Evaluation of the Relaxation Times for *Rhizophora spp*. Wood as Human Tissue Equivalent for MRI Breast Phantom

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ABSTRACT---- ***Rhizophora spp. type of mangroves have been tested to make it as a possible human breast tissue equivalent magnetic resonance image (MRI) phantom that is realistic, inexpensive and stable over time. This study involves variations of relaxation times with water distribution inside Rhizophora spp. wood phantom. The sample was fabricated to comparable breast phantom dimension and evaluated by using breast coils at different MRI imaging sequences available for diagnosis using 1.5T clinical MRI equipment. The T1 relaxation time were measured using spin echo sequence with six repetitions and fast spin echo sequence were used to measure T2 relaxation time with six echoes. The fabricated phantom was found to have mean T1 values of ROI 1, ROI 2, ROI 3 and ROI 4, 434.78 ms ± 23.05 , 714.28ms ± 16, 666.67ms ± 19.70ms and 454.55ms ± 26.63, respectively. T2 values of 76.92 ± 20.85ms, 84.03ms ± 29.29, 89.28ms ± 29.07 and 79.36ms ±19.2, respectively. The change on the results due to water distribution and organic substances inside the sample. The relaxation times measured are similar to human breast tissue, especially fat and normal fibroglandular tissue.***

Keywords---- MRI. Phantom. Relaxation times T1, T2. *Rhizophora spp.*

1. INTRODUCTION

Over the years, Magnetic Resonance Imaging (MRI) has developed into the most sought after diagnostic tool in the field of clinical imaging as compared to other innovative systems that utilize the X-ray. where it can to distinguish the properties of human tissues, the distribution of proton nuclei, and imaging the difference in the relaxation properties of nuclei in the tissues being assured [1, 2]. This advantage allows MRI to be effectively used to investigate soft tissue particularly the brain, spine, breast and vascular organs [3]. Phantom measurement is requisite parameter for a range of MRI applications, such as evaluating equipment performance, image quality correction, and safety of the equipment. Therefore, the reliability of images obtained in MRI experimental research depends on the type of phantom used as well as intrinsic properties of the phantom material, which include: similarity to physical properties and relaxation times of human tissue; stability over long periods, hazardous effect, availability, cost, and durability [4, 5]. In line with these mentioned properties, water, agar and agarose are the most frequently used phantoms in MRI applications. Polyvinyl alcohol (PVA) hydrogel phantoms are also used because they are easy and safe to handle; although irregularly given their susceptibility to vibrational effects. However, there is the need to explore new raw materials for the fabrication of phantom in order to enhance the characteristics mentioned above, End of first paragraph - identify a rationale for why the characteristics need to be enhanced - give examples there is the need to explore new raw materials for the fabrication of phantom in order to enhance the characteristics mentioned above, where have some disadvantage points such as, formation bubbles, hard to manufacture in agar phantom during the preparation process it need high thermal [4].

In MRI applications the image influenced by many parameters is mainly density of protons and relaxation times (T1 and T2) [6]. The measurement of relaxation times in vivo is an important approach to examining the properties of tissues, so as to accurately distinguish normal tissue from cancerous tissue, which suggesting to possibility of its use for diagnosing cancer [7]. Cognition of the spin - lattice T1 and the spin-spin T2 relaxation times are necessary to simulate the properties of actual human tissue. Thus, MRI application extends beyond the medical field into the imaging of wood sciences such as, Hall *et al.*, (1986)b, Wang and Chang (1986), Flibotte *et al*., (1990) and Müeller and Bammer, (2001) [6, 8-10]. Preferring MRI imaging application because it detects free water contained in a wooden specimen [11], and provides excellent data with high resolution in relation to the structural features and pathology of whole body of wood samples in a non-invasive manner [12].

In this study, relaxation times (T1 and T2) of *Rhizophora* spp. wood were measured and investigated to determine any differences in relaxation times due to moisture content and water distribution in wood cells to as compared to human body tissue relaxation times especially breast tissue, all that to manufacture phantom from *Rhizophora* spp. wood to mimic the breast tissue.

Rhizophora spp. is a mangrove tree that mainly grows in saline (brackish) environments of the tropics and subtropics [13]. It can be used as a fuel wood, charcoal, and building material [14]. Earlier studies have investigated the ability of *Rhizophora spp.* to simulate the ionizing properties of human tissue Bradley and Tajuddin, (1991) and Che Wan Sudin, (1993) [15, 16]. In the study by Tajuddin et al., (1996) showed that the use of mangrove wood, specifically *Rhizophora spp.* yields results analogous to water-equivalent materials where ionizing radiation were used. Radiation therapy analysis using high energy and electrons showed that *Rhizophora spp.* and modified rubber exhibited scattering and radiographic properties similar to water [17]. Generally, similarities between the dosimetric properties of *Rhizophora spp.* and other common standard materials in phantom diagnostic radiotherapy lent support to the need for further studies on the subject by extending it to non-ionizing radiation.

