INVESTIGATION UPON THE RADIOFREQUENCY RADIATION IMPACT IN THE BIOLOGICAL TISSUES*

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The radiation with the frequency of 400 MHz was generated within a transverse electromagnetic cell having adequate geometry and sizes. Exposures of different time durations were applied to samples of liver, muscle and bone – characterized by different contents of water, protein and lipids. The extraction of DNA and RNA biomolecules was carried out in adequate selective solvents. Spectrophotometric device type Metertek was used to assay the levels of nucleic acids in the exposed samples in comparison to the control ones. The main results concern the slight stimulatory effect of low radiation doses in contrast with the disruptive effect of high doses.

Key words: wave guide, *in vitro* exposure, nucleic acids, biosynthesis, synergetic processes.

1. INTRODUCTION

Following the industrial and communication development one can found a permanent radio frequency component into the environment radiation background. Scientific data reports regarding the physiological perturbations induced by microwaves and radio frequency waves are often focused on this subject. The first published study that showed that pulsed RF radiation cause significant chromosome aberrations was signed by Heller and Teixeira-Pinto [1]. Then, different independent laboratories have published data on DNA strand breaks induced by electromagnetic exposure [2–4] while some others demonstrated the involvement of free radicals and the protective effect of melatonin. One of the first biological mechanisms to be identified, confirmed and established is calcium ion efflux (positive and negative) [5]. Calcium ions were induced to flow out of or into cells, depending of the combination of exposure conditions.

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Blackman [6] found that electromagnetic exposure that can alter normal calcium ion homeostasis and lead to changes in the response of biological systems to their environment. Following gene transcription and expression is altered. The lowest published exposure level associated with significant alteration of cellular calcium ions induced by radiofrequency waves associated to mobile phones was reported by Schwartz *et al.* [7].

In the next we aimed to evidence the non-thermal effects of radiofrequency electromagnetic wave acute exposure with respect to nucleic acids molecular damage in the animal cells.

2. MATERIALS AND METHODS

The electromagnetic exposure. A transverse electromagnetic cell (TEM) that was designed [8] to deliver 0.6 mW/cm^2 at a frequency of 418 MHz was used to irradiate the biological samples (Fig. 1). The TEM device, built in aluminum, has the dimensions: $a = 715$ mm, $b = 340$ mm, $w = 450$ mm, where a – the length, b – the height of the rectangular area, w – the septum length that were calculated to assure the characteristic impedance Z_0 of 50 Ω. This way a rectangular coaxial wave guide was obtained that was connected to the power generator through adequate bi directional cable so that the transverse propagation mode is the dominant. When the frequency is tuned on 418 MHz practically whole electromagnetic energy is propagating along the exposure device in the form of TEM mode. Animal tissue specimens (muscle, liver and bone) freshly extracted from the same individual, were exposed *in vitro* for 1-2-4-8-16 hours, unique (acute) exposure. Repeated measurements have been carried out in order to ensure the statistical significance of experimental results.

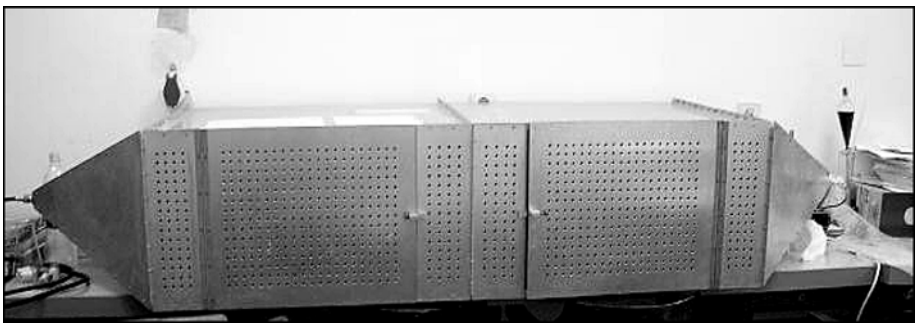

Fig. 1 – The transverse electromagnetic cell (TEM).

