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The Impact of 950MHz Electromagnetic Radiation on the Brain and Liver of Rats and the Role of Garlic Treatment

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THE USE of mobile phones, laptops and wireless networks has become essential components of daily life. However, despite they make life easier, they may also cause a number of health problems.

This study aims at investigating the changes induced in the liver and brain of male albino rats caused by the exposure to 950MHz and the role of garlic treatment. Male Albino rats were exposed to 950MHz electromagnetic field (power density of 1mW/cm^2). Whole body average specific absorption rates (SAR) were 0.238 and 0.372, respectively, for duration of one hour, thrice a week for a period of seven weeks. Garlic extract was administered to the rats at a dose of 500mg/kg body weight, half an hour before each exposure. Animals were sacrificed one day post the last exposure dose. Exposure to 950MHz has triggered oxidative stress in both tissues verified by a significant increase of malondialdehyde (MDA) and nitric oxide (NO) associated with a significant decrease in the activity of superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GSH-Px). Exposure to 950MHz has also induced alteration in the xanthine oxidoreductase system (XOR) identified by a significant increase in the activity of xanthine oxidase (XO) concomitant to a significant decrease of xanthine dehydrogenase. The results showed also accumulation of iron (Fe), and cupper (Cu), and decreases in zinc (Zn) and manganese (Mn). Garlic extract treatment has significantly improved these changes. In conclusion, Garlic might attenuate the impact of 950MHz in liver and brain of male rats.

Keywords: Garlic, Electromagnetic radiation (EMR), Brain, liver, Oxidative stress, Trace elements.

Introduction

Electromagnetic radiation ranges from very high-energy radiation (high frequency, short wave length) to very low-energy radiations (low frequency, long wave length). High-energy radiations include X-rays and gamma rays and are termed as ionizing radiation, which means that they have enough energy to remove an electron from an atom or a molecule. Ionizing radiation can cause a significant biological damage (Shedid et al., 2018). Low-energy radiations as the radiofrequency waves and microwaves are called non-ionizing radiation. Non-ionizing radiation has sufficient energy only for excitation, the movement of an electron to a higher energy state, but does not carry enough energy to ionize atoms or molecules.This does not exclude non-ionizing radiation from being injurious to humans (Megha et al., 2012 and Demers et al., 2014). Headache, decreased learning potential, poor concentration, and oxidative stress were reported (Calcabrini et al., 2017 and Ahmed et al., 2017).

The biological impacts of the radiofrequency and microwaves have been classified as thermal and non-thermal. The thermal effect is caused by the absorption of energy by the skin and superficial tissues and its conversion to heat (Challis, 2005). The non-thermal effect is associated with the amount of energy absorbed and mediated by the generation of reactive oxygen species (ROS) (Tkalec et al., 2007).

Studies concerned with the deleterious effects of the radiofrequency waves and microwaves demonstrated that they can induce damage to the

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brain, liver, kidney and reproductive system (Hao et al., 2015; Deniz et al., 2017 and Sepehrimanesh et al., 2017). However, although numerous studies demonstrated that they can affect vital organs (Yu & Peng, 2017, Samta et al., 2017 and Kivrak et al., 2017), their biological effects are still controversial due to many exposure parameters such as frequency, orientation, modulation, power density, and duration of exposure.

Mammalian XOR exists in two interconvertible forms, xanthine oxidase (XO) and xanthine dehydrogenase (XDH) which predominates *in vivo*. Both forms of the enzyme reduce molecular oxygen, although only XDH can reduce NAD^+, which is its preferred electron acceptor. Reduction of oxygen generates the ROS, superoxide anion, and hydrogen peroxide, and because of this, XOR has been implicated as a destructive agent, particularly in many forms of ischemia-reperfusion (IR) injury **(**Harrison, 2002 and Meneshian & Bulkley, 2002).

Regulation of reducing and oxidizing (redox) state is critical for cell viability, activation, proliferation, and organ function. Aerobic organisms have integrated antioxidant systems, which include enzymatic and nonenzymatic antioxidants that are usually effective in blocking harmful effects of ROS. The major enzymatic antioxidants are SODs, catalase, and GSH-Px. Since superoxide is the primary ROS produced from a variety of sources, its dismutation by SOD is of primary importance for each cell (Zelko et al., 2002). The H_2O_2 produced is reduced to water by catalase (Kirkman et al., 1999) and the GSH-Px (Flohé, 1988).

