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Shakhnoza Abduvaxitovna Sultanova
Tashkent State Technical University Address: 2 Universitetskaya st., 100095, Tashkent city, Republic of Uzbekistan, E-mail: sh.sultanova@yahoo.com, Phone: +99893 506-22-00;, sh.sultanova@yahoo.com

Jasur Safarov
Tashkent State Technical University Address: 2 Universitetskaya st., 100095, Tashkent city, Republic of Uzbekistan, E-mail: jasursafarov@yahoo.com, Phone: +99893 569-02-88;, jasursafarov@yahoo.com

Azamat Bakir o'g'li Usenov
Tashkent State Technical University Address: 2 Universitetskaya st., 100095, Tashkent city, Republic of Uzbekistan, E-mail: azamat_usenov_92@mail.ru, Phone: +99894 205-35-75;, azamatusenov1111@gmail.com

Doston Ishmuhammat ogli Samandarov
Tashkent State Technical University Address: 2 Universitetskaya st., 100095, Tashkent city, Republic of Uzbekistan, E-mail: Ishmuxammedovich@mail.ru, Phone: +99894 205-35-75;, Ishmuxammedovich@mail.ru

Qobil Akmal ogli Mukhiddinov
Tashkent State Technical University Address: 2 Universitetskaya st., 100095, Tashkent city, Republic of Uzbekistan, E-mail: m_qobil@yahoo.com, Phone: +99899 662-54-20., m_qobil@yahoo.com

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ULTRASONIC EXTRACTION OF INSTANT FORMS OF PLANT SUBSTRATES IN INDUSTRIAL PRODUCTION

Sultanova Shaxnoza Abduvaxitovna[1], Safarov Jasur Esirgapovich[2], Usenov Azamat Bakir ogli[3], Samandarov Doston Ishmuhammat ogli[4], Mukhiddinov Qobil Akmal ogli[5]

[1,2,3,4,5]Tashkent State Technical University
Address: 2 Universitetskaya st., 100095, Tashkent city, Republic of Uzbekistan,
E-mail: [1]sh.sultanova@yahoo.com, Phone: +99893 506-22-00; [2]jasursafarov@yahoo.com, Phone: +99893 569-02-88; [3]azamat_usenov_92@mail.ru, Phone: +99894 205-35-75; [4]Ishmuxammedovich@mail.ru, Phone: +99894 205-35-75; [5]m_qobil@yahoo.com, Phone: +99899 662-54-20.

Abstract: *In recent years, both in our country and abroad, ultrasonic extraction methods have been increasingly used in industrial production, which is associated with the extraction of various substances and compounds from natural plant substrates. Domestic and foreign experience shows that this method has significant advantages over traditional methods and can significantly increase the efficiency and profitability of industrial enterprises, producing complete and functional food products.*

This article discusses a brief theory of ultrasonic cavitation and the experience of extracting substrates from plants. Different results have been compared and analyzed.

Keywords*: extraction, ultrasound, solvent, cavitation,effective value of sound pressure.*

Аннотация: *Сўнгги йилларда мамлакатимизда ҳам чет элда ҳам табиий ўсимлик субстратларидан турли хил моддалар ва бирикмаларни олиш билан боғлиқ бўлган саноат ишлаб чиқаришида ультратовушли экстракция усуллари тобора кўпроқ қўлланилмоқда. Маҳаллий ва хорижий тажриба шуни кўрсатади-ки, бу усул анъанавий усулларга қараганда сезиларли афзалликларга эга ва тўлиқ ва функционал озиқ-овқат маҳсулотларини ишлаб чиқарадиган саноат корхоналарининг самарадорлиги ва рентабеллигини сезиларли даражада ошириши мумкин.*

Ушбу ишдада ультратовуш кавитациясининг қисқача назарияси кўриб чиқилган ва ўсимликлардан экстракт олиш тажрибаси акс эттирилган. Турли натижалар бир-бирига солиштирилган ва таҳлил қилинган.

Таянч сўзлар: *экстракция, ультратовуш, эритувчи, кавитация, товуш босимининг самарали қиймати.*

Аннотация: *В последние годы как в нашей стране, так и за рубежом в промышленном производстве все чаще используются методы ультразвуковой экстракции, что связано с извлечением различных веществ и соединений из природных растительных субстратов. Отечественный и зарубежный опыт показывает, что этот метод имеет значительные преимущества перед традиционными методами и может значительно повысить эффективность и рентабельность промышленных предприятий, производящих полноценные и функциональные пищевые продукты.*

В этой работе рассматривается краткая теория ультразвуковой кавитации и отражен опыт экстракции из растений. сравнивались и анализировались разные результаты.

