

# Evaluation of the Protective Role of Vitamin C on the Metabolic and Enzymatic Activities of the Liver in the Male Rats After Exposure to 2.45 GHz Of Wi-Fi Routers

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## ABSTRACT

**Background:** The use of devices emitted microwave radiation such as mobile phones, wireless fidelity (Wi-Fi) routers, etc. is increased rapidly. It has caused a great concern; the researchers should identify its effects on people's health. We evaluated the protective role of Vitamin C on the metabolic and enzymatic activities of the liver after exposure to Wi-Fi routers.

**Material and Methods:** 70 male Wistar rats weighing 200-250 g were randomly divided into 7 groups (10 rats in each group). The first stage one –day test: Group A (received vitamin C 250 mg/kg/day orally together with 8- hour/day Wi-Fi exposure). Group B (exposed to Wi-Fi radiation). Group C (received vitamin C). Group D or Control (was neither exposed to radiation of Wi-Fi modem nor did receive vitamin C). The second phase of experiment had done for five consecutive days. It involved Group E (received vitamin C), Group F (exposed to Wi-Fi radiation), Group G (received vitamin C together with Wi-Fi radiation). The distance between animals' restrainers was 20 cm away from the router antenna. Finally, blood samples were collected and assayed the level of hepatic enzymes including alkaline phosphatase (ALP), alanine amino transferase (ALT) aspartate amino transferase (ASL), gamma glutamyl transferase (GGT) and the concentration of Blood Glucose, Cholesterol, Triglyceride (TG), High density lipoprotein (HDL) and low density lipoprotein (LDL).

**Results:** Data obtained from the One day test showed an increase in concentration of blood glucose, decrease in Triglyceride level and GGT factor ( $P < 0.05$ ), however no observed significant difference on the Cholesterol, HDL, LDL level and hepatic enzymes activities in compare to control group. Groups of the five-day test showed reduction in the amount of blood glucose, elevation of cholesterol level and LDL relative to control group ( $P < 0.05$ ).

**Conclusion:** WiFi exposure may exert alternations on the metabolic parameters and hepatic enzymes activities through stress oxidative and increasing of free radicals, but the use of vitamin C protects them from changing induced. Also taking optimum dose of vitamin C is essential for radioprotective effect and maintaining optimum health.

## Keywords

Wi-Fi modem, Vitamin C, Hepatic enzyme activities

## Introduction

Advances in technology, industry, and the rapidly increased application of microwave (MW) radiation in telecommunication and medicine has forced humans to use relatively high intensi-

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ties of microwave radiation which can threaten people's health. The physiologic effects of microwave radiation depend on magnetic field intensity, frequency and physical characteristics of irradiated tissues [1-3].

Wireless communication systems can be considered as one of the most popular technologies. Wi-Fi (wireless fidelity) with frequency of 2.45 GHz is widely used in houses, schools, offices and public places [4]. Nowadays, scientists are performing different experiments to better understand the health effects of MW radiation. They believe that MW radiation can cause biological effects on people's health [1, 2, 5, 6]. Non-ionizing electromagnetic radiation is a part of the electromagnetic spectrum. In contrast with the ionizing part, the energy level in non- ionizing component of electromagnetic spectrum is not high enough to produce ionization events [5, 7]. The use of non-ionizing radiations such as MW in frequency range of 300 MHz to 300 GHz can cause a wide variety of biological effects [7, 8]. There is a wide variety of devices that is considered as radiofrequency emitting devices. These devices are being used in different fields such as medicine [9], industry (in heat producing devices) [10], welding [11], sealing plastic and metallic tools [12] military purposes [13], and communication services, such as mobile phones [14] and Wi-Fi routers [15]. Over the past several years attentions have focused on the biological effects of MW radiation [16]. we recently have been studying the effects of exposure to different sources of EMFs such as mobile phones [17-19], mobile base stations [20], mobile phone Jammers [6, 21], laptop computers [19], radars [22] and MRI [23] on human health. The results of these studies have shown that EMFs can reduce the response time of students [24] and the personnel of the radar stations. However exposure to EMFs was capable of reducing the short-term memory of Radar staffs [19]. On the other hand these exposures had a significant role in increased secretion of mercury from dental amalgam fillings [25] and decreasing of sperm

quality [26].

Researchers have evaluated the effects of the exposure to EMFs on physiologic processes including the cell proliferation [27] ion transfer [28] bone healing [29], nerve repair [30], production of free radicals [31], hormones levels [32], modification of enzymatic activities [32-34] and changes in membrane and intracellular proteins [35, 36].