In order to overcome the potential harmful effect of free radicals and to reduce the damage by oxidants, many natural substances have been tried as antioxidants. Garlic has been used for culinary and medicinal purposes by people from many cultures for centuries (Lawson, 1998). Garlic is a particularly rich source of organosulfur compounds, which are thought to be responsible for its flavor and aroma, as well as its potential health benefits. Consumer interest in the health benefits of garlic is strong enough to place it among the best-selling herbal supplements in the United States (Blumenthal, 2005). Scientists are interested in the potential for organosulfur compounds derived from garlic to prevent and treat chronic diseases, such as cancer and cardiovascular disease (Tapiero et al., 2004). *Alliums sativum* or garlic, contains various substances including minerals, carbohydrates, proteins, fats and vitamins. Vitamins found in garlic include vitamin A, various kinds of vitamin B, such as riboflavin, thiamine, nicotinic acid, and vitamins C and E. Garlic is one of these plant products, traditionally used for its cytotoxic, antitumor, antifungal, antibacterial, antiviral and anti protozoal properties. In an elegant study, Duvvu et al. (2018) revealed that Buffalo Calves supplemented with garlic powder at the dose rate of 250 as well as 300mg per kg body weight, for a period of 90 days showed a significant increase in the total protein, albumin, globulin and HDL-cholesterol levels and a significant decrease in the blood glucose level, and serum cholesterol level compared with the control group calves.

This work is conducted to determine the effect of 950MHz on the liver, and brain of male albino rats by measuring the oxidant/antioxidant status, and changes in the level of trace elements, and to evaluate the role of garlic treatment in the alleviation of these changes.

Materials and Methods

Experimental animals

Male Albino rats were obtained from the Atomic Energy Authority, National Center for Radiation Research and Technology (NCRRT). Rats 3–4 month's age, weighing (200±10g), were used as experimental animals. The animals were maintained under standard conditions of temperature, humidity and lighting with free access to standard food and drinking water *ad libitum*, and kept under observation for one week prior to experimentation. All animal procedures were performed in accordance with the Ethics Committee of the National Research Center, conformed to the Guide for the care and use of Laboratory Animals, published by the National Institutes of Health (NIH publication No.85 – 23, revised 1996).

Irradiation process

Exposure of rats to 950MHz was carried out at the NCRRT Atomic Energy Authority, Cairo, Egypt. The animals were exposed to an electromagnetic field (EMF) exposure system, generated from a synthesized CW generator, model 83712b, with around tube cage and adipole exposure antenna was used to produce EMF with frequency of 950MHz at power densities 1mW/cm^2 (Durney et al., 1986). Rats were exposed to

the EMF 3 times a week, each time lasts for one hour, for 7 weeks.

Preparation of garlic extract

Fresh garlic was purchased from a local grocery store. The garlic extract was prepared according to the method reported by Alnaqeeb et al. (1999). In brief, the fresh garlic cloves were peeled on crushed ice, and 50g of garlic was homogenized in 75ml of cold, distilled water in the presence of some crushed ice. The filtered homogenized mixture was then centrifuged at 2000×g for 10min and the clear supernatant was made up to 100ml with distilled water. The concentration of the garlic preparation was considered to be 500mg/ml. The prepared garlic extract was stored at -20^{0}C until being used. The extract was given to the rats at a dose of 500mg/kg body weight, half an hour before each EMF exposure

Animal groups

Experimental animals were randomly divided into 4 groups of 6 rats each, as follows, group I (Control group): Rats received distilled water via gavages for seven weeks; group II (Garlic group): Rats orally received 500mg/kg b.w. of garlic extract three times a week (day after day) for seven weeks. Group III (Irradiated group): Rats were exposed to 950MHz EMF for 1hr three times a week (day after day) for seven weeks, group IV (Garlic - Irradiated group): Rats orally administered with 500mg/kg b.w. of garlic extract and exposed to 950MHz EMF for 1hr three times a week (day after day) for 7 weeks after half hour of the garlic dosage.

