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ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
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Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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ACOUSTIC VIBRATION EFFECT ON GENUS *SACCHROMYCES* YEAST POPULATION DEVELOPMENT

Abstract. The intensive development of yeast populations determines the technological and economic efficiency of food and microbiological productions. Because of this, a large number of methods for the microbial biomass accumulation processes intensification have been developed and applied in industrial practice. The literature data analysis demonstrates that for the activation of biological, biochemical or other nature objects, the use of various types of effects is proposed: electromagnetic waves and electric field, laser and X-rays, electron-ion processing, microwave energy, ultrasound, ultraviolet rays, photoactivation, mechanical-acoustic treatment. However, the effect of inoculating yeast pretreatment by acoustic vibrations – by the audible range sound – with a fixed frequency practically has not been studied. The aim of our work was to determine such influence on the development of bottom-fermenting brewer's yeast populations and, subsequently, their technological characteristics.

For processing of the yeast with the audible range sound, a 3-watt PC column was used, which, in addition to acoustic, also generated electromagnetic vibrations.

To take into account their impact on the monitored indicators, a comparison variant was used in which the yeast was exposed only to electromagnetic oscillations, for which purpose the same column with a damaged diffuser was used. The yeast was treated with a sound of fixed frequency using the "Generator" program for a certain time with an amplitude of 100% and a sinusoidal waveform. The distance between the speaker and the object to be processed was 3 cm. The processing of the experimental variant was carried out in a soundproofed cell at room temperature. Yeast that was not subjected to sound and/or electromagnetic vibrations was used as a control. To assess the effect of acoustic and electromagnetic vibrations on yeast, the yeast populations of all three variants were cultivated - the control, experimental, and comparison – on a 5% sucrose solution for 3 days at 25-28 °C. Immediately after substratum inoculation, every day, and also at the end of cultivation, the total cell titer, the percentage of dead cells and the concentration of solids were determined. As a result of the research, a significant effect of acoustic treatment on the yeast populations development was revealed, and depending on the frequency of the sound, such treatment can be either positive or negative. The treatment only by electromagnetic vibrations had an effect on controlled indicators that was less pronounced and, at many frequencies, was different from that in sound processing, both in magnitude and in direction. It was established that the acoustic impact at rational parameters can be technologically expediently for yeast generation and for the activation of the main fermentation.

Keywords: treatment of yeast with a sound of audible range, treatment of yeast with electromagnetic vibrations, increasing the total titer of yeast cells, intensifying the utilization of dry matter, reducing the number of non-viable cells.

Introduction. When conducting technological processes based on the use of yeast, the intensification of the microbial population and/or increasing its productivity development (if yeasts are used as a producer of certain target substances) is the important task.

The traditional approaches to ensuring the specified result are supporting the optimal composition of the nutrient medium, its microbiological purity, rational values of temperature and pH, the use of stimulants/growth promoters. However, at present, when working with well-studied yeast strains, the potential of such approaches is almost exhausted. Genetic modification, which improves the yeast's desired technological characteristics, opens up significant prospects, but the use of genetically modified yeasts and, more generally, GMOs in food production causes a wary attitude among a number of food products consumers.

Because of this, in the last decades research on the possibility of yeast populations development activating by pretreatment with impacts of different types are being conducted. In particular, it can be wave/field effects. The aim of our work was to study the results of the effect of the audible range sound with a fixed wavelength on the technological characteristics of the brewing yeast.

Literature review. Information about the results of the some types of waves and fields impact on different levels of organization objects is quite extensive. Thus, it is reported about the possibility of accelerating the barley grains germination due to pretreatment with ultrasonic waves [1]. Barley certainly belongs to a different level of living matter organization compared to yeast, however, the data presented in the paper prove the possibility of biological objects ultrasonic treatment not only for the purpose of their structures suppression or destruction [2, 3], but, on the contrary, to activate their metabolic processes. The possibility of such treatment effective use, including for the seeds stimulation before sowing, is confirmed by data published in a number of other sources [4-6].

The yeast ultrasonic processing used in alcohol production have been studied, also [7]. It has been established that at constant ultrasound power and frequency, by varying only the duration of exposure, it is possible, by treating the yeast biomass before seeding, to activate the population development, and at the end of the process by repeated (longer) ultrasound treatment to reduce the number of viable cells significantly.