Furthermore, in several studies the effects of EMF exposure on the antioxidant and oxidant balance in various tissues such as, liver, heart and lens have been investigated [37-39]. In addition, MW radiation effects were evaluated on the blood glucose level, and other metabolic and enzymatic parameters, and also on the endocrine systems such as reproductive and adrenal glands [40, 41]. In present study, we have evaluated the protective role of vitamin C on the metabolic and enzymatic activity of liver after exposure to 2.45 GHz Of Wi-Fi routers.

## Material and Methods

In this study, 70 male Wistar rats weighing 200-250g were randomly divided into 7 groups (10 rats in each group). In first stage, one day test: Group A (received vitamin C, 250 mg/kg/day orally together with 8- hour /day Wi-Fi exposure). Group B (were exposed to Wi-Fi radiation for 8 hours / day). Group C, received only vitamin C. Group D or Control were neither exposed to radiation of Wi-Fi modem nor did receive vitamin C. The second phase of experiment has done for five consecutive days. It involved Group E (received vitamin C), Group F (was exposed to Wi-Fi radiation for 8 hours / day), and Group G (received vitamin C together with Wi-Fi radiation). The distance between animals' restrainers was 20cm away from the router antenna in all groups. Finally, blood samples were collected and were assayed the level of hepatic enzymes including ALP, ALT, ASL, GGT and the concentration of Blood Glucose, Cholesterol, TG, HDL and LDL in all groups. A DLINK Wi-Fi router (model DWL-3200, Taiwan) and vitamin

C was purchase of Sigma Aldrich with 99% pure. This study was approved by the Medical Ethics Committee of Shiraz University of Medical Sciences.

### Statistical analysis

The results were expressed as mean ± SD. Data were analyzed using the SPSS statistical program (version 19.0 software). ANOVA test for P<0.05 was considered significant.

### Results

Effect of Wi-Fi radiation on metabolic parameters and the level of hepatic enzyme activities in comparison with the control group and between groups are presented in Tables 1 and 2.

### Results of acquired from the one-day tests

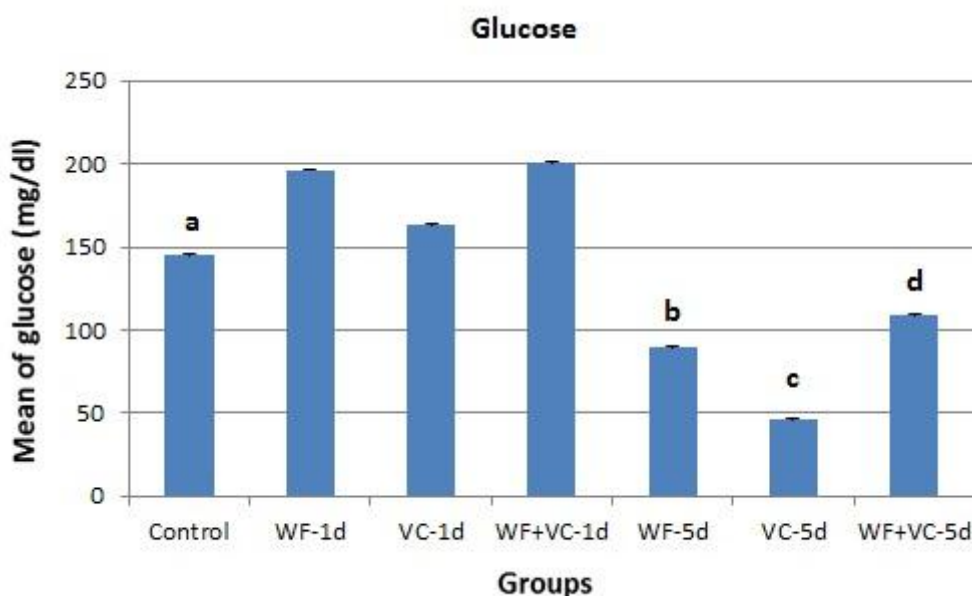
The blood sugar level increased significantly in all groups, but this rise in groups A and B are higher than in compare with C and control groups (P value<0.014 and P value<0.037) (Figure 1 and Table 1). Also TG level decreased significantly in all groups, however in groups A and B are lower than in compare with control (P value<0.019 and P value<0.000). In other way, results obtained revealed no statistically significant changes from Cholesterol, HDL, LDL. In addition hepatic enzymes activities such as ALP, AST, ALT in different groups relative to control group weren't significant. But the level of hepatic enzyme of GGT showed significant reduction in all groups,