Biochemical analysis

All chemicals and kits were obtained from Sigma-Aldrich, St Louis, MO, USA. Measurement of absorbance was done using a T60 UV/VIS spectrophotometer (PG instruments, London, UK). At the end of the experimental period (7weeks), rats from each group were sacrificed by decapitation one day post the last EMF exposure. For the assessment of oxidative stress, the liver and brain tissues were rapidly excised and 10% (w/v) tissue homogenate was prepared in normal 0.9% saline using Teflon homogenizer (Glass-Col, Terre Haute, Ind., USA). The homogenates were centrifuged at 10,000g for 15min using refrigerated centrifuge (K3 Centurion Scientific, Ltd, London, UK) and aliquots of the supernatant were separated and used for further analysis.

Lipid peroxidation was assayed according to Yoshioka et al. (1979). The method is based on the determination of malondialdehyde (MDA) an end product of lipid peroxidation, which reacts with thiobarbituric acid in acidic medium to yield a pink colored trimethine complex exhibiting an absorption maximum at 532nm. Nitric oxide (NO) level was determined following the procedure described by Miranda et al. (2001), based on the measurement of total nitrite levels which is the only stable end product of the autoxidation of NO in aqueous solution (formed by reaction of NO with superoxide or oxyhemoglobin) which provides a reliable and quantitative estimate of NO output *in vivo*. Vanadium (III) in dilute acid solution effects the quantitative reduction of nitrate to nitrite and/or nitric oxide, both of which are captured by Griess reagents. The Griess reaction entails formation of a chromophore from the diazotization of sulfanilamide by acidic nitrite followed by coupling with bicyclic amines such as *N*-1- (napthyl)-ethylenediamine, which results in a measurable pink metabolite measured at 540nm.

Superoxide dismutase activity (SOD) was determined according to the method of Niskikimi et al. (1972). The assay relies on the ability of the enzyme to inhibit the phenazinemethosulfate-mediated reduction of nitrobluetetrazolium (NBT) dye. The increase in absorbance at 560nm due to the formation of reduced NBT was recorded in a spectrophotometer. Catalase activity was determined according to Aebi (1984) in which the disappearance of peroxide is followed spectrophotometrically at 240nm. The method is based on the catalytic function of the enzyme where it catalyzes the decomposition of H_2O_2 into water and oxygen. Glutathione peroxidase (GSH-Px) activity was determined according to the method of Paglia & Valentine (1967). GSH-Px reduces H_2O_2 to water by oxidizing the reduced glutathione (GSH) to glutathione disulfide (GSSG) giving a deep yellow color measured spectrophotometrically at 340nm.

The xanthine oxidoreductase (XOR) system, which consists of xanthine dehydrogenase (XDH) and xanthine oxidase (XO) were assayed using the method of Kaminski & Jezewska (1979). The xanthine oxidoreductase activity was measured spectrophotometrically as formation of uric acid and NADH at 302 and 340nm, respectively. The reaction mixture contained 50mM xanthine,

150mM tris-HCL and the protein samples. The total activity (XDH+XO) was determined at the same wavelength by adding NAD (150mM) to the reaction mixture. The reaction mixture (without tissue extract) was mixed and incubated at 25˚C for 5min. The reaction was started by adding the enzyme (tissue extract) and the progress of the reaction was monitored after an initial delay of 2min. The activity of XDH was calculated by subtracting the XO activity from the total activity (XDH+XO). One unit of enzyme activity was defined as amount of enzyme required to catalyze the formation of 1µmol of uric acid per minute at 25°C. The enzyme activity was expressed as mU/mg protein.

The levels of total iron, total copper, total zinc, and total manganese were measured by thermo scientific ice 3000 series atomic absorption spectrophotometer according to the method of Kirbright & Sargent (1974).

Statistical analysis

The data is presented as mean±standard deviation (SD). Groups were compared by one-way analyses of variance (ANOVA), and post hoc multiple comparisons were done with LSD test using SPSS/PC software program (version 21; SPSS Inc., Chicago, IL, USA).

Results

The administration of Garlic extract, to normal rats, has not affected the level of malondialdehyde (MDA) and Nitric oxide (NO) as well as xanthine oxidase (XO) and xanthine dehydrogenase (XDH) activities, in the brain and liver tissue of rats (Tables 1 and 2). The activity of antioxidant enzymes superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GSH-Px) was in the normal level (Table 3). There was no significant change recorded for the levels of total iron, copper, zinc, and manganese, in the liver and brain of rats (Table 4).