The food production thermotechnical processes in the electromagnetic field of ultra-high frequencies (microwave) are studied. It has been established that the yeast microwave processing efficiency used in the fermented beverages production may be high, but it depends "on the selectivity of the electromagnetic field energy extraction" by the yeast biomass [8]. In order to maximize the yeast enzymes activity during the alcoholic fermentation cycle and the finished product quality, the brewing yeast pressed mass was subjected to heat treatment for τ = 6–15 s in the electromagnetic field of the microwave (frequency 2375 MHz) to a temperature of 283÷3080 K. It is shown that the brewing yeast treatment with microwave range waves increases their fermentation activity by 265% compared with the control and is significantly more efficient than heating in a thermostat, while it has a much shorter duration. It was established experimentally that the microwave electromagnetic field effect enhances the alcoholic fermentation enzymes synthesis, weakens the yeast cells respiratory enzymes synthesis. According to the authors of the work, the developed method can be used in any industry related to fermentation processes [8]. It is important to note that in order to achieve a positive result, careful selection of microwave treatment parameters is necessary, since the same type of effect with other conditions can be used to effectively suppress of microbial, primarily yeast cells development [9].

A method has been developed for treating brewer's yeast, which stipulates exposure to electromagnetic oscillations of the millimeter wavelength range. It is reported that the fermentation time compared with the control decreased 1.3 times, the fermentation activity increased 1.3 times, the concentrations of diacetyl and aldehydes in the green beer of the experimental irradiated variant were about 1.2 times less than in the control one [10]. The method disadvantages include the possibility of irradiating a yeast suspension small amount in one session only, as well as its complexity.

In another research, it was found that after a seven-time (daily, exposure time 2 hours) exposure to electromagnetic radiation with a wavelength of about 6 mm (frequency is about 50 GHz) of a genus *Endomycopsis* fungus, an increase in culture activity was observed by 50%. Similar results were obtained for brewing yeast: exposure to electromagnetic radiation with a wavelength of about 6 mm non-thermal power level resulted in an yeast fermentation activity increase of 1.2-1.5 times compared to the control (non-irradiated) sample. After a tenfold irradiation with electromagnetic radiation with a wavelength of 6.4 mm of a genus *Aspergillus* fungus suspension, an increase in the activity of the culture in 2–2.5 times was observed [11].

At the same time, a method has been developed to effectively suppress the vital various microorganisms activity with pathogenic properties in relation to the human body, based on the object irradiation with electromagnetic radiation with a frequency of 20–95 GHz with a power flux density of not more than 10 μW/cm^2 for at least 20 minutes [12].

The microorganisms biological activity changes that were exposed to magnetostatic wave (MSW) radiation with various parameters for 5 to 60 minutes were studied [13]. Dry baker's yeast and *Saccharomyces bayanus* strain LW 185-25 were subjected to irradiation. It was established that during irradiation in one interval of the MSW the yeast biomass increment increases, while in the other interval it decreases. The increase in the biomass volume in comparison with the control (untreated) sample can be as high as 25%, while the decrease can be equal to 15%. The ultrasound multidirectional effects on microbial cells are confirmed by other authors [14].

The literature provides information [15] on the method of accelerating the microorganisms growth and increasing the microbial biomass yield when cultured on ordinary nutrient media by treating the microbial suspension with laser radiation with a certain power, impulse duration and wavelength.

A patent has been issued for [16] a method for producing highly active streptomycetes strains – avermectin producers by irradiating a spore of a *Streptomyces avermitilis* culture at least once with short-impulse X-rays with certain parameters. It can be assumed that with this method of action, it is not the enzyme systems microorganism-producer activation take place, but mutations in which positive changes in the genome are fixed in cell generations, ensure the production of highly active strains.

A method has been developed to activate the wine yeast populations development as a pretreatment with infrasonic oscillations result [17]. For this, a yeast suspension mixture with a sterile wort is treated by vibration action with a frequency of 5-11 Hz with an oscillation amplitude of 4-5 mm for 15-30 minutes at a yeast suspension and wort ratio 1: 40-50, respectively. The source of vibration action is placed in the volume of the mixture at a distance of 1/3 ÷ 2/3 from its surface. This provides an increase in the pure yeast culture cells mass and an increase in the number of active (living) cells in the finished yeast starter, allowing to speed up the wort fermentation process, which leads to a decrease in the duration of the winemaking process.

It should be noted also an indirect method – the use of electrochemically activated systems/solutions – which allows to solve such problems as improving the brewing barley quality, activating malt enzymes, the effect on grain microflora [18].

Another way to affects the biochemical and biological objects in order to improve their characteristics is the acoustic treatment by the sound of the audible range.

