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Review Article

Bioeffects induced by exposure to electromagnetic fields and mitigation by natural antioxidants

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Abstract: This review aims to determine whether antioxidants can modulate the harmful effects of electromagnetic fields, thereby influencing health and disease outcome associated with oxidative stress-induced insults. Electromagnetic fields increase oxidative stress and that dietary supplementation with antioxidants may play a role on the neutralization or buffering of the effects of electromagnetic fields with oxidizing properties. This review summarizes the most common and health-relevant sources of oxidative stress like electromagnetic fields. There are several reports related to the protective effect of natural based substances in prevention and treatment of deleterious effects induced by electromagnetic radiation. Due to space constrains and a broad scientific data, not all the studies could be covered in this review. The use of natural antioxidants from plant is increasing day by day. In this review, we summarized mitigation of bioeffects induced by exposure to electromagnetic fields by some plants rich in natural antioxidants such as, plum *(Prunus domestica)*, bitter orange *(Citrus aurantium*), green tea *(Camellia sinensis)*, rosemary *(Rosmarinus officinalis)*, basil *(Ocillium basilicum)*, garlic *(Allium sativum), Loranthus longiflorus, Alstonia scholaris.* In addition, numerous natural antioxidants such as, vitamins C, E and their derivatives, date palm pollen, quercetin, caffeine, chlorogenic acid, ellagic acid, bixin, flavonoids, epigallocatechin and other polyphenols consumption before or after radiation exposure can protect cells against radiation induced damage. Clinical studies imply that eating a diet rich in fruits, vegetables, whole grains, legumes, and omega-3 fatty acids can help humans in decreasing oxidative stress. It can be concluded that dietary supplementation with antioxidants may play a role on the neutralization or buffering of the effects of electromagnetic fields with oxidizing properties.

Keywords: Basil, Bitter orange, Garlic, Green tea, Natural antioxidants, Mitigate the harmful effects of EMFs, Plum, Rosemary, Vitamin C, E.

INTRODUCTION

Electrical energy enters into the operation of a myriad industrial, scientific, medical, community and house equipment and appliances. The accompanying electromagnetic fields (EMFs) are partially transformed into radiation that affects human health [1]. Electromagnetic radiation (EMR) of cellular phones may affect biological systems by increasing free radicals and changing the antioxidant defense systems of tissues, eventually leading to oxidative stress [2]. EMFs exposure has a cumulative effect, increasing over time and with the dose [1, 2]. The biological effects and health hazards of non ionizing radiation have been debated for over fifty years. The results of extensive studies showed that acute exposure to non-ionizing radiation can lead to increased internal temperature, speeds up chemical reactions rate which result in biochemical and physiological effects [4]. Children, pregnant women and those with poor health conditions are especially at risk for a lifetime of exposure [1, 5]. Exposure of human and animals to EMFs have been a negative effects on cardiovascular system, CNS, endocrine, immune systems and reproductive system, the developing embryo/fetus, and cause a histopathological changes and disturbances in functions of different body organs [6]. EMFs might produce a variety of adverse in vivo effects such as chronic fatigue, headaches, cataracts, heart problems, stress, nausea, chest pain, forgetfulness, influence the learning and memory, cardiovascular system and reproductive system, CNS, endocrine, immune systems, sleep disturbances. It have been implicated in adversely affecting multiple facets of human health such as leukemia, brain cancer, lung and breast tumors, Lou Gehrig's disease, genotoxicity and neurodegenerative disease, infertility, birth defects, increased risk of miscarriage, childhood morbidity, de novo mutations, amyotrophic lateral sclerosis, depression, reproduction anomalies, suicide, and Alzheimer's' disease [6].

Exposure to EMFs induces harmful effects on testis and reproductive activities [7].

