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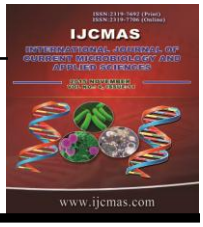

Original Research Article

The effect of mobile waves on the growth of pathogenic Fungi

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Fungal species, mobile waves, exposure time, percentage of inhibition.

A B S T R A C T

The effect of mobile waves on some fungal species were examined in This study, group of pathogenic fungal species characterized by their effect on human health it was using to show the effect of mobile waves (which are Microwaves are non-ionizing electromagnetic waves with frequencies between 0.3 and 300 GHz) on the growth of these fungal species (*Trichophyton mentagrophytes, Aspergillus niger*, *Pencillium* sp.),by exposing the vegetative growth of above fungal species to mobile waves for 20 minutes the results revealed that the inhibition of growth were less than 100%and as the following: (*Trichophyton mentagrophytes* 42%, *Aspergillus niger* 48%, *Pencillium* species45%). While when fungal species exposed to mobile waves for 60 minutes the inhibition of growth were 100% for all species. This refer to that increasing in the exposure time of mobile waves will cause increasing in the percentage of inhibition.

Introduction

In the last decade, the human population has been increasingly exposed to radiation from microwave-operating devices, such as radars, diathermy devices, and cellular or cordless phones; in the first quarter of 2012 the number of mobile phone users in all over the world has been increased.

Microwaves are non-ionizing electromagnetic waves with frequencies between 0.3 and 300 GHz (i.e., with wavelengths from 1 meter to 1 millimetre, respectively (Balbami and Montavan,2008). Industrial microwave generators used for communications are the most important sources of microwave radiation, that speed up chemical reactions or are used for heating (896 or 915 MHz); cordless phones (from 46 to 5800 MHz); cellular phones (824–850,900, 1800 or 1900 MHz); certain diathermy applicators (915 and 2450 MHz); microwave ovens (915 and 2450 MHz);UHF radios (from 470 to 890MHz); traffic radar (10.5 and 24 GHz) and dish antennas (from 0.8 to 15 GHz);. The energy of microwaves is relatively low: one quantum has approximately 10-5 electron volts (eV), which is considerably lower than the quantum energy needed for the ejection of an electron from a molecule or the breaking of an intra-molecular bond (> 10 eV) (Mischaelson,1974) ; therefore, microwave

radiation is considered non-ionizing radiation.

Numerous experiments with microwave irradiation of various cultures of bacteria and yeasts in a wet environment such as a water suspension did not show additional killing of the microbes by microwaves compared to that caused by conventional heating to the same temperature (Grony *et al*,2007;Vela and Wu,1979;Duhain *et al*, 2012). While Various bacteria, fungi, Actinomycetes, and bacteriophages were exposed to microwaves of 2.450 MHz in the presence and in the absence of water. It was found that microorganisms were inactivated only when in the presence of water and that dry or lyophilized organisms were not affected even by extended exposures (Vela and Wu, 1979).

Microwaves produce two types of effects: thermal and non-thermal on the living thing things. Thermal effects are the consequence of absorption of microwave energy by cell molecules, causing them vibrate much faster and producing general heating of the cell (Mischaelson,1974).While The concept of non-thermal effects of microwaves came from experiments in which bacterial cultures were to a large extent destroyed by microwave-induced heating than by other heating methods producing the same working temperature and from studies showing an increase in the growth of bacteria induced by microwaves When microwaves are applied at certain frequencies, with high energy and for a sufficiently long period of time, their thermal effect is most likely dominant and kills bacterial cells or yeasts(Slobodan *et al*,2014).

Microwave bands called UHF (300 to 3,000 MHz) are used in many commercial devices, including microwave communications, microwave, ovens, television radio navigation, long-range radar, medical diathermy and an abundance of special equipment designed for specific use (Al-Mayh and Ali, 2010).

Another study showed that microwaves could be effectively used for reducing the number of bacteria on previously worn dentures (Glass *et al*,2011).Microwaves showed a resonant-like effect on the growth of some yeasts, including Saccharomyces cerevisiae, which was not dependent on the amount of absorbed energy from the microwaves. The growth was interchangeably enhanced or decreased at steps of 10 MHz within the frequency range studied (Slobodan *et al*, 2014).

There are little studies deal with effect of mobile waves on molds especially pathogenic mold species (species which produce diseases) Present day use of mobile phones is ubiquitous. This causes some concern for the effect of mobile waves on the growth of fungal species especially molds.

The purpose of this study is to determine what effects such fields have on fungal species.

Materials and Methods

Mobile waves: mobile type Samsung, Duos, Android, No.GT-S6802 was used in this experiment.

In vitro fungal evaluation

Sabouraud dextrose agar containing cephalexin and cycloheximide at the 1.5:1.5 ml, all Petri dishes were inoculated with fungal spore then divided to two groups of three replicates, first group radiated with mobile waves for(20)min. and the second

group radiated with mobile waves for (60) min. both incubated at 30° for 5-7 days (Faraj,1990).The diameter of fungal colonies was determined after the first, second, third, fourth, fifth, sixth and seventh day of incubation to check the effect of mobile waves on the growth of fungal species as compared with one plate as a control without radiation.

