper reports dielectric properties of rice seeds of two varieties namely Gandhsala and Sona masuri in the temperature range of 30-48°C in the varying frequency range of 5 KHz to 2 MHz. In order to investigate the effect of moisture content on the dielectric properties of seeds, the measurements have been taken at five different moisture levels and at different frequencies in the grain material.

2. Materials and Methods

2.1 Material-Rice seeds namely Oryza Sativa L (Gandhsala and Sona masuri) have been procured from agro market Lucknow and International (P) LTS P.O. Box. 5 Lucknow respectively. The rice varieties selected due to their chemical compositon such as moisture, protein, fat, minerals, fiber and carbo-hydrate.

2.1.1 Sample preparation- The rice seeds were cleaned manually to remove foreign matter moisture contents in seeds were determined on wet basis. The different moisture content were adjusted by adding distilled water and conditioning of the sample at 20°C. The samples were subjected to frequent agitation to aid uniform distribution of moisture. These were kept in sealed jar at 20°C and allowed to reach at room temperature in sealed jars before opening for experiments. The samples were left in this condition for 24 hours before performing the experiment.

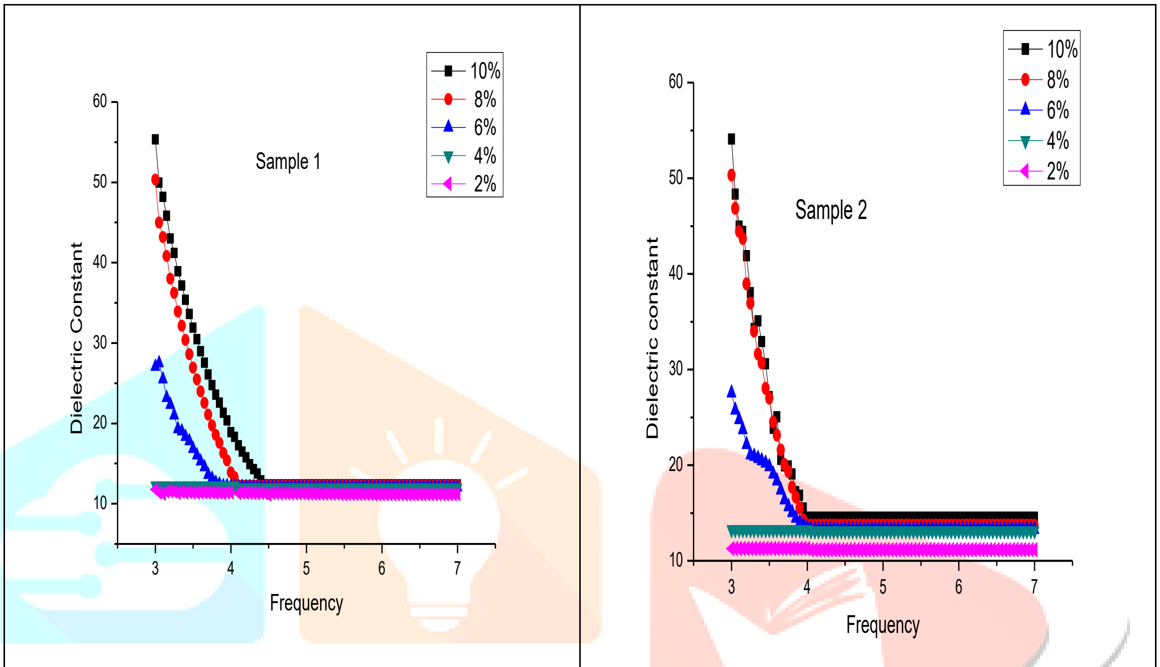
2.2Method- The capacitances (C_M) and dissipation factor (D_M) measurements have been made with the help of impedance/gain phase analyzer (Model No. -HP- 4194A, range of frequency 100 Hz to 40 MHz) using a specially designed open ended coaxial probe to measure permittivity of rice seeds. The sample holder has been silver plated to reduce dissipation losses. It was calibrated by using standard liquids (Benzene and Methanol) and error in measurement for dielectric constant (ε') was found to be + 1% and for dielectric loss (ε″) was 1.5%. The dielectric parameters and conductivity have been calculated with the help of formulae published by many researchers. (1,4,12).

