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EFFECTS OF X-IRRADIATION ON THE DIELECTRIC PROPERTIES OF ALBINO AND TROPICAL RATS' LIVER TISSUES

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Abstract

This study is aimed at analyzing the effects of X-irradiation on the dielectric properties of six albino and tropical rats' livers employing dielectric technique. A conductometer and a signal generator model TH 27 were used to take measurements. The rats were sacrificed and the required tissues were removed and irradiated using a diagnostic X-ray machine at the University of Agriculture, Makurdi Veterinary Hospital. The measurement and analytical techniques were applied to acquire new data on the albino and tropical rats' liver in the band of 0.0001 to 0.5 GHz and peak voltages of 50 kV-70 kV. While some of the liver tissues were left non-irradiated and used as control samples. The measured results ranged from 3.4 S/m-32.0 S/m, 33.1-42.7, (11.5-726) x 10^7 for conductivity σ, dielectric permittivity ε′, and dielectric loss factor ε′′ of non-irradiated and irradiated albino rats' liver tissues. While for the tropical rats, these results ranged from 3.4 S/m-32.02 S/m, 34.3-41.6, and (11.8-682) x 10^7 for conductivity σ, dielectric permittivity ε′, and dielectric loss factor ε′′ of non-irradiated and irradiated liver tissues. The results suggested that variation in the doses of X-rays and frequencies has a tremendous impact on the dielectric properties of mammalian tissues. The results of the investigation were further compared with the results of published work on the radiofrequency dielectric properties of similar tissues and found to be in good agreement, confirming our techniques of detection and analytical procedures. We concluded that the dielectric technique is useful in investigating the mechanism of mammalian tissue radiation damage at molecular and cellular levels. It is recommended that an X-ray should be strictly utilized in a well-prevented and protected condition.

***Keywords*:** Rats' liver; Dielectrics relaxation and dispersion; Measurement of permittivity and conductivity.

1.0 Introduction

Applications of ionizing radiation in hospitals and other health centre for diagnostic and therapeutic purposes are of tremendous benefit to man, even though it could be accompany with varying levels of side effect [1].

Dielectric properties of biological tissues are used frequently to study changes in material composition, cell structure and water content under certain physical conditions. The dielectric properties of biological tissue result from the interaction of electromagnetic radiation with its constituents at the cellular and molecular level. Data on the dielectric properties of mammalian tissues is useful in understanding the basic biophysical interaction mechanisms of electromagnetic fields with mammalian tissues [2].

The use of X-ray radiation in radiology has greatly advanced the practice of medicine. The use of diagnostic X-rays for clinical investigations has become very common recently in almost all hospitals and in some clinics all over Nigeria including other parts of the world [3-5]. However, recent researches revealed that X-rays are capable of causing serious damage to mammalian tissues. Increasing applications of X-ray radiation has led to concerns globally due to the suspected health effects associated with its exposure. There is, therefore, concern as to the effects of X-ray exposure dose rates such as those encountered by patients in diagnostic radiology departments. In this regard, the emphasis is on producing maximum benefit from radiology with a minimum amount of radiation consistent with good quality control in medical X-rays [6].

A survey conducted by many researchers showed that x-ray is still the dominant practice of ionizing radiation used in medicine in Nigerian hospitals despite advances in magnetic resonance imaging and ultrasound techniques. It has maintained a key role in the diagnosis of diseases, injury, and in X-ray therapy. In effect, it is the largest man-made source of ionizing radiation to the Nigerian

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population. X-ray is the major contributor to the effective dose of both the patient and the personnel [7]. Diagnostic risk analysis can be achieved by carrying out experiments with animal tissues [8]. This paper analyzes the effect of x-irradiation on the dielectric properties of albino and tropical rat's liver by taking into account the variations of the frequency with electrical conductivity and relative permittivity to investigate the extent of damage induced by x-irradiation during medical examinations using albino and tropical rats' liver tissues.

