GROWTH RATE INHIBITION OF SOME SPOILAGE FUNGI OF FOOD BY MAGNETIC FIELD

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ABSTRACT

The main objective of this paper was to study the inhibitory effects of static and oscillating magnetic field on growth rate of pathogenic fungus for extending the shelf life of food. The treatment of various food material with the static or oscillating magnetic field reduces the growth rate of the different selected fungus species. The spoilage fungi used to experiments procedure were include the specie of Plasmopara viticola, Rhizopus stolonifer, Asperguillus niger and Rhizopus nigricans was isolated respectively from cheese, apple, bread. Some fungus were more sensitive to the magnetic field. The effect of oscillating magnetic field was more active compared with static magnetic field with the same exposure times. The inhibition rate of fungus was increased in both static and oscillating magnetic fields percent of the control, this relative increase was larger than 55 % with static magnetic field after 120 h at 0.4 T and 72% with oscillating magnetic field after 120 h at 0.25 T.

INTRODUCTION

Fungal infections of foods such as fruits, vegetables, bread, meat and dairy products may occur during the handling, transport, storage and marketing conditions and after purchase by consumers. The magnetic field technology will be useful in inactivating the microorganisms without any detectable change in quality and shelf life compared to conventional pasteurization process **(Barbosa et al., 1998**). The application of static or oscillating magnetic field might be used in disinfecting agricultural products and food. The traditional methods of food preservation though guarantees its safety, sometimes cause loss of sensitive nutrients, denaturation of proteins as well as changes of structure, colour and taste. The non-thermal methods preserve the nutritious value of food and at the same time, reduce threat by spoilage organisms.

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The antimicrobial effect of exposure to electromagnetic field is not due to the temperature effect, but rather its ability to cause damage to the cell structure and composition. Results of previous studies have confirmed the inhibition of microorganisms when placed in electromagnetic fields and inhibitory effect on microbial population **(Lipiec et al., 2004)**. The main objective of this study was to evaluate the inhibitory effects of static and oscillating magnetic field on growth rate of pathogenic fungus for extending the shelf life of food as non-thermal method for food preservation without any change in food properties. Moulds and yeasts are significant spoilage organisms of food and feed. Inaddition, the potential production of toxic and carcinogenic mycotoxins by mouldsis of particular concern. Besides this problem, fungal spoilage of food also causes significant economic losses. Worldwide, about 5-10 % of the food production is estimated to be spoiled by these organisms **(Pitt & Hocking, 1999)**. Moulds belonging to the species Penicillium, such as P. commune, P. nalgiovense and P. roqueforti commonly spoil various foods as cheese, bread and meat products **(Lund, et al. 1995)**. *Aspergillus sp. and Penicillium sp*. frequently occur as spoiling organisms during storage of grain, whereas *Fusarium sp*. are the most common spoilage fungi of crops in the field **(Filtenborg, et al. 1996). Sadauskas et al. (1987)** examined the effect of 200 mT flux density static and 29 mT flux density pulsating magnetic field on the different species of fungi. According to their examination, morphological changes were observable on the conidia of *Aspergillus puniceus* and *Alternaria alternata*. The pigmentation of the colony of *Aspergillus niger* changed, the cultures remained white. The effects of weak magnetic fields on the growth and membrane lipid ergosterol of mycorrhizal fungi *Pisolithus tinctorius* were studied. Two types of media were used: solid (pH 6) and liquid (pH 3). The homogenous sinusoidal magnetic field, generated by a pair of Helmholtz coils with magnetic flux density 0.025 and 0.1 mT and frequency of 50 Hz enhanced the growth of mycelia at early stages of development. The same field at 0.01 mT, 46 Hz had no observable effects. Analysis of the fungi specific membrane constituent ergosterol by high performance liquid chromatography reveals a slightly increased content of ergosterol in the mycelia (along with the observation of

stimulated growth). The results indicate some importance of the membrane which is most probably the acceptor of electromagnetic signals, as has been revealed by many studies with animals. However, more exact mechanisms for the explanation of these effects are not known yet. **(Ruzic et al. 1997).**