3. Results and discussion-

The experimentally obtained values of dielectric constant (ε') dielectric loss (ε″) and electrical conductivity (σ) of Gandhsala and Sona masuri rice seeds over the frequency range 5 kHz to 2 MHz at various moisture content 2%, 4%, 6%, 8%, 10%.

3.1 Variation of dielectric constant with frequency

Fig. 3.1 represents the variation of dielectric constant with different frequencies at indicated moisture content, for Gandhsala, Sona masuri, rice varieties.

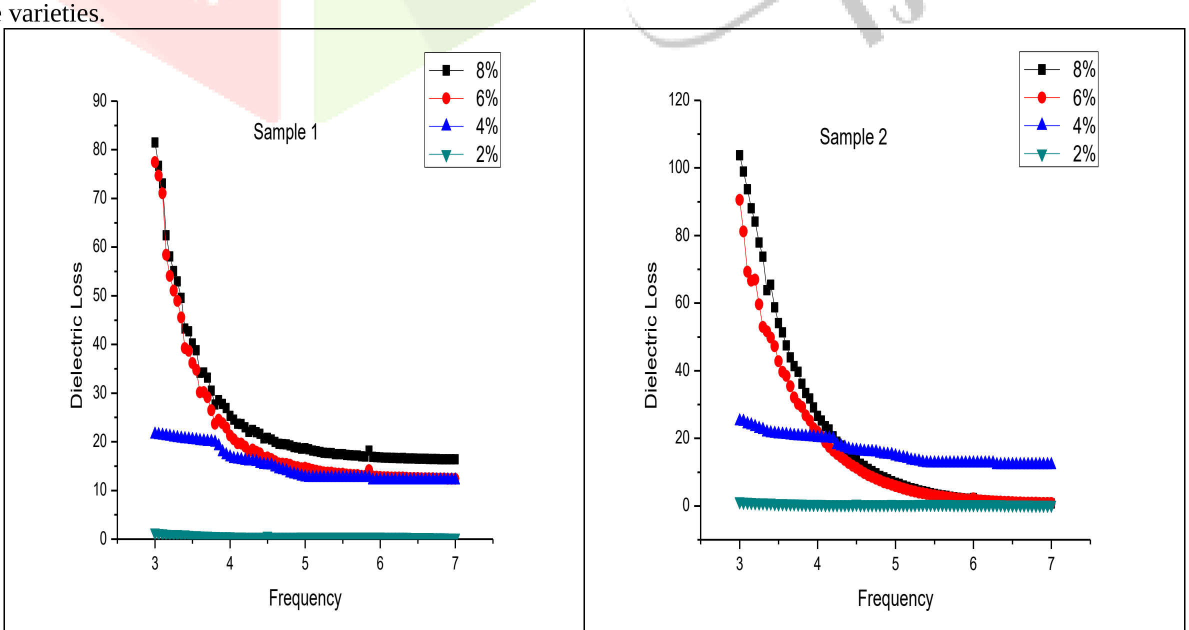


(a) Gandhsala | (b) Sona masuri

Fig.3.1: Variation of dielectric constant with different frequencies at indicated moisture content of different rice varieties.

3.2Variation of dielectric loss with frequency

Fig. 3.2 represents the variation of dielectric loss with different frequencies at indicated moisture content for Gandhsala and Sona masuri, rice varieties.