1.1 **Theoretical Review of Dielectric theory**

1.1.1 **General Tissue Theory**

The conductivity, σ and permittivity, ε is usually considered to be of great interest since they govern the dielectric attenuation. The Permittivity is a complex quantity and is given by:

$$\varepsilon = \varepsilon' - i\varepsilon'' = \frac{D}{E} \quad (1)$$

Whereε' is the dielectric permittivity or constant, $i = \sqrt{-1}$, ε'' *is the* is the dielectric lost factor, D is electric flux density, E is the electric field strength. ε_o (= 8.854 x 10^{-12} Fm^{-1}) is the permittivity of free space and ε_r' is the relative dielectric constant such that;

$$\varepsilon_o = \frac{\varepsilon'}{\varepsilon_r'} \quad (2)$$

The orthogonal axes below showed the real and imaginary part of the permittivity.

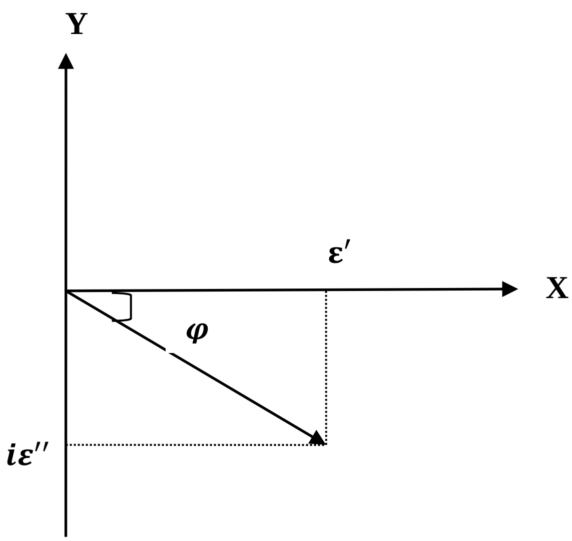

Figure 1: Complex dielectric permittivity

The loss tangent of figure 1 gives the dielectric loss as in equation (3);

$$\tan\varphi = \frac{\varepsilon''}{\varepsilon'} = \frac{\sigma}{\omega\varepsilon_r'\varepsilon_o} \quad (3)$$

Equation (3) has higher values for lossy dielectric [9].

Electromagnetic propagation is characterized by a propagation constant given by equation (4):

$$\Upsilon = a + ib \quad (4)$$

Where a, is the real part and is called the attenuation factor and the imaginary part b, is the phase constant. The wave equation which has the general solution of equation (4) from the Maxwell equation is given as:

$$\Upsilon = i\omega\sqrt{\mu\varepsilon} \quad (5)$$

Where $\mu = \omega\sqrt{\mu\varepsilon'}$ *and is* $= \mu_o$= $4\pi \times 10^{-7}$ Hm^{-1} (Permeability of free space for non- magnetic materials). If we combine equation (1) and (2) we have:

$$\varepsilon = \varepsilon'(1 - i\tan\varphi) \quad (6)$$

Plugging in equation (6) into equation (5) gives:

$$\Upsilon = i\omega\sqrt{\mu\varepsilon'}(1 - i\tan\varphi)^{1/2} \quad (7)$$

Expanding the term in the bracket on the right-hand side using binomial expansion and considering the first two terms only we get:

$$\Upsilon \approx i\left(1 - \frac{i\tan\varphi}{2}\right)^{1/2}$$

$= i\omega\sqrt{\mu\varepsilon'} + \frac{\omega\sqrt{\mu\varepsilon'}}{2}\tan\varphi$ with the real part given as equation (8);

$$a = \frac{1}{2}\omega\sqrt{\mu\varepsilon'}\tan\varphi \quad (8)$$

Equation (8) describes the attenuation through a lossy dielectric of radiofrequency and should not be confused with the spread parameter [9-10].

1.1.2 **Theoretical Model of Dielectric Relaxation**
Polar molecules in materials usually undergo an orientation when such materials are subjected to an applied external electric field thereby contributing to the polarization. This phenomenon is referred to as dielectric relaxation. A heterogeneous material containing free charges may also be blocked by the interfaces in the material and this can also result in dielectric relaxation which is well known to be a frequency-dependent process [11]. Based on the frequency-dependent process, dielectric properties of a material are characterized by relaxation time constants. By Debye equation, we represent the single-time-constant response by equation (9):

$$\varepsilon = \varepsilon_\infty + \frac{\varepsilon_s - \varepsilon_\infty}{1 + i\omega\tau} \quad (9)$$