MATERIALS AND METHODS

The spoilage fungi used in this study include the species of *Plasmopara viticola, Rhizopus stolonifer, Asperguillus niger and Rhizopus nigricans* were isolated respectively from cheese, apple, bread. The inoculums for experiments were taken from the spoilage food material and grown on the same nature food material. The cultures were incubated for 48 hours after the inoculation at 25-33°C. After the incubation the cultures, uniform from the point of view of growing and morphology, were placed into the magnetic field. To investigate of the effect of a magnetic fields on the fungi growth, the magnetic field was generated by a long coil of wire consisting of many loops (solenoid). If the turns are closely spaced, this configuration can produce a reasonably uniform magnetic field within a small volume of the solenoid interior region. Each of the turns can be regarded as a circular loop, and the net magnetic field is the vector sum of the fields due to all the turns. If N is number of turns in the length l (Fig. 1). Therefore, Amperes low applied to this path gives:

$$B = \frac{\mu_o \ N \ I}{l} = \qquad (1)$$

where: B is the magnetic flux density *(T)*

μ_o is permeability of free space (N/A^2)

I is the electrical current (A).

For the present experiment two types of the magnetic field wear generated, static magnetic field (SMF) (generated by directed current) or oscillating magnetic field (OMF) (generated by alternating current) with low frequency 50/60 Hz. The solenoid was made with 7 cm length and 10 cm diameter. The coil was made from enameled copper wire of 2 mm diameter with 1000 turns. The copper wire of 3.14 mm^2 cross section could be loaded by the current of 8 A, which means a magnetic flux

density up to 0.4 T SMF and 0.25 T OMF. The magnetic flux density has been changed by a change of loading current according to the previous equation .In the course of experiments, the ambient temperature of 28-33°C and relative humidity 45-50 % were the same for the control and the treated cultures. The diameters of the growing cultures were measured every 24 hours in two directions, perpendicular each other. The average of this two diameters was used as the diameter of the culture. The growth of fungi followed the well known logistic function. The middle part of this function can be fitted by a straight line (**Wilson and Bosset 1981**). A straight line was fitted for the average diameters with the help of Excel program, and the growth speed in mm/h was calculated as a slope of straight line **(Nagy P., 2005)**.

Experimental set-up

Samples were placed on a dielectric holder in the center of the coil, where the magnetic field is a reasonably uniform. All samples were made in three replicates and treatment with three value of magnetic field 0.1, 0.25 and 0.4 T magnetic flux densities of SMF and 0.05, 0.15, 0.25 T of OMF with 24, 48, 72, 96 and 120 h exposure time of SMF and OMF.

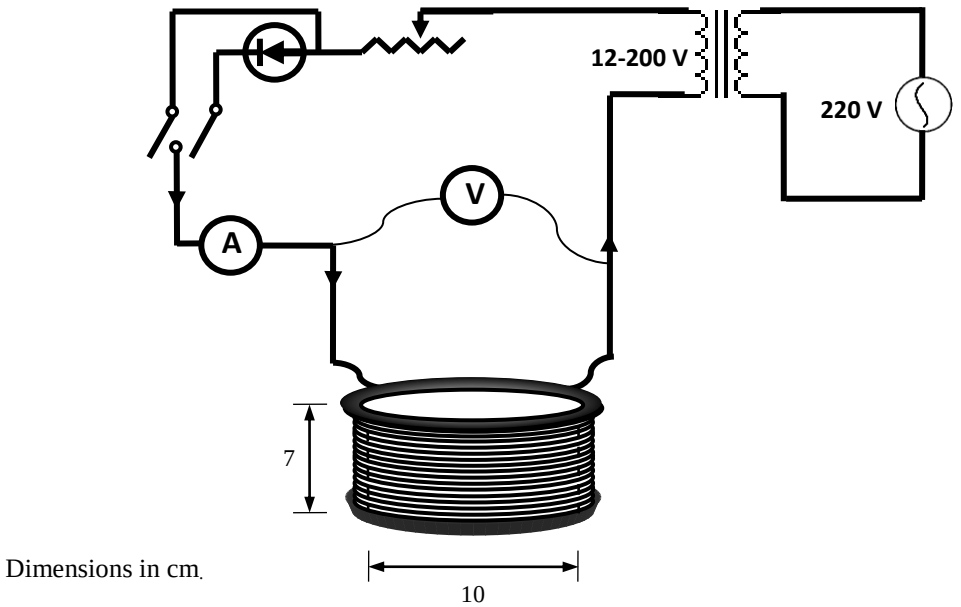

Fig. (l): Schematic diagram of experimental set up.