As a wave, sound is characterized by amplitude and frequency spectrum. Usually, a person hears sounds in the frequency range from 16-20 Hz to 15-20 kHz. Among the audible sounds should also be distinguished phonetic, speech sounds and phonemes (of which oral speech consists) and musical sounds [19]. Published results prove the possibility of changing the biological objects characteristics at various levels of organization as a result of the action of certain musical compositions or simply voiced fragments of the text, individual words [20-22], and these changes in living systems can have as positive and negative character [23]. The musical composition is based on the use of a broadband frequency range, the individual frequencies of which, hypothetically, can coincide with the resonant frequencies of various biological objects, including cells. From our point of view, it is impossible or, at least, extremely difficult to systematize the effect of acoustic vibrations on biological objects by studying the effects of melodies.

The possibility of changing the raw materials technological parameters and semi-products of various, including food, industries with fixed-frequency sound was demonstrated by a number of studies [24-26].

The reasonability of studying the audible range sound effect on the yeast is confirmed, in our opinion, by the research results previously conducted at the Moscow State University of Food Production [27-30]. Based on them, it was concluded that sound processing with frequencies from the range of 20–20,000 Hz provides a significant increase in the target enzymes activity microbial enzyme preparations, hop and light barley malt extractability. Additional confirmation of the yeast activation method perspectivity by sound treatment ares data [31], according to which the positive effect was achieved by treating the cell suspension with a sound with frequencies of 20–20,000 Hz in a rotary pulsation apparatus together with the use of the activation medium.

A priori, modern technologies assume the presence of complex process solutions. This applies to the technology of drinks from animal and vegetable raw materials, general and special purpose. Accordingly, there is a need to expand the scope of evaluation criteria of quality [32-41].

It seemed to us expedient to assess the effect on the *Saccharomyces cerevisiae* yeast population, used for the production of bottom-fermenting beer, of the fixed frequency sound of the audible range only.

Methods. Dried yeast *Saccharomyces cerevisiae* species S was used as test objects.

A sterilized 5% sucrose solution was used as a nutrient medium.

The yeast was cultured in flasks of 250 cm^3 with 100 cm^3 of the nutrient medium statically, without stirring at 26–28 °C.

The development of populations was evaluated by the change in cultures of the yeast cells total titer, the solids content, and by the non-viable cells proportion, also. The controlled characteristics values in the experimental variants were expressed in relation to the control (unprocessed by sound), taken as 100 %.

Dried yeast was processed by sound in a soundproofed cell for 60 min (unless otherwise indicated) at room temperature.

The sound of a certain frequency was generated using a 3-watt PC speaker using the "Generator program"; the waveform was sinusoidal.

In view of the fact that sound was generated in the PC speaker due to electromagnetic oscillations, the acoustically processed object was also subjected to the effects of these electromagnetic oscillations (EMO). In order to evaluate the contribution of the EMO to possible changes in the controlled characteristics of the processed yeast, comparison samples were used, which were similar weights of yeast, which were located at the same distance as in the experimental sample, near the PC speaker with a purposely damaged diffuser that did not generate sound.

The yeast cells total titer was determined by counting in the Gorjaev's chamber.

Non-viable cells were determined by staining with methylene blue solution (Fink suspension).

The concentration of dry matter (DM) in solutions was determined pycnometrically.

The replication of experiments at all stages of the experiment – not less than 3. The results of experimental studies were processed by methods of mathematical statistics using Student's criterion.

Results. The preliminary acoustic treatment effect on the dried *Saccharomyces cerevisiae* species S brewer's yeast populations development was studied. The acoustic treatment impact on the yeast populations development in the first series of experiments was assessed by the change in dry matter concentration in the nutrient medium, the increase in total yeast cell titer and the non-viable yeast cells proportion.

At the first stage of our research, the problem of determining the presence or absence of the fixed frequencies sound influence from the range of 20–20,000 Hz generated by an acoustic column, as well as electromagnetic oscillations (EMO) arising for the generation of certain frequency sound on the population brewing yeast development in a model nutrient medium (5% sucrose solution) was solved. In case of revealing the existence of such an effect, the goal was to determine the most effective for yeast population activation frequencies. In these experiments, the following calculation was used to assess the change (decrease) in the sugar concentration in the culture medium: the sucrose concentration decreases in the experimental sample (pre-pitching sound processing of yeast) and a reference sample (pre-pitching processing by EMO) for the entire cultivation period (3 days at 25–30 °C) were expressed as a percentage relative to the value of the same indicator in the control (pitching yeast, not subjected to any processing), taken as 100% (table).