2. MATERIALS AND METHOD

2.1 Sample Preparation

Rhizophora spp. tree fresh trunks were obtained from Kuala Sepetang, Perak, Malaysia with the aid of Forest Department in Mangrove Reserve Forests. Fresh middle tree-trunks of *Rhizophora spp.* of approximately 100 cm length were cut into wood blocks (17 x 15 cm), and found the moisture content (MC) percentage for the samples. The MC was calculated using Equation (1) taking the weight of the fresh wood sample, after that, take the weight sample after put in oven dried at 105 ± 1 °C (typically exceeding 18 h).

$$Moisture\ content\ (MC) = \frac{Air\ dry\ weight - Oven\ dry\ weight}{Oven\ dry\ weight} \times 100\% \qquad (1)$$

2.2 Image Protocol

Signa HDxt 1.5T clincal magnetic resonance scanner at the Advanced Medical and Dental Institie (AMDI), Universiti Sains Malaysia (USM) was used to measure the relaxation times, T1 and T2. The samples were scanned with an axial projection using a head coil with a matrix size of 256 × 256, a field of view (FOV) of 220 mm and slice thickness of 10 mm. For T1 measurement, the spin-echo sequence was used. The intensity equation for T1 measurements is as in Equation (2) outlined below:

$$Intensity = C1\ \left(1 - e^{\left(-TR/_{T1}\right)}\right) \qquad (2)$$

Where C1 is constant, TR denotes repetition time and T1 stands for spin – lattice relaxation time. The fast spin-echo sequence (FSE) was used to measure relaxation time, T2. The equation for calculating T2 is:

$$Intensity = C2\ e^{\left(-TE/_{T2}\right)} \qquad (3)$$

Where C2 is a constant, TE represents echo time, with TE varying 15, 39, 69, 92, 125, and 200 ms with TR of 2000 ms while T2 denotes spin-spin relaxation time [18]. For the evaluation of T1 relaxation times, with constant TE = 15ms and TR values of 140, 410, 724, 962, 1699 and 2000ms [3, 18].

The resonance of MR signals intensities from different regions were determined using measurements of the regions of interest (ROI) where chose in center wood (heartwood) and around center (sapwood). T1 and T2 relaxation times were estimated by adjusting the average signal values of the defined region of interest corresponding to the mono-exponential equation [19].

3. RESULTS AND DISCUSSIONS

The images of *Rhizophora* spp. wood cross section of T1 and T2 weighted in Figure (1), in addition, shows disparity in the distribution of water in the wood cells of T1 and T2 weighted. The measurements obtained of 4 Regions of Interest (ROI) in the sample as shown in Figure (2) in order to evaluation the moisture content effect with relaxation time as well as the distribution of water contained in the samples. Of the weighted image of T1, the water content is depicted as dark zone, but visualized as a bright zone in the weighted image of T2. The intensity curves associated with the repetition time and echo time of the T1 and T2 characteristic images for ROI are shown in Figures 3 and 4, respectively.

The T1 and T2 values were derived from the data plot of intensity curves versus the TE and TR values. Table 1 contains a summary of the MRI analysis parameters used in this study, comprising the relaxation times (T1, T2).