Rate of fungus inhibition:

Rate of fungi growth is usually attributed to control, the following equation was originated to calculate the rate of fungi inhibition (FI) percent:

$$FI\,(\%) = 100 - \left(\frac{a_M - a_I}{a_C - a_I} \times 100 \right) \quad \ldots\ldots\ldots (2)$$

Where:

a_M = growing area of fungi with the magnetic field

a_C = growing area of fungi of control

a_I = Initial growing area of fungi

The area was calculated by mean diameter measurement all 24 h.

RESULTS AND DISCUSSION

The growth speed of the all examined pathogen fungi cultures were decreased in both static and oscillating magnetic fields. The fungus inhibition (FI) was calculate from equation (2).

1. Effect of static magnetic field

The growth rate of the different fungus species in the static magnetic field 0.1, 0.25 and 0.4 T magnetic flux densities are shown in Figs (2a) and (3). The increasing of magnetic flux density leads to increase inhibition of fungi (FI), fungus *Plasmopara viticola* were more sensitive to the static magnetic field effects, where the relative increase in inhibition of fungi (FI) was increased up to 21%, 36% and 57% percent of the control after 120 h with increasing of magnetic flux densities of 0.1, 0.25 and 0.4 T respectively, and the less effect of the static magnetic field with fungus *Asperguillus niger*. where FI was 11% 26% and 47% after 120 h with increasing of magnetic flux densities 0.1, 0.25 and 0.4 T respectively. Fig (3) shows that the inhibition rates of fungus growth of all species was increased with increasing the exposure time of SMF (24, 48, 72, 96 and 120 h). With increasing the time from 24 – 120 h, FI was increased from 4 - 15 %, 7.5 – 28 % and 11 – 50 % with *Rhizopus nigricans* and 3 – 12 %, 9 – 32 % and 10 – 56 % with *Rhizopus stolonifer* at 0.1, 0.25 and 0.4 T respectively. The inhibition of microorganisms when subjected to the magnetic field may be attributed

to transfer of energy to the ions of the cells, results in an increase in the velocity of ions such as Ca^{2+} across the cell membrane, the changes occur in the metabolic activities of the cells. The ions transmit the effects of magnetic fields from the interaction site to other tissues and organs.

2. Effect of oscillating magnetic field

The oscillating magnetic field applied in this study proved to be effective in reducing the growing of fungus, the tests on the selected fungus are less satisfactory. Figs. (2b) and (4) show the inhibition of fungus "FI" (%) with increasing of oscillating magnetic flux density from zero T to 0.05, 0.15, and 0.25 T, also with increasing the exposure time of OMF (24, 48, 72, 96 and 120 h), fungus inhibition "FI" (%) percent of the control was increased up to 53, 65, 69 and 72 % respectively after 120 h of the different fungus species. Observe that the inhibition rate of fungus with oscillating magnetic field was more active compared with static magnetic field. This may be attributed that the oscillating magnetic field cause anisotropically vibrates of ions and altering the vibrational structure of enzymes.