Based on the experimental data, a significant dependence of the controlled parameters on the processing of pitching yeast both by sound and electromagnetic oscillations was revealed. Depending on the frequency, the preliminary processing under the experimental conditions led to both intensification and inhibition of the development of the brewing yeast population. The greatest decrease in the sucrose content in the cultivation medium in comparison with the control was recorded in the samples after sound processing with frequencies of 6000, 8000, 9000, 12000, 17000 and, especially, 19000 Hz. The largest increase in total cell titer compared with the control was observed in the experimental samples obtained after exposure to sound with frequencies of 8000, 9000, 12000 and 17000 Hz.

However, at most of the sound frequency indicated values, an increase in the non-viable cells proportion was observed compared to the control. In addition, in the experimental sample obtained after

The effect of sound processing of pitching yeast on the cultural fluid indicators after 3 days of cultivation

Frequency, Hz	The decrease in the concentration of DM, % of the control		The increase in cell titer, % to control		Non-viable cells, % of control	
	Sound	EMO	Sound	EMO	Sound	EMO
20	84.2±2.6	110.5±3.3	111.3±6,2	23.5±2.2	113.6±3.3	179.0±3.1
1000	40.7±1.7	100.0±1.9	56.1±3.1	45.5±3.2	59.2±1.8	111.7±3.3
2000	65.0±2.2	77.5±2.0	105.4±4.8	76.6±3.5	95.6±2,6	89.4±2.4
3000	107.3±3.4	107.3±2.3	111.4±4.1	101.4±5.1	74.3±3.1	72.8±2.6
4000	88.4±3.0	53.6±1.4	86.6±3.4	80.8±3.9	86.0±3.7	89.8±3.3
5000	51.7±2.1	117.2±3.4	117.7±4.4	117.7±4.1	61.0±3.1	57.1±2.1
6000	143.1±4.1	92.2±3.0	84.4±3.7	118.1±4.3	86.7±2.9	97.2±3.2
7000	94.9±2.2	179.5±4.1	76.4±4.3	99.5±3.9	92.0±2.8	85.5±3.4
8000	118.4±5.9	120.4±1.2	145.9±4.4	160.5±5.3	92.0±3.2	113.6±2.7
9000	128.9±4.3	133.3±3.3	133.3±5.9	141.5±5.1	95.6±2.9	83.9±2.7
10000	45.5±0.9	54.6±1.9	79.4±3.7	88.6±3.8	110.4±3.3	108.6±3.1
11000	68.2±1.4	90.9±2.1	115.7±5.0	99.0±3.6	88.8±2.7	93.0±2.9
12000	300.0±4.7	115.8±3.4	142.4±4.8	138.2±4.4	103.8±2.6	97.1±2.8
13000	85.7±1.7	117.9±3.2	119.0±5.2	116.7±4.1	108.9±3.1	115.1±1.9
14000	88.9±2.3	100.0±2.8	113.1±4,1	151.4±4.9	129.6±3.9	109.3±0.7
15000	100.0±1.7	225.0±4.7	92.9±3.2	97.1±2.8	96.2±2.8	101.2±2.2
16000	78.9±2.0	73.7±0.9	86.4±2.7	100.4±3.7	101.8±3.0	95.4±1.9
17000	178.6±3.4	121.4±2.0	123.1±5.6	127.8±4.5	113.1±2.7	105.1±2.4
18000	70.0±1.1	60.0±1.5	93.1±4.9	78.5±3.5	104.3±1.9	101.1±3.6
19000	310.0±4.6	180.0±4.1	80.5±3.7	108.3±4.2	95.1±2.1	98.1±1.8
20000	107.7±3.2	46.2±2.3	93.8±3.6	82.7±3.7	103.4±2.2	101.4±2.6

preliminary sound processing at the frequency of 3000 Hz there was an improvement in all three controlled indicators, although it was not as significant as the increase in individual characteristics of other samples mentioned above. It should be noted that the pitching yeast EMO processing was on average less effective than sound one.

Because of this, at the next stage of work, it was decided to carry out clarifying experiments, the conditions of which were similar to the previous one, except that the cultivation period was 4 days. Besides, it was decided to refuse to set comparison samples (preprocessing by EMO). The value of the DM concentration loss in the experimental sample was expressed as a percentage relative to the value of a similar indicator in control sample on the same day of cultivation, and not at the end of the process. The sound processing was performed at the frequencies of 3000, 8000, 9000, 12000, 17000 and 19000 Hz. The results are shown in figure 1–3.