Several mechanisms of how MFs lead to cancer have been proposed. One possible mechanism is the impact of EMFs on free radical combination rates in certain enzymes, such as coenzyme B_{12}-dependent ethanolamine ammonia lyase [8, 9]. It was evidenced that despite the small influence of EMFs on radical pair recombination, the enzyme reaction rate may be amplified by a factor of up to 100 [9, 10]. An alternative mechanism may be the interactions between electric field and airborne pollutant particles. The corona ions emitted from high voltage power lines are able to attach the pollutants and increase their electric charge states, which can be deposited on the skin or in the lung through inhalation [9, 11].

Magnetic field is produced by a magnetic object with particles or by changing the electric field, and is identified by the force applied to other magnetic materials or movement of the electric charge. Magnetic field is identified at any given point by both parameters of direction and intensity (or resistance), which is known as a vector field and in today's industrial and economic world makes its effects on health, forecasting, and management implications of these developments difficult [12, 13].

EMR of cellular Mobile phones may affect biological systems by increasing free radicals, which appear mainly to enhance lipid peroxidation, and by changing the antioxidant defense systems of human tissues, thus leading to oxidative stress [14].

Electromagnetic waves have been shown to exert their effects on biological systems through generation or increase in reactive oxygen species (ROS). ROS, as a medium, contributes to numerous biological impacts including DNA damage and mutation induction [15, 16]. Mitochondria are the main site of intracellular oxygen consumption and the main source of ROS formation [17]. Once ROS are produced, they are removed by cellular defenses which include the enzymes superoxide dismutase (Mn-SOD, Cu/Zn-SOD, and extracellular (EC)-SOD), catalase, glutathione peroxidase, peroxiredoxins, and the nonenzymatic antioxidants, like glutathione (GSH), thioredoxin, ascorbate, α-tocopherol, and uric acid [18]. The balance between production and neutralization of ROS levels can increase dramatically, which may cause damage to cell structures leading to behavioral, histopathological and biochemical alterations [19]. The increase in oxidative stress in hematopoietic centers has also been reported due to use of mobile phone [16, 20].

Free radicals and reactive oxygen species play an essential role in the occurrence of more than hundred disorders. Human cells through radiation produce free radicals and they can damage macromolecules such as DNA, lipid, proteins and carbohydrate [21].

Since oxidative damage of cells increases with age, the increased intake of exogenous antioxidants may support the endogenous antioxidative defense. Clinical studies imply that eating a diet rich in fruits, vegetables, whole grains, legumes, and omega-3 fatty acids can help humans in decreasing oxidative stress and postponing the incidence of degenerative diseases [22].

Herbal medicines have been popular for prevention and treatment of diseases from ancient times and in recent years herbal remedies are used as primary health care with minimum side effects around the world [7, 23]. The use of natural antioxidants from plant is increasing day by day [7]. In addition, numerous natural antioxidants such as, vitamins C, E and their derivatives, Vitamin A, β-carotene, curcumin, date palm pollen, Allium cepa, quercetin, caffeine, chlorogenic acid, ellagic acid, bixin, flavonoids, epigallocatechin and other polyphenols consumption before or after radiation exposure can protect cells against radiation induced damage [7, 24, 25].

Researchers have confirmed that an adequate intake of antioxidant rich diet helps to prevent these degenerative disorders because food rich in antioxidants play an essential role in the prevention of many diseases viz cardiovascular diseases cancers and neurodegenerative diseases [19]. There are several reports related to the protective effect of natural based substances in prevention and treatment of deleterious effects induced by electromagnetic radiation [7, 9, 13, 16, 24-29].

Nowadays, scientists' effort to use natural ingredient instead of drugs and chemicals to maintain human health more and prevention of diseases. Among such, consumption of green tea has the longest history in the world and now in over 160 countries around the world as the common beverage is consumed daily. Recently, green tea due to its numerous benefits in health, in prevention and in treatment of diseases such as cancer has been considered in the public opinion and in the scientific community. Because of its application, in addition to traditional methods of brewing has prevalence as a natural ingredient in food or feed products and in the pharmaceutical and cosmetics industries [30].

