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BIOLOGICAL EFFECTS OF CHRONIC AND ACUTE MICROWAVE IRRADIATION IN SOME ANIMAL TISSUES*

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Abstract
The authors intent to evidence the non-thermal effects of microwaves for either acute or chronic exposures. Low power density microwaves have been used at the frequency of 10.75 GHz (delivered by a suitable generator designed and assembled in our laboratory). Animal tissue samples (muscle, liver, lung and bone) have been irradiated for 1-2-4-8-16 hours (unique exposures) as well as for 1-2-4 hours per irradiation session with 2 hours breaks between sessions (repeated exposures). Comparative graphical representations have been done for each tissue in order to reveal the effects of the electromagnetic exposures on the nucleic acid content. The concurrent phenomena of DNA damage and DNA damage repair under low exposure condition have been considered. Repeated measurements have been carried out in order to ensure the statistical significance of the experimental results (t-test was applied).
Keywords: microwaves, nucleic acid, biosynthesis.

1. Introduction

The questions regarding the biological effects of microwave exposure are more and more challenging in our days. One of the most convenient issues is that cancer appearance seems to be not correlated with the **electromagnetic irradiation** – though various other physiological disturbances are. Nevertheless, the **perturbation of the nervous system** (headaches, sleep disturbances, learning disabilities, memory loss), the lowered performances of cardiovascular and reproductive systems are noticeable – as epidemiological studies have shown. Since the genetic effects are of large interest the DNA response to microwave represents the target of numerous studies, one of the most conclusive being that of Kakita [1], that showed since ten years now (by electron microscopy) that the bacterial DNA was broken down following microwave exposure (1995). The single DNA strand damage in brain cells was evidenced in rats using an alkaline microgel electrophoresis technique (Lai &Sing, 1995,

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[2]). Considering the importance of the microwave effects in living bodies [3-5] the authors of the present paper have focused on the changes induced in some animal tissues, freshly withdrawn from the animal body with destination on the food market (taking into account also the fact that microwaves are used to dry the meat and the food items).

2. Method and samples

Biological material. Animal tissues freshly withdrawn from the body (pork), such as liver, muscle, lung, bone, have been studied.

Microwave exposure. The microwave generator set-up was designed on the basis of an IMPATT diode. It was able to deliver microwave flow with the power density of about 10 mW/cm^2 and a frequency of 10.75 GHz. A probe detector measured the power density of electromagnetic waves flux, which was of about 1 mW/ cm^2 (low power density microwaves) in the sample plan (at a distance of 25 cm from the horn antenna). The wave reflection has been avoided by using absorbent polystiren bed as tissue sample support. The generator was designed to deliver continuous wave flow all over the duration of the irradiation. The four tissue samples have been exposed simultaneously for every type of exposure. The controlled micro-climate conditions have been assured by using the large Angelantoni Scientifica room (4 C degrees and 70% humidity). Microwave acute exposure of 1-2-4-8-16 hours was carried out. The chronic exposures have been arranged for sessions of 1-2-4 hours with 2 hours breaks so that the total exposure time to be the same -16 hours (the longest exposure time to acute irradiation).

Biochemical measurement. The spectrophotometric assay of the average content of DNA and RNA was accomplished using ultraviolet absorption spectra [6]. ***Statistics***. Repeated exposure and measurements were carried out in order to assure statistic significance. The t-test was applied to compare the average values of exposed samples and control ones.

3. Results and Discussions

In **muscle** tissue (fig. 1) the acute irradiation led to significant variation only for the shortest exposure time while chronic irardiation led to linear dependence on the exposure time (up to 75% increase for 4 % hours).

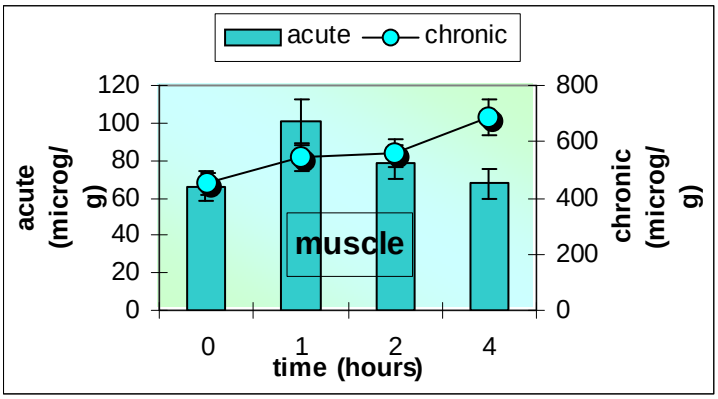

Fig. 1. The nucleic acid content in muscle after acute and chronic exposure

In **liver** (fig. 2) the chronic exposure has induced considerable increase (up to 90%) for 1-2 hours followed by 25% diminution for 4 hours; the acute exposure led to similar variation except the 4 hours sample where the value is lower than in the control sample.