(a) Gandhsala | (b) Sona masuri

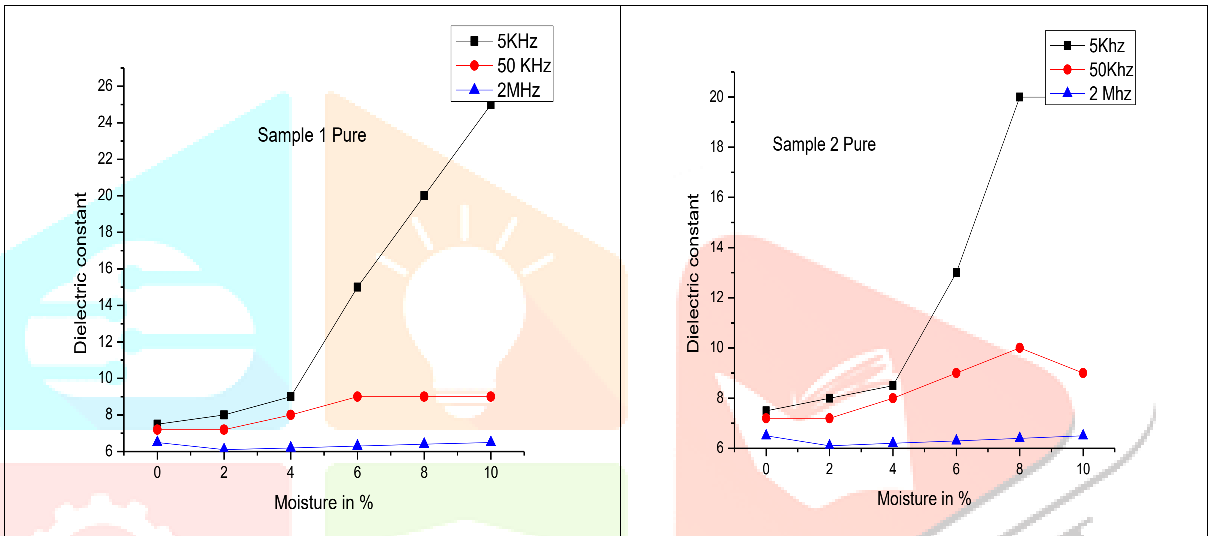
Fig.3.2: Variation of dielectric loss with different frequencies at indicated moisture content of different rice varieties.

Frequency dependence – From the fig. 3.1 and 3.2 it is observed that both the dielectric constant (ε') dielectric loss (ε″) of the dielectric parameters decreases with increase in the frequencies. This shows dielectric dispersion in the material at various frequencies. At lower frequencies and higher moisture content high values of dielectric constant obtained which attributed to high mobility of dipole for free water dipole, electrode polarization and increase in surface and ionic conductivity[10]. The correlation between dielectric loss and ionic conductivity is given by Magario and Yamaura[11]. At the lower frequency side the ionic loss becomes almost absent at higher frequencies because of dipolar energy dissipation, which is the predominant loss and ionic loss become almost absent. The electrical properties of the seeds and other food materials can be represented as combination of ionic and dipolar polarization losses.

The variation in dielectric constant and their corresponding dielectric loss at indicated frequencies exhibit that the changes in loss factor are comparatively less regular than the change in dielectric constant. Nelson noticed similar behaviour in corn seeds between the moisture range of 10 to 50% and frequency range of 1 to 11 GHz[12]. In other studies on wheat corn and Soybean over the frequency range of 1 to 200 MHz range similar types of behavior have been reported. The irregular behaviour of loss may be because of the complex nature of dielectric relaxation and dispersion phenomenon. From the figure 3.1 it is investigated that the curves divers and the separation increases between the curves for different moisture levels but as it moves to lower frequency range no change is found and it shows nearly straight line. Separation in Sona masuri is observed more than Gandhsala.

3.3Variation of Dielectric constant with moisture

Fig. 3.3 represents the variation of dielectric constant with different moisture content at indicated frequencies for Gandhsala, Sona masuri, rice varieties.

