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Determination of Mass Attenuation Coeffıcients on Boric Acid Injected Liver of Male Rats

N. Ekinci, R. Durak, E. Kavaz*, E.Cinan, F. Geyikoglu

Abstract— Ionizing radiation causes irreversible molecular changes (i.e. damage) to the tissues. Damage is caused by direct ionization or reactions of hydroxyl free radicals (•OH) from water radiolysis. Boric acid (BA) having antimicrobial and free radical scavenging activity. BA is able to strengthen the tissue antioxidant and radiation defenses via a yet unidentified mechanism that may involve changes in oxidative metabolism. In this work, the linear radiation attenuation coefficients of normal, malignant and boric acid injected malignant rat liver tissues have been measured at 59.54 keV photons emitted from Am-241-point source by using Si(Li) detector. The measured linear attenuation coefficient values of malignant tissue are found to be lower than normal tissue. When compared to the malignant tissue, BA injected malignant rat liver tissues have higher linear attenuation coefficients. These results have showed that boric acid is a radio and chemical protective compound for the target tissues.
Index Terms— mass attenuation coefficient, Boric Acid, Liver, malignant.

1 INTRODUCTION

Radiation produces highly reactive and dangerous molecular species called free radicals in cells and tissues. Free radicals have a life of approximately $10E^{-5}$ seconds and can interact with membrane lipids, nucleic acids, carbohydrates and proteins [1-3]. As a result of interaction with membrane lipids lipid peroxidation chain reactions which disrupt membrane structure and transport processes may be triggered; interaction with DNA may cause mutations, and interactions with proteins may cause structural damage in many hormones and enzymes [4,5].

- *Esra KAVAZ, *Atatürk University, Science Faculty, Department of Physics, 25240, Erzurum, TURKEY. E-mail: esrakvz@gmail.com*
- *Neslihan EKİNCİ, Atatürk University, Science Faculty, Department of Physics, 25240, Erzurum, TURKEY. E-mail: nekinci@atauni.edu.tr*
- *Rıdvan DURAK, Atatürk University, Science Faculty, Department of Physics, 25240, Erzurum, TURKEY. E-mail: rdurak@atauni.edu.tr*
- *E.Cinan Atatürk University, Science Faculty, Department of Physics, 25240, Erzurum, TURKEY*
- *F. Geyikoglu, Atatürk University, Science Faculty, Department of Biology, 25240, Erzurum, TURKEY*

In addition to being used for different purposes in hundreds of industries, boron is also an important mineral in terms of health. Calcium, magnesium and phosphorous minerals contribute to the protection of dental and bone health by helping to protect and effectively use Vitamin D in the body. Failure to take the tube in sufficient quantity will result in lack of vitamin D, resulting in bone loss and thinning, and breakage of the bones more easily. Fruit, green vegetables, mushrooms, legumes and nuts are nutrients rich in boron [6]

The most common inorganic form of Boron is Borax or Boric Acid (BA). Several studies suggested that boric acid had anti-tumoral properties [7]. The mechanism of its lethal effects did not involve apoptosis, but it is suspected to be through histone deacetylase inhibition. Boric acid improves the anti-proliferative effectiveness of chemo-preventative agents, selenomethionine and genistein, while enhancing ionizing radiation cell kill [8].
The mass attenuation coefficient (μ/ϱ) is an important parameter for industrial, biological, agriculture and medical applications such as dosimetry, radiography and computerized tomography (Jackson and Hawkes).There are numerous articles in the literature on mass absorption coefficients for various materials [9-11]. The mass

ISSN 2229-5518

attenuation coefficient (μ/ϱ) depends on the photon energy and the chemical composition of the material.

In this study, the mass attenuation coefficients (μ/ϱ) for the rat liver samples were measured at 59,54 keV photon energy, by performing transmission experiments using ^{241}Am point source. A Si(Li) detector was used for detection. The liver samples were analyzed using a wavelength dispersive X-ray fluorescence spectrometer (WDXRF). These data were further used for determination of theoretical mass attenuation coefficients for liver samples with WinXCOM programe.

