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STUDY OF *SACCHAROMYCES CEREVISIAE* ACTIVITY IN A SUBMEGAHERTZ BAND MAGNETIC FIELD

Research article

Abstract

Magnetic field is one of the possible physical factors influencing microbiological objects. At present, quite a lot of contradictory experimental data have been obtained characterizing the effect of magnetic fields of different frequencies and amplitudes on the process of reproduction of the yeast species *Saccharomyces cerevisiae*. In this work, the influence of 90 kHz magnetic field with amplitude of 2 mT and 5 mT on the growth and survival of yeasts was studied. It has been established that yeast treatment in alternating magnetic field of 2 mT amplitude does not lead to a noticeable change in their activity and survival. An increase of the field amplitude up to 5 mT and treatment duration of more than 10 minutes leads to the death of impaired yeast cells. The latter conclusion may also implicitly confirm the hypothesis of a possible direct effect of the sub-megahertz band magnetic field when using magnetic hyperthermia in oncology.

Keywords: alternating magnetic field, yeast, activity, survival rate, magnetic hyperthermia.

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ИССЛЕДОВАНИЕ АКТИВНОСТИ *SACCHAROMYCES CEREVISIAE* В ПЕРЕМЕННОМ МАГНИТНОМ ПОЛЕ СУБМЕГАГЕРЦОВОГО ДИАПАЗОНА

Научная статья

Аннотация

Магнитное поле является одним из возможных физических факторов, оказывающих влияние на поведение микробиологических объектов. В настоящее время получено достаточно много противоречивых экспериментальных данных, характеризующих влияние магнитных полей различной частоты и амплитуды на процесс размножения дрожжей вида *Saccharomyces cerevisiae*. В данной работе исследовано влияния магнитного поля частотой 90 кГц, амплитудой 2 и 5 мТл на рост и выживание дрожжей. Установлено, что обработка дрожжей в переменном магнитном поле амплитудой 2 мТл не приводит к заметному изменению их активности и выживаемости. Увеличение амплитуды поля до 5 мТл и продолжительности обработки более 10 минут приводит к гибели ослабленных дрожжевых клеток. Последнее заключение может также косвенно подтверждать гипотезу о возможном прямом эффекте переменного магнитного поля субмегагерцового диапазона при использовании магнитной гипертермии для лечения онкологических заболеваний.

Ключевые слова: переменное магнитное поле, дрожжи, активность, выживаемость, магнитная гипертермия.

1. Introduction

Despite the rather conservative nature of food production technologies, there has recently been a noticeable interest of both manufacturers and researchers to explore the possibilities of using the latest results obtained by specialists in the fields of fundamental science. Most modern technologists are aware that a significant modernization of traditional food technologies or fast development of new ones can be carried out only on the basis of a deep understanding of the physical and chemical features of technological processes [1], [2].

One of the directions in the study of fundamental processes in food systems is the study of the influence of various physical factors on microbiological objects involved in the technological processes. Such factors include, for example, electric and

magnetic fields, acoustic effects, including ultrasonic, as well as various types of radiation. There are two main reasons for the development of this direction in food science applications.

On the one hand, due to the extreme complexity of biological systems that are raw materials for the food industry, their response to the physical effects is often unpredictable and ambiguously depends on the intensity of the impact of the selected factor. The complex response of a biological system to a selected impact, in turn, is of interest to researchers, as it can lead to the emergence of new unexpected effects that can significantly change traditional approaches to food technologies.

On the other hand, development of the instrumental base, mainly for medical purposes, makes new methods of physical impact on biological objects available to researchers.

Magnetic field is one of the possible physical factors influencing the microbiological objects. The great variety of microbiological systems and the extreme complexity of their detailed structural analysis leads, as noted above, to an ambiguous response of these systems to applied external magnetic field [3]. Nevertheless, over the past decades, a number of theoretical approaches have been proposed to explain the mechanisms of magnetic fields influence on microorganisms [4], [5].

The yeast of the species *Saccharomyces cerevisiae* is one of the most well-studied microorganisms. They are quite easy to grow and practically do not have pathogenic properties for the human body, due to which they are widely used both in medicine and in the food industry. The properties of *Saccharomyces cerevisiae* make it a convenient object for model studies. Therefore, researchers' interest in studying the influence of magnetic field on processes involving yeast is obvious.

At present, quite a lot of conflicting experimental data have been obtained that characterize the effect of magnetic fields of various frequencies and amplitudes on the reproduction process of Saccharomyces cerevisiae. For example, in [6] it is noted that a uniform constant magnetic field of moderate magnitude (200 mT) had practically no effect on the fermentation process for 24 hours, while an inhomogeneous magnetic field of the same magnitude caused an increase in fermentation intensity by 8%. A report on the enhancement of yeast activity in a magnetic field of 220 mT is also given in [7]. Very strong (more than 1 T) inhomogeneous constant and pulsating magnetic fields lead to the death of some cells [8], [9], [10], [11], which may allow the use of such fields for bactericidal purposes. It was also reported in [10] that after exposure to a magnetic field, surviving yeast cells exhibit higher activity

The aim of this work is to study the effect of sub-megahertz band magnetic field (90 kHz) with amplitudes of 2 mT and 5 mT on the growth and survival of the yeast species *Saccharomyces cerevisiae*. Magnetic fields of this range are widely used for hyperthermia in the treatment of malignant tumors [12], [13]. Therefore, in addition to checking the possibility of the influence of such magnetic fields on the activation of yeast in the food industry, the hypothesis of a possible direct effect of an alternating magnetic field on living cells was implicitly tested in this work [14].