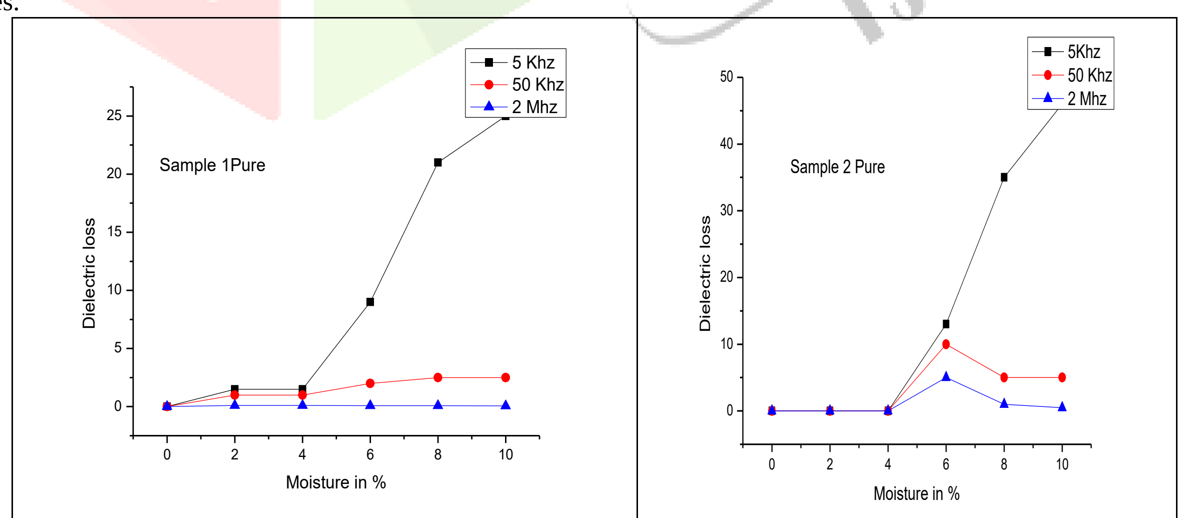


(a) Gandhsala.	(b) Sona masuri

Fig.3.3: Variation of dielectric constant with different moisture content at indicated frequencies of different rice varieties.

3.4 Variation of dielectric loss with moisture

Fig. 3.4 represents the variation of dielectric loss with different moisture content at indicated frequencies for Gandhsala, Sona masuri, rice varieties.



(a) Gandhsala	(b) Sona masuri

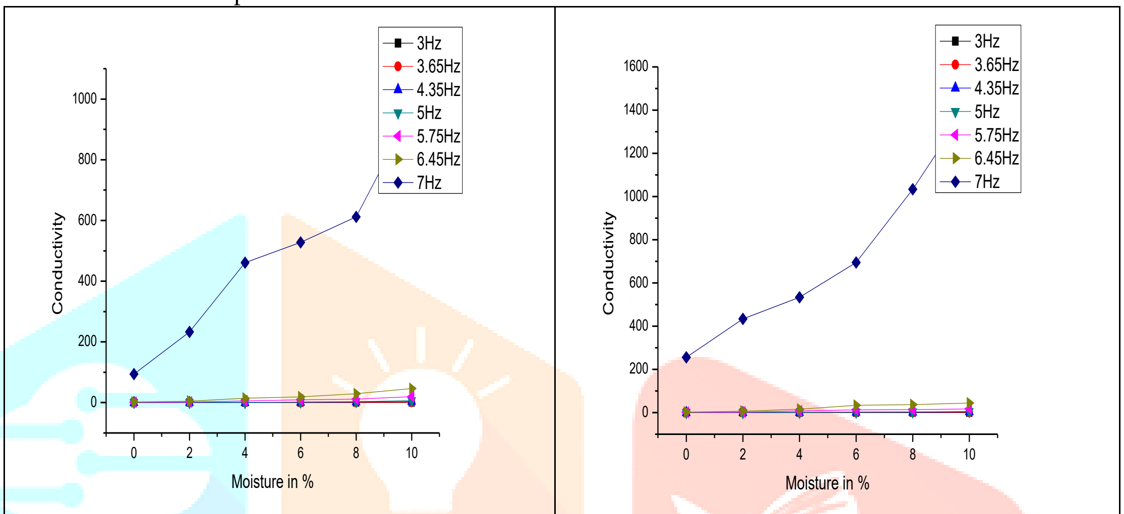
Fig.3.4: Variation of dielectric loss with different moisture content at indicated frequencies of different rice varieties.

Moisture dependence- It is clear from the fig. 3.3 and 3.4 that the dielectric permittivity increases with increase in the moisture content for provided frequency and temperature. It is noticed that the rate of increase in dielectric constant (ε') dielectric loss (ε″) is achieved high at 5KHz and 50KHz. This is inferred from the fact that at high moisture level more water dipoles contribute to the polarization, due to high water mobility, reason is that the water dipoles easily follow the applied field variations. At low moisture contents, particularly below 4% both ε’ and ε″ of the complex permittivity are small. This is due to the strong bound water state (monolayer) where distance between the water molecule and cell wall is very small and attraction force is very large. Therefore the dielectric constant and dielectric loss both are small. As moisture level increases beyond 4% increase in the both the, ε’ and ε″ of the complex permittivity increases and this trend could be attributed to change of bound water state from first (monolayer) to second (multilayer) type. Sharp increase is observed for all the given frequencies for the moisture content reaching beyond 6%. At low frequency the ionic conductivity is high therefore for such moisture level and low frequencies, the dielectric losses are considerably high. At high moisture content particularly when moisture content is 10% and frequency is below 10 KHz samples exhibits very high values of ε′ and ε″. Sona masuri also show irregular jump at 6% moisture content at 50 KHz and 2MHz frequencies. Graph for Sona masuri is found slightly different from Gandhsala. Separation between the curves is greater than Gandhsala variety.

