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Research Article

DIELECTRIC SPECTROSCOPY OF PROSO MILLET *(Panicum miliaceum)* AT SINGLE FREQUENCY USING VARIOUS TEMPERATURE

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ABSTRACT
The effect of packing density, moisture content and temperature on dielectric parameters such as dielectric constant (ε'), dielectric loss (ε''), loss tangent (tanδ), relaxation time (τ_p), conductivity (σ_p) for Presso Millet was assessed. We used 9.85 GHz single frequency to measure the dielectric properties of selected sample. The scientific name of Proso millet is Panicum Milliaceurs and related to Poaceae family. It germinates in warm climate between 10 to 45°C. The climate for yield production Kharif-1 July with onset of minor rain. It has rich source of vitamin Cherin B-complex vitamin and folic acid it also contains P, Ca, Zn, Fe and like methenamine and cysteine. It supports the neural health system, high lecithin phospholipid. Due to this reason the sample is taken for dielectric study. The results show that, there was a systematic increase in dielectric constant (ε') and loss factor (ε'') with increasing values of relative packing fraction (δ_r) and decrease in dielectric constant and loss factor with increasing temperature. Experimental results of different relative packing fractions were further used to obtain transformation to 100% solid bulk using correlation equations of Landau-Lifshitz- Looyenga and Bottcher. There is a fair agreement between experimental values and theoretical values of different dielectric parameters.

Keywords: *Dielectric constant, Loss, Relaxation time, Conductivity, Temperature, Proso Millet*

INTRODUCTION
In view of the applications of the dielectric properties of agricultural -vegetable product in microwave heating such as processing or cooking and in using their properties for non-destructive sensing of moisture content studies of the dielectric properties such materials are of considerable interest. The dielectric properties of usual interest are the dielectric constant (∈') and the dielectric loss factor (∈''). The permittivity of water is very high about 80 at low frequencies compared to about 3 for grain dry matter. For sensing moisture, it is important to know the dependence of the dielectric properties on moisture content and generally the dielectric constant always increases with increasing moisture content and generally the dielectric loss factor does well. Knowledge of variation of dielectric properties with frequency as well as with the temperature is important in designing the moisture – sensing instrument. In addition to frequency, moisture content and temperature, the bulk density[2] is an important factor influencing the dielectric properties. As the bulk density of sample increases, additional mass is present to react with fields. Consequently, the dielectric constant and loss will increase. Thus, all these factors are very important in designing and calibrating instruments for measuring grain moisture content.
Proso millet, also known as *Panicum miliaceum*, is a type of cereal grain that is grown in various parts of the world, including India, China, and parts of Europe. It is an annual, herbaceous plant that is known for its ability to grow in diverse climates and soil conditions. Proso millet is a nutritious grain, rich in fibre, protein, and various vitamins and minerals. It is also naturally gluten-free, making it a suitable option for individuals with celiac disease or gluten intolerance.

Botanical Description: Proso millet is an erect, tillering plant that can grow up to 45-100 centimetres tall. It has slender, linear leaves and a much-branched panicle inflorescence. The seeds vary in colour, including creamy white, yellow, red, or black.

Nutritional Value: Proso millet is a good source of dietary fibre, both soluble and insoluble, which aids in digestion. It also provides a moderate amount of protein and is rich in vitamins and minerals like iron, calcium, magnesium, phosphorus, and B vitamins.

Health Benefits: Proso millet is known for its potential health benefits, including its ability to help regulate blood sugar levels due to its low glycaemic index. It may also contribute to heart health by helping to raise HDL (good) cholesterol levels.

Culinary Uses: Proso millet can be used in a variety of dishes, including breakfast porridges, salads, soups, and as a side dish. It can also be used to make traditional Indian dishes like upma, dosa, and Pongal.

Cultivation: Proso millet can be grown in various soil types, including sandy loam and slightly acidic soils. It is relatively drought-tolerant and can be cultivated in both rainfed and irrigated conditions.

Other Names: Proso millet is also known by different names in various regions, such as "Panivaragu" in Tamil Nadu, "Baragu" in Kannada, and "Chena" in Hindi.