1.1 EXPERIMENTAL PROCEDURE AND THEORY

Sprague Dawley rats (250-270 g), grown in ATADEM and optimized to experimental conditions, were randomly selected and divided into 10 groups before the experiment began:

1. Control group (made laporatomic),
2. Patient control group (with bilateral ovarian ischemia),
3. The group to which 100 mg / kg propolis was administered,
4. The group to which 200 mg / kg propolis was administered,
5. The group receiving 14 mg / kg of boric acid,
6. The group in which 100 mg / kg propolis was administered and the ovarian ischemia-
7. The group treated with 200 mg / kg propolis and formed with ovarian ischemia,
8. The group treated with 14 mg / kg of boric acid and formed with ovarian ischemia,
9. Group treated with 100 mg / kg of propolis + 14 mg / kg of boric acid and formed with ovarian ischemia.
10. Group treated with 200 mg / kg of propolis + 14 mg / kg of boric acid and formed with ovarian ischemia.

The samples were irradiated by 59.54 keV photons from 100 mCi ^{241}Am point source. For each sample and energy, Io and I were measured by a Si(Li) detector (FWHM = 160 eV at 5.9 keV, active area 12 mm^2, thickness 3 mm, Be window thickness 0.025 mm) coupled with a multichannel analyzer system and spectroscopy amplifier. The detector was also placed in a stepdown shield made from Pb, Fe and Al to minimize the detection of any radiation coming directly from the source and scattered from the surroundings (Fig.1). The peak areas have been calculated from the spectrum obtained for each measurement. The spectrums were analyzed by using Microcal Origin 9.0 Version software program with least-squares fit method. Gaussian function has been used for the lines. To determine the net peak areas, the areas under the peak Gaussian function were subtracted to correct for background in the peak region.

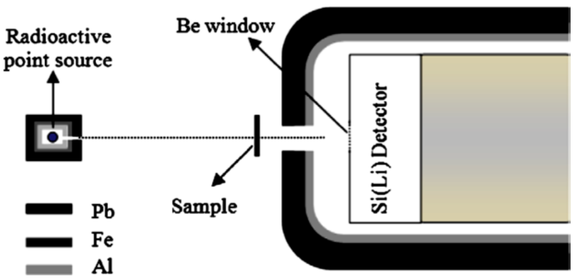

Fig.1. Experimental setup.

The net counts of photon intensities with (I) and without (Io) were measured for the samples. These counts after the subtraction of background was used to determine the mass attenuation coefficient (μ/ϱ) by following equation [12],

$$\mu_m = \frac{\mu}{\rho}(cm^2 gm^{-1}) = \frac{1}{\rho t}\ln(\frac{I_0}{I}) \qquad (1)$$

Where ϱ (g/cm^3) and t (cm) are the density and thickness of the sample.

Mass attenuation coefficient for any chemical compound or mixture of elements can be calculated by mixture rule [13],

$$(\mu / \rho) = \sum_i w_i (\mu / \rho)_i \qquad (2)$$

Where wi and (μ/ϱ)i are the weight fraction and mass attenuation coefficient of the ith constituent element, respectively. The value of mass attenuation coefficient (μ / ρ , cm^2/g) of the samples are calculated by the WinXCom computer program. This program provides partial cross section for coherent and incoherent scattering, photoelectric absorption and pair production for photon energies ranging from 1 keV to 1 GeV [14].