3.5Conductivity measurements properties of food materials.

3.5.1 Variation of conductivity with moisture at temperature 30°C

Fig. 3.5 represents the variation of conductivity with different moisture content at indicated frequencies for Gandhsala and Sona masuri, rice varieties at constant temperature 30°C.

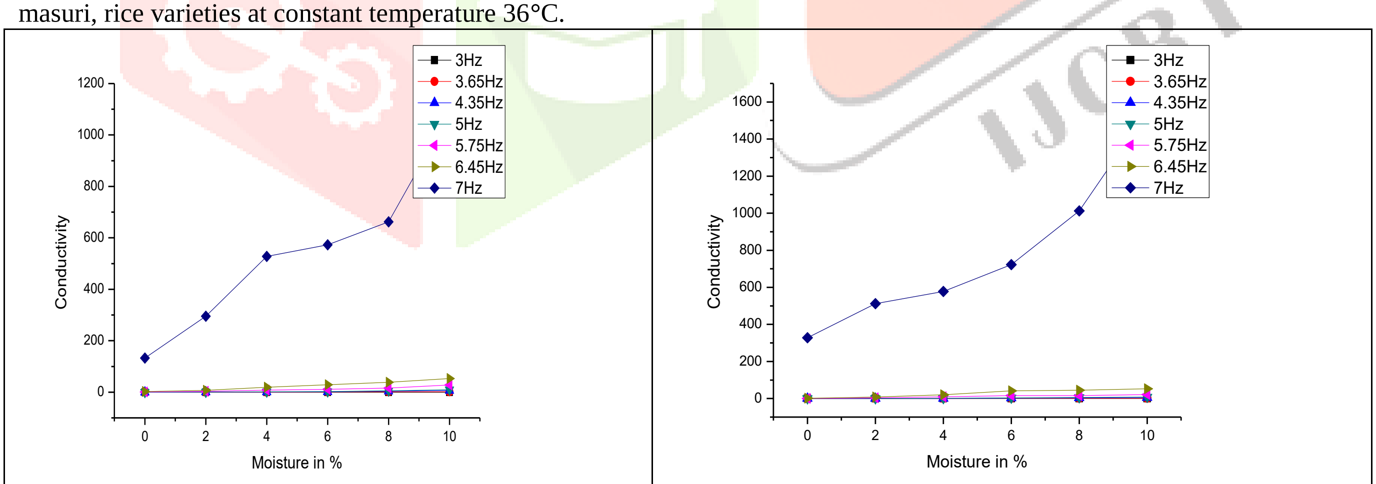


(a) Gandhsala. **(b) Sona masuri**

Fig.3.5 Variation of conductivity with different moisture content at indicated frequencies of different rice varieties.

3.5.2 Variation of conductivity with moisture at temperature 36°C

Fig. 3.6 represents the variation of conductivity with different moisture content at indicated frequencies for Gandhsala and Sona masuri, rice varieties at constant temperature 36°C.

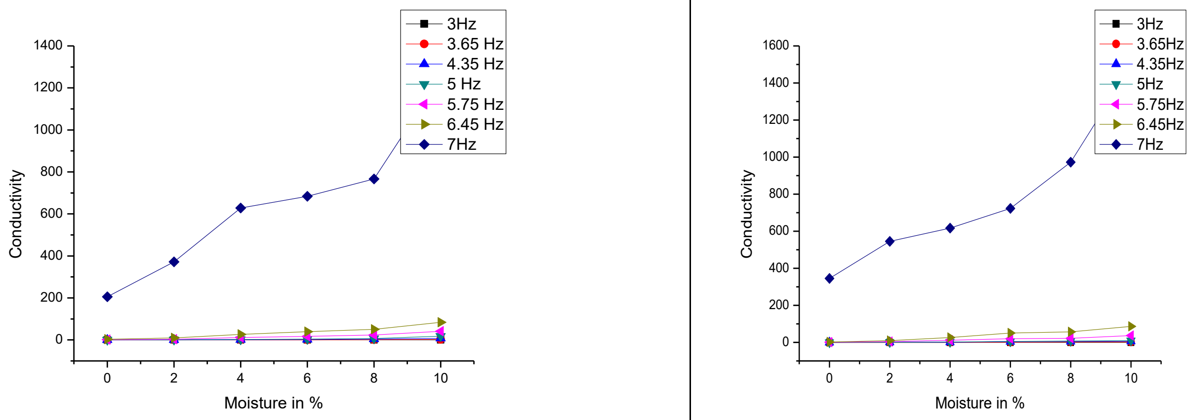


(a) Gandhsala. **(b) Sona masuri**

Fig. 3.6: Variation of conductivity with different moisture content at indicated frequencies of different rice varieties.