In **lung** tissue (fig. 3) the two types of exposure induced parallel variation curves with higher amplitudes for chronic exposures. In bone (highly inhomogeneous tissue with considerably low water content) there were recorded significant variations (fig. 4) though not correlated with the exposure time.

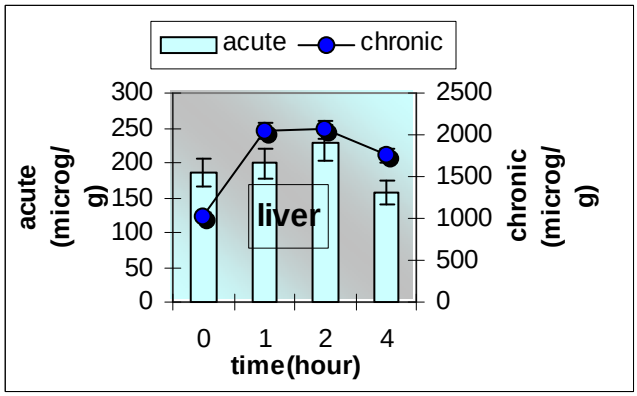

Fig. 2. The nucleic acid content in liver after acute and chronic exposure

The statistic ensurence was assessed in all cases by applying the t-test – the significance threshold of 05.

The microwave influence was evident from the quantitative assay -only the sense of the variation is apparently surprisingly since the premise of the nucleic acid damage is indubitably accepted. Indeed, though having an energy of million times lower than that required to destroy the covalent bonds within the DNA molecules, the microwave absorption is supposed to able to trigger complex synergic phenomena resulting finally in the DNA breaking.

This is certainty a possible phenomenon - but what could be its frequency within the irradiated cells – this could depend on many factors (cell nature, physiological state, exposure arrangement, power density level, microwave frequency etc.).

If the frequency of DNA breaking is low then the quantitative assay could not be able to evidence it. If the nucleic acid damaging is not the only result of low microwave doses then the quantitative assay would emphasize the overlapped results of concurrent phenomena.

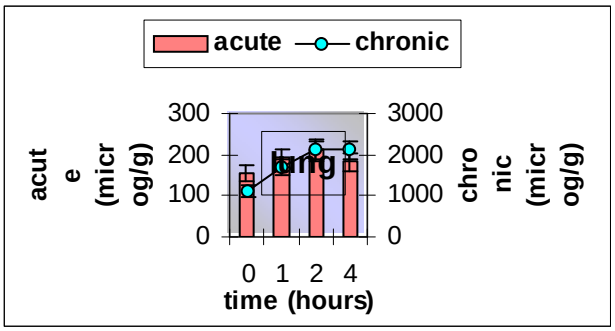

Fig. 3. Comparative data (nucleic acid content) regarding the acute and chronic exposure of lung

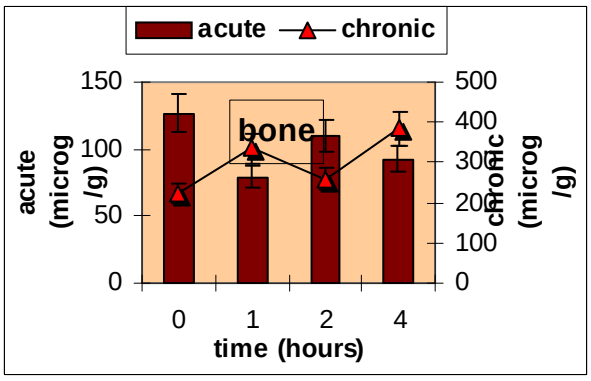

Fig. 4. Comparative data (nucleic acid content) regarding the acute and chronic exposure of bone

If the nucleic acid damaging is not the only result of low microwave doses then the quantitative assay would emphasize the overlapped results of concurrent phenomena. The microwave power density was quite small (1 mW/cm^2) and the investigated tissues, though not exposed in vivo (but freshly withdrawn from the animal body), were still alive, their metabolic activity being characterized by reduced (but not zeroed) physiological parameters. Nevertheless, the resonant effect of microwave absorption in the samples having several centimeters dimensions need to be pointed out, especially in relation with the considerable amplitude of the observed effects. Further experiments are planned to be carried out in order to accomplish deeper investigation on the nucleic acid level in animal tissues with alternative methods

4. Conclusions

The non-thermal effect of microwaves was evidenced by measuring the nucleic acid content in animal tissue samples exposed to low power density microwaves that have induced significant variations in all types of investigated samples. The amplitude of the variations recorded in the nucleic acid level was up to 75% in muscle and up to 95% in liver (chronic exposures). The ability of the living cells of repair the damages induced by microwave exposures resulted in the increase of the DNA and RNA biosynthesis intensity which led also to the supplementary increase in comparison to the control.

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