Bitter orange *(Citrus aurantium*):

Mansouri and Khaki, [13] evaluated the diminishing effects of *Citrus aurantium* on uterus cell injury in female Wistar rats induced by EMF. In the experimental rats, apoptotic cells showed significant increase in the EMF groups. However, in the exposed group that received *Citrus aurantium*, apoptotic cells and serum malondialdehyde (MDA) were decreased and superoxide dismutase (SOD) was increased (P <

0.05). *Citrus aurantium* juice has antioxidative effects on uterus tissue by reduction of apoptosis.

Date palm pollen

Baharara *et al.,* [7] investigated that the protective effect of the date palm (*Phoenix dactylifera)* pollen (DPP) in preventing the detrimental effects of low frequency electromagnetic field (50 Hz) on sperm parameters and sexual hormones. Adult male mice were randomly divided into 7 groups of 8 and exposed to EMF 4 h/day for 10 days. In this study experimental groups received DPP with doses of 25, 50, 100 and 200 mg/kg, respectively before exposure. At the end of the experiment each group were tested for sperm parameters including: motility, count, morphology, viability and the level of luteinizing hormone (LH) and testosterone. The results revealed that exposure to EMF induced significant reduction ($P < .001$) in sperm count, viability and progressive motility in comparison with control group. EMF caused abnormalities in sperm and significant decrease in testosterone level. In testis the rates of metabolism and cell replication is high and oxidative stress can be harmful in seminiferous tubules because electromagnetic exposure and heat can affect the blood-testis barrier and cause spermatogonial degeneration [7]. Administration of DPP before exposure improved the sperm count, viability, motility and testosterone level in experimental groups. In addition, pretreatment with DPP prevented the sperm abnormality induced by EMF. The results indicate the protective effect of DPP against EMF adverse effects on sperm parameters and sexual hormones in male mice [7]. Date palm pollen (DPP) has been used for curing male and female infertility and impotency for thousands of years as a traditional herbal medicine. DPP contains various types of phytochemicals such as estrone, α-amirin, triterpenoidal saponins, flavonoids estrone, estradiol and estriol and a crude gonadotrophic substance [7, 31]. DPP is a good source of natural antioxidants and has remarkable health benefits and nutritional values. Many studies have shown that DPP can enhance spermatogenesis, increase sperm count and concentration of testosterone, FSH and LH [7, 32].

Plum *(Prunus domestica)*

Rifat *et al.,* [19] study the effects of 10 GHz microwave (MW) exposure on hematological changes in Swiss albino mice and possible modulatory role of plum *(Prunus domestica*) fruit extract. MW exposure resulted in significant decrease ($P \leq 0.001$) in hemoglobin, monocytes, packed cell volume, red blood cells, mean corpuscular hemoglobin and mean corpuscular hemoglobin concentration whereas, white blood cells, lymphocytes, erythrocyte sedimentation rate and mean corpuscular volume increased significantly ($P \leq 0.001$) in MW exposed mice compared to the sham exposed. Cholesterol, alkaline phosphatase and lipid peroxidation also increased significantly ($P \leq 0.001$) after MW exposure compared to sham exposed mice. The depletion in the values of hematological parameters following MW radiation exposure may be attributed to (a) direct damage caused by lethal dose of radiation (b) due to overproduction of ROS by MW interactions [19, 28]. Changes in hematological parameters may be attributed to inhibition by free radicals produced by MW interactions [19]. Depletion was noted in blood sugar, total protein, acid phosphatase and glutathione level after microwave exposure compared to sham exposed mice. Histopathological alterations in blood cells were also noted. Signs of improvements in the hematological and histopathological parameters were recorded in mice of group received 500mg/kg/b.wt (milligram per kilogram body weight) of *Prunus domestica* fruit extract orally once daily 1 hour before exposure to10 GHz (2 h/day) for 30 consecutive days. The antioxidants present in *Prunus domestica* fruit extract have suppressed these harmful effects by scavenging some of the free radicals [19].

