The use of ultrasonic exposure in the production of functional beverages based on natural raw materials

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Abstract. The technology of drinks production makes it possible to create a variety of tastes and use various natural foundations. Expanding the assortment of "wholesome" and "functional" drinks reveals possibilities for controlling the process of biologically active substances entering the body. From a technological point of view, the drink is the most convenient model for creating new products, including the use of natural plant materials. For creating them, traditional extraction methods are often used. They have several drawbacks: they are long, laborious, occur when exposed to high temperatures, which leads to the loss of raw materials of biologically active substances, the taste of aroma, and a decrease in biological value. In this regard, the actual direction of improving technological solutions in this area is the application of the ultrasonic intensification of the extraction process method. Ultrasound can significantly reduce the duration of the process, increase the yield of biologically active target components and improve the organoleptic characteristics of beverage extracts [2]. The work is devoted to the study of the ultrasonic extraction method in the preparation of functional beverages. The obtained data indicate that the use of this method helps to reduce the time of the extractant saturation, increase the antioxidant activity and yield of extractive substances. This result helps to ensure higher organoleptic characteristics of drinks.

1. Introduction

The functional products' creation is a new field of research lying at the junction of food and biomedical sciences. Noting the constant decrease in energy consumption of modern man, and, accordingly, the amount of food consumed, it must be emphasized that fluid intake by all groups of the population remains unchanged and cannot be reduced without harming health. In this regard, the prospects for developing a range of drinks with functional properties (fruit drinks, juice drinks) are apparent. From a technological point of view, these products are also preferred, as the scheme of their products makes it easy to introduce a variety of functional ingredients [3, 4].

The most promising is the development of drinks based on natural raw materials, enriched with biologically active substances of plant origin and possessing general strengthening properties. Research and developments of scientists are devoted to the technology of the drink's production. They are aimed at expanding the range of drinks with high biological value, improving the technology of their production, creating drinks that strengthen the immune system, tonic, normalize the work of the cardiovascular and nervous system. Such drinks are intended for systematic use in the composition of
food rations by all age groups of a healthy population in order to reduce the risk of various diseases, maintain and improve health [5].

In the context of the beverages production based on natural raw materials, there is a real need to solve many problems, among which the maximum extraction of all physiologically valuable substances from plant materials is very important. In this regard, unique technologies are used for maximizing the preservation and improvement of the beneficial natural properties of the plant components used in the manufacture [6].

Many studies aimed at the scientific and practical justification of the use of ultrasonic exposure in the production of beverages with directed functional properties have been carried out. Under the influence of ultrasonic vibrations, more rapid and active destruction of intracellular tissues of plant materials occurs, which leads to an intensification of the extraction process and makes it possible to increase the content of biologically active compounds in the solution. When choosing raw materials, they were guided by their combination among themselves, the method and stage of the application, which would provide them with the maximum safety of biologically active substances in the production and storage process.

Raspberry (Rúbusidáeus) and cranberry (Oxycóccus) berries were selected as the initial raw material for the preparation of drinks. Raspberry berries have an antitoxic effect on the body, acts as an anti-inflammatory and analgesic natural remedy; increase appetite, protect against colds and flu, prevent the accumulation of cholesterol plaques on the vascular walls, reduce blood pressure and improve blood composition. Cranberry berries have antibacterial properties, increase immunity, normalize blood pressure, tone, increase mental and physical abilities; prevent the development of cardiovascular diseases. The effect of berries on the human body is due to the presence in their composition of biologically active components - vitamins, minerals, trace elements. The creation and production of new types of drinks directed action, will allow expanding the range, make maximum use of enriching components of plant origin.

2. The purpose of the study
An important task in the production of drinks from natural raw materials with directed functional properties is the maximum extraction of physiologically valuable substances and their preservation at all stages of the production cycle. A distinctive feature of this technology is the use of the ultrasonic extraction method, which allows improving the extraction process and preserve biologically active substances, high organoleptic characteristics, and reduce the extraction time [7]. The purpose of the study is the application of the ultrasonic extraction method in the preparation of a drink of functionally directed action from natural raw materials.

3. The object of study
The objects of research were raspberries (Rúbusidáeus) and cranberries (Oxycóccus), widely known for their beneficial properties. Experimental drinks (fruit drinks) were prepared in two ways: the 1st method — using the traditional technology for preparing fruit drinks; the 2nd method — using the ultrasonic method in the frequency range 20–20.5 kHz and the ultrasonic power 150 W.