This series of experiments results, from our point of view, show that the most expedient is the preliminary sound processing of pitching yeast at frequency of 3000 Hz (curve 1). In this case after 4 days of cultivation the most intensive sucrose utilization from the nutrient medium was observed, as well as the smallest non-viable cells proportion, although from the point of view of biomass accumulation, sound effects with frequencies of 8000 and 12000 Hz (curves 2 and 4, respectively). Because of this, it was decided to use the sound frequency equal to 3000 Hz at the next stages of our work as a “starting point” when searching for rational parameters of pitching yeast acoustic processing in order to intensify the development of their population.

To solve the problem, experiments were carried out in which different parameters of acoustic treatment were varied. Under the experimental conditions, the best results were ensured by the sound processing of dry pitching yeast with the following parameters: sound frequency 2765 Hz; processing time 30 minutes; the distance between the processed sample of the yeast and the sound source is 5 cm; the amplitude of sound vibrations is 100%.

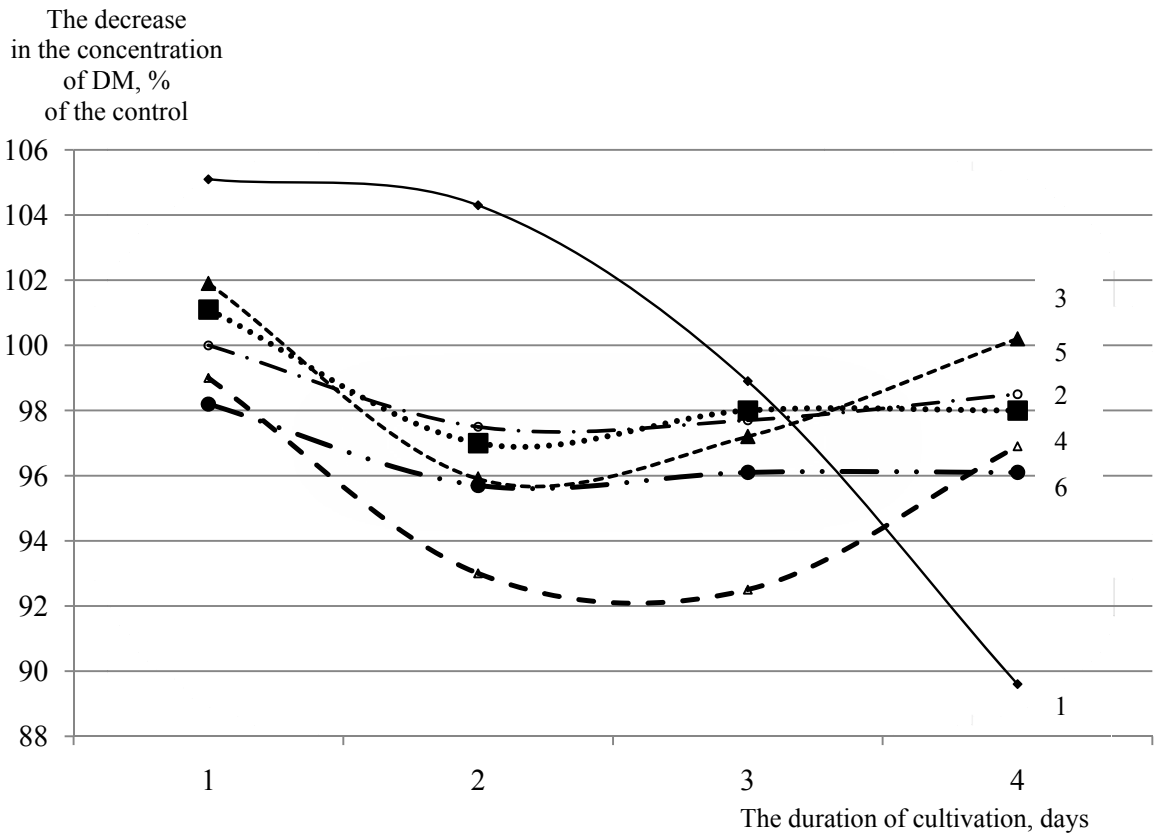

Figure 1 – The effect of processing by the different frequencies sound on the change in the dry matters concentration in the nutrient medium
(sound frequency: 3000 Hz - 1; 8000 Hz - 2; 9000 Hz - 3; 12000 Hz - 4; 17000 Hz - 5; 19000 Hz - 6)