Where ε_∞ denote the dielectric constant at frequencies much higher than, $\frac{1}{2\pi\tau}$, ε_s is the very low frequency or static dielectric constant, and τ is the relaxation time.
Following equation (9), we write the dielectric constant and loss factor as equation (10) and (11) respectively.

$$\varepsilon' = \varepsilon_\infty + \frac{\varepsilon_s - \varepsilon_\infty}{1 + \omega^2\tau^2} \quad (10)$$

$$\varepsilon'' = (\varepsilon_s - \varepsilon_\infty)\frac{\omega\tau}{1 + \omega^2\tau^2} \quad (11)$$

The conductivity of a dielectric with a single-time relaxation was presented by Foster and Schwan [12] as follows:

$$\sigma = \sigma_s + (\sigma_\infty - \sigma_s)\frac{\omega^2\tau^2}{1 + \omega^2\tau^2} \quad (12)$$

Where $(\sigma_\infty - \sigma_s) = \frac{\varepsilon_o(\varepsilon_s - \varepsilon_\infty)}{\tau}$, and satisfies equation (11) and the relation $\sigma = \sigma_s + \omega\varepsilon_o\varepsilon''$ respectively.
In exception of pure polar compounds, single-response functions are rare, hence for dielectric properties with multiple relaxation times, the relative complex permittivity may be written as:

$$\varepsilon = \varepsilon_\infty + \frac{\Delta\varepsilon_1}{1 + i\omega\tau_1} + \frac{\Delta\varepsilon_2}{1 + i\omega\tau_2} + \ldots + \frac{\Delta\varepsilon_n}{1 + i\omega\tau_n} \quad (13)$$

Equation (13) can be analogously applied to equations (10-12) respectively.

For relaxation times that are closely distributed, commonly at certain frequency region, equation (13) can be replaced by an integral of the form:

$$\varepsilon = \varepsilon_\infty + (\varepsilon_s - \varepsilon_\infty)\int_0^\infty \frac{f(\tau)}{1 + i\omega\tau} d\tau \quad (14)$$

where $f(\tau)$ *is* the relaxation times distribution function. Inferring the $f(\tau)$ and identifying the underlying physical mechanisms gives a good explanation of the experimental data. The process involved physical modeling and is usually complicated [11].
An empirical approach that is usually used to parameterized experimental data without clarifying the underlying mechanisms is the Cole and Cole equation as follows:

$$\varepsilon = \varepsilon_\infty + \frac{\varepsilon_s - \varepsilon_\infty}{1 + (i\omega\tau)^{1-\alpha}} \quad (15)$$

Where α is an adjustable parameter indicating the relaxation time distribution and takes values from 0 to 1. For most biological tissues, [12] showed that α = 0.3 to 0.5 indicates a very broad spectrum of relaxation times. The spectrum of tissue may, therefore, be more appropriately described in terms of multiple Cole and Cole dispersion as:

$$\hat{\varepsilon}(w) = \varepsilon_\infty + \sum_n^\infty \frac{\Delta\varepsilon_n}{1 + (iw\tau_n)^{(1-\alpha_n)}} \quad (16)$$

Which with a choice of parameters appropriate to each tissue, can be used to predict the dielectric behaviour over the desired frequency range. Also, [13] pointed out that the Cole-Cole analysis graph can be used to obtain the relaxation time of the relaxation process using the relation:

$$\frac{V}{U} = (\omega\tau)^{1-\alpha} \quad (17)$$

Where V is the distance on the Cole-Cole plot between ε_s and an experimental point, U is the distance between the experimental point and ε_∞. Taking the logarithm of equation (17), one finds the dielectric spread parameter, α as in equation (17) respectively.

$$\alpha = 1 - \frac{\log\left(\frac{V}{U}\right)}{\log(\omega\tau)} \quad (18)$$

Equation (18) showed that dielectric dispersion is the dependence of the permittivity of a dielectric material on the frequency of an applied electric field.