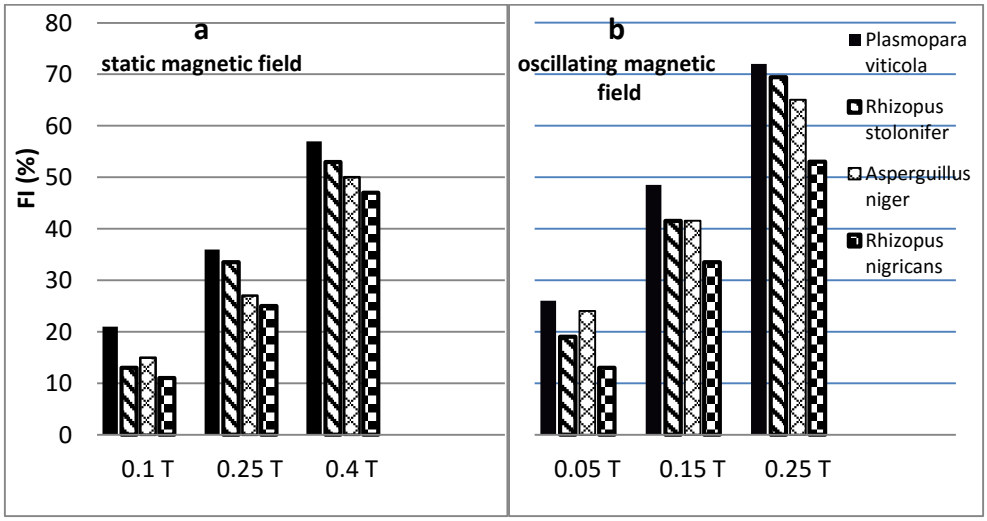

Fig. (2): Effect of magnetic field on inhibition of different Fungi species "FI" (%) after 120 h.

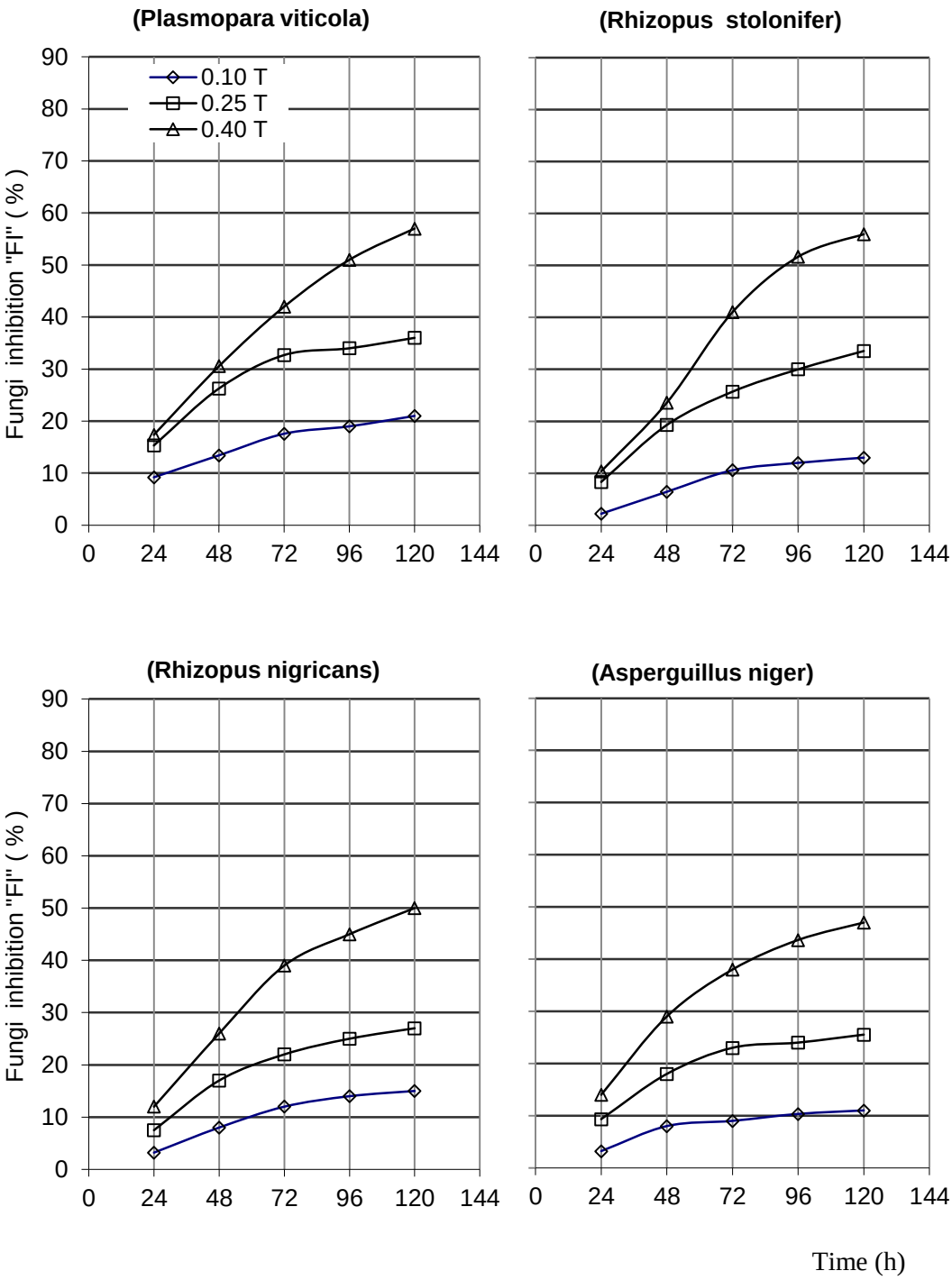

Fig.(3): Effect of exposure time of static magnetic field on Fungi inhibition "FI" (%)