**Table 1:** Mean ± SD metabolic parameters and hepatic enzymes activities during one day

Group	(Mean ± SD)								
	GLU (mg/100)	TG (mg/dl)	CHO (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	ALP (mg/dl)	AST (mg/dl)	ALT (mg/dl)	GGT (mg/dl)
A (Wi-Fi+ Vitamin C during 1 day)	2×10 <sup>2</sup> ±33.4	74.1±21.69	42.4±5.64	25.3±3.62	5.9±1.66	1.11×10 <sup>2</sup> ±438.6	1.8×10 <sup>2</sup> ±32.1	78±12.53	0.3±.67
B (Wi-Fi during 1 day)	1.96×10 <sup>2</sup> ±60.4	46.4±17.2	57.4±7.39	35.6±5.89	7.8±2.57	7.83×10 <sup>2</sup> ±279.81	1.54×10 <sup>2</sup> ±21.7	64.5±14.66	0.8±1.61
C (Vitamin C during 1 day)	1.62×10 <sup>2</sup> ±30.4	1.24×10 <sup>2</sup> ±54.4	52.6±9.28	28.6±7.1	7.9±2.13	8.39×10 <sup>2</sup> ±144.17	2.01×10 <sup>2</sup> ±62.1	79.8±10.37	0.00
D (control)	1.44×10 <sup>2</sup> ±19.56	1.26×10 <sup>2</sup> ±24.3	51.2±7	27.2±3.22	7.2±1.39	7.82×10 <sup>2</sup> ±243.13	2.17×10 <sup>2</sup> ±90.93	74±16.95	2.3±2

**Table 2:** Mean ± SD metabolic parametric and hepatic enzymes activities for consecutive five days

Group	(Mean ± SD)								
	GLU (mg/100)	TG (mg/dl)	CHO (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	ALP (mg/dl)	AST (mg/dl)	ALT (mg/dl)	GGT (mg/dl)
D (control)	1.44×10 <sup>2</sup> ±19.56	1.26×10 <sup>2</sup> ±24.3	51.2±7	27.2±3.22	7.2±1.39	7.82×10 <sup>2</sup> ±243.13	2.17×10 <sup>2</sup> ±90.93	74±16.95	2.3±2
E (Vitamin C during 5 days)	46.2±30.22	1.67×10 <sup>2</sup> ±28.7	99.1±20.84	29.3±6.34	4.1±2.02	4.83×10 <sup>2</sup> ±247.26	3.78×10 <sup>2</sup> ±70.47	1.038×10 <sup>2</sup> ±13.8	0.3±.48
F (Wi-Fi during 5 days)	89.9±17.64	85.1±40.2	98.2±29.8	42.7±11.72	9.2±3.32	5.11×10 <sup>2</sup> ±123.62	2.53×10 <sup>2</sup> ±74.86	84.8±14	1.6±1.4
G (Wi-Fi +Vitamin C during 5 days)	1.08×10 <sup>2</sup> ±36.7	80.4±33.3	85±21.39	36.8±8.05	11.2±4.13	4.23×10 <sup>2</sup> ±195.87	2.46×10 <sup>2</sup> ±80.66	99.3±43.85	2.2±1.2



**Figure 1:** The mean of Glucose in all groups

however in groups A and C are lower than in compared with control group (P value<0.014 and P value<0.002) (Table 1).

### Results of acquired from the five-day tests

The blood sugar level decreased in all groups, and in groups E and F significantly are lower than (P value<0.000 and P value<0.018) relative to control group. But reduction in G group that both factors used simultaneously wasn't significant (Figure 1 and Table 2). Also Triglyceride level decreased in all groups however in compare to control group weren't significant. In other way, in all groups the level of Cholesterol increased relative to control group significantly (Pvalue<0.000, P value<0.000 and P value<0.001) (Figure 2 and Table 2). Also HDL and LDL level increased in all groups, however HDL elevation in group F (P value<0.000) and the increase of LDL level in group G (P value<0.024) significantly higher than in compare with control. While hepatic enzymes activities, such as ALP, AST, ALT, and GGT in different groups relative to control group weren't significant, however activities AST, ALT and GGT in group E (only