TABLE 1. The level of malondialdehyde (MDA) and nitric oxide (NO) in the liver and brain of rats in the different groups.

	Organ	Control	Garlic	EMF	Garlic+EMF
MDA (nmol/g tissue)	Liver	237±4.1	234±6.1 (-1%)> 0.05 [a]	289±6.6 (+22%)≤ 0.001[a]	250±3.7 (+5%)≤ 0.01[a]≤ 0 .001[b]
	Brain	152±5.6	150±3.4 (-1%)> 0.05 [a]	179±3.3 (+18%)≤ 0.001[a]	159±3.4 (+5%)≤ 0.01 [a]≤ 0.001[b]
NO (nmole/g tissue)	Liver	24±3	22±2 (-8)> 0.05 [a]	34±1.6 (+42%)≤ 0.001 [a]	27±2.1 (+13%)≤ 0.01 [a]≤ 0.001[b]
	Brain	20±1.6	18±1.5 (-10%)> 0.05 [a]	25±1.7 (+25%)≤ 0.001[a]	22±1.9 (+10%) >0.05 [a]≤ 0.001[b]

- Data are expressed as means± standard deviation (n= 6).
- The number between brackets shows the percentage of change from the respective control value.
- [a]: Significance vs control, [b]: Significance vs EM.
- Differences between means were considered significant at P≤ 0.05, highly significant at $p \leq 0.01$ and very highly significant at P≤ 0.001, non-significant at P> 0.05.

TABLE 2. The values of the xanthine oxidoreductase system in the liver and brain of rats in the different groups.

	Organ	Control	Garlic	EMF	Garlic+EMF
Xanthine Oxidase (mU/mg protein)	Liver	2.13±0.02	2.04±0.05 (-4%)> 0.05 [a]	2.90±0.38 (+38%)≤ 0.001[a]	2.17±0.19 (+2%)> 0.05 [a]≤ 0.001[b]
	Brain	1.28±0.03	1.25±0.05 (-2%)> 0.05 [a]	1.70±0.14 (+31%)≤ 0.001[a]	1.42±0.08 (+9%)≤ 0.01 [a]≤ 0.001[b]
Xanthine Dehydrogenase (mU/mg protein)	Liver	4.9±0.20	5.0±0.02 (2%)> 0.05 [a]	3.1±0.11 (-37%)≤ 0.001[a]	4.5±0.15 (-8%)≤ 0.01 [a]≤ 0.001 [b]
	Brain	2.61±0.39	2.63±0.42 (0.8%)> 0.05 [a]	1.67±0.11 (-35%)≤ 0.001[a]	2.42.±0.31 (-8%)> 0.05 [a]≤ 0.001[b]

- Data are expressed as means± standard deviation (n= 6).
- The number between brackets shows the percentage of change from the respective control value.
- [a]: Significance vs control, [b]: Significance vs EM.
- Differences between means were considered significant at P≤ 0.05, highly significant at $p \leq 0.01$ and very highly significant at P≤ 0.001, non-significant at P> 0.05.

TABLE 3. The activity of superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GSH-Px) in the liver and brain of rats in the different groups.

	Organ	Control	Garlic	EMF	Garlic+EMF
SOD (U/g fresh tissue)	Liver	132 ±6.2	135±5.3 (+2%)> 0.05 [a]	95±3.9 (-28%)≤ 0.001[a]	120±2.9 (-9%)≤ 0.01 [a]≤ 0.001[b]
	Brain	155 ±7.4	153±7.5 (-1.2%)> 0.05 [a]	110±5.9 (-29%)≤ 0.001[a]	132±4.4 (-15%)≤ 0.01 [a]≤ 0.001[b]
CAT (U/g fresh tissue)	Liver	12.4±0.2	12.3±0.5 (-0.8%)> 0.05 [a]	8.4±0.3 (-32%)≤ 0.001[a]	10.9±0.5 (-12%)≤ 0.01 [a]≤ 0.001[b]
	Brain	5.7±0.2	5.4±0.5 (-5.2%)> 0.05 [a]	4±0.14 (-30%)≤ 0.001[a]	4.9±0.13 (-14%)≤ 0.01 [a]≤ 0.001[b]
GSH-Px (mg consumed glutathione/min/g fresh tissue)	Liver	1.2±0.19	1.3±0.28 (8%)> 0.05 [a]	0.8±0.12 (-33%)≤ 0.001[a]	1.1±0.20 (-8%)> 0.05 [a]≤ 0.01[b]
	Brain	0.60±0.08	0.65±0.06 (8%)> 0.05 [a]	0.43±0.02 (-28%)≤ 0.001[a]	0.56±0.04 (-7%)> 0.05 [a]≤ 0.001[b]