Physical Properties:

The behaviour of dielectric substance is changed by the ap plication of external electric field. The important concept in dielectric theory is that of an electric dipole moment which is measure of electrostatic effect of a pair of opposite charges separated by a finite distance. By using the Clausius-Mossotti equation, which leads to complex number for relative permittivity. By convention, we generally write the complex dielectric constant as,

$$\in_r = \in'_r - j \in''_r \quad \text{……..(5)}$$

where, $\in'_r$ - is the real part and $\in''_r$ - is the imaginary part.

The dielectric parameters are generally dependent on frequency, temperature, density and other factors such as mate rial structure and composition. In this paper influence of temperature and density and dielectric parameters and thermodynamic parameters are reported. For the development of the field such as dielectric heating effect in germination and early growth of agri-products, improvements in nutritional quality, stored grain insect control, drying of grains, sterilization of grains etc. It is important to know the actual process of molecular level. To get some information in this direction we have undertaken the study of some millets.

MATERIAL AND METHODS

For the determination of dielectric and thermodynamic parameters of pulses four samples were prepared by using sieves of different sizes. All the samples transferred into the glass bottles and labelled according to their grain size. To determine the relative packing factor (δ) densities for each powder sample is measured. Measurement of dielectric parameters ($\in'$) and ($\in''$) for these powder samples of different packing fractions were carried out using reflectometer technique at 9.85 GHz. [11,12,13] microwave frequency and at temperature (20°C to 50°C). But in this paper, we have noted the values of dielectric parameters for smallest grain size i.e. 62.5-micron particle size which can be considered as solid bulk at a 98 N force. For the accurate measurements of wavelength in dielectric (λ_d), sample is introduced in the dielectric cell in steps. Applying constant force on the sample, each time the corresponding output power is measured by using crystal pick in the directional coupler. The relationship between reflected power and the sample height is approximately given by a sampled sinusoidal curve. The distance between two adjacent minima of the curve gives half the dielectric wavelength (λ_d).

Determination of molecular parameters*:*

The dielectric constant ($\in'$) and loss factor ($\in''$) for the red gram powder at microwave frequency are determined by using relations [7,8,9.]

$$\in' = \left(\frac{\lambda_0}{\lambda_c}\right)^2 + \left(\frac{\lambda_0}{\lambda_d}\right)^2 \quad \text{........(1)}$$

$$\in'' = \frac{1}{\pi}\left(\frac{\lambda_0}{\lambda_d}\right)^2 \alpha_d \beta_d \quad \text{............(2)}$$

Where,
λo = is free space wavelength,
λd = is wavelength in dielectric
λc = is cutoff wavelength of the wave guide
λg = is guide wavelength
The conductivity (σp) and relaxation time (τp) are obtained by using following relations,

$\sigma p = \omega \in 0 \in''$…….(3)

$\tau p = \in'' / \omega \in'$ ………. (4)

Using relation (1) and (2) values of dielectric constant ∈'p and dielectric loss ∈''p different temperatures are obtained. The values of conductivity (σp) and relaxation time (τp) are obtained using the above relations (3) and (4). The values of ∈'s and ∈''s for bulk materials can be co-related for powder by using the relations given by Bottcher and Landau-Lifshtz Looyenga [4,10,11,12,.]

RESULT AND DISCUSSION

Table 1: Values of output power with plunger position (x) for different relative packing fractions (δ_r) and temperature

Relative Packing fraction	**20°C**		**35°C**		**50°C**	
(δ_r)	**Plunger position (x) mm**	**Output Power (I) µA**	**Plunger position (x) mm**	**Output Power (I) µA**	**Plunger position (x) mm**	**Output Power (I) µA**
	17.32	6.0	17.16	5.8	17.00	3.8
	28.25	4.2	26.83	0.9	25.50	1.8
0.9546	38.00	0.6	37.15	0.3	30.75	1.2
	50.12	0.2	47.52	0.1	39.25	0.9
	16.62	5.4	16.76	4.3	13.50	3.5
	27.12	2.3	26.90	0.7	22.50	1.1
0.791	36.23	1.0	37.58	0.4	30.25	0.8
	47.21	0.1	48.36	0.1	39.01	0.2
	15.00	5.0	17.13	4.2	13.25	4.6
	26.19	2.0	27.20	0.4	22.15	3.3
	35.02	1.8	37.18	1.2	30.25	1.0
1.000	47.10	0.1	47.56	0.1	38.17	0.3