Percentage of inhibition:
[average of control-average of treated growth /average of control growth] x 100

Results and Discussion

The results revealed the effect of the mobile waves on the growth of the fungal growth (Aspergillus niger, *Trichophyton mentagrophytes* and *Penicillum* species) after tow different exposure duration (20 and 60)min of mobile call.

The first period of exposure showed less effect on growth of the above fungal species the inhibition were (*Trichophyton mentagrophytes* 42%, *Aspergillus niger* 48%, and *Pencillium* species45%) as shown in table I.

While the results shown that after 60min. of exposure the fungal growth were completely inhibited and the percentage of inhibition were 100 % for (*Aspergillus niger*, *Trichophyton mentagrophytes* and *Penecillum* species).as shown in table II.

When microwaves are applied at certain frequencies, with high energy and for a sufficiently long period of time, their thermal effect is most likely dominant and kills bacterial cells or yeast(Al-Mayah and Ali,2010) However, in a dry environment, the killing effect of microwave radiation was significantly decreased and happened only after a prolonged period of irradiation, because of a lower transformation of microwave energy to heat. Some other studies showed that the extent of killing of microorganisms (bacteria and bacterio phages [viruses that attack bacteria] was correlated with the moisture content of the experimental specimens. In contrast, when microorganisms were irradiated with microwaves at temperatures lower than the thermal destruction level; various effects were observed, from killing to enhanced growth (Kuchma *et al*,1992).

Gram positive bacteria Cultures of Staphylococcus aureus was completely inactivated after three consecutive exposures to radiation with such characteristics (Patel *et al* 2010). When cultures of Bacillus cereus spores were exposed to the maximum microwave power in a home microwave oven, they were completely destroyed after two and four minutes, respectively (Park *et al* 2006).

At frequencies of 41, 640-41, and 835 MHz, microwaves showed a resonant-like effect on the growth of some yeasts, including *Saccharomyces cerevisiae*. The growth was interchangeably enhanced or decreased at steps of 10 MHz within the frequency range studied. Similar effects of microwaves on cell membranes were observed in another study(Kim *et al*,2009) in which Bacillus licheniformis spores were irradiated with microwaves (2450MHz, 2 minutes, 2 kW), which make spore cortex hydrolysis (brake of molecular bonds by insertion of water), swelling and finally rupture, as well as damaging of the inner membrane. This effect could be attributed to the non-thermal action of microwaves because the same temperature (as produced by the microwaves) did not cause such changes in the spore coat and inner membrane. When microwave radiation of the same characteristics was applied to Bacillus

subtilis vegetative forms (Kim *et al*, 2008), cell walls were fragmented, and the aggregation of cytoplasmic (intracellular) proteins was detected on transmission electron microscopy. Microwave photon energy is millions of times lower than that of chemical or even hydrogen bonds so that the absorption of a microwave photon cannot break these bonds. But more complex, indirect, phenomena, possible within cell complex structures, may occur.

Table.1 Percentage of inhibition of fungal species after 20 minute of mobile wave exposure

Fungal species	Time of exposure/minute	Percentage of inhibition
Aspergillus niger	20	48%
Trichophyton mentagrophytes	20	42%
Penecillum species	20	45%

Table.2 Percentage of inhibition of fungal species after 60 minutes of mobile wave exposure

Fungal species	**Time of exposure-minute**	**Percentage of inhibition**
Aspergillus niger	60	100%
Trichophyton mentagrophytes	60	100%
Penecillum species	60	100%

Fig.1 Trichophyton mentagrophytes (control)

Fig.2 Trichophyton mentagrophytes after (20 minutes)

May be the accumulation of oxygen radicals, is the primary cause, as they are suspected for dissociating the covalent bonds of DNA. Both the aggregation of cytoplasmic proteins and swelling of the cell wall were observed in Escherichia coli and Bacillus subtilis after microwave irradiation (2450 MHz and 600 W at 40, 60 and 80 degrees of Celsius)(Woo *et al*,200). The factor of the time play an important role in the effect of the mobile waves which is time-dependent, where the intensity of the

cell wall damage is proportional to the total absorbed microwave energy. Increases in irradiation time from 0 to 9 minutes resulted in a gradual increase in the extracellular soluble chemical oxygen demand, from 0.14 to 2.38 g/L (i.e., 72-fold) as well as the increasing from 20 to 60 minutes resulted in a great effect by completely inhibit the growth of the fungal species (*Aspergillus niger*, *Trichophyton mentagrophytes* and *Penecillum* species) this showed the clear effect of exposure time. Apart from their effects on cell membranes, microwaves cause non-thermal acceleration of enzymatic reactions in microbial cells, such as non-aqueous esterification (formation of ester-type of chemical compounds without participation of water), and this effect is substrate concentration-dependent(Wan *et al*,2012).

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