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Dielectric study of *Syzygium cumini* Lin. at 9.85 GHz frequency.

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Abstract

The values of dielectric constant ($\in'$), dielectric loss ($\in''$), relaxation time (τp), conductivity (σp) and moisture content of pulverized *Syzygium cumini* Lin. were measured for different packing densities at 9.85 GHz microwave frequency and different temperature (20°c, 35°c and 50°c). Experimental results on powders of different packing fractions (δr) were used to obtain transformation to 100% solid bulk using correlation formulae of Landau- Lifshitz-Looyenga and Bottcher. There is fair agreement between the calculated values of dielectric parameters and the values obtained experimentally for solid bulk. This shows cohesion in the particles of spicy products under investigation.

Keywords: *Syzygium cumini*, Dielectric constant, Dielectric loss, Conductivity, Moisture content.

INTRODUCTION

The evergreen *Syzygium Cumini* plant is originally from Indonesia and India; it now grows abundantly in Suriname. The juicy fruit-pulp contains resin, gallic acid and tannin; it tastes usually from acid to fairly sweet. The somewhat astringent, *Syzygium Cumini* fruit can be utilized for juice. The berry has one seed, although a tropical tree it grows easy in sub-tropical climate, it starts bearing fruit in 4-7 years. The fruit and seeds are sweet, acrid, sour, tonic and cooling used in diabetes, diarrhea and ringworm. The *Syzygium Cumini* fruit seeds bark and its content complex chemical compounds such as nutritive value per 100 gm. All parts of the Java plum can be used medicinally and it has a long tradition in alternative medicine.

In India the seed and bark is used for diabetes which reduces the blood sugar level quickly, the fruit for dysentery, blood pressure. Medicinally, the fruit is stated to be astringent, stomachic, carminative, antiscorbutic and diuretic. Cooked to a thick jam, it is eaten to alloy acute diarrhea.

The juice of the ripe fruit or a decotion of the fruit or *Syzygium Cumini* vinegar may be administered in India in cases of enlargement of the spleen, chronic diarrhea and Urine retention.For the development of microwave process control, it is important to know the dielectric properties of medicinal materials and the actual process at molecular level. The dielectric properties of materials and their constituents describe their interactions with microwave energy [1, 8, 10 and 11] and depend on the frequency of electromagnetic field as well as materials (packing fractions, moisture content, temperature and composition of the material).

Moisture content is important parameter of pulverized medicinal products affecting their suitability for storage, transport and processing, if the products are stored at high moisture content they can spoil because of action of micro-organism and the value is degraded. Therefore, it is essential to determine the moisture content.

Different workers [2, 5, 6 and 13] have tried to correlate dielectric behavior of bulk materials and their powders. Due to non-availability of required size of bulk materials for mounting in wave - guide brings restrictions for the analysis. Landau- Lifshitz-Looyenga and Bottcher [3, 9 and 10] have given useful relations to correlate dielectric behavior of bulk materials and their powder form. The dielectric properties of corn and wheat kernals and soybeans were studied by Nelson [9] and Bansal et al. [1].

In the present paper, dielectric properties of *Syzygium Cumini* were determined at various packing fractions and temperatures. The effects of temperature and density on the dielectric parameter were reported. We correlated dielectric parameter of powder with solid bulk. This type of correlation is useful because it makes possible to correlate without the necessity of making big enough samples of the bulk materials for the dielectric measurement. We compared measured values with the values obtained from the correlation formulae between powder and bulk derived independently by Landau-Lifshitz-Looyenga and Bottcher [9].

MATERIALS AND METHODS

The dielectric constant ($\in'$), and dielectric loss ($\in''$), were measured by using reflectrometric technique [4, 5, 12, 13] of measuring the reflection co-efficient from the air dielectric boundary of the sample in the microwave X – band at 9.85 GHz frequency and at different temperatures (20°c, 35°c and 50°c). The following relations were used to determine the dielectric parameters of materials.

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

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

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Where,

$\lambda 0$ – is the wavelength in free space.
$\lambda c = 2a$ – is the cut-off wavelength of the waveguide.
a – is the broader dimension of the rectangular waveguide.
αd – is the attenuation introduced by the unit length of the materials.
$\beta d = 2\pi / \lambda d$ - is the phase shift introduced by the unit length of the dielectric material.
λd – is the wavelength in dielectric powder.

To determine relative packing fractions (δr), density (ρ) for each sample is measured. The moisture percentage of material is measured using thermo-gravimetric method [14]. For accurate measurement of dielectric wavelength (λd), the dielectric cell is designed and fabricated by Kalamse [6] is used. Such that one can introduce the sample in the cell conveniently by simply raising up the plunger without taking it outside the cell.