2.0 Materials and Methods

2.1 Sample Preparation and Irradiation Procedures

The liver tissue samples were extracted from Tropical and Albino rats which were duly certified healthy by the veterinary doctor of the University of Agriculture Veterinary Hospital, Makurdi. The rats were sacrificed and the liver samples excised one at a time for an accurate result. The excised tissue samples were thoroughly washed with double distilled water. The liver tissues were irradiated using a 3-phase diagnostic X-ray machine. The tissue x-ray doses ranging from 50kv to 70kv were determined using Conductometer TH 27 in conjunction with a signal generator. The instrument was switched on, and the sensitivity of the meter set approximately by the sensitivity control knob, and also the knob was rotated for maximum deflection. The water content of the samples was collected following the procedure of [14].
The experiment was carried out with a total of 12 rats, 6 each of tropical and albino type weighing 85.0 g approximately. The rats were divided into two main groups: one rat each of tropical and albino to be used as control (non-irradiated group) and a group of 5 rats. The five rats liver each of albino and the tropical type was each confined in a rectangular plastic box, and exposed to the x-ray peak voltages of 50 kV, 55 kV, 60 kV, 65 kV, and 70 kV respectively, at the Federal University of Agriculture, Makurdi Veterinary Hospital. The dielectric measurements were carried out for the liver samples of each of the five albino and tropical rats in the frequency range of 0.0001 MHz to 0.5 MHz.

3.0 Results and Discussion

The results of the variation of the measured dielectric permittivity,ε', conductivity,σ, dielectric loss factor, ε'' with frequency and applied x-ray voltages raging from 50 kV-70 kV for the non-irradiated and x-irradiated albino rats' liver tissue is presented in tables 1-3 and figures 2-4. While that of tropical rats' liver tissues are depicted in tables 4-6 and figures 5-7, respectively.

Table 1: Values of dielectric permittivity, ε' for x-irradiated and non–irradiated (control) albino rats' liver tissues at some selected frequencies

F(MHz)	0.0001	0.0005	0.005	0.01	0.95	0.10	0.20	0.30	0.40	0.50
Doses (mGy)										
0 (Control)	42.61	38.39	36.85	36.20	35.95	35.86	35.20	34.54	33.90	33.26
50	43.19	38.77	36.94	36.39	36.16	35.98	35.31	34.69	34.02	33.35
55	43.19	38.77	36.94	36.39	36.16	35.98	35.31	34.69	34.02	33.35
60	43.96	39.16	37.04	36.52	36.38	36.02	35.35	34.73	34.04	33.38
65	44.10	39.59	37.16	36.64	36.38	36.40	35.40	34.76	33.94	33.40
70	44.58	39.70	37.21	36.74	36.51	36.15	35.49	34.80	34.14	33.46

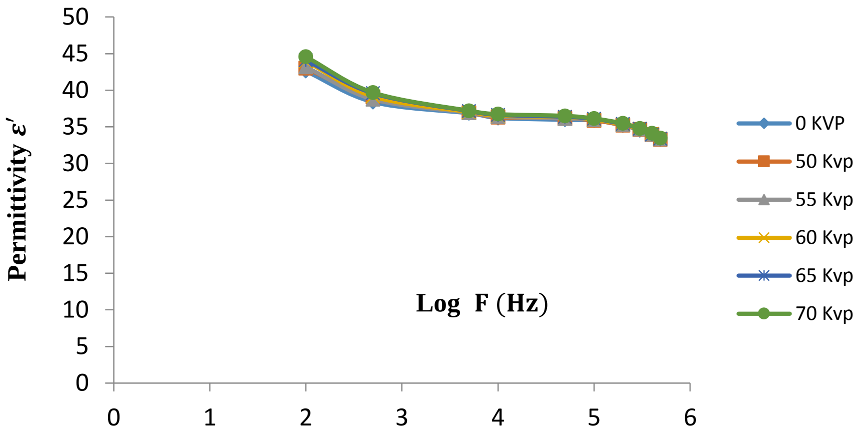

Figure 2: Frequency dependent of the dielectric permittivity, ε' for x-irradiated and non–irradiated (control) of the albino rats' liver tissues at some selected frequencies

Table 2: Values for conductivity, σ (S/m) for x-irradiated and non-irradiated (control) for albino rats' liver tissues