Vitamins (C& E)

Mottawie and Ibrahiem, [27] reported that exposure of Wistar albino rats to electromagnetic waves emitted from mobile phone led to a significant difference in the levels of hydrogen peroxide, glutathione, glutathione peroxidase, conjugated diene, and lipid hydro peroxide in serum, liver and kidney when compared to the control group. Supplementation of Vitamin C and E caused a significant decreased in the levels of hydrogen peroxide, conjugated diene, and lipid hydro peroxide while a significant increased in the activities of glutathione, and glutathione peroxidase in serum, liver and kidneys of rats when compared to the control group. The potent free radical scavenger and antioxidant agent's Vitamins C and E seem to be highly promising agents for protecting liver and kidney tissues from oxidative damage and preventing organ dysfunction. Since vitamin E , the most important lipophilic antioxidant resides mainly in the cell membranes, thus helping to maintain membrane stability [27, 33]. Vitamin C is the most important hydrophilic free radical scavenger in extracellular fluids: It traps radicals in the aqueous phase and protects bio membranes from peroxidative damage [27, 34]. In addition to providing its antioxidant effects, Vit C is involved in the regulation of tocopherol from tocopheroxyl radicals in the membrane. Thus, vitamins E and C may have interactive effects **[**27, 35].

Assasa, [36] found that exposure of rats to electromagnetic field radiated from cellular telephones base stations with frequency equals 900 MHz caused a significant decrease in a growth rate. Significant increase in the following blood indices: the white blood cell count as compared to control level, mean corpuscular hemoglobin concentration and blood platelets count. And a significant decrease in red blood cell count, hemoglobin incidence, hematocrit value, the mean corpuscular volume and mean corpuscular hemoglobin concentration. Serum aspartate

aminotransferase, serum alanine aminotransferase and alkaline phosphatase were significantly increased under electromagnetic field exposure. Signs of improvements in the body weight rate, the hematological parameters and the serum of liver enzymes were noticed during treatments with electromagnetic field in addition to vitamin C or E. Vitamin E was more effective in reducing the elevation of ALT, AST, and ALP.

Al-Damegh, [37] investigated the possible effects of electromagnetic radiation from conventional cellular phone use on the oxidant and antioxidant status in rat blood and testicular tissue and determine the possible protective role of vitamins C and E in preventing the detrimental effects of electromagnetic radiation on the testes. There was a significant increase in the diameter of the seminiferous tubules with a disorganized seminiferous tubule sperm cycle interruption in the electromagnetism-exposed group. The serum and testicular tissue conjugated diene, lipid hydroperoxide, and catalase activities increased 3-fold, whereas the total serum and testicular tissue glutathione and glutathione peroxidase levels decreased 3-5 fold in the electromagnetism-exposed animals. Vitamins C and E ameliorate the EMR-induced oxidative stress in the testes, thus facilitating the restoration of testicular tissue morphology and function by suppressing testicular lipid peroxidation and restoring the levels of GST and GSH to normal physiological levels.

Abd El Rahman *et al.*, [4] evaluated the effect of vitamin E, Silymarin and their co-administration on oxidative stress and hormonal changes in rats whole body exposed to 950 MHz electromagnetic field for 2months (2hrs/day, 3times/week). Vitamin E (1.35mg/Kg BW) and/or Silymarin (18mg/Kg BW) were orally administered to rats for 2months before EMF exposure. Exposure to EMF provokes oxidative stress identified by significant increases in serum thiobarbituric acid reactive substances (TBARS), advanced oxidation protein products (AOPP) and protein carbonyl (CO) levels associated to significant decreases in superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GSH-Px) activities and glutathione (GSH) content. Oxidative stress was accompanied by significant decreases of serum follicle stimulating hormone (FSH), luteinizing hormone (LH), and total and free testosterone levels. Vitamin E as well as silymarin has significantly reduced oxidative stress and ameliorated hormone levels. The co-administration of vitamin E with silymarin before EMF exposure afford a better protection, compared to each treatment alone, against oxidative stress and hormonal.