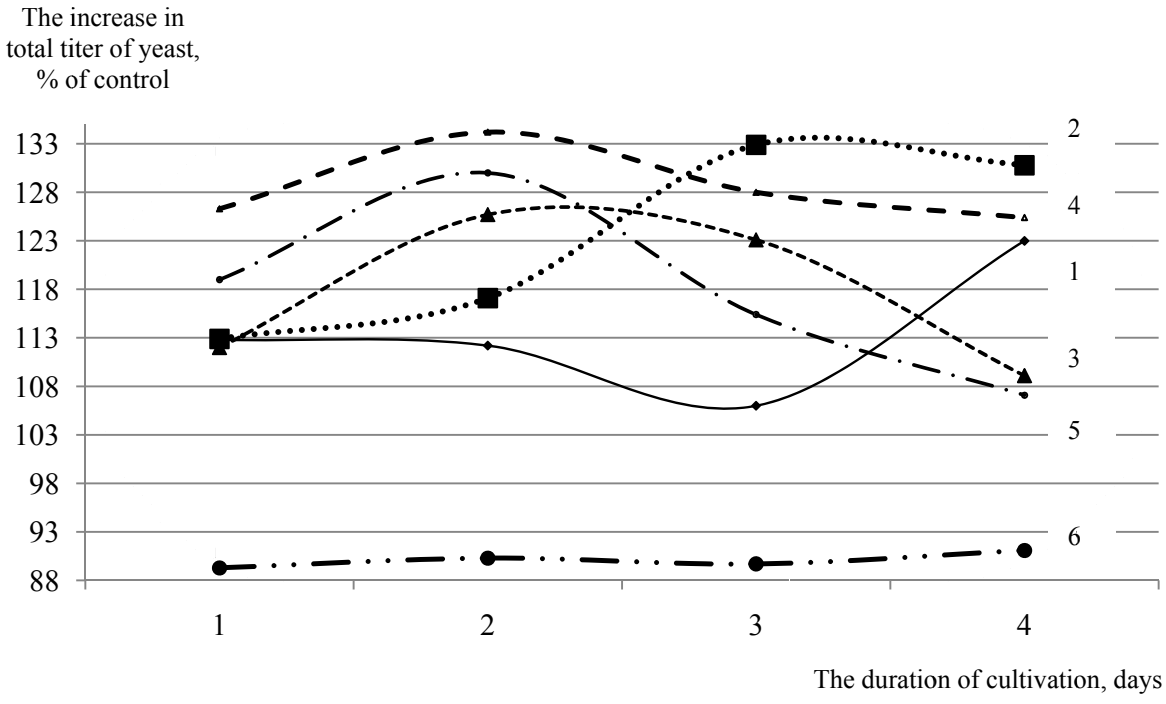

Figure 2 – The effect of processing by the different frequencies sound on the change in the yeast cells total titer increase
(sound frequency: 3000 Hz - 1; 8000 Hz - 2; 9000 Hz - 3; 12000 Hz - 4; 17000 Hz - 5; 19000 Hz - 6)