The electric field within the exposure area might be considered uniform being calculable through the formula:

$$E = \frac{\sqrt{PZ_0}}{d} \tag{1}$$

where P – the power supplied by the electric generator, Z_0 the cell characteristic impedance, d – the distance between the central planar conductor and the external one:

$$d = \frac{b}{2} \tag{2}$$

The power density (W/m^2) of the plan wave traveling through the cell is given by:

$$S = \frac{PZ_0}{d^2 Z_\infty} \tag{3}$$

where Z_∞ is the free space impedance. For each tissue a control sample was arranged to remain in the same conditions of temperature, illumination and humidity but tightly isolated against the electromagnetic waves.

The biological samples. Tissues freshly extracted from the body and provided by the same individual (pork) were cut to adequate dimensions. The specimens were placed in Petri dish situated in the area with uniform electromagnetic field and energy distribution (Fig. 1). The exposure time durations were: 1–2–4–8–16 hours.

Nucleic acid assay. The nucleic acid levels was measured in selective solvent extracts (perchloric acid 6%) on the basis of light extinction values in the ultraviolet range at the wavelengths of 270 nm and 290 nm (basically the Spirin method [9]). The five repetitions of the whole experiment ensured the statistical significance of the measured data.

3. RESULTS AND DISCUSSIONS

The average content of RNA and DNA for the liver tissue in Fig. 2 is represented as 3-D computational approach of numerical data corresponding to exposed samples (average values calculated relatively to the control sample).

Continuous decrease to the increase of the exposure time is obvious suggesting the nucleic acid damage following RF exposure.

The computational fitting of average data corresponding to the muscle tissue is presented in Fig. 4.

In Fig. 3 the response of the bone tissue is presented. There is an increase first, for short and medium exposure times, followed by a diminution, for the longest exposure time. The response induced in muscle in Fig. 4 is given; it is visible a continuous decrease for all the tested exposure time durations. The data

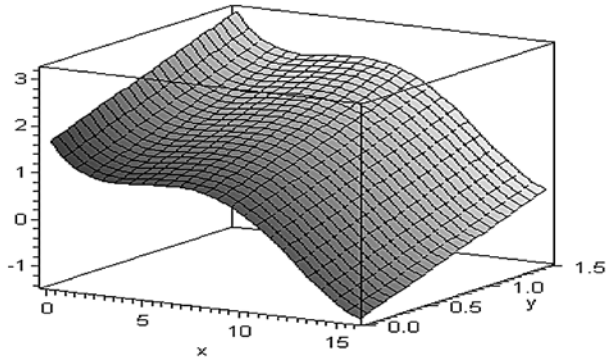

Fig. 2 – 3-D computational approximation of average values of nucleic acid contents in liver tissue (x – exposure time in hours, y – nucleic acid average content in arbitrary units); polynomial fitting – correlation coefficient over 0.9.

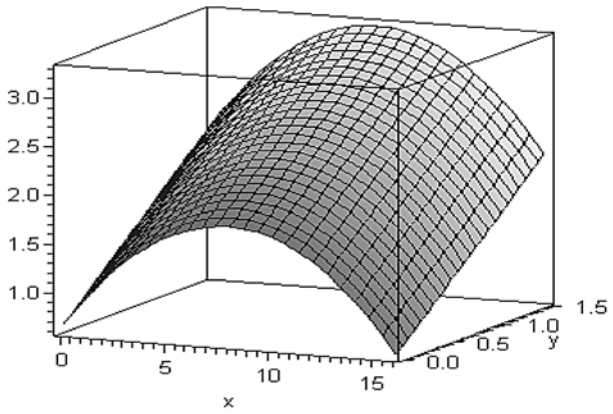

Fig. 3 – 3-D computational approximation of average values of nucleic acid contents in bone tissue (x – exposure time in hours, y – nucleic acid average content in arbitrary units); polynomial fitting – correlation coefficient over 0.9.