For the determination of dielectric parameters of *Syzygium cumini*, three particle sizes were prepared by using sieves of different sizes. For the comparison of correlation formulae between powder and bulk, the packing fractions (δr) is taken as the ratio of density of powder and the density of the finest crushed closely packed particle assembly of the spicy products. The conductivity (σp) and relaxation time (τp) were obtained by using the following equations.

$$\sigma_p = \omega \in_0 \in'' \qquad \text{.......... ... (3)}$$

$$\tau_p = \frac{\in''}{\omega \in'} \qquad \text{.......... (4)}$$

Where,

ω - is the angular frequency of measurement 9.85 GHz.
ε_o - is the permittivity of vacuum.

RESULTS AND DISCUSSION

Dielectric constant ($\in'$), and dielectric loss ($\in''$), along with the values of relative packing fraction (δr) of medicinal are listed in table (1). The values of ($\in' p$) and ($\in'' p$) obtained experimentally for different grain sizes and temperatures show that there is systematic increase in dielectric constant ($\in' p$) and loss factor ($\in'' p$) with increasing values of relative packing fraction (δr) and there is systematic decrease in ($\in' p$) and ($\in'' p$) with increasing temperature. This is expected because with higher values of relative packing fraction the interparticle hinderance offered to the dipolar motion of the material in an electromagnetic field at microwave frequencies for compact medium will be much higher than for a material constituting less bounded particles. Such observation has already made by other workers [1, 2, 5, 6, 11] for higher values of packing fraction.

An examination of values of relaxation time (τp), loss tangent ($Tan\delta$), conductivity (σp), moisture content values with relative packing fraction and different temperatures revealed that there is systematic increase in σp, τp, and $Tan\delta$ with the increasing values of packing fraction (δr) and temperature. There is systematic decrease in σp, τp, and $Tan\delta$ and moisture content with increasing values of temperature. Such behaviour is expected because when polar molecules are very large, due to increasing hindrance to the process of polarization, the rotatory motion of the molecules is not sufficiently rapid for the attainment of equilibrium with the field. The increase in conductivity suggests that at higher compactions, no micro cracks are developed in the sample due to high mechanical pressure. The decrease in relaxation time (τp) with increase in temperature may be due to increase in the effective length of dipole. Again, due to increasing temperature number of collision increase causes increase in energy loss and thereby decreasing relaxation time.

The table shows list of measured and computed values of dielectric parameters for bulk from powder measurements. The result show at $\delta r = 1$ are those measured on the finest crushed powder sample packed very closely in a wave guide cell pressing it under a fixed pressure, so as to obtain minimum voids between the particles. Out of three powder samples of different packing fractions, the samples having minimum particle size is defined as finest which is about 0.70 micrometer. In this case we assumed it as solid bulk for getting correlation between powder and solid bulk. The correlation formulae were used to find other values for $\delta r > 1$. The bulk values obtained for ($\in' p$) and ($\in'' p$) are same to the measured values calculated from Landau-Lifshitz-Looyenga formulae [9] and closer to the values calculated from Bottchers formulae [3].

Table 1. Dielectric constant (Є'), dielectric loss (Є''), relaxation time (τp), conductivity (σp) and moisture percentage of *Syzygium Cumini* powder at different temperature and packing fraction (δr)

Temp ºC	Packing Fraction (δr)	Є'	Є''	tanδ	τp (p.s.)	Σp (10^{-2})	Moisture (%)
20	0.8601	2.329	0.195	0.084	1.35	10.66	0.768
	0.9536	2.353	0.204	0.086	1.40	11.14	0.715
	1.00	2.407	0.235	0.097	1.58	12.85	0.508
35	0.8601	2.285	0.156	0.068	1.10	8.52	1.193
	0.9536	2.331	0.175	0.075	1.20	9.57	1.06
	1.00	2.382	0.225	0.094	1.52	12.33	0.792
50	0.8601	2.231	0.108	0.048	0.77	5.91	0.761
	0.9536	2.323	0.138	0.059	0.96	7.55	0.690
	1.00	2.352	0.217	0.082	1.30	10.00	0.495

Table 2. Measured and calculated values of dielectric constant (Є'), and dielectric loss (Є") for bulk from powder of *Syzygium Cumini* at different temperatures and packing fraction. (δr)