4. Materials and methods

4.1 Determination of the mass fraction of solids
The refractometric method is used for determining the mass fraction of solids in drinks. The method is based on the optical phenomenon of refraction of a ray of light when it passes through a gas-liquid interface. For determining the number of soluble solids in drinks, a refractometer, shown in Figure 2.3 is used. Before conducting research, the surface of the glass prisms is cleaned with distilled water. The remaining moisture is removed with filter paper. Next, a small volume of the sample is placed on the lower prism of the refractometer, making sure that the test drink uniformly covers the glass surface.
Then the lower prism is covered with the upper prism, and then measurements are carried out, determining the mass fraction of solids on the scale of the device.

4.2 Determination of antioxidant activity
To determine the antioxidant activity, the TsvetYauza-01-AA device, which allows direct quantitative measurements of the antioxidant activity of the studied samples, is used. The device works as follows: the pump constantly pumps the solvent, making it through the entire system from the tank. The solvent stream directs a specific dose of the test substance to the detector cell. In the cell of the detector on the surface of the working electrode, electrochemical oxidation of the molecules of the substance under study occurs, which contributes to an increase in the electric current between the two electrodes.

Samples of solutions of the analyzed objects were prepared. Five consecutive measurements of the signals (the area of the output curve) of the studied solutions were carried out. The result was taken as the arithmetic mean of 4 measurements (standard deviation does not exceed 3%). The calculation of the total antioxidant activity \( SA, \text{ mg} / \text{dm}^3 \) of the test sample was carried out according to the formula (1):

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CA = \frac{CA_{gr} \times N}{N} \]

where \( CA_{gr} \) - the value of the antioxidant activity of quercetin according to the calibration graph, \( \text{mg} / \text{dm}^3 \);

\( N \) - dilution of the analyzed sample.

4.3 Organoleptic evaluation
The organoleptic evaluation of the samples was based on a scoring; a five-level scale was used with the following nomenclature of indicators: taste, smell, colour, appearance. The nomenclature of quality indicators was compiled, taking into account the requirements of regulatory documents for juice-containing drinks. Sample preparation and organoleptic evaluation were carried out, taking into account existing requirements [8]. The results of the evaluation operations were recorded in the tasting lists. Ten people took part in the tasting assessment of the studied samples.

5. Discussion of the results

| Name of raw materials | The chemical composition of the raw material (per 100 g of product) |
|-----------------------|---------------------------------------------------------------|
|                       | vitamins | macrocells | trace elements |
| Berries               |          |            |               |
| raspberries           | A - 33 mcg, beta carotene - 0.2 mg, B1 - 0.02 mg, B2 - 0.05mg, B5 -0.2mg, B6-0.07mg, B9 – 6mcg, C – 25mg, E - 0.6mg, H - 1.9mcg, PP - 0.7mg | K – 224mg, Ca – 40mg, Mg – 22mg, Na – 10mg, S – 16mg, P – 37mg, Cl – 21mg, | B – 200mcg, Fe-1,2mg, Co – 2mcg, Mn - 0,21mg, Cu – 170mcg, Mo – 15mcg, P – 3mcg, Zn - 0,2mg |
| Berries               | B - 0.02mg, B2-0.02mg, B6 – 0.08mg, B9 – 1mcg, C- 15mg, E- 1mg, PP- 0.3g | K –119mg, Ca – 14mg, Mg – 15mg, Na –1g, | Fe -0.6mg |

Table 1. The chemical composition of the raw materials used
The effect of berries on the human body is due to the presence of biologically active components in their composition (see table 1).

As a result of the experiment, graphs of changes in optical density depending on the duration of the process were obtained (Figure 1).

Under ultrasonic action, the equilibrium state is reached within 15 minutes. During this time more complete saturation of the extractant than with traditional technology occurs. This is explained by the fact that the ultrasonic effect provides a greater penetration of the solvent into the plant tissue and improves mass transfer due to the processes that occur during ultrasonic extraction, resulting in a product with a higher optical density.

Experimental data on the determination of the antioxidant activity of the obtained drinks indicate that using ultrasonic extraction, the antioxidant activity of the drinks is doubled compared to drinks prepared using traditional technology, which confirms the preservation of biologically active substances of raspberries and cranberries and a corresponding increase in functional properties drinks based on them (see table 2) [9,10].

**Table 2.** The value of antioxidant activity (AOA)

| Sample Name                               | AOA