Values of dielectric constant (∈'), dielectric loss (∈"), relaxation time (τ) and conductivity (σ) of Proso millet powder are presented in Table 1. An examination of Table - 1 indicates that, there is a decrease in ∈', ∈", relaxation time and conductivity values with the increase of temperature. Such behaviour is expected because according to Debye, when polar molecules are very large then under the influence of electromagnetic field of high frequency, the rotary motion of polar molecular of system is not sufficiently rapid to attain equilibrium with the field. The decrease in relaxation time with increased values of temperature due to increase in effective length of dipole. Again, increase in temperature causes an increase in energy loss due to large number of collisions and there by decrease the relaxation time. Graphical representation of ∈', ∈", relaxation time and conductivity for different temperature (20°C to 50°C) are shown in figure 1 to 4. In the present study, it is observed that there is a fair agree ment between experimental values and theoretical values. Hence, it may be predicted that the Proso millet powder form shows large cohesion in its particles and may serve as a continuous medium.

Values of wavelength in dielectric (λ_d) and $\left(\frac{d\rho}{dn}\right)_{mean}$ (i. e. slope of graph between VSWR (1/ρ) and powder length $\left(n\frac{\lambda_d}{2}\right)$ along with relative packing fraction (δ_r) at temperature 20°C to 50°C.

The operating frequency *(f)* = 9.850 GHz

The free space wavelength (λ_o) = $\left(\frac{C}{f}\right)$ = 3.061 cm

The cutoff wavelength of the wave guide λ_c =2a = 4.572 cm

The guide wavelength λ_g for empty cell = 3.550 cm

Forward current (I_f) = 117µA

Table 2:

Relative Packing fraction	**20°C**		**35°C**		**50°C**	
(δ_r)	**λ_d (cm)**	$\frac{d\rho}{dn}$	**λ_d (cm)**	$\frac{d\rho}{dn}$	**λ_d (cm)**	$\frac{d\rho}{dn}$
0.9546	2.101	0.165	2.107	0.140	2.116	0.125
0.9791	2.015	0.170	2.029	0.148	2.038	0.132
1.000 **(Solid bulk)**	2.010	0.179	2.024	0.157	2.030	0.144

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Graphical representation:

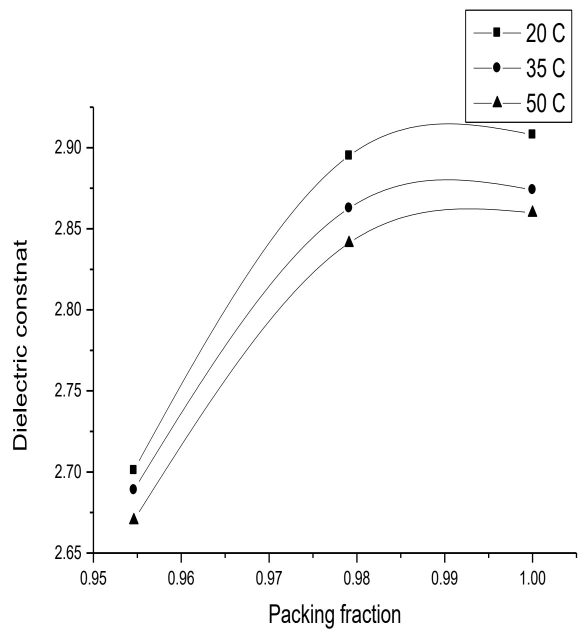

Fig. 1: Packing fraction Vs Dielectric constant

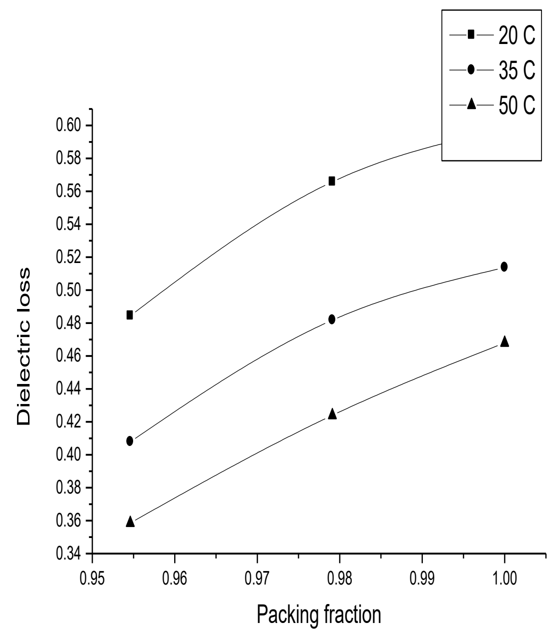

Fig. 2: Packing fraction Vs Dielectric loss

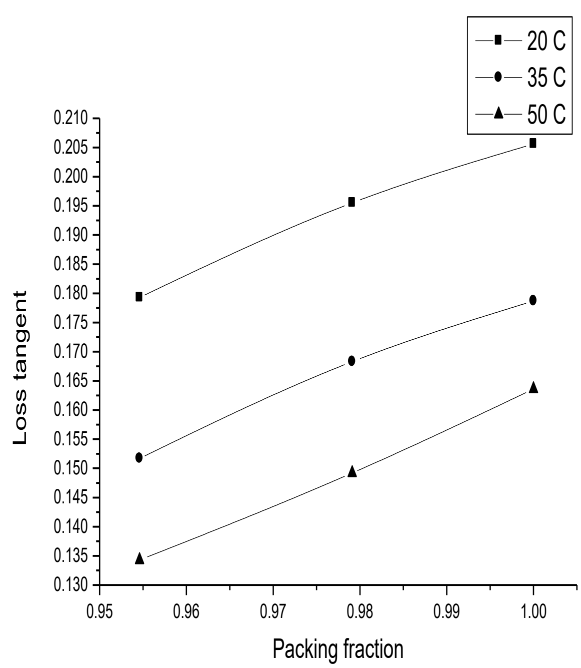

Fig. 3: Packing fraction Vs Loss tangent

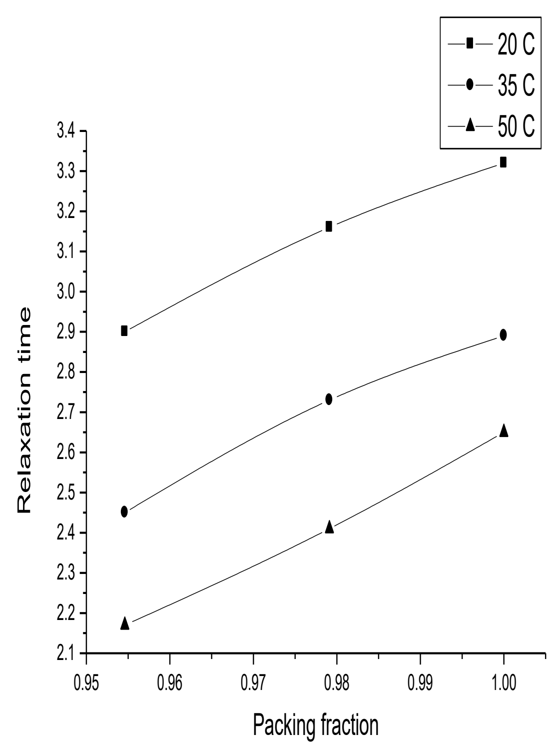

Fig. 4: Packing fraction Vs Relaxation time

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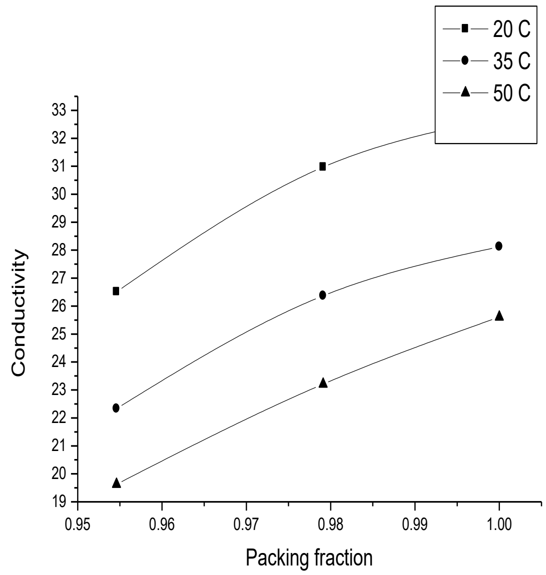