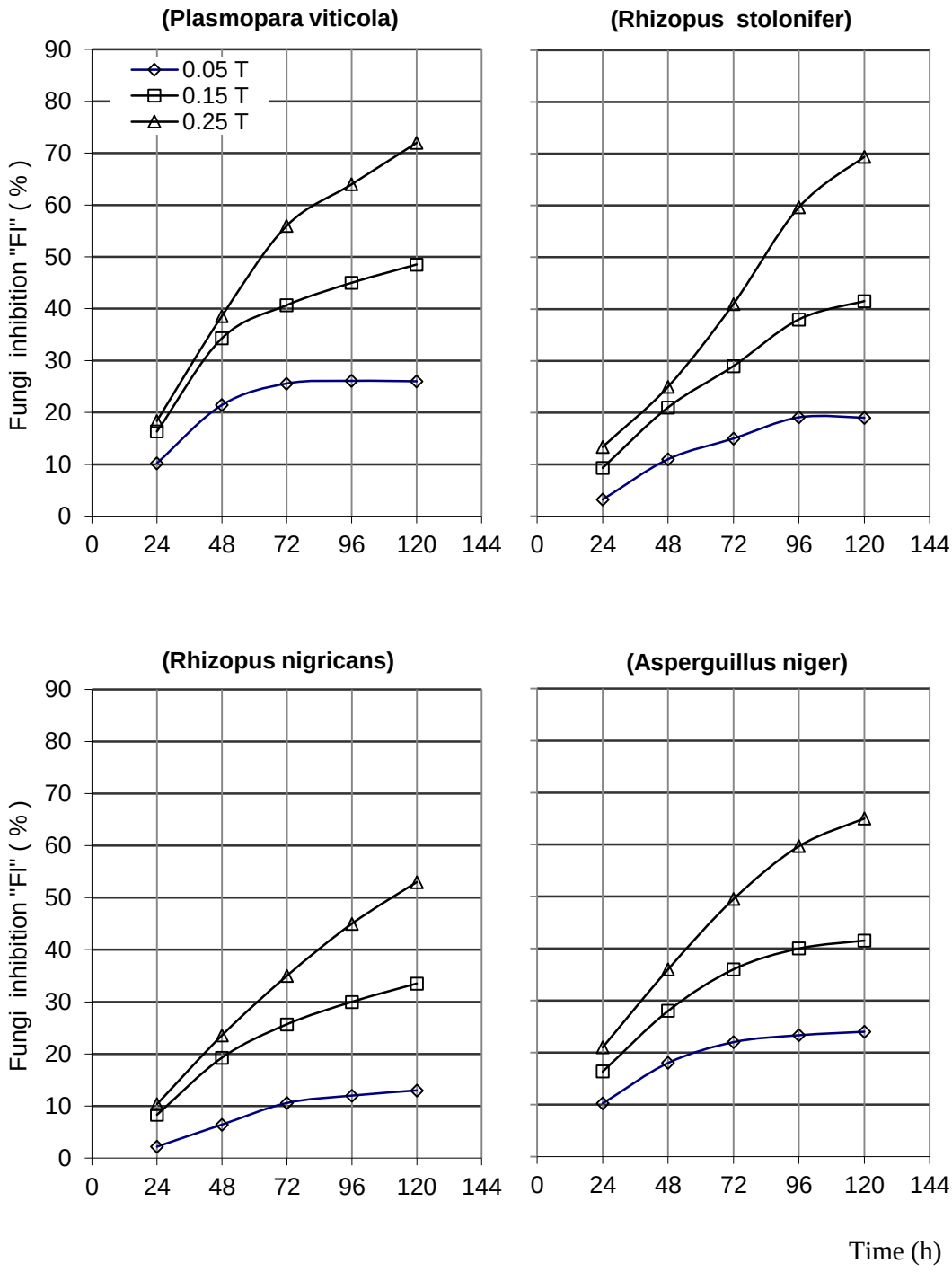

Fig.(4): Effect of exposure time of oscillating magnetic field on Fungi inhibition "FI" (%)