- Data are expressed as means± standard deviation (n= 6).
- The number between brackets shows the percentage of change from the respective control value.
- [a]: Significance vs control, [b]: Significance vs EM.
- Differences between means were considered significant at P≤ 0.05, highly significant at $p \leq 0.01$ and very highly significant at P≤ 0.001, non-significant at P> 0.05.

TABLE 4. The level of total manganese (Mn), iron (Fe), copper (Cu), and zinc (Zn) in the liver and brain of rats in the different groups.

	Organ	Control	Garlic	EMF	Garlic+EMF
Mn (µg/g fresh tissue)	Liver	8.0±0.9	8.8±1.2 (10%)> 0.05 [a]	5.5 ±1.1 (-31%)≤ 0.001[a]	7.3±1.0 (-9%)> 0.05[a]≤ 0.01[b]
	Brain	3.0±0.5	3.4±0.4 (13%)> 0.05 [a]	2.1 ±0.3 (-30%)≤ 0.001[a]	2.6±0.3 (-13%)> 0.05[a]≤ 0.01[b]
Fe (µg/g fresh tissue)	Liver	73±3	72±5 (-1%)> 0.05 [a]	96±6 (31%)≤ 0.001[a]	80±5 (10%)≤ 0.01 [a]≤ 0.001[b]
	Brain	36±3	39±5 (8%)> 0.05 [a]	46±4 (28%)≤ 0.001[a]	41±4 (14%)≤ 0.01 [a]≤ 0.01[b]
Cu (µg/g fresh tissue)	Liver	2.7±0.1	2.6±0.4 (-4%)> 0.05 [a]	3.5±0.7 (30%)≤ 0.01[a]	2.8±0.3 (4%)> 0.05[a]≤ 0.01[b]
	Brain	1.7±0.1	1.6±0.2 (-6%)> 0.05 [a]	2.1 ±0.2 (23%)≤ 0.001[a]	1.8±0.2 (6%)> 0.05 [a]≤ 0.01[b]
Zn (µg/g fresh tissue)	Liver	38±3.3	39±4.9 (3%)> 0.05 [a]	29±3 (-24%)≤ 0.001[a]	32±2 (-16%)≤ 0.01 [a]≤ 0.01[b]
	Brain	11±1.2	12±1.5 (9%)> 0.05 [a]	8±0.9 (-27%)≤ 0.001[a]	9±1.0 (-18%)≤ 0.01 [a]> 0.05 [b]

- Data are expressed as means± standard deviation (n= 6).
- The number between brackets shows the percentage of change from the respective control value.
- [a]: Significance vs control, [b]: Significance vs EM.
- Differences between means were considered significant at P≤ 0.05, highly significant at $p \leq 0.01$ and very highly significant at P≤ 0.001, non-significant at P> 0.05.

The exposure of male albino rats to 950MHz has triggered oxidative stress, in brain and liver tissues as demonstrated by a significant elevation in the level of malondialdehyde (MDA), an end product of lipid peroxidation and nitric oxide (NO) (Table 1). Also, a significant increase was recorded in xanthine oxidase (XO) activity, while a significant decrease was recorded in the activity of xanthine dehydrogenase (XDH), compared to their respective values in control rats (Table 2). The activity of the antioxidant enzymes superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GSH-Px) was significantly decreased (Table 3). The levels of total iron, total copper were significantly increased, while the levels of total zinc, and total manganese were significantly decreased, compared to their respective control levels (Table 4). Garlic treatment, has significantly attenuated the impact of 950MHz in the brain and liver.