Fig. 5: Packing fraction Vs Conductivity

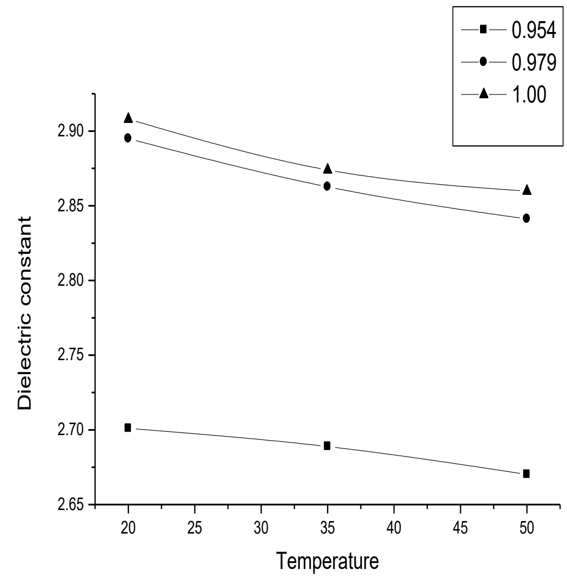

Fig. 6: Temperature Vs Dielectric constant

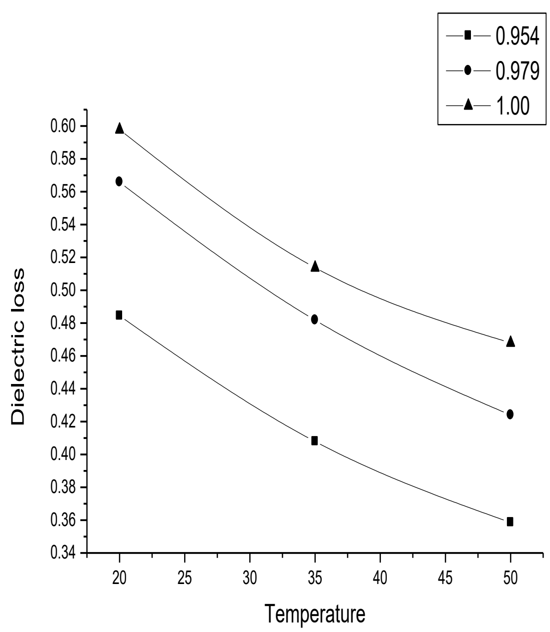

Fig. 7: Temperature Vs Dielectric loss

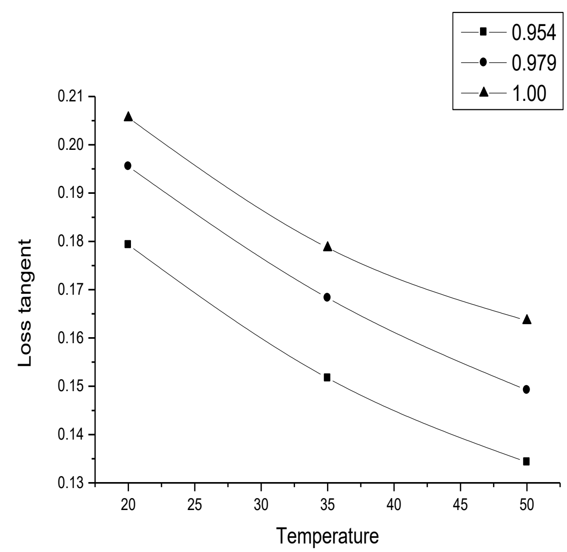