CONCLUSIONS

The treatment of various food materials with the static or oscillating magnetic field reduces the growth rate of the different selected fungus species. Some funguses were more sensitive to the magnetic field. The effect of oscillating magnetic field was more active compared with static magnetic field with same exposure times. The inhibition rate of fungus percent of the control reach 5٧% with static magnetic field and 72% with oscillating magnetic field. The growing of fungus in the magnetic field may be stop by using high intensity of static or oscillating magnetic field with increasing the exposure time.

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الملخص العربى

تثبيط نمو بعض الفطريات المسببة لفساد الأغذية بإستخدام المجال المغناطيسى

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تمثل الفطريات أحد أهم مسببات الفساد للمواد الغذائية ويحدث التلوث الفطري أثناء الحصاد والنقل أو بعد عمليات التداول والتصنيع المختلفة وأغلب نمو الفطريات يحدث أثناء التخزين. يهدف هذا البحث لمحاولة منع أو تثبيط نمو الفطريات علي المواد الغذائية بغرض حفظ أو إطالة فترة الصلاحية بإستخدام المجال المغناطيسى كطريقة غير حرارية وبالتالى لا تحدث التغيرات التى تسببها الطرق الحرارية في المواد الغذائية. تم عمل نموذج عبارة عن ملف من سلك النحاس المعزول لتوليد المجال المغناطيسى بنوعية الثابت والمتذبذب ، بمرور التيار الكهربى المستمر فى الملف يتولد مجال مغناطيسى ثابت وبالتحكم فى شدة التيار بواسطة محول متغير الجهد ولوحة تحكم تحتوى على ريوستات تولد مجال مغناطيسى ثابت بشدة حتى ٠,٤ تسلا (٤٠٠٠ جاوس) ، وبإستخدام التيار الكهربى المتردد تولد مجال مغناطيسى متذبذب بشدة حتى ٠,٢٥ تسلا (٢٥٠٠ جاوس). تم تنمية أربعة أنواع من الفطريات هى: *Plasmopara viticola* و *Rhizopus stolonifer* و *Asperguillus niger* و *Rhizopus nigricans* على المواد الغذائية التى تنمو عليها طبيعياً فى ظروف بيئية ملائمة من حيث الحرارة ٢٨ – ٣٣ ْم والرطوبة النسبية (٤٥ – ٥٥ %) ، وتم قياس معدل النمو للفطر بقياس القطر المتوسط لبقعة الفطر النامى كل ٢٤ ساعة ومن ثم حساب مساحة البقعة ونسبتها للكنترول وفقاً للمعادلة:

$$FI\,(\%) = 100 - \left(\frac{a_M - a_I}{a_C - a_I} \times 100 \right)$$

حيث: FI هو معدل التثبيط الفطرى ، a_M المساحة المتغيرة للفطر النامى في المجال المغناطيسى ، a_C المساحة المتغيرة للفطر النامى خارج المجال المغناطيسى (الكنترول) ، a_I المساحة الإبتدائية للفطر. النتائج بينت أن المجال المغناطيسى له تأثير فعال فى تثبيط نمو الفطريات وكانت أقصى معدلات التثبيط مع المجال المغناطيسى الثابت هى ٢١ , ٣٦ , ٥٧ % بالنسبة للكنترول عند شدة مجال مغناطيسى ٠,١ ، ٠,٢٥ ، ٠,٤ تسلا على التوالى ومع المجال المغناطيسى المتذبذب كان أقصى معدلات التثبيط ٢٦ , ٤٩ , ٧٢ % بالنسبة للكنترول عند شدة مجال مغناطيسى ٠,٠٥ ، ٠,١٥ ، ٠,٢٥ تسلا على التوالى. يُلاحظ أن المجال المغناطيسى المتذبذب كان أكثر فاعيلة فى تثبيط نمو الفطريات.

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