2. Methods

Active bottom-cropping dry brewer's yeast SafLager S-23 (Fermentis, France) was used for research. First generation liquid yeast was obtained on the basis of pasteurized beer wort (PIKEM LLC, Russia). Yeast was stored under beer wort at 4±2 °C.

To assess the activity of yeast by release of CO_2, a slightly modified express method described in [15] was used. 4 ml liquid yeast was thoroughly mixed with 6 ml of 20% glucose solution. The resulting suspension was divided into two parts, one of which was subjected to treatment in magnetic field for 1 to 20 minutes. The second part of the suspension was not processed and was a control sample for comparison. 2 ml of experimental and control samples were placed in 4 disposable syringes (2 experimental and 2 control samples), so that the samples, if possible, did not contain air bubbles. Syringes with sealed ends were placed in a thermostated water bath at 30°C. Yeast activity was assessed by the volume of CO_2 released under the syringe plunger in 60 minutes.

The remains of experimental and control samples were used to estimate yeast survival by counting of dead cells by microscopy after staining with methylene blue.

Induction device of our own design, described in [13], was used to create alternating magnetic field. The samples were placed in the center of inductor coil, which was a solenoid 24 cm long with 5 turns and 35 cm in diameter. The induction device makes it possible to obtain 90 kHz magnetic field with amplitude of 2 mT to 5 mT at the center of the coil.

3. Results

First, a number of experiments were carried out to study the effect of 2 mT and 5 mT 90 kHz magnetic field on samples of freshly prepared second-generation yeast after they were stored no more than a day.

Figure 1 shows the results of microscopy of stained control (a) and treated (b) samples. The last one was hold in 5 mT 90 kHz magnetic field for 20 minutes. As can be seen in the control sample, the number of dead cells does not exceed 1%, and in the treated sample, the number of such cells does not exceed 5%.

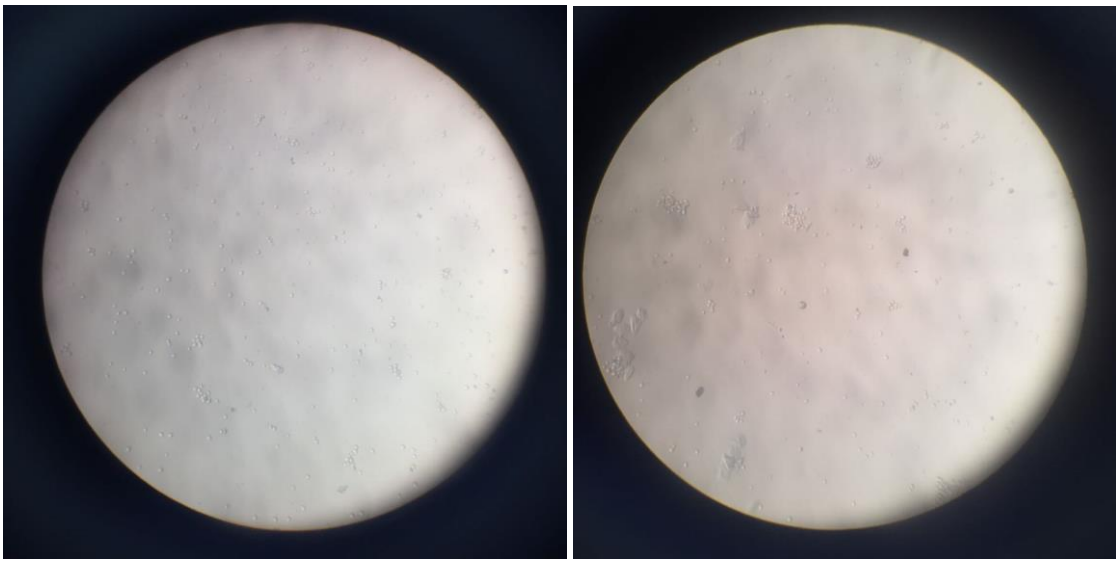
When yeast was treated for less than 10 minutes in 5 mT 90 kHz magnetic field, there was practically no difference with control samples. It was also found that there was no significant effect on the survival of yeast after treatment of the samples in 2 mT 90 kHz magnetic field for 20 minutes or less.

Table 1 presents the results for freshly prepared yeast activity after treatment in 2 mT and 5 mT 90 kHz magnetic field. Our studies have shown that the treatment of freshly prepared yeast in 2 mT 90 kHz magnetic field does not lead to a noticeable change in their activity and survival. Increasing the field amplitude to 5 mT leads to a slight decrease in yeast activity after treatment in a magnetic field for more than 10 minutes. In our opinion, this occurs because of the death of impaired yeast cells. A slight increase in yeast activity after exposure to 5 mT 90 kHz magnetic field for 2 to 10 minutes can be explained by heating of the samples in the inductor.