2 RESULTS AND DISCUSSION

Experimental and theoretical values of mass attenuation coefficients (μ_ρ , cm^2/g) for the samples at gamma energy 59.54 keV, have been given Table 1 and Fig.2. The relative standard error of the measured mass attenuation coefficients were 3.%. It is seen from this figure and table

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that mass attenuation coefficients of the samples consisting different elements decrease with increasing gamma energies. At low photon energies; photoelectric effect is the most important gamma absorption process and probability of photoelectric effect decreases with increasing gamma energy. The cross section of photoelectric effect is proportional to Z^4 and inversely proportional to the incident photon energy as E.[3-5]In this region, some small sharp peaks are observed (Fig.2). These are absorption edges of the elements in the samples. The maximum and minimum values (both theoretically and experimentally) of μ_ρ were obtained for 3, 4 samples (100 and 200 mg / kg propolis) and 9,10 samples (100 and 200 mg / kg of propolis + 14 mg / kg of boric acid) respectively. At the intermediate energy region; Compton scattering (incoherent) predominates and is proportional to the atomic number Z of the atom in the target material. And it is clear from Fig.2. that the value of μ_ρ stays almost constant after 1 MeV. The reason behind this pattern is the possibility of pair production, which is proportional to Z^2. Sample 10 and 9 have minimum $\mu_\rho$values. Boric acid and propolis regulates ion balance. It destroys new and harmful ions that occur during the disease. For this reason, since the element concentration in the sample decreases, the values of the smallest mass absorption coefficient are observed in boric acid and propolis injected samples.

3 CONCLUSION

In this work, the values of the mass attenuation coefficient (μ_ρ) for ten rat livers have been calculated in the energy region from 1 keV 100 GeV using WinXCom program and determined experimentally at 59.54 keV. The results obtained from this study indicate that this parameter depend on the incident photon energy; the maximum values of μ_ρ are obtained in the lower energy region. It is generally observed that boric acid provides ion balance. Ion disequilibrium in the diseased tissue has been eliminated by propolis and boric acid. The ion balance of the diseased tissues has approached the control group's. For this reason, boric acid and propolis injected samples have lower mass attenuation coefficient than the patient tissue.

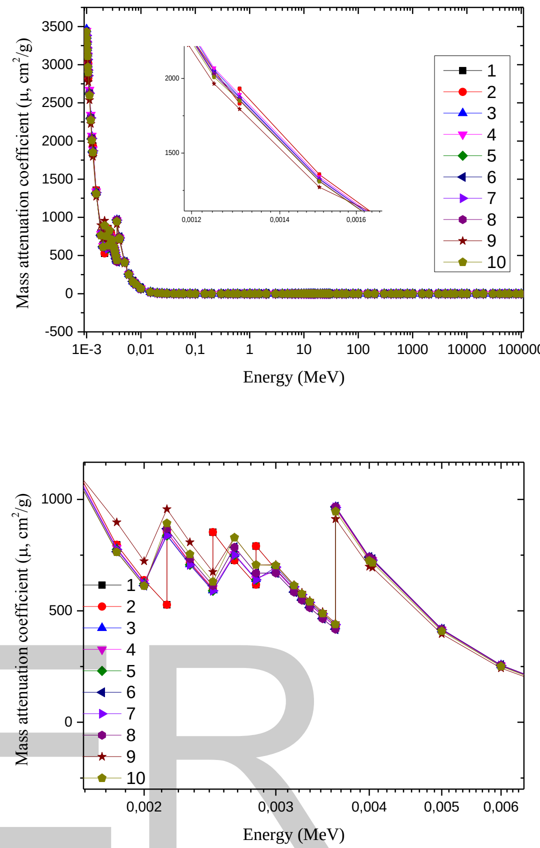

Fig.2. Theoretical mass attenuation coefficients of the samples versus the incident photon energy (MeV).

Table.1 Mass attenuation coefficients of the liver samples.

59.54 keV	μ/ρ	
Sample	Expt.	Theo.
1	0.5883±0,0176	0.5220
2	0.5880±0,0174	0.5262
3	0.5999±0,0179	0.5428
4	0.5995±0,0179	0.5408
5	0.5880±0,0174	0.5260
6	0.5870±0,0176	0.5254
7	0.5830±0,0174	0.5268
8	0.5713±0,0171	0.5250
9	0.5698±0,0170	0.5240
10	0.5643±0,0169	0.5239

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