F(MHz)	0.0001	0.0005	0.005	0.01	0.95	0.10	0.20	0.30	0.40	0.50
Doses (mGy)										
0 (Control)	3.492	3.531	11.857	11.955	12.054	31.810	31.869	31.927	32.000	32.038
50	3.510	3.574	11.884	11.994	12.077	31.846	31.886	32.012	32.041	32.083
55	3.540	3.610	11.887	12.016	12.122	31.920	31.969	32.054	32.099	32.126
60	3.584	3.643	11.923	12.052	12.154	31.962	32.003	32.087	32.134	32.160
65	3.614	3.673	11.957	12.097	12.200	32.026	32.075	32.129	32.177	32.180
70	3.638	3.696	11.974	12.130	12.243	32.078	32.130	32.163	32.215	32.233

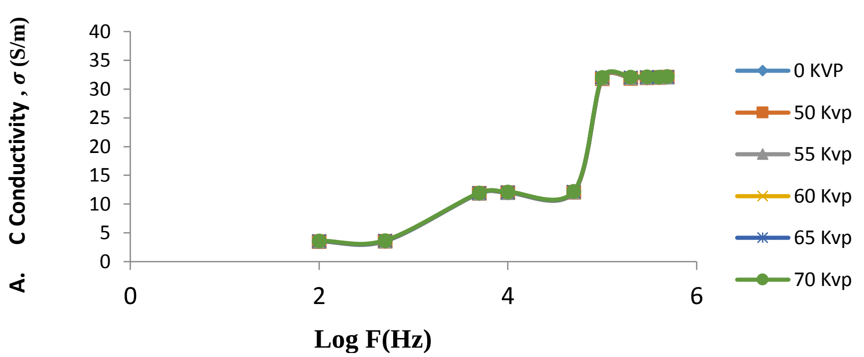

Figure 3: Frequency dependent of the a.c conductivity, σ (S/m) for x-irradiated and non–irradiated (control) of the albino rats' liver tissues at some selected frequencies

Table 3: Values of dielectric loss factor $\varepsilon'' \times 10^6$, for x-irradiated and non-irradiated (control) for albino rats' liver tissues

F(MHz)	0.0001	0.0005	0.005	0.01	0.95	0.10	0.20	0.30	0.40	0.50
Doses (mGy)										
0 (Control)	698.4	130.7	42.65	21.50	4.334	5.718	2.864	1.913	1.438	1.152
50	702.1	132.4	42.75	21.57	4.343	5.725	2.866	1.918	1.440	1.153
55	707.9	133.7	42.76	21.61	4.359	5.738	2.873	1.921	1.443	1.155
60	716.8	134.9	42.87	21.68	4.370	5.745	2.876	1.923	1.444	1.156
65	722.8	136.0	43.01	21.76	4.387	5.757	2.883	1.925	1.446	1.157
70	727.7	136.9	43.07	21.82	4.402	5.766	2.888	1,927	1.448	1.159

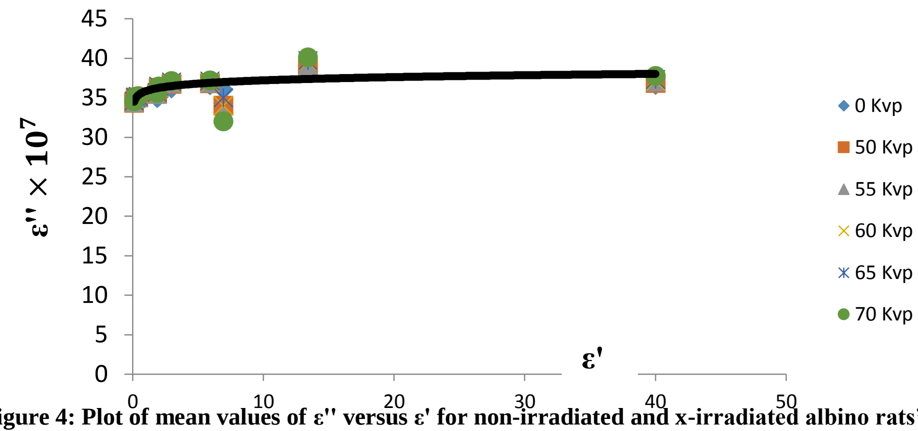

Figure 4: Plot of mean values of ε'' versus ε' for non-irradiated and x-irradiated albino rats' liver tissues

Table 1and figure 2 shows that dielectric permittivity ε' increases with X-irradiation doses and decreases with frequency and later become fairly the same at all frequencies. In table 2 and figure 3, conductivity σ, all increases with a corresponding increase in frequency and X-irradiation doses while the dielectric loss factor ε'', in table 3 decreases with frequency but increases as X-irradiation doses increase. The trends of these results are also shown in figure 4, where the dielectric loss factor ε'', rises slightly with permittivity and later reached a static point.