Temp ºC	Relative Packing Fraction (δr)	Є' For solid bulk			Є"For solid bulk		
		Measured	Calculated From Bottcher's Formula	Calculated From Landu, et al formula	Measured	Calculated From Bottcher's formula	Calculated From Landu, et al formula
20	0.8601	----	2.608	2.593	----	0.244	0.240
	0.9536	----	2.435	2.422	-----	0.218	0.217
	1.00	2.407	2.407	2.398	0.235	0.235	0.235
35	0.8601	----	2.552	2.543	-----	0.195	0.192
	0.9536	----	2.433	2.423	----	0.188	0.187
	1.00	2.382	2.383	2.381	0.225	0.225	0.225
50	0.8601	----	2.529	2.520	----	0.135	0.133
	0.9536	-----	2.404	2.398	----	0.148	0.147
	1.00	2.352	2.325	2.351	0.217	0.218	0.218

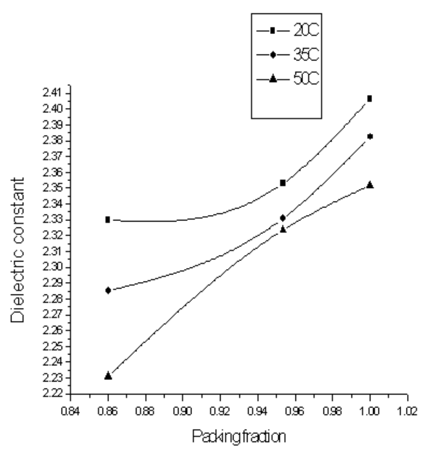

Fig 1.Packing fraction Vs Dielectric constant

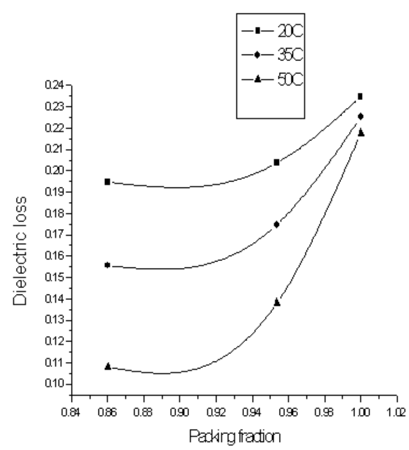

Fig 2. Packing fraction Vs Dielectric loss

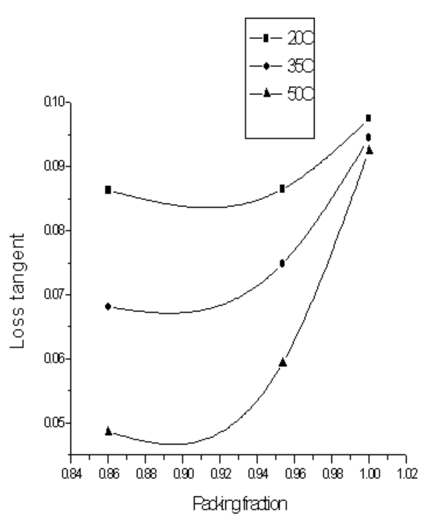

Fig 3. Packing fraction Vs Loss tangent

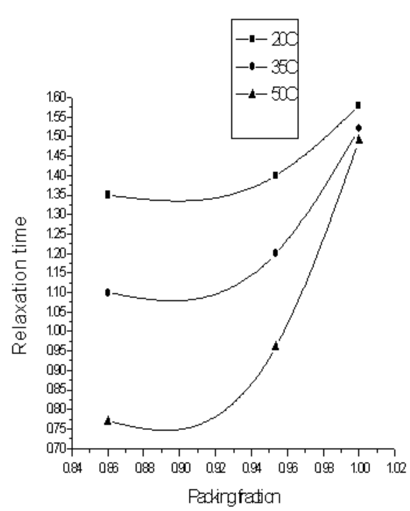

Fig 4. Packing fraction Vs Relaxation time