3.5.3 Variation of conductivity with moisture at temperature 42°C

Fig. 3.7 represents the variation of conductivity with different moisture content at indicated frequencies for Gandhsala and Sona masuri, rice varieties at constant temperature 42°C.

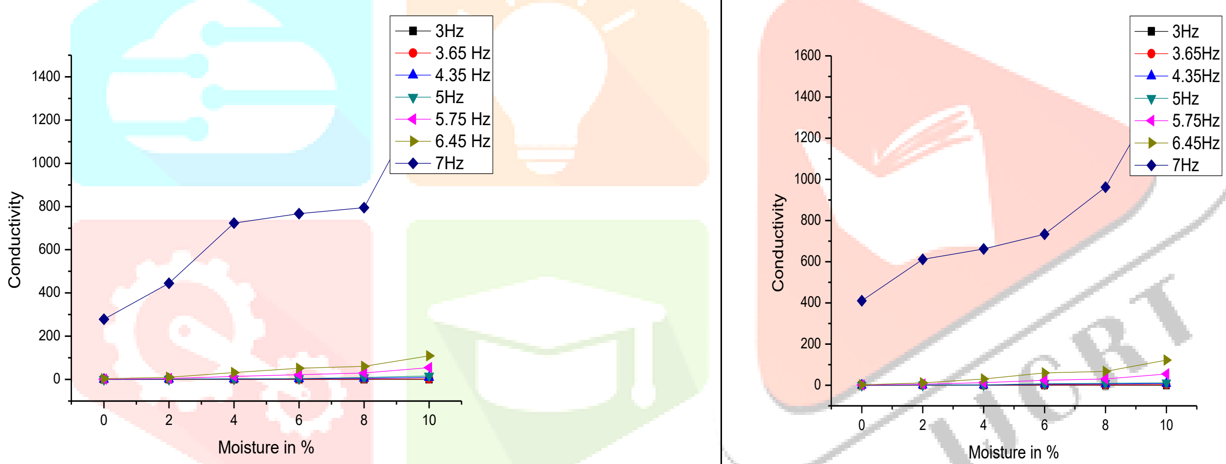


(a) Gandhsala **(b) Sona masuri**

Fig.3.7:Variation of conductivity with different moisture content at indicated frequencies of different rice varieties.

3.5.4 Variation of conductivity with moisture at temperature 48°C

Fig. 3.8 represents the variation of conductivity with different moisture content at indicated frequencies for Gandhsala and Sona masuri, rice varieties at constant temperature 48°C.



(a) Gandhsala **(b) Sona masuri**

Fig.3.8: Variation of conductivity with different moisture content at indicated frequencies of different rice varieties.

The numerical value for electrical conductivity over the frequency range of 3Hz to 7Hz, moisture content 0%, 2%, 4%, 6%, 8% ,10% and temperature range of 30-48°C for four rice varieties Gandhsala and Sona masuri, are presented in fig. 3.5 to 3.8. It is evident from the graph 3.5-3.8 that the electrical conductivity for all the two rice varieties under investigation increases with increase in moisture content, temperature and frequency. Increase with the frequency lies in the definition of electrical conductivity, which is defined as

$$(\sigma = \omega \times \varepsilon_0 \times \varepsilon'') = 55.63 \times 10^{-12} f \varepsilon'' \text{ micro ohm}^{-1} \text{ cm}^{-1}.$$

In this formula the electrical conductivity (σ) is directly proportional to frequency (f) and dielectric loss (ε″) factor. As previously observed, the dielectric loss factor increases with moisture content, therefore on account of the relationship between ε″ and σ, the electrical conductivity also increases with moisture content.

4. Conclusion

The dielectric constant (ε’) dielectric loss (ε″) of the dielectric parameters decreases with increase in the frequencies.
The dielectric permittivity increases with increase in the moisture content for provided frequency and temperature.
The electrical conductivity for all the two rice varieties under investigation increases with increase in moisture content, temperature and frequency.

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