Ghanbari *et al*., [38] evaluated the effects of 3MT EMF exposure on oxidative stress parameters in substantia nigra in Wistar rats and the role of vitamin E in reducing oxidative stress and preventing of LPO process. A significant increase in MDA levels and Glutation peroxidase (GSH-Px) activity of the substantia nigra following 50 days exposure to EMF was detected, but the superoxide dismutase (SOD) activity was decreased. Exposure did not change total antioxidant capacity (TAC) levels in plasma. Vitamin E treatment significantly prevented the increase of the MDA levels and GSHPx activity and also prevented the decrease of SOD activity in tissue but did not alter TAC levels. The GSH-Px activity increased because the duration and intensity of exposure were not enough to decrease it. Treatment with the vitamin E significantly prevented the oxidative stress and lipid peroxidation.

Mohamed and Elnegris [39] evaluated the effect of low frequency electromagnetic fields (LF-EMF) on the structure and function of the thyroid gland and evaluated their reversibility and role of vitamin E in adult male albino rats. Exposed group showed significant decline T3 and T4 levels together with significant increase in TSH level as compared to other groups. Histologically, this group showed congestion and dilatation of blood capillaries, cellular infiltration, follicular disintegration and vacuolar degeneration of some follicular cells. Other apoptotic follicular cells appeared with condensed chromatin or desquamated. The epithelial height and connective tissue area also affected. Vitamin E improves the biochemical and histological picture of thyroid gland. Recovery group had variable alteration as compared to other groups.

Green tea *(Camellia sinensis)*

Guinea pigs exposed to 900 MHz of cell phone radiation are scattered cardiac autonomic adjustments, but green tea has beneficial effects on endothelial function and reduce the risk of cardiovascular [30, 40]. By using of green tea catechin can prevent microwave oxidative damages on cardiac tissue [30, 41]. Zahedifar and Baharara, [30] reported that pro-oxidant and antioxidant properties of green tea can effective to neutralize the harmful effects of chemical-physical environmental pollutants such as electromagnetic radiation. Therefore, in order to promotion of health level and prevention of diseases spread, particularly cancer and reduce the costs of treatment, it is recommended to predict the daily consumption of green tea, with the exception of pregnant women.

Baharara *et al.*, [16] found that the mean number of promyelocytes, myelocytes, erythrocytes, necrotic and apoptotic cells in bone marrow of Balb/C mice fetuses exposed to electromagnetic field with 50 gauss intensity compared with sham exposed embryos showed significant increased but the mean number of eosinophils showed significant decrease. The mean number of promyelocyte and erythrocyte in bone marrow of Balb/C fetuses of pregnant mice treated by *Camellia sinensis* extract and exposed to electromagnetic field with 50-gauss intensity compared with bone marrow of Balb/C mice fetuses exposed to electromagnetic field with 50 gauss intensity showed significant decrease, and significant increase in the

mean of necrotic and apoptotic cells. *Camellia sinensis* is rich in natural antioxidants and antioxidants can neutralize free radicals effects. So, usage of *Camellia sinensis* can decrease the damage due to teratogenicity induced by low frequency electromagnetic field in some cells. *Camellia sinensis* returned the change in the levels of minerals including iron, manganese, and zinc due to the impact of 900-mHz electromagnetic fields in hepatic and ovarian cells to a normal level in pigs [16, 26].