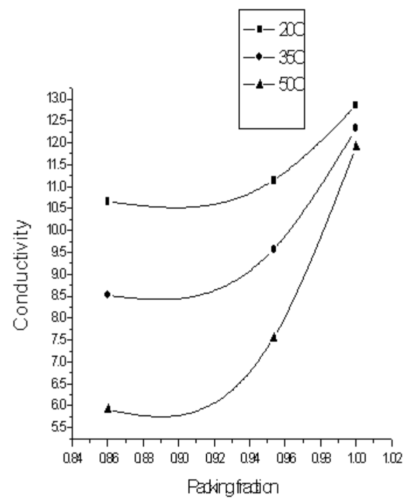

Fig 5. Packing fraction Vs Conductivity

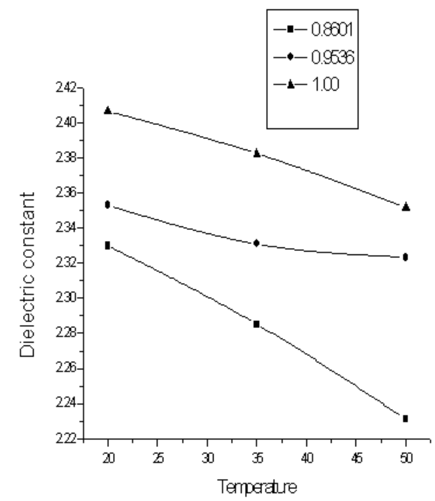

Fig 6. Temperature Vs Dielectric constant

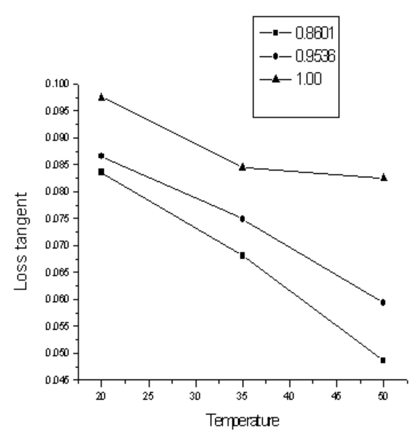

Fig 7. Temperature Vs Loss tangent

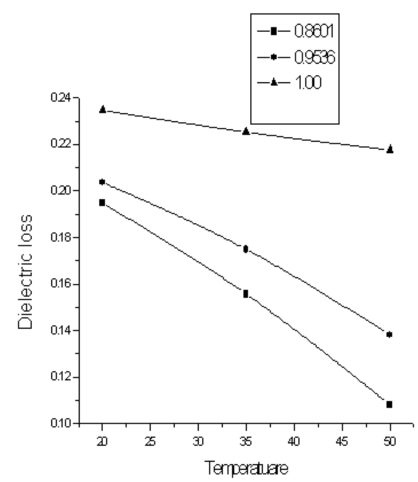

Fig 8. Temperature Vs Dielectric loss

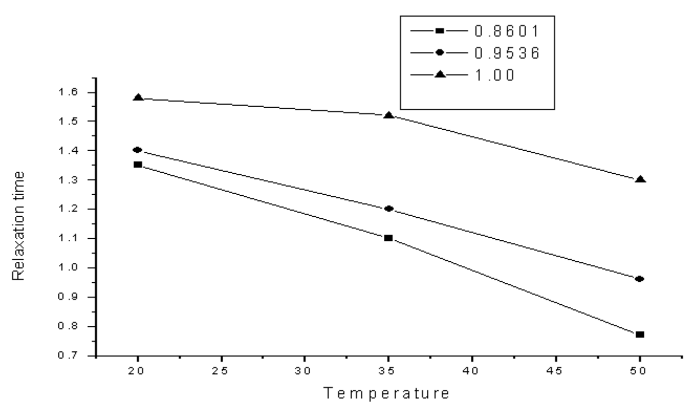

Fig 9.Temperature Vs Relaxation time

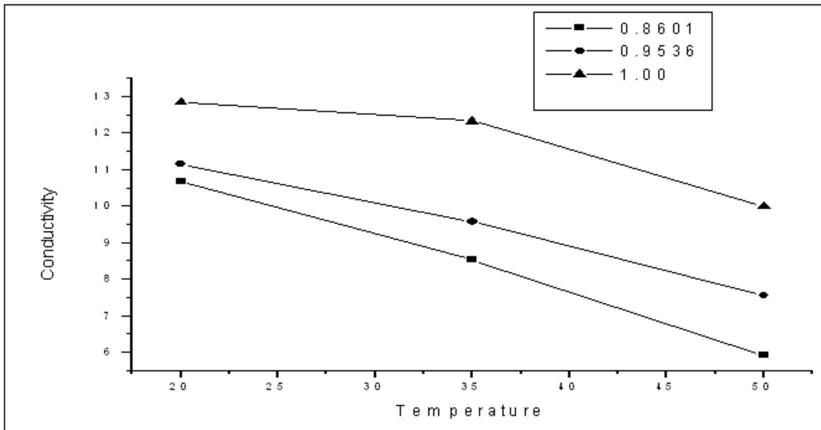

Fig 10.Temperature Vs Conductivity

CONCLUSION

Finally, it may be predicted that medicinal product powder is having cohesion in its particles and may serve as continuous medium. There is fair agreement between the values obtained experimentally and calculated theoretically by using Bottchers formulae. The correlation formulae of Landau-Lifshitz and Bottcher can be used to provide accurate estimates of ($\in'$p) and ($\in''$p) of powdered material at known bulk densities.

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