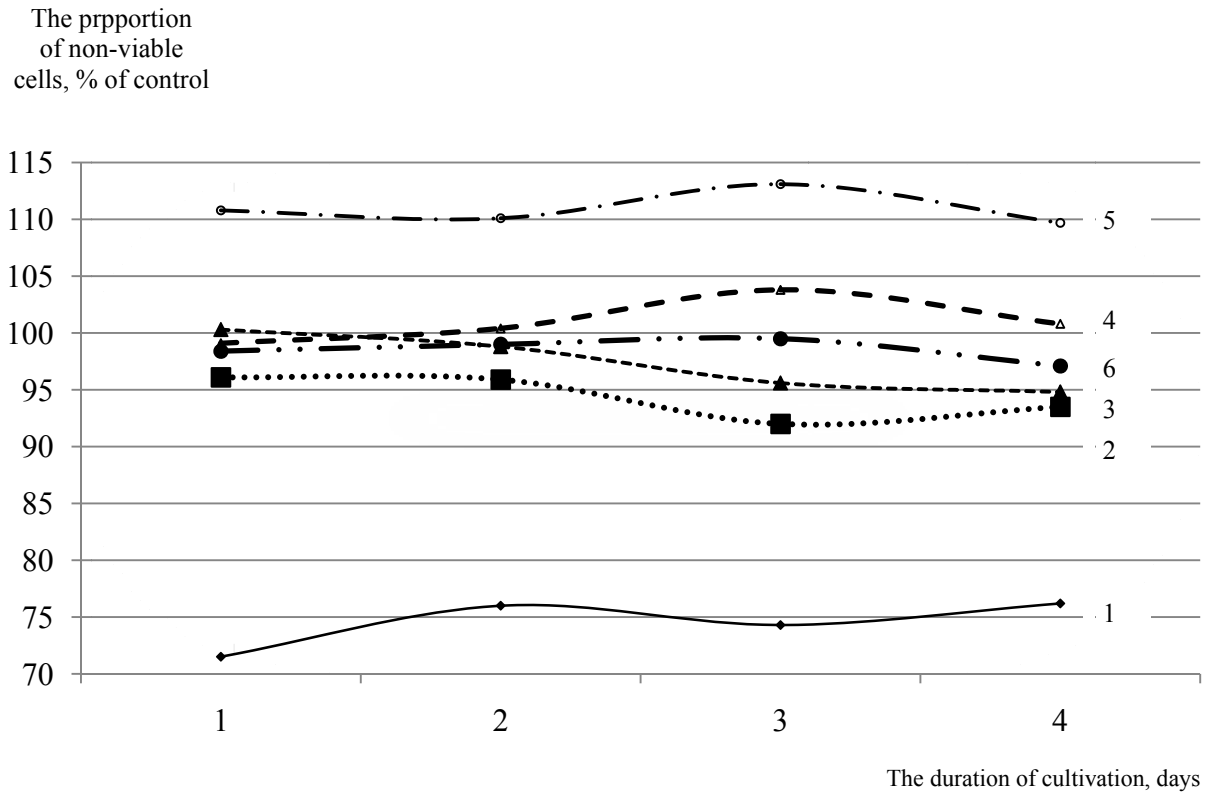

Figure 3 – The effect of processing by the different frequencies sound on the change in the non-viable yeast cells proportion
(sound frequency: 3000 Hz - 1; 8000 Hz - 2; 9000 Hz - 3; 12000 Hz - 4; 17000 Hz - 5; 19000 Hz - 6)

Discussion. Analyzing all the above experimental data, we can make a number of conclusions:

An audible range sound generated by a device for converting electrical signals into acoustic signals and emitting them into the surrounding space, used for yeast processing before introducing them into the nutrient medium, in particular, beer wort, can have both positive and negative effects on the development of a bottom-fermenting yeast population, as well as on the ethanol accumulation in the alcoholic fermentation process; The direction and intensity of influence depends on the sound frequency and some other parameters of acoustic processing.

Electromagnetic oscillations applied to the pitching yeast processing also have a multidirectional effect on the results of cultivation the microbial population, however, for the most part, less pronounced than the audible sound.

The results of the discussed and previous studies, as well as literature information suggest that at least one of the sound influence mechanisms is a change in conformation and, as a consequence, the enzyme molecules activity involved in the yeast metabolic processes, in particular, the alcohol fermentation cycle enzymes.

Acoustic processing parameters that determine its effectiveness in terms of yeast population development activating are the sound frequency and its amplitude, the processing time and the distance from the sound source to the object being processed.

The audible range sound acoustic processing while establishing rational parameters of its implementation can provide both technological and economic effect during yeast generation or at the stage of main fermentation of the brewing industry. It is also of great importance in other fermented beverages technology, including on vegetable raw material beverage [32, 33].

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АКУСТИКАЛЫҚ ТЕРБЕЛІСТЕРДІҢ АШЫТҚЫ *Saccharomyces* ТУЫСЫНЫҢ ПОПУЛЯЦИЯСЫНА ӘСЕРІ