Zhang *et al.,* [9] investigated that the change in oxidative stress after exposure to ELF-EMFs, and potential protective effects of green tea polyphenol supplementation (GTPS) on ELF-EMFs induced oxidative stress. A total of 867 subjects, including workers with or without exposure to ELFEMFs of 110–420 kV power lines, participated and were randomized into GTPS and placebo treatment groups. Oxidative stress and oxidative damage to DNA were assessed by urinary tests of 8-isoprostane and 8-OHdG. Significant increased urinary 8-isoprostane and 8-OHdG were observed in workers with ELF-EMFs exposure, which were diminished after 12 months of GTPS. No protective effects of GTPS on oxidative stress and oxidative damage to DNA were observed after three months of GTPS withdraw. Authors found a negative impact of high-voltage power lines on the health of workers. Long-term GTPS could be an efficient protection against the health issues induced by high-voltage power lines.

Ahmed et *al.*, [2] investigated the effect of EMR (frequency 900 MHz modulated at 217 Hz, power density 0.02 mW/cm2, SAR 1.245 W/kg) on different oxidative stress parameters in the hippocampus and striatum of adult rats. This study also extends to evaluate the therapeutic effect of green tea mega EGCG on the previous parameters in animals exposed to EMR after and during EMR exposure. EMR exposure resulted in oxidative stress in the hippocampus and striatum as evident from the disturbances in oxidant and antioxidant parameters. Co-administration of green tea mega EGCG at the beginning of EMR exposure for 2 and 3 months had more beneficial effect against EMR-induced oxidative stress than oral administration of green tea mega EGCG after 2 months of exposure. Tea mega EGCG may play a protective role against EMR-induced oxidative stress in the hippocampus and striatum by stimulating the antioxidant defense system and inhibiting lipid peroxidation. This emphasizes the ability of green tea and its polyphenolic compounds – catechins – to prevent oxidative stress. This recommends the use of green tea before any stressor to attenuate the state of oxidative stress and stimulate the antioxidant mechanism of the brain.

Rosemary *(Rosmarinus officinalis)*

Ghoneima and Arafat, [42] investigated the histological and histochemical changes of the parotid glands of rats exposed to mobile phone and study the possible protective role of rosemary against its harmful effect. The results of this study revealed that exposure of parotid gland of rat models to electromagnetic radiation of mobile phone resulted in structural changes at the level of light and electron microscopic examination which could be explained by oxidative stress effect of mobile phone. Rosemary could play a protective role against this harmful effect through its antioxidant activity.

Basil *(Ocillium basilicum):*

Ocillium basilicum has been used since ancient times as a medicine and food and it is known that the antioxidant effect of *Ocillium basilicum* is beneficial to protect tissue and decreasing carcinogenic effect of electromagnetic field [43]. Khaki *et al.,* [43] reported that EMF has negative effect on ovary histology in rats by increasing fibrosis and vein congestion. There was a significant increase in apoptosis in EMF group when compared with other groups ($P<0.05$). However, these side effects are less seen in the EMF group that received *O. basilicum* extract. Usage of *O. basilicum* extract could be one of the useful methods as antioxidant therapy against EMF exposure in industrial area. L-carnitine and coenzyme Q10 (CoQ10) are 2 effective antioxidants which scavenge free radicals.

Sesame oil

Marzook *et al.,* [44] studied the effect of chronic exposure to electromagnetic radiations, produced by a cellular tower for mobile phone and the possible protective role of sesame oil on glutathione reductase, superoxide dismutase, catalase, total testosterone and total cholesterol, triglycerides, low density lipoprotein cholesterol and high density lipoprotein cholesterol in male albino rats. The results obtained revealed that TG and testosterone were raised significantly over control in all groups and the significant increase in oil groups occurred in dose dependent manner. SOD and CAT activities were reduced significantly in exposed rats than control and increased significantly in sesame oil groups as the dose of oil increased. Total cholesterol only showed remarkable reduction in the group treated with 3 ml sesame oil. Also, in this latter group, significant elevation of GSH-Rx was recorded. Changes in serum HDL-c and LDL-c followed an opposite trend in exposed and sesame oil groups reflecting their affectation by EMR or sesame oil. All results of the current study proved that sesame oil can be used as an edible oil to attenuate the oxidative stress which could be yielded as a result of chronic exposure to EMR.