Discussion

With the rapid development of electronic technologies, the health hazards induced by non-ionizing radiation have been growing in recent years. Technological devices such as mobile phones, computers, wireless networks, household appliances and other electronic equipment have become essential components of daily life, however, despite making life easier, they may also cause a number of health problems due to the increased durations of exposure to radiofrequency and microwaves (Yu & Peng, 2017; Samta et al., 2017 and Kivrak et al., 2017).

In the current study, exposure of rats to 950MHz for 1hr 3 times a week for 7 weeks has promoted oxidative stress in the brain and liver verified by a significant increase of MDA, NO, and XO accompanied by a significant decrease in XDH, SOD, CAT and GSH-Px compared to the control group. Increased lipid peroxidation was accompanied by an increase in the levels of Fe and Cu and a decrease of Mn and Zn that may be attributed to alteration in the permeability of plasma membranes.

These changes may indicate the high vulnerability of brain (Cao et al., 2004; Martinez-Samano et al., 2012 and Ghanbari et al., 2016) and liver (Liu et al., 2013 and Kivrak et al., 2017) and their susceptibility to oxidative stress (Ragy, 2015). The results corroborate the findings of Samta et al. (2017) that the exposure of rats to 900MHz EMR for 2hr daily for 3 months causes a considerable damage in the liver, and brain.

The results are in line with previous findings that exposure to radiofrequency raises nitricoxide (NO), induces lipid peroxidation (Ozgur et al., 2010), decrease catalase (Sokolovic et al., 2008 and Odaci et al., 2015), superoxide dismutase (SOD), and glutathione peroxidase (GSH-Px) activities (Ozgur et al., 2010 and Sepehrimanesh et al., 2017), increase the activity of xanthine oxidase (Sokolovic et al., 2008). The decreased activity of enzyme might be attributed to changes in transcription and protein expression (Friedman et al., 2007).

Meanwhile, the increase of MDA and NO may be attributed to imbalance in iron homeostasis that increases free iron levels and leads to the formation of hydroxyl radicals via the Fenton reaction, followed by lipid peroxidation and calcium leakage from internal storage that trigger nitricoxide synthesis, which is responsible for damage to DNA and other macromolecules(Lai & Singh, 2004).

The elevated MDA concentration corroborates the cytotoxic effect of non-ionizing radiation, where an elevated oxy radical generation and subsequent cell membrane disruptions were reported to be the reasons for electromagnetic field induced cell damage (Dindic et al., 2010).

In the current study, the significant decrease of SOD, CAT, and GPx activities in the brain and liver point out that alterations in the level of antioxidants, and enzymological activity could be considered the indicators of deteriorating animal homeostasis that further resulted in stress and declined the functional ability (Gecit et al., 2014 and Saravanan et al., 2012). Oxidative insult via deterioration of antioxidant defense capacity is apathogenic pathway involved in all the organ dysfunction or disorders (Saravanan et al., 2012). Compelling evidence has demonstrated that EMF exposure is capable of causing substantial oxidative damage to the body (Sharma et al. 2014; Aydin & Akar et al., 2011 and Maaroufi et al., 2014).

The levels of trace elements can vary considerably depending on age, sex, diet, geographical and climatic conditions, or genetic

factors. The concentration of an element may also change by physical or chemical factors (Shen et al., 2005).

In the current study, the changes in the level of total iron, copper, zinc and manganese in liver and brain tissues might indicate the detrimental effects of EMF exposure. It is well documented that many elements are co-factors of several antioxidant enzyme systems. In this context, zinc and copper in SOD (Zelko et al., 2002) play a role in quenching free radicals through reduction of the peroxidation ratio and breaking the free-radical production chain.

Garlic has long been used for medicinal purposes by people from many cultures for centuries (Lawson, 1998). The main pharmacological effects of garlic are attributed to 'allicin', an organosulphur compound that exhibits antioxidant (Yousef et al., 2015), hypocholesterolemic, and hypoglycemic action (Duvvu et al., 2018). In the current study, the administration of Garlic (500mg/kg body weight), to normal rats, has not induced toxic effects in liver and brain tissues as demonstrated by the normal level of oxidants, and antioxidants as well as iron, copper, zinc, and manganese, compared to their corresponding levels in the control group.