Ключевые слова: *экстракция, ультразвук, растворитель, кавитация, эффективное значение звукового давления.*

Introduction

In the production of alcoholic and non-alcoholic beverages belonging to the category of high-grade and functional food products, various types of technological processes for the extraction of natural plant raw materials are widely used [1–5]. A significant technological disadvantage of most methods for extracting biologically active substances and compounds from natural plant substrates is their energy intensity and duration, and in some cases, low selectivity and efficiency. For this reason, in the industrial extraction of these biochemical components, it is often necessary to use combined extraction methods, which complicates the technological process and leads to additional costs of various types of resources. In recent years, both in our country and abroad, in industrial production associated with the extraction of various substances and compounds from natural plant substrates, methods of ultrasonic extraction are increasingly used. Domestic and foreign experience shows that this method has significant advantages over traditional ones and can significantly increase the efficiency and profitability of industrial enterprises that produce complete and functional food products.

Brief description of the proposed method.

Sources of ultrasonic vibrations in industrial production can be various vibrational systems that convert electrical or mechanical energy into a system of elastic vibrations [6]. Harmonic vibrations of particles in a sound wave are described by the well-known equation:

$$\alpha = A \sin \omega\, (\tau - x/c) \tag{1}$$

where α is the displacement of the particle relative to the resting position, μm; A - wave amplitude, μm; ω - angular velocity, rad / s; τ - time, s; x is the distance of the particle from the emitting surface, cm; c-speed of sound, cm / s. The propagation of an ultrasonic wave is not associated with the transfer of matter. The total energy of the wave is equal to the sum of the potential and kinetic energies. In different media, the speed of propagation of ultrasound is different and depends on the vibration frequency and viscosity of the medium. Ultrasound propagates well in liquids and even better in solids.

The main parameter characterizing the properties of the medium with respect to the wave passing through it is the product of the density of the medium ρ (kg / m^3) by the speed of sound s (m / s):

$$\rho\, c = p/u \tag{2}$$

where p is the effective value of the sound pressure, Pa; u - vibrational speed of sound, m / s. The product ρ with is called the specific acoustic resistance of the medium. In turn, the sound intensity is estimated by the sound strength - the energy of sound vibrations passing along the normal to a surface with an area of 1 m^2 for 1 s. Sound intensity (W / m^2) is determined by an expression of the form

$$I = p^2 /(\rho\, c) \tag{3}$$

For sounds palpable by the human ear, the intensity I is estimated in relation to the hearing limit of the human ear, that is, the intensity is determined by the sound power level, which is measured in decibels (dB)

$$1\, dB = 101\, g(I/I_0\,) \tag{4}$$

where I_0 is the hearing limit equal to 10–12 W/m^2. The most important effect for industrial purposes, accompanying ultrasonic vibrations and determining the efficiency of the ultrasonic extraction process, This phenomenon is accompanied by the formation of microvoids, instantly filled with steam and gases dissolved in the liquid. When vapor condenses, the voids "collapse", causing high pressure shock waves that have a destructive effect on particles in the liquid. Under the influence of the cavitation process, the mechanical destruction of the cell walls and the formation of diffusion microcurrents occur, which, in turn, ensures the release of the cell juice and its subsequent dissolution in the extractant.