Garlic *(Allium sativum)*

Sharaf-Eldeen *et al.,* [45] reported that exposure of mature female albino rats to mobile phone microwave caused induction of newly synthesized polypeptides in liver and brain tissues. The daily administration of 20mg/kg garlic decreased the number

of protein fractions in liver while such fractions were increased in brain tissue and this effect was associated especially in liver tissue with expression of new proteins which may be stress proteins; these proteins have low molecular weight. Also, garlic prevented significantly the depression of mitotic index that occurred under the effect of mobile phone microwave exposure. This work suggested the in vivo radioprotective role, antimutagenic and anticarcinogenic effect of garlic. The protective effects of garlic has been attributed to the presence of organosulphur compounds like diallyl sulphide, diallyl disulphide, ajoene, allixin, allyl mercaptans and allyl methyl sulphides [45, 46].

Hajiuon, [29] investigated that the probable effects of radiation and consumption of garlic on estrogen, progesterone and testosterone levels. In this experimental study, 5 male and 5 female groups of rat were used: control, sham (under exposed), experimental 1 (receiving garlic extract), and experimental 2 and 3 (receiving both extract and microwaves). After a one month, rats were weighed and serum levels of hormones were measured. In male the mean body weight in the sham showed a significant decrease, whereas, an increase was seen in the experimental 3 compared with sham. Also, mean plasma testosterone levels in experimental 2 and 3 were reduced. Estrogen showed this decrease in all groups. Also in all groups progesterone showed increase. In female the mean body weights in different groups showed no significant changes, whereas a significant increase was seen in serum level of progesterone in experimental 2 and 3. Although, microwaves can cause weight lost, presence of allicin and vitamins A and B in garlic can compensate some of this weight lost. Microwaves and garlic extract have fewer effects on female reproductive system, reflected only in the serum progesterone concentration. Also they reflected in the number of Leydig cells and serum testosterone and estrogen concentration. The differences observed in the responses of male and female to cell phone radiation might be attributed to the position of gonads in the body and sensitivity of testis to heat.

Loranthus longiflorus

Nagar *et al.,* [47] aimed to experiment on the antioxidative property of a parasitic plant *Loranthus longiflorus* (Loranthaceae) to protect central nervous system against oxidative damages of mobile phone electromagnetic radiation (EMR). Healthy male albino wistar rats were exposed to RF-EMR by giving 5 min calling/ 5min interval for 1 hour per day for two month, Keeping a GSM (0.9 GHz/1.8 GHz) mobile phone in Silent mode (no ring tone) in the cage. After 15, 30, 45, 60 days exposure, three randomly picked animals from both groups were tested with using Morris water maze. Antioxidant compounds and their Neuroprotective action of *Loranthus longiflorus* bark sample collected from *Ficus religiosa* host trees were assessed. The Ethyl acetate extract of *Loranthus longiflorus* bark possesses protective effect on learning and memory against EMR exposure. The presence of tannins and phenolic compounds in the Ethyl acetate extract of the plant may be responsible for these activities.

Alstonia scholaris

Gupta *et al.,* [48] investigated the radioprotective potential of the *Alstonia scholaris* extract and noted that this extract could be efficient against radiation-induced biochemical alterations. So the protective effect of this extract might prove the beneficial use of plants as radioprotector.

CONCLUSION

It can be concluded that dietary supplementation with some plants rich in natural antioxidants such as, plum *(Prunus domestica)*, bitter orange *(Citrus aurantium*), green tea *(Camellia sinensis)*, rosemary *(Rosmarinus officinalis)*, basil *(Ocillium basilicum)*, garlic *(Allium sativum)*, *Loranthus longiflorus*, *Alstonia scholaris*, and vitamins C, E may play a role on the neutralization or buffering the effects of electromagnetic fields with oxidizing properties.

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