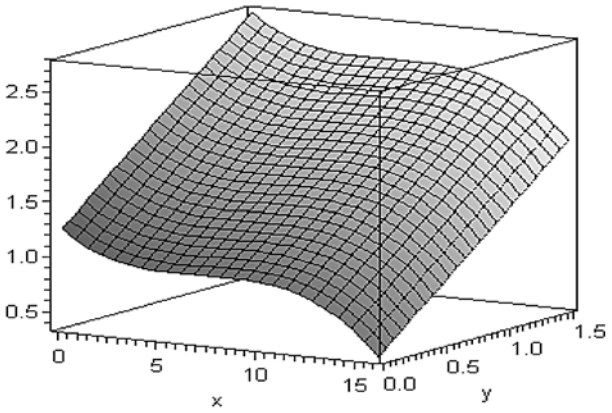

Fig. 4 – 3-D computational approximation of average values of nucleic acid contents in muscle tissue (x – exposure time in hours, y – nucleic acid average content in arbitrary units); polynomial fitting – correlation coefficient over 0.9.

for all the three tissues in Fig. 5 are presented – average values and standard deviations. The application of the *t*-test led to statistical significant changes in the exposed samples in comparison to the control ones (relatively to the significance threshold of 0.05).

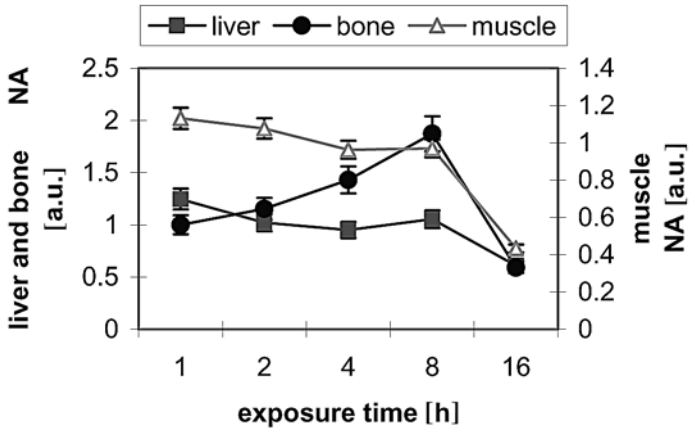

Fig. 5 – Nucleic acid average content (N.A.) *versus* exposure time; a.u.-arbitrary units.

In all the graphs the data corresponding to the exposed samples are given relatively to the non exposed control samples so that one can see that the slight increase revealed for the shorter exposure times in liver and muscle is ranging between 1.13 and 1.24 while the final diminution is given by values of about 0.4. The interpretation of the responses obtained from muscle and liver might be related mainly to the disruptive effect of RF radiation upon the nucleic acid molecules as well as on the inhibitory effect of the electromagnetic exposure on the nucleic acid biosynthesis. In the case of the bone tissue it seems that the living cells were still able to recover some of the damages induced following the exposure to radiation; more, possible mechanisms of biosynthesis stimulation were activated in order to recover the lost molecules so that for short and medium exposure times the measured values were higher than for the control. But when the irradiation lasted for 16 hours the disruptive effect was also the dominant – as in the case of the liver and muscle. The main issue related to the nucleic acid damages following the irradiation with electromagnetic waves having energy per photon of millions times lower than those required to break the chemical bonds can not be explained following the investigation presented inhere, which is only a supplementary proof of the existent biological effects already recognized in the literature. The possible explanations are related to the triggering of synergic complex phenomena within the living cells that are absorbing electromagnetic wave energy so that finally drastic chemical changes occur such as the covalent bond disorganization within the DNA and RNA molecules. In the frame of our experiment we revealed that the fresh tissue of animal origin – consistent with meat planned for population supply – can be affected by environmental or accidental exposure to radiofrequency sources. Further investigations are planned to provide new data regarding the protein response to the electromagnetic exposure, mainly the enzyme activity.

4. CONCLUSIONS

The disruptive effect of electromagnetic exposure was evidenced using low radiation power density (0.6 mW/cm^2) and radiofrequency energy range. The effects were deeper in wet tissues – muscle and liver – where the nucleic acid average level is diminished for the exposure times of 4–8–16 hours. One might presume that the relatively high content of water could amplify the disruptive biological effects. In the case of the bone tissue the diminution of the nucleic acid level was revealed only for 16 h while for 1–2–4–8 hours the recovery mechanisms within the irradiated cells were still able to lead to the biosynthesis stimulation resulting finally in the increase of the nucleic acid level.

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