The essence of his work was as follows. The processed plant material (hydromodule - a mixture of drinking water and plant substrate in various ratios) was loaded into a container with a stirrer, after which the ultrasonic generator was turned on. Elastic vibrations of ultrasonic frequency, formed by the emitters, excited high-frequency mechanical vibrations, under the influence of which zones of intense cavitation and diffusion dissolution of cellular substrates in the extractant were formed in the hydromodule. From the extractor, the resulting liquid extract entered the storage tank and was subjected to detailed biochemical studies. If the degree of processing of the plant substrate was insufficient, the obtained extract was sent for repeated extraction. Thus, the “UZE-0.5” extractor could operate both in a closed cycle and per pass. As the experiments have shown, practically all known biochemical substances and compounds contained in it can be extracted from various types of used plant raw materials by the method of ultrasonic extraction. During the research, it was found that most of the flavonoids, tannins, phenol glycosides, related coumarins, phenolcarboxylic acids and a number of other compounds were extracted from the raw material and transferred to the extractant 10 to 100 times faster than with the most effective standard extraction methods. The kinetics of ultrasonic extraction of biologically active substances and compounds was mainly determined by their belonging to a certain chemical group. For example, the degree and quality of the extraction of substances in the experiments increased in the following sequence: oils, alkaloids, furanochromones, sequiterpenes, flavonoids, saponins, tannides, irinoids. At the same time, not only the acceleration of the extraction processes in time was observed, but also an increase in the mass yield of the biologically active substance and compounds. For example, the increase in the yield of the tannin-catechin complex from natural green tea in the experiments performed was 5–10%. In the process of carrying out experimental studies, technological methods of carrying out the extraction process were identified and optimized for specific types of plant raw materials used in the industrial production of products of adequate and functional nutrition. For example, when extracting natural plant materials, it is usually necessary to use primarily dried materials. Therefore, at the first stage of extraction, the plant raw material must be soaked. Usually, soaking takes up to 5-10 hours. Ultrasonic vibrations can significantly reduce the time of soaking. So, if for the crushed herb St. John's wort, thyme, mint leaves, the optimal swelling time under normal conditions is 2 hours, and for the rhizomes of valerian, elecampane, calamus and other raw materials up to 6 and 8 hours, then when using the UZE-0.5 »30 minutes is enough for soaking and only 10 minutes for ultrasonic treatment and completion of the extraction process. In the course of the experiments, the technological scheme of preliminary grinding of plant substrates before extraction was optimized.

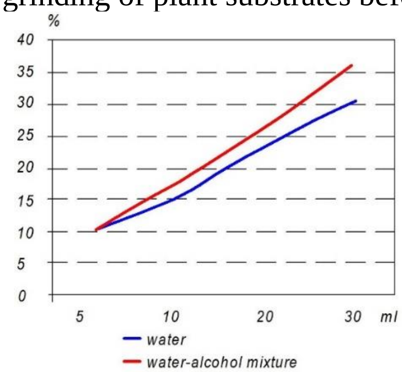

Fig. 1. ***The yield of green tea extractives when using various extractants.***

Results.

It was found that the efficiency of the process of ultrasonic extraction of plant raw materials largely depended on the dispersion of the raw material. When using as a raw material grasses of plants with a thin and loose leaf blade with soft shells, a large number of veins and intercellular spaces, the particle size does not play a significant role and can vary from 2 to 8 mm. Typical examples of such plant materials are lily of the valley herb, wormwood, peppermint leaves, St. John's wort, belladonna, foxglove, adonis, yarrow, chamomile flowers, marigolds, etc. Such raw materials swelled under the action of ultrasound for several minutes. For the extraction of plant materials with stiff cells of a dense structure, the particle size must be much smaller. The optimal yield of biologically active substances when using ultrasound for the extraction of the roots or rhizomes of hellebore, ginseng, steel, radiola, bait, belladonna, valerian, burdock, rootwort, etc. was noted at particle sizes from 0.25 mm to 1.0 mm. The optimum particle size for the extraction of bark, oak, buckthorn, cathedral fruits, hawthorn, pomegranate peel was 0.5–1.5 mm. The correct choice of the extractant is essential for an efficient extraction process using the above-described ultrasonic method. It was found that there are no special restrictions on the use of various types of solvents as extractants. The only requirement for the extractant is the absence of explosiveness, as well as spontaneous biochemical destruction and decomposition during the technological process. The best results for the extraction of various types of natural plant substrates were obtained using alcohol-water mixtures.