To study the possible negative effect of 90 kHz magnetic field on impaired cells, similar studies were carried out with yeast samples of the second generation after they were stored for 10 days.

Figure 2 shows micrographs of stained control and treated (5 mT for 20 minutes) samples. In the control sample, the number of dead cells was at least 10%. In the treated sample, almost all cells died.

The results of our study of the treated yeast activity after their storage in the refrigerator for 10 days are presented in Table 2. As in the previous series of experiments, it was found that there was no significant effect on the survival and activity of yeast after their treatment in 2 mT 90 kHz magnetic field. At the same time, when yeast was treated after long-term storage with 5 mT 90 kHz magnetic field for more than 10 minutes, a significant decrease in their activity was observed as a result of cell death.

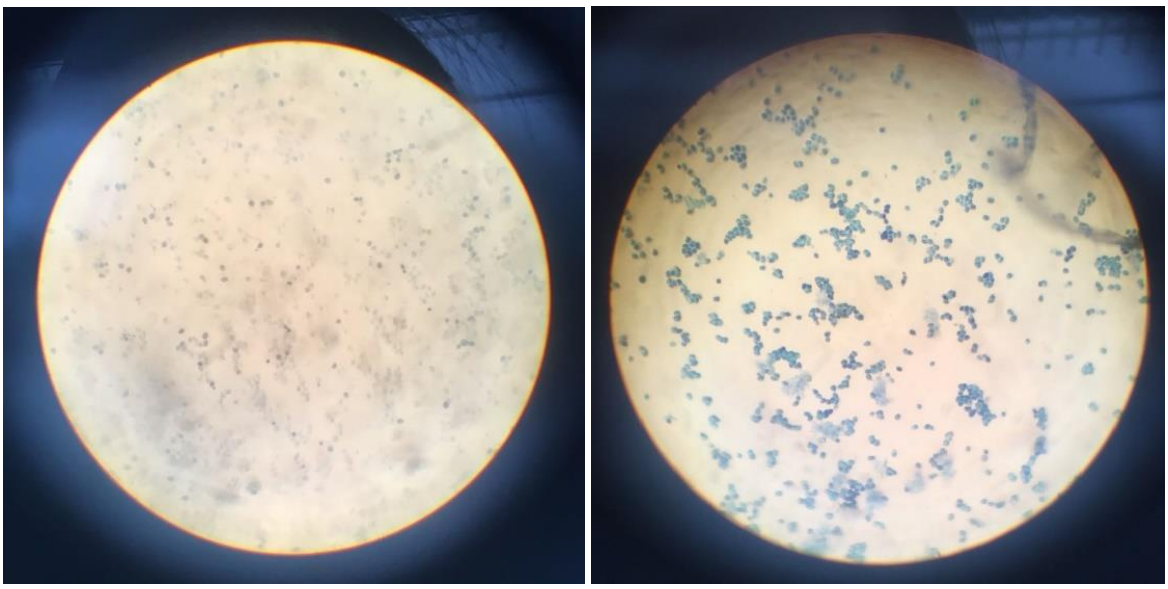


a *b*

Fig. 1 – Micrographs of stained with methylene blue control (*a*) and treated with magnetic field (*b*) fresh yeast samples

Table 1 – Effect of 90 kHz alternating field on the activity of fresh yeast

Processing time, min.	2 mTl	5 mTl
	Volume of released carbon dioxide, ml	
0 (control)	2,1±0,2	2,1±0,2
1	2,0±0,3	2,1±0,3
2	2,1±0,3	2,3±0,3
5	2,3±0,3	2,3±0,3
10	2,2±0,3	2,5±0,3
15	2,2±0,3	2,1±0,3
20	2,3±0,3	1,8±0,3



a *b*

Fig. 2 – Micrographs of stained with methylene blue control (*a*) and treated with magnetic field (*b*) impaired yeast samples.

Table 2 – Effect of 90 kHz alternating field on the activity of impaired yeast

Processing time, min.	2 mTl	5 mTl
	Volume of released carbon dioxide, ml	
0 (control)	0,5±0,2	0,5±0,2
1	0,5±0,2	0,5±0,2
2	0,5±0,2	0,3±0,2
5	0,4±0,2	0,2±0,2
10	0,6±0,2	0 ÷ 0,2
15	0,6±0,2	0 ÷ 0,1
20	0,5±0,2	0 ÷ 0,1

4. Conclusion

Thus, it was found that treatment of yeast samples in 90 kHz magnetic field with amplitude of 2 mT does not lead to a noticeable change in their activity and survival. Increase in the field amplitude up to 5 mT and a treatment duration of more than 10 minutes leads to death of impaired yeast cells. The latter conclusion may also implicitly confirm the hypothesis of a possible direct effect of an alternating magnetic field when magnetic hyperthermia is used in the treatment of oncological diseases.

Conflict of Interest

None declared.

Конфликт интересов

Не указан.

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