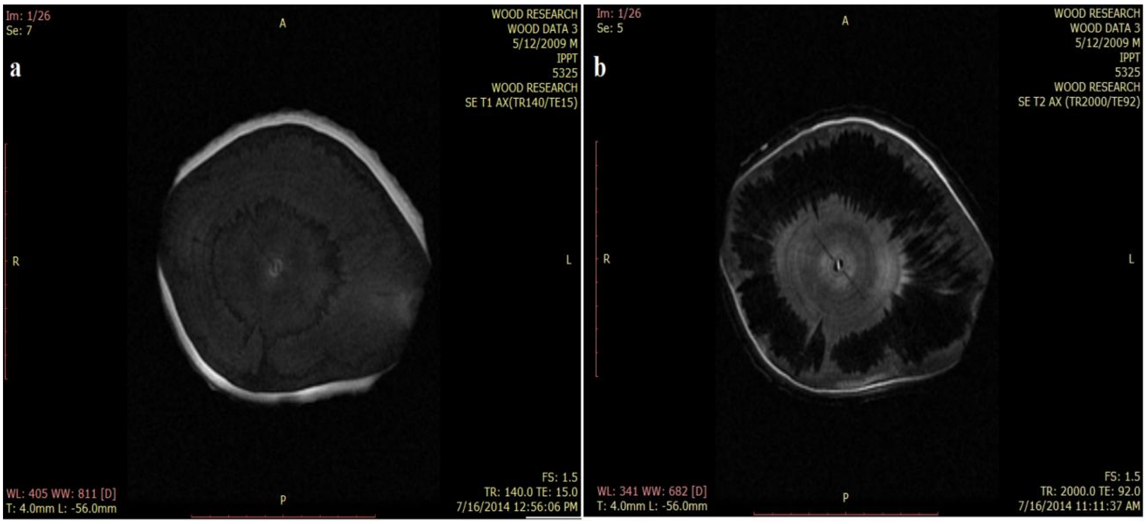

Figure 1. Magnetic resonance image (MRI) of the prepared sample, a) T_1 - weighted images, b) T_2-weighted images.

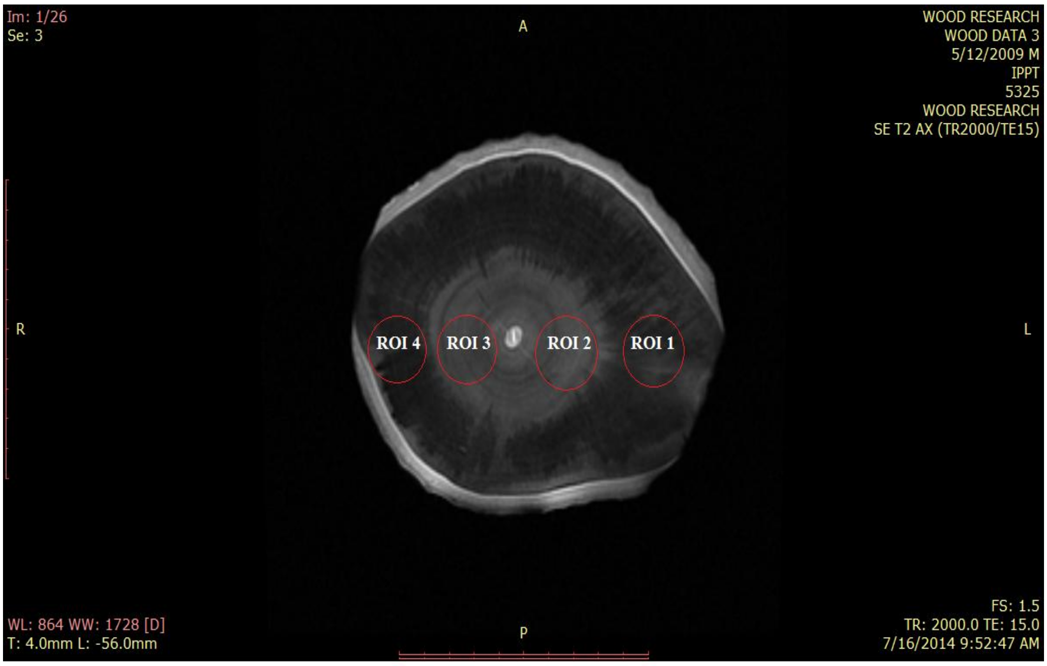

Figure 2. 4 Regions of Interest (ROI) on an magnetic resonance image (MRI) for measuring T1 and T2 values.