Conclusion

To increase the efficiency of the ultrasonic extraction process in the course of experimental studies, various additives to the extractant were used. Glycerin and surfactants had the best technological indicators, which effectively regulated the formation of cavitation zones and thereby excluded the possibility of negative destructive changes in the course of the extraction process. In some cases, weak organic acids were used as inhibitors: tartaric, citric, ascorbic, and also some alkaloids. The addition of small amounts of surfactants to the extractant (from 0.1 to 0.3%) provided an increase in the yield of useful substances by 15–20%. An important technological point contributing to the effective implementation of the ultrasonic extraction process, ensuring continuous and intensive mixing of the extractant and the crushed plant substrate in the working chamber. This, firstly, ensures optimal access of the extractant to each particle, and secondly, it allows to carry out a cavitation effect on practically every particle separately. Moreover, the ratio of raw materials - extractant must be strictly defined. The following results were obtained on the optimal filling of the working chamber of the extractor with plant substrates (%): green tea - 11; dill seeds - 7; carrot seeds - 9; calamus rhizomes - 1; chamomile flowers - 25; rose hips - 15. The duration of ultrasonic exposure is of great importance for the implementation of the above technological process. Obviously, with an increase in the exposure time, the yield of the sum of biologically active substances increases proportionally, which was observed in the experiments. However, such an increase occurred until the depletion of the feedstock. Complete depletion of raw materials was noted, as a rule, with a particle size of up to 0.5 mm and exposure to ultrasound for no more than 15 minutes. With a particle size of up to 1 mm, the plant material was completely depleted after 60 min of treatment. Finally, 2 hours were required to completely deplete the feedstock with a particle size of 2 mm. With a particle size of 8 mm to 10 mm, less than 55% of biologically active substances passed into the extractant in 2 hours of treatment. Thus, it was found that preliminary grinding of raw materials to a particle size of less than 0.5 mm ensured complete depletion of raw materials in 10–15 minutes of ultrasonic treatment. An increase in the temperature of the extractant significantly affects the intense formation of gas bubbles at the interfaces, which leads to a decrease in the intensity of propagation of ultrasonic energy. The maximum yield of biologically active substances and compounds was noted at a temperature of 30 ... 60 ˚C. In this regard, when carrying out experiments on the extraction, the factor of increasing the temperature of the extractant due to the absorption of ultrasonic energy was taken into account.

References

1. Renewables, Global status report. Renewable Energy Policy Network for the 21st Centure, http://www.ren21.net, 2013.
2. S.M.Turabdjanov, H.Hasanov, A.Boboev, L.Yotova, “Effect of Hydrolysis products of different proteins of wheat on antioxidant enzymes”, *International Journal BIOautomation*, no. 15(1), pp. 5-12, 2011.
3. N.R.Yusupbekov, A.R.Marahimov, Sh.M.Gulyamov, H.Z.Igamberdiev, “APC fuzzy model of estimation of cost of switches at designing and modernizations of data-computing networks”, *4th International Conference on Application of Information and Communication Technologies*, AICT 2010, 5612015, 2010, DOI: 10.1109/ICAICT.2010.5612015
4. N.Yusupbekov, F.Adilov, F.Ergashev, “Development and improvement of systems of automation and management of technological processes and manufactures”, *Journal of Automation, Mobile Robotics and Intelligent Systems*, no. 11(3), pp. 53-57, 2012.
5. Sh. Sultanova, J. Safarov, A. Usenov, T. Raxmanova, “Definitions of useful energy and temperature at the outlet of solar collectors”. *E3S Web of Conferences: Rudenko International Conference “Methodological problems in reliability study of large energy systems”* (RSES 2020). Vol. 216, pp.1-5, 2020.
6. Sh.A.Sultanova, A.B.Usenov, “Ispol'zovaniye analiticheski-raschetnogo metoda dlya opisaniya dvizheniya elementov potoka v ekstraktore sokslet” [Using the analytical and computational method to describe the movement of flow elements in the soxlet extractor]. *Universum: tekhnicheskiye nauki: elektron. nauchn. zhurn.* no 11(80), 2020. (in Russian).
7. F.M.Francisco Vazquez, “Tuning Decentralized PID Controllers for MIMO Systems with Decouplers”, *15th Triennial World Congress*, Barcelona, 2002.
8. T.H.K.Astrom, “PID Controllers”. *Theory, Design and Tuning 2nd Edition*, 1995.
9. N.Yusupbekov, D.Mukhitdinov, Y.Kadirov, O.Sattarov, A.Samadov, “Control of non-standard dynamic objects with the method of adaptation according to the misalignment based on neural networks”, *International Journal of Emerging Trends in Engineering Research*, no. 8(9), pp. 5273–5278, 2020.
10. D.S.Pereira, J.O.P.Pinto, “Genetic algorithm based system identification and PID tuning for optimum adaptive control”, *Advanced Intelligent Mechatronics. Proceedings, 2005 IEEE/ASME International Conference*, 2005, pp. 801 - 806.
11. N.R.Yusupbekov, A.R.Marakhimov, H.Z.Igamberdiev, Sh.X.Umarov, “An Adaptive Fuzzy-Logic Traffic Control System in Conditions of Saturated Transport Stream”, *Scientific World Journal*, 2016, 6719459. DOI: 10.1155/2016/6719459.