Аннотация. Ашытқы популяцияларының қарқынды дамуы азық-түлік және микробиологиялық өндірістердің технологиялық және экономикалық тиімділігін анықтайды. Осыған орай, өндірістік тәжірибеде микробтық биомасса жинақтау үдерістерін күшейтудің көптеген әдістері әзірленді және қолданылды. Әдеби мәліметтерді талдауға биологиялық, биохимиялық немесе басқа табиғат нысандарын белсендіру үшін толқын немесе өріс әсерінің әртүрлі түрлерін қолдану ұсынылады. Дегенмен, тұқымның ашытқыларын белгілі бір жиіліктегі естілетін диапазон дыбысымен алдын ала өңдеу әсері зерттелмеген. Біздің жұмысымыздың мақсаты осы әсерлердің ашытуда сыра ашытқысының популяциясын дамытуға және одан әрі, олардың технологиялық сипаттамаларына әсерін анықтау болды. Ашытқыны естілетін диапазонмен өңдеу үшін акустикалықпен қатар қосымша генерациялайды және электромагниттік ауытқуларға қуаты 3Вт дербес компьютер колонкасы қолданылды. Олардың бақыланатын көрсеткіштерге әсерін ескеру үшін, ашытқылар тек электромагниттік тербелістерге ғана ұшыраған зарарланған диффузоры бар бір бағанды салыстыру нұсқасы қолданылды. Тәжіриебелік нұсқаны өңдеу бөлме температурасында дыбыс өткізбейтін ұяшықта жүргізілді. Бақылау ретінде дыбыс және/немесе электромагниттік ауытқуларға ұшырамаған ашытқы пайдаланылды. Акустикалық және электромагниттік тербелістердің ашытқыға әсерін бағалау үшін барлық үш нұсқадағы ашытқы популяциясы – бақылау, тәжіриебелік және салыстыру – 25–28 °С температурада 3 күн бойы 5% сахароза ерітіндісінде өңделді. Қоректік ортаға егілгеннен кейін күн сайын, сондай-ақ өсіру аяқталғаннан кейін дереу жалпы жасуша титрі, өлі жасушалардың пайызы және құрғақ заттар концентрациясы анықталды. Зерттеу нәтижесінде акустикалық өңдеудің ашытқы популяцияларын дамытуға айтарлықтай әсері анықталды және дыбыстың жиілігіне байланысты мұндай әсер оң және теріс болуы мүмкін. Электромагниттік тербелістер арқылы өңдеу тек бақыланатын көрсеткіштерге әсерін тигізді, алайда олардың көпшілігі жиілікте және көлемде де, бағытта да дыбысты өңдеуден ерекшеленді. Рационалды көрсеткіштердегі акустикалық әсер технологиялық тұрғыдан ашытуды генерациялау үшін және негізгі ашытудың белсендіруі мүмкін екендігі анықталды.

Түйін сөздер: ашытқыларды дыбысты диапазонмен өңдеу, ашытқыны электромагниттік тербелістермен өңдеу, ашытқы жасушаларының жалпы титерін арттыру, құрғақ заттарды кәдеге жаратуды арттыру, өмірге қабілетті емес жасушалардың санын азайту.

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ВЛИЯНИЕ АКУСТИЧЕСКИХ КОЛЕБАНИЙ НА РАЗВИТИЕ ПОПУЛЯЦИЙ ДРОЖЖЕЙ РОДА *Saccharomyces*

Аннотация. Интенсивное развитие дрожжевых популяций обуславливает технологическую и экономическую эффективность ряда пищевых и микробиологических производств. В силу этого разработано и применяется в промышленной практике большое количество способов интенсификации процессов накопления микробной биомассы. Анализ литературных данных демонстрирует, что для активации объектов биологической, биохимической или иной природы предлагается использование различных типов волновых или полевых воздействий. Однако воздействие предварительной обработки засевных дрожжей звуком слышимого диапазона с фиксированной частотой практически не изучалось. Целью нашей работы было определение такого воздействия на развитие популяций пивных дрожжей низового брожения и, в дальнейшем, их технологические характеристики. Для проведения обработки дрожжей звуком слышимого диапазона использовали

колонку для ПК мощностью 3 Вт, которая помимо акустических, генерировала еще и электромагнитные колебания. Для учета их воздействия на контролируемые показатели использовали вариант сравнения, в котором дрожжи подвергали воздействию только электромагнитных колебаний, для чего использовали такую же колонку с поврежденным диффузором. Обработку опытного варианта проводили в звукоизолированной ячейке при комнатной температуре. В качестве контроля использовали дрожжи, не подвергавшиеся обработке звуком и/или электромагнитными колебаниями. Для оценки влияния акустических и электромагнитных колебаний на дрожжи проводили культивирование дрожжевых популяций всех трех вариантов – контрольного, опытного и сравнения – на 5 %-ном растворе сахарозы в течение 3 суток при 25–28 °С. Сразу после засева питательной среды, каждые сутки, а также по окончании культивирования определяли общий титр клеток, процент мертвых клеток и концентрацию сухих веществ. В результате исследований было выявлено существенное влияние акустической обработки на развитие дрожжевых популяций, причем в зависимости от частоты звука такое воздействие может быть как положительным, так и отрицательным. Обработка только электромагнитными колебаниями оказывала на контролируемые показатели эффект, менее выраженный и при многих частотах отличный от такового при обработке звуком как по величине, так и по направлению. Установлено, что акустическое воздействие при рациональных параметрах может быть технологически целесообразным для дрожжегенерации и для активации главного брожения.

Ключевые слова: обработка дрожжей звуком слышимого диапазона, обработка дрожжей электромагнитными колебаниями, увеличение общего титра клеток дрожжей, интенсификация утилизации сухих веществ, снижение количества нежизнеспособных клеток.

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