

Study the Effects of High and Low Frequencies Pulsed Square Electromagnetic Fields on the Logarithmic Growth of the *E. coli*

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Abstract: The effect of high frequency electromagnetic fields (110 Hz with an intensity of 700 milli gauss) and low frequency (10 Hz with an intensity of 700 milli gauss) on the bacterium *Escherichia coli* (ATCC 1533) were studied. In this study, the bacterium *Escherichia coli* was cultured in BHI broth, then it was incubated in BHI broth at 37°C for 24 hours then serial dilutions were made to and from the sixth dilution (10^{-4}), one sample was treated with electromagnetic field for six hours and one put aside as control sample. The results showed, a significant increase in the logarithm of the number of *Escherichia coli* (CFU / ml) treated with high frequency electromagnetic field and a significant decrease in the number of *Escherichia coli* (CFU / ml) exposed to low-frequency electromagnetic field. The results of biochemical tests also showed negative effects of electromagnetic fields on the biochemical properties of *Escherichia coli* as a bacterium.

Key words: Electromagnetic Field • Bacterial Growth • *E. coli*

INTRODUCTION

The bacteria are prokaryotic microorganisms and many species and genera of them are widely distributed in nature. Depending on the beneficial and harmful bacteria in nature are these microorganisms, they have so different effects [1, 2].

E. coli is a bacterium known in this field; it has certain physical properties and cellular and biochemical characteristics [3, 4].

For the first time, in 1976, the biological effects of electromagnetic fields usage were considered [5]. With the growing development of technology in various fields and waves, organisms and especially the human who has affected today it can be argued the existence of electromagnetic waves in the ocean and float fields [6].

So far what has been reported in connection with the damaging and harmful effects of electromagnetic fields in biological tissues since the course consists of static magnetic fields and pulsed electromagnetic fields associated with electric currents in the frequency range of sinusoidal AC (city electrical flow) power [7].

Electromagnetic radiation is a type of energy that can move in space with the speed of light. The quantum radiation as a stream of energy called photons, each photon energy is considered to depend on the radiation frequency [2, 8].

We've worked with a pulse of electromagnetic fields caused by electrical two-phase square waves in the frequency range of 10Hz-110 KHz (700 mG). In this study we have tried to influence the growth of bacteria on the highlighted field and so it can be used in the prevention of infection and treatment and industrial purposes.

MATERIALS AND METHODS

Magnetic Field Generating Device:

- Power supply: with DC flow, 6 V, 500 mI that give 3 W.
- The wave-making machine that can produce the two phases square wave is used in this study.
- Signal generator: it can generate a frequency of 10 Hz to 110 kHz.
- Source: 2 pcs soft iron core with winding number around 600, the internal resistance of 2.5ohms with a maximum tolerance of 2 amps, the wire 0.6 mm and the core area in $2 \times 2=4$ cm with between, 14.5 inch of being parallel to the power supply have been closed.

Intensity of electromagnetic field generated from the 7.25 cm of the coil measured by the digital Tslamtr and it is 700 ± 20 mm gauss.

Culture and Radiation of *Escherichia Coli* Bacteria:

Escherichia coli (ATCC1533) was provided from Microbiology Laboratory Faculty of Veterinary Medicine of Urmia University in the standard Medium and conditions. A colony of bacteria was inoculated into BHI broth medium and incubated for 24 hours at 37°C and then in BHI broth dilution system and the OD of prepared dilutions was measured at 260 nm and 10^3 dilution was exposed to radiation for 6 hours and then cultured in BHI. After 2 days incubation, colonies were calculated. The recovered colonies were tested by the standard method [1, 2 & 6] for the presence of any mutation in the essential characteristics of the bacteria. In this study 50 samples treated with 110 KHz (700 mG) and 50 samples treated with 10 Hz (700 mG) were compared with control groups. Results were obtained using the statistical software SPSS version 17 and paired-samples T test. Statistical analysis was used under Windows.

RESULTS

Experiments related to the biochemical changes caused by magnetic field had no effect on biochemical properties of *Escherichia coli*.

DISCUSSION

This study showed that putting *E. coli* (ATCC 1533) in BHI medium under the effect of electromagnetic pulsed field of two phases squared electrical waves with 10 Hz

Table 1: Comparison of *Escherichia coli* in the treated and control samples (treated with high frequency) (50 samples)

	Hour 0	Hour 6
Control	1.3×10^3	6.1×10^7
Treated high frequency	1.4×10^3	1.5×10^8

Table 2: Comparison of *Escherichia coli* in the treated and control samples (treated with low-frequency) in 50 samples

	Hour 0	Hour 6
Control	1.2×10^3	5.7×10^7
Treated low frequency	0.95×10^3	1.2×10^7

frequencies and 700 mG intensity for 6 hours reduce the number of the bacteria, but electromagnetic pulsed field of two phases squared electrical waves with 1-5 Hz frequencies and 1 tesla intensity has no effect on the colony number of *E. coli*. In our study irradiation with 10 Hz after 6 hour growth of bacteria decreased 475% but with 110 kHz after 6 hour growth of bacteria increased 246% that showed high frequency increase and low frequency decrease growth of this bacteria.