The decrease in dielectric permittivity, ε'with frequency increases noticed with the control sample and the X-irradiation albino rats' liver tissue, is in agreement with the results of [15] on mammalian kidney tissues. The reasons for these variations observed may be due to changes in the cellular membrane components of the albino rats' liver tissues since cell membranes are the major target when mammalian cells are X-irradiated. Also at higher frequencies, the effect of membrane charging falls, due to the short-circuiting effects of membrane capacitance and the dielectric permittivity, ε' is contributed mainly by the relaxations of sub-cellular organelles and tissue proteins which depend very little on cell membranes [15-16]. This could account for the reason why dielectric permittivity ε' values of both the X-irradiated and non-irradiated albino liver tissues appear to level off at higher frequencies. Similar findings were reported by [14] on Kidney tissues.

Other variations in the dielectric properties discussed above may be due to frequency- dependent on conductivity σ, (S/m), as it represents all the dissipative losses in a tissue sample arising from dielectric polarization charges along with the field constituting a conduction process. I.e. it reflects the extent to which polarization charges move in the applied electric field [16].

Table 4: Values of dielectric permittivity ε' for x-irradiated and non-irradiated (control) for tropical rat's liver tissues at selected frequencies

F(MHz)	0.0001	0.0005	0.005	0.01	0.95	0.10	0.20	0.30	0.40	0.50
Doses (mGy)										
0 (Control)	41.62	38.28	36.63	36.59	36.51	36.17	35.40	34.98	34.86	34.34
50	42.04	38.66	36.86	36.83	36.74	36.27	35.49	35.05	34.95	34.37
55	42.61	39.04	37.07	36.93	36.86	36.33	35.50	35.08	34.96	34.45
60	42.90	39.59	37.11	36.95	36.88	36.39	35.57	35.16	35.07	34.50
65	43.04	39.71	37.32	37.10	36.98	36.45	35.64	35.17	35.08	34.55
70	43.50	40.12	37.75	37.20	36.71	35.43	35.63	35.23	34.14	34.58

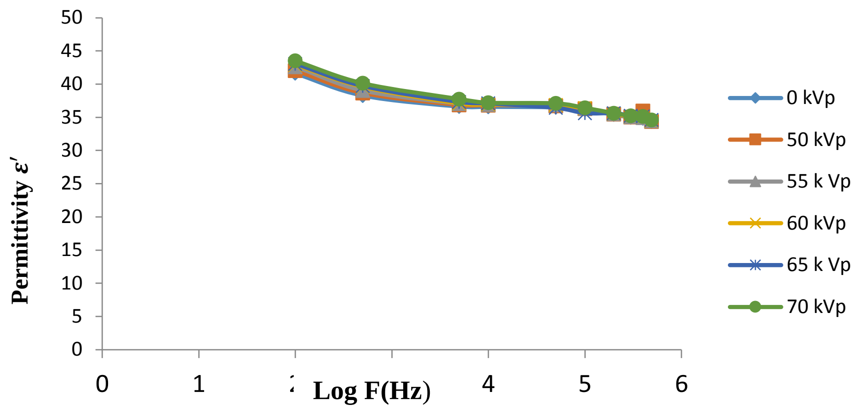

Figure 5: Frequency dependent of the dielectric permittivity ε', for x-irradiated and non–irradiated (control) of the tropical rat's liver tissues at some selected frequencies

Table 5: Values of conductivity σ (S/m), for irradiated and non-irradiated tropical rat's liver tissues at some selected frequencies

F(MHz)	0.0001	0.0005	0.005	0.01	0.05	0.10	0.20	0.30	0.40	0.50
Doses (mGy)										
0 (Control)	3.411	3.553	11.786	12.039	12.194	32.853	32.853	31.916	32.920	32.015
50	3.445	3.588	11.863	12.117	12.273	31.902	31.902	32.975	33.080	32.063
55	3.475	3.624	11.885	12.149	12.313	31.950	31.950	32.019	33.070	32.119
60	3.515	3.673	11.941	12.157	12.321	31.007	32.003	32.078	33.130	32.175
65	3.521	3.686	11.964	12.207	12.353	32.047	32.075	32.114	33.170	32.220
70	3.549	3.724	12.020	12.237	12.393	32.066	32.130	32.150	32.200	32.259