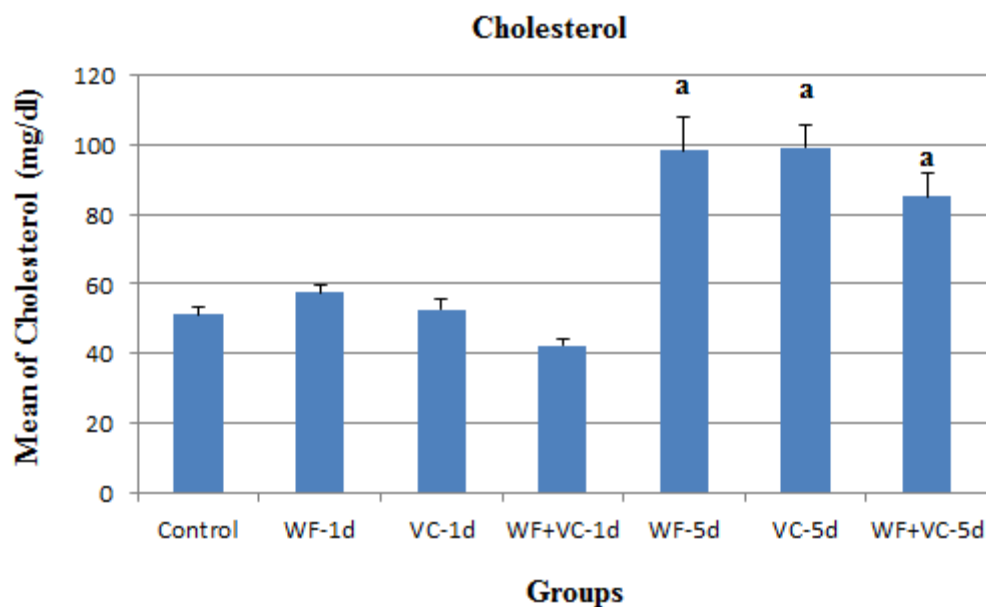
received vitamin C) relative to control group have changed significantly (Table 2).

### Discussion

The current study demonstrated that Wi-Fi exposure and the use of vitamin C during the one day leads to significant increase on the blood glucose amount and decrease of the triglyceride level and GGT activity in compared to control group. But didn't shown significant effect on the Cholesterol, LDL, HDL level and other hepatic enzymes activities like ALP, AST, and ALT relative to control group.

While results achieved in the 5-day tests, revealed significantly reduction of blood sugar and elevation of cholesterol and lipoproteins in different groups in compare to control group. However didn't have any significant effect on the triglyceride and hepatic enzymes activities.

It seems that observed affects probably the result of antioxidant properties of vitamin C. It has been reported vitamin C acts on the physiological and metabolically reactions and protecting induced damage from radiation exposure, via scavenging of free radicals and change them to non-free radical form [42, 43].



**Figure 2:** The mean of cholesterol in all groups

In other way, without considering the kind of radiation exposure, induced changes is caused via elevation of oxidative stress. Also, imbalance among production and neutralization free radicals especially reactive oxygen species (ROS) can be lead to biochemical changes [44-46]. Hence antioxidant agents like Vitamin C Will diminish and protect them.

In other way, maybe radio protective effect of vitamin C have restricted to effective dose, because in present study combination of Wi-Fi exposure with Vitamin C in one -day test lead to increase of blood sugar, but in stage of 5-day test observed reduction of blood sugar .This result agree with report of M. Afkhami et al. [47] that was seen reduction of blood glucose after using of 1000mg vitamin C, but didn't show affect in dose of 500mg .Also in a research rabbits exposed to aflatoxin B1 as hepatotoxic agent, their results show that the level of hepatic enzymes, after receiving aflatoxin were significantly increased, however the amount of these parameters decreased with vitamin C administration [48]. Probably Vitamin C mediates increase in insulin effect by development of antioxidant process. May be an increase in blood glucose associated with a

reduced insulin secretion in rats exposed to a constant magnetic field of moderate intensity.

Recently, Çelik Ö, and et al observed in pregnant rats and their neonates oxidative stress level of brain and liver increased by Wi-Fi (2.45GHz) exposure [49]. Hence vitamin C as water soluble antioxidant agent maybe suppresses the hepatotoxic effect of radiation by interference with lipid peroxidation reaction. Our findings agree with study has done by Sisodia et al. reported that Cholesterol, Lipid peroxidase significantly increased after MW exposed [50].

Huge evidences from animal and human studies have reported hepatotoxic effect of various agents involved chemical agents, radiations, drugs and heavy metals to be associated with the production of reactive oxygen species (ROS).It is necessary for natural cellular functions ,like regulation of cell signaling, generation of energy ,phagocytosis and synthesis of several physiological processes. ROS usually destroyed by antioxidant agents' existent in cells. However in large scale and pharmacologic amounts are harmful and toxic. Hence, the best way to omit them of body is taking antioxidant compounds like vitamin C.

For this reason Ascorbic Acid probably protects body from oxidative injuries caused by WI-FI radiation exposure in metabolic processes and hepatic activities[51, 52].

## Conclusion

The present study demonstrated 2.45 GHz Wi-Fi exposure may exert alternations on the metabolic parameters and hepatic enzymes activities through stress oxidative and increasing of free radicals, but the use of vitamin C protects them from changing induced via reducing oxidative damage by antioxidative defense system. Also taking optimum dose of vitamin C is essential for inducing of radioprotective effect and maintaining optimum people health.

## Conflict of Interest

None Declared.

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