Thus we could say that the field power in comparison with time and frequencies (oscillation) had no effect on growth of *E. coli* (ATCC). Our results showed that putting *E. coli* under the effect of electromagnetic pulsed field of two phases squared electrical waves with 10 Hz frequencies and 700 mG intensity reduce the Logarithmic growth of this bacteria and putting *E. coli* under the this field but frequency of 110 kHz increase growth of this bacteria amount 246% under same conditions. Changing of other indexes and factors include intensity of the field, type of wave and ect have no effect in the growth of bacteria.

The decrease in the number of *E. coli* colonies in the field of the frequency range 10 Hz could be due to:

- Changes in bacterial membrane permeability that this channel could cause biological changes in the organism lead [9].
- It might been that effect of the production of free radicals by bacteria in the electromagnetic field due to the low-frequency fields so that It seems likely that the irrational very low intensity are not able to produce free radicals [10].

Putting bacteria in Electromagnetic field for less than 4 hours, does not affect the number of colony growth.

Inhibitory effects of EMF after 16 hours can be charged due to interaction of the membrane electric field as Decreased synthesis of macromolecules and even DNA damage [11].

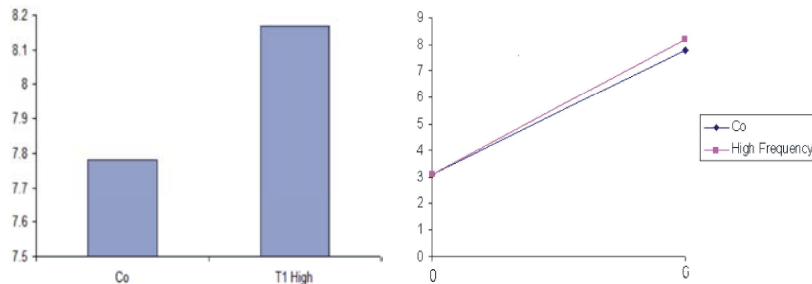


Fig. 1: Comparison of log numbers of *E. coli* (CFU / ml) between the control and treatment groups (irradiated electromagnetic field with an intensity of 700 m Gauss high frequency (6 hours) using statistical paired-samples T test with $P < 0.05$ indicates significant difference

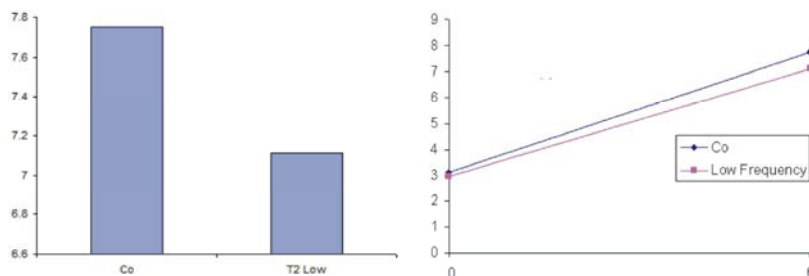


Fig. 2: Comparison of log numbers of *E. coli* (CFU / ml) between the control and treatment groups (irradiated electromagnetic field with an intensity of 700 m gauss low frequency (6 hours) using statistical paired-samples T test with $P < 0.05$ indicates significant difference

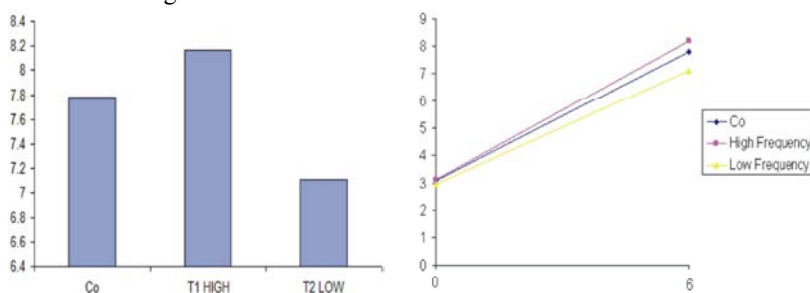


Fig. 3: Comparison of logarithm numbers of *E. coli* (CFU / ml) between the control and treatment groups (irradiated electromagnetic field with an intensity of 700 m Gauss high frequency (6 hours) using statistical paired-samples T test with $P < 0.05$ indicates significant difference

Irradiation time was 6 hours, but in this study because the DNA damage and the change in molecular synthesis can not be expected. It seems that the field intensity 1-5 G Within 8 hours of irradiation can increase the use of glucose in the culture medium for bacteria to be fluid, The relationship between glucose and glucose consumption in the tube radiation exposure seen a significant difference is observed in wait. The result is that the field is able to stimulate and accelerate the entry of glucose from the bacterial membrane [12].

Despite the previous studies that the significant increase in bacterial growth with field intensity 1-5G and frequency of 60 Hz sinusoidal electric waves have been reported [13].

Field research was conducted at a frequency of 110 kHz and 700 mG intensity increase 2.4 times the number of bacteria.

10 kiloGauss to 700 miliGauss had no effect on logarithmic growth of bacteria.

Therefore in this study the most effect causes by quantity of the applied field and the other contributing factors have little impact. The need for research in the field of frequency on other parameters is preferred.

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