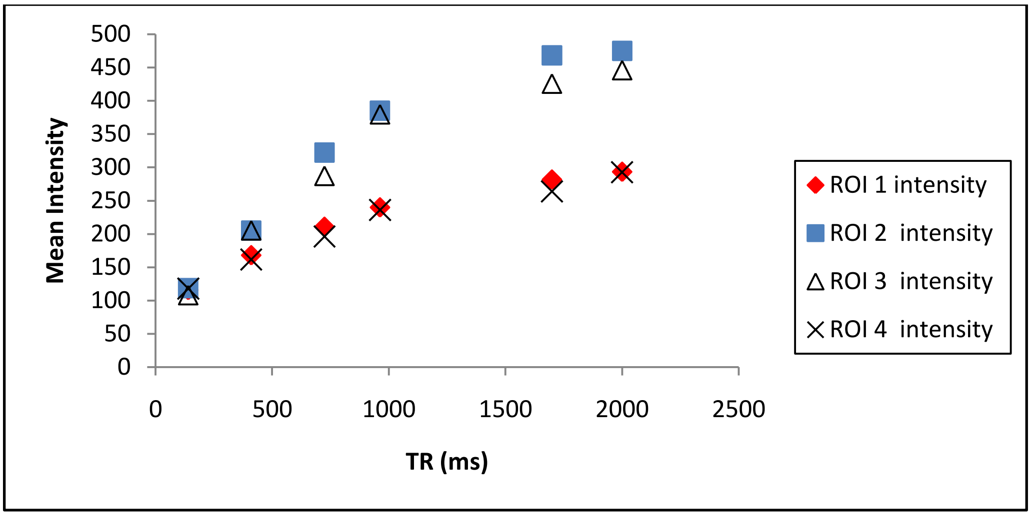

Figure 3. Intensity curves versus the repetition time TR representative was obtained from the analysis of the *Rhizophora spp.* wood samples at 33% MC from the magnetic resonance Images.

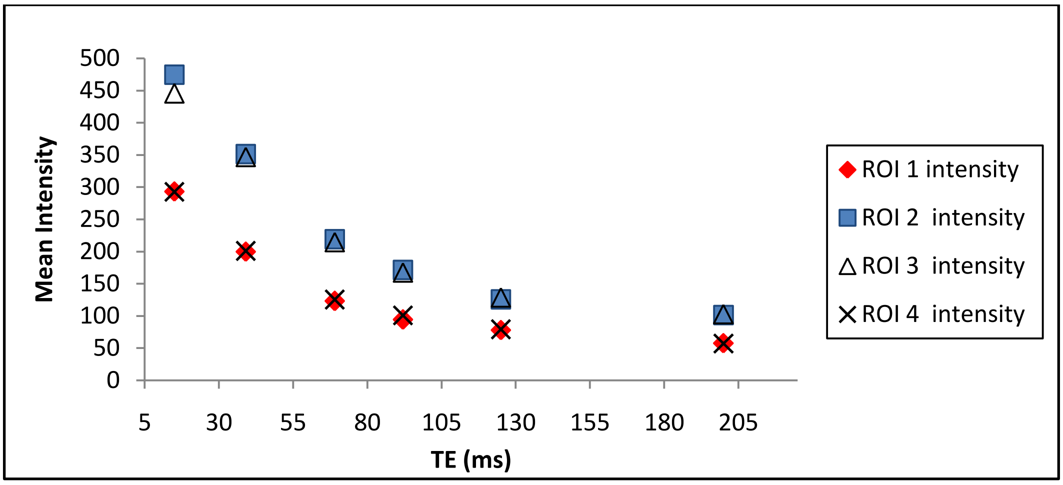

Figure 4. Intensity curves versus the echo time TE representative was obtained from the analysis of the *Rhizophora spp.* wood samples at 33% MC from the magnetic resonance Images.

Where T1 Values of ROI 1 and ROI 4 (sapwood part) have similarity value, same for ROI 2 and ROI 3 (heartwood part) values 714.29 ms ± 16 and 666.67 ms ± 19.7, respectively. T2 exhibited a similar trend of T1 values where the ROI 2 and ROI 3 values equal 84.03ms ± 29.29 and 89.28ms ± 29.07ms, respectively. However, an increase in ROI values was observed as the measurements approaches the middle of the part wood referred to as heartwood. This part is characterized by higher concentration of organic substances [20, 21]. The large values of T1 and T2 value is attributed to tissues with greater amounts of cellular water [22].

Table 1: T1 and T2 Relaxation time measurement in 4 regions of interest from the magnetic resonances image of *Rhizophora spp.* wood samples.

Regions of Interest	T1 (ms)	T2 (ms)
ROI 1		76.92 ± 20
ROI 2	434.78 ± 23	84.03 ± 29
ROI 3	714.28 ± 16	89.28 ± 29
ROI 4	666.67 ± 19	79.365 ± 19
	454.54 ± 26	

In the breast tissue, the measured T1 value is lower for fatty cells (approximately 250 ms), slightly increase for normal fibroglandular tissues range 790 ms to 460 ms at 1.5T this agreement with ROI's values has found in same range, where the corresponding T2 value for breast tissue, comprising both fat and normal fibroglandular tissue ranges between 60 - 80 ms [23, 24].

4. CONCLUSION

In this study, the *Rhizophora spp.* phantoms that mimic breast human tissue in terms of the relaxation times were interpreted. The studies show the effect of organic substances to produce accurately simulating breast tissue. These phantoms, including soft phantoms for breast MRI offer flexibility and a realistic model of human tissue. The relaxation rates can be changed by mimicking water between cells of *Rhizophora spp.* wood. Such phantoms could assist in the standardization of scanner performance, and assist in quantitative measurements of contrast media, developed a *Rhizophora spp.* phantom it opens a new window of research for MRI phantoms.

5. REFERENCES

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