Nevertheless, the administration of garlic extract to the rats, half an hour before exposure to 950MHz, has significantly attenuated oxidative stress, and induced a remarkable improvement in the level of trace elements, when compared to their values in the brain and liver of irradiated rats. This could be attributed to the presence of organosulfur compounds (Tapiero et al., 2004). In addition**,** *Alliums sativum* or garlic contains various substances including minerals, carbohydrates, proteins, fats and vitamins. Vitamins found in garlic include vitamin A, various kinds of vitamin B, such as riboflavin, thiamine, nicotinic acid, and vitamins C and E. Moreover, garlic is a rich source of many elements including zinc, calcium, potassium, manganese, magnesium (Saada, 2013). Also, garlic contains germanium and selenium that play an important role in normalizing the oxygen utilization in the cells (Hussein et al., 2007).

In the current study, garlic administration has effectively alleviated oxidative stress as evidenced by the enhancement of SOD, catalase and GSH-Px activities in liver and brain tissues. This elevation of the antioxidant capacity suggests that garlic extract protects from oxidative stress (Ghalehkandi, 2014); promotes the scavenging of reactive free radicals that improve the antioxidant enzyme activities and supported by the decreased levels of NO and MDA (Ghalehkandi et al., 2013).

The protective property of garlic may be attributed to the presence of organosulfur compounds, which have antioxidant and detoxifying properties. This detoxifying effect is explained by the induction of antioxidant enzymes (Munday & Munday, 2004).

According to the results obtained in the current study, there is a possibility that orally administered garlic extract exerts a preventive effect on injury progression in EMF treated rats through its indirect antioxidant action to maintain antioxidant defense system in addition to its direct antioxidant action to scavenge ROS and to inhibit lipid peroxidation.

Conclusion

In Conclusion, EMFs interaction with biological systems may cause deleterious changes in tissues. Garlic extract may attenuate these changes..

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التأثير المحسن لمستخلص الثوم في الأنسجة المختلفة لذكور جرذان بيضاء عرضت لمجال مغناطيسي

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أصبح استخدام الهواتف المحمولة وأجهزة الكمبيوتر المحمولة والشبكات اللاسلكية مكونات أساسية للحياة اليومية. ومع ذلك، على الرغم من أنها تجعل الحياة أسهل، فإنها قد تسبب أيضًا عددًا من المشكلات الصحية. الهدف من هذه الدراسة هو تقييم فعالية مستخلص الثوم لحماية وعلاج التغيرات التي يسببها المجال الكهرومغناطيسي في الفئران. تم إعطاء مستخلص الثوم الجاهز (500 ملجرام/كلجرام) فميا للفئران قبل نصف ساعة من التعرض للموجة الكهرومغناطيسية مع تردد يساوي (950 ميجاهرتز) 3 مرات في الأسبوع، في كل مرة ساعة واحدة لمدة 7 أسابيع. تم تشريح الحيوانات بعد 7 أسابيع. وقد أدى تعرض الفئران البيضاء إلى المجال المغناطيسى إلى حدوث إجهاد تأكسدي في أنسجة المخ والأنسجة الكبدية من خلال زيادة ملحوظة في malondialdehyde (MDA) وأكسيد النيتريك (NO) المرتبط بانخفاض كبير في نشاط ديسموتاز الفائق أكسيد (SOD)، الكاتالاز (CAT) والجلوتاثيون بيروكسيديز (GSH) (Px-). أدى التعرض إلى 950 ميجا هرتز أيضًا إلى إحداث تغيير في نظام أوكسيدوروكتاز الزانثين (XOR) الذي تم تحديده من خلال زيادة كبيرة في نشاط الزانثين أوكسيديز (XO) المصاحب لانخفاض كبير في الزانثيندى هيدروجينز(XDH). وأظهرت النتائج أيضا تراكم (الحديد) و (النحاس)، وانخفاض (الزنك) و(المنجنيز) في الكبد والدماغ فى مجموعة الفئران المشعة مقارنة مع المجموعة الضابطه. ونستنتج أن مستخلص الثوم قد خفف بشكل كبير من الإجهاد التأكسدي. والتحسن الملحوظ في جميع العوامل المقاسة، مقارنة بقيمها في الدماغ وكبد الفئران المشعة. ويمكن استنتاج أن مستخلص الثوم تمكن من تخفيف الإجهاد التأكسدي الناجم عن الإشعاع وقد لعب دورا في الحفاظ على الدماغ وسلامة الكبد.