Fig. 8: Temperature Vs Loss tangent

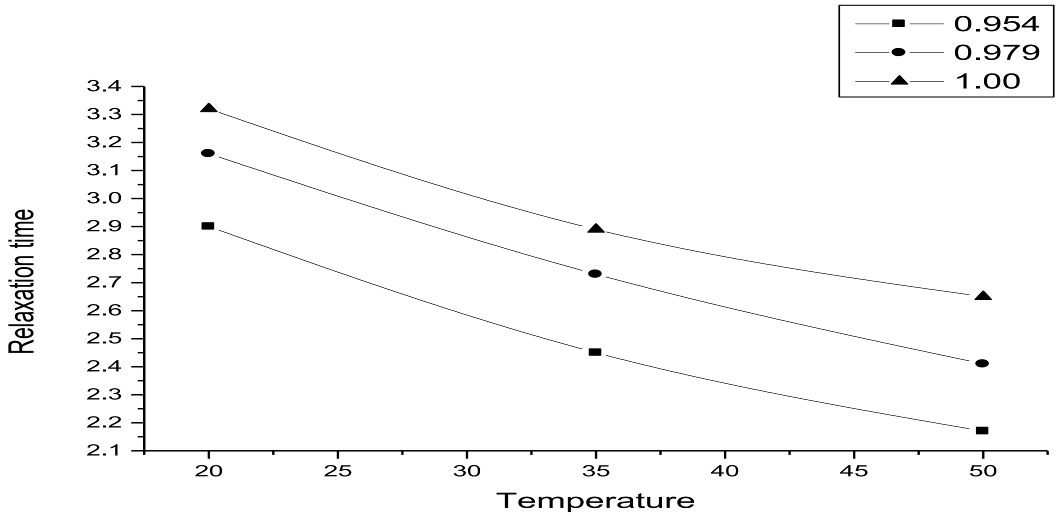

Fig. 9: Temperature Vs Relaxation time

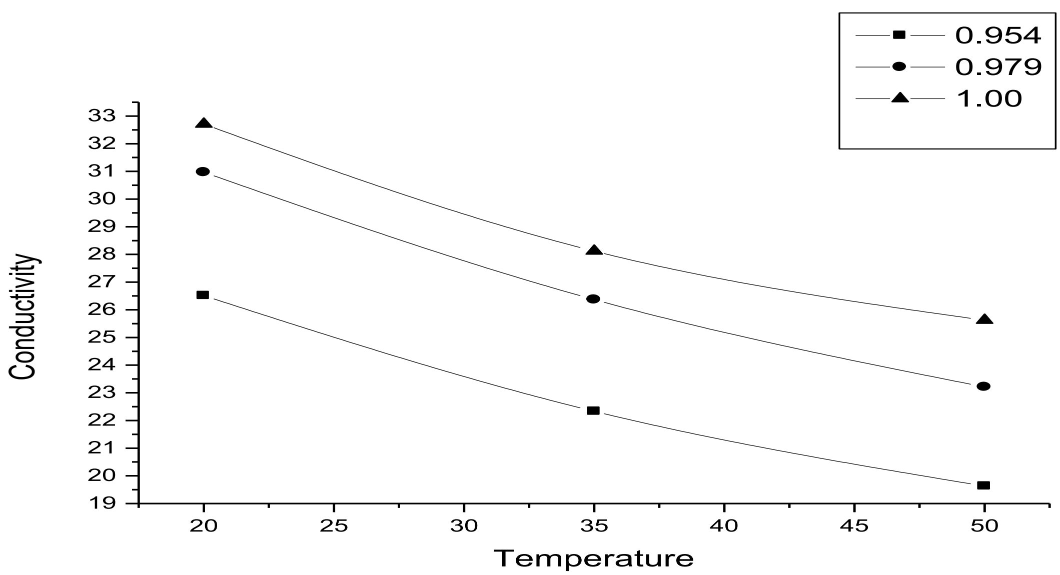

Fig. 10: Temperature Vs Conductivity

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