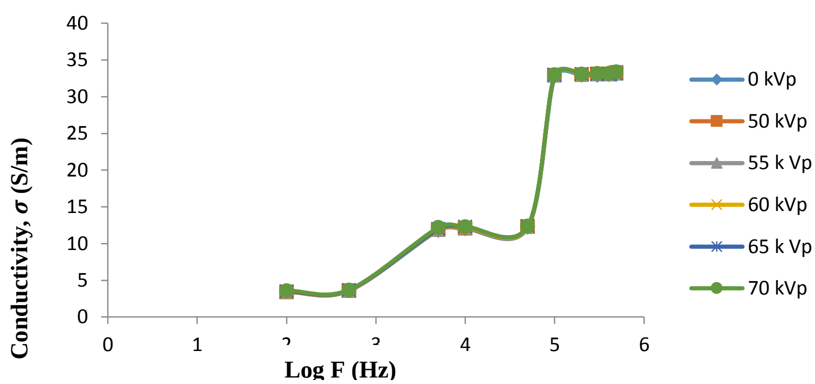

Figure 6: Frequency dependent of the a.c conductivity, σ (S/m) for x-irradiated and non–irradiated (control) of the tropical rat's liver tissues at some selected frequencies

Table 6: Values of dielectric loss factor, ε'' × 10^6 for x-irradiated and non-irradiated (control) for tropical rat's liver tissues

F(MHz)	0.0001	0.0005	0.005	0.01	0.95	0.10	0.20	0.30	0.40	0.50
Doses (mGy)										
0 (Control)	682.2	131.6	42.40	21.65	4.385	5.899	2.958	1.972	1.482	1.187
50	689.1	132.9	42.67	21.79	4.413	5.909	2.957	1.976	1.484	1.188
55	694.9	134.2	42.75	21.85	4.428	5.919	2.961	1.978	1.486	1.191
60	703.1	136.1	42.95	21.86	4.430	5.928	2.967	1.982	1.489	1.193
65	705.5	136.5	43.04	21.95	4.442	5.937	2.970	1.984	1.491	1.194
70	710.0	137.9	43.24	21.01	4.456	5.940	2.972	1.986	1.492	1.195

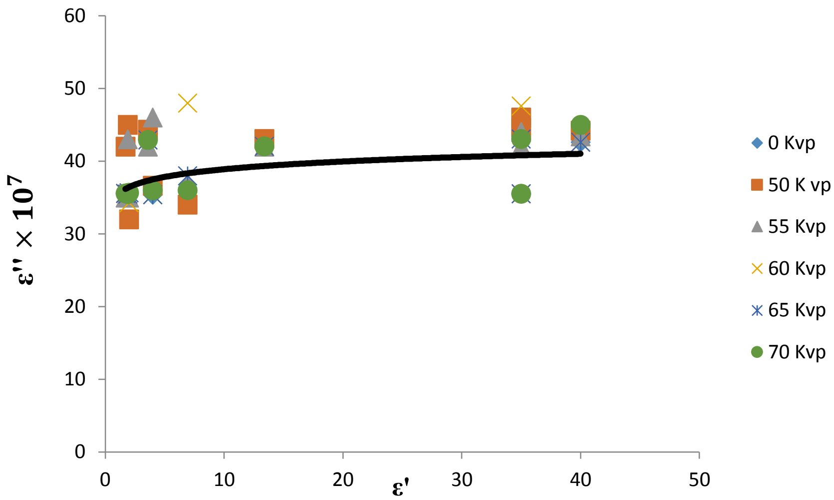

Figure 7: Plot of mean values of ε'' versus ε' for non-irradiated and x-irradiated for tropical rat's liver tissues

Variation trends of the dielectric Permittivity ε' (table 4), Conductivity σ(table 5), of the tropical rats' liver tissues show an increase with a corresponding increase in frequency and X-irradiation doses while the Dielectric Loss Factor ε'' (table 6) decreases with frequency but increases with X-irradiation doses.

Once again we may attribute most of the variations observed in the dielectric properties of the control sample and the irradiated sample to the facts that X-irradiation can randomly cause damages to all cellular components and induces a variety of DNA lesions, like a strand-break, double-strand break or base damage [17]. This means that biological response of tropical rats' liver tissues to X-irradiation is highly a complex process that depends on frequency, both dose and dose rate [2, 18-19]. Figure 7 showed the relationship between dielectric loss factor and permittivity for tropical rats' liver tissues. While tables 7-8 depict the dielectric parameter values calculated from the mean of the dielectric dispersion of the plots of ε'' against ε' for X-irradiated and non-irradiated albino and tropical rats' liver tissues.

Table 7: Dielectric parameters obtained from dielectric dispersion of the plots of ε'' against ε' for X-irradiated and non-irradiated albino rats' liver tissues

Doses mGy	ε_s	ε_∞	Δ $(\varepsilon_s - \varepsilon_\infty)$	F_R (MHz)	τ (ns)	α
0 (Control)	42.61	33.26	9.35	0.30 ±0.01	42.60 ±0.89	0.23 ±0.05
50	43.01	33.32	9.69	0.31 ±0.01	43.00 ±0.91	0.33 ±0.05
55	43.19	33.35	9.84	0.33 ±0.01	43.20 ±0.88	0.34 ±0.07
60	43.96	33.38	10.58	0.34 ±0.02	44.00 ±0.89	0.35 ±0.06
65	44.10	33.40	10.70	0.32 ±0.02	44.10 ±0.89	0.34 ±0.05
70	43.96	33.40	10.58	0.33 ±0.03	44.00 ±0.89	0.36 ±0.06

Table 8: Dielectric parameters obtained from dielectric dispersion of the plots of ε'' against ε' for X-irradiated and non-irradiated tropical rats' liver tissues

Doses mGy	ε_s	ε_∞	Δ $(\varepsilon_s - \varepsilon_\infty)$	F_R (MHz)	τ (ns)	α
0 (Control)	41.62	34.34	7.28	0.30 ±0.01	34.60 ±0.90	0.20 ±0.02
50	42.04	34.37	7.67	0.30 ±0.01	34.70 ±0.90	0.31 ±0.04
55	42.61	34.45	8.84	0.32 ±0.01	39.20 ±0.89	0.31 ±0.04
60	42.90	34.50	8.40	0.32 ±0.02	38.60 ±0.88	0.32 ±0.05
65	43.04	34.55	8.49	0.32 ±0.02	39.20 ±0.89	0.33 ±0.06
70	43.50	34.58	8.92	0.34 ±0.01	39.90 ±0.89	0.35 ±0.05

In tables 7-8, the liver tissues of albino and tropical rats produce α -dispersions in a similar way with the dispersions observed with albino liver tissues recording slightly higher values. This is also evident in figures 4 and 7. We may attribute these differences in the dispersion to many ion passages in liver tissues formed by intermembrane spaces, intercellular spaces, and membrane pores, around which convex counter ion layers are formed producing the dispersions [11, 18, 21-23].

4.0 Conclusion

The effect of X-irradiation on the dielectric properties of albino and tropical rats' liver tissues has been examined. Similar results were observed for both albino and tropical liver tissues which can be attributed to the presence of similar protein tissues (collagens, structural glycoproteins, and proteoglycans) content of the liver. However, the α dispersion calculated for the albino rats' liver tissues were slightly greater than those of the tropical rats' liver and this may possibly be due to differences in ion passages between the liver tissues of the rats' specie. Our results give support to the work of [2, 6, 20, 23] that cellular membranes are major targets of X-rays during tissues X-irradiation. It confirmed also that the dielectric properties of mammalian tissues are slightly affected by X-irradiation. Since X-irradiations are used in diverse medical applications. The X-radiations can enter the living tissues resulting in the destruction of living cells, chromosomal aberrations, and carcinogenic effect. X-radiation can randomly cause damage to all cellular components and morphological components including normal nuclear structure loss and degradation of DNA cells.

Hence we concluded that the dielectric technique is useful in investigating the mechanism of mammalian tissue radiation damage at molecular and cellular levels. It is recommended that an X-ray should be strictly utilized in a well-prevented and protected condition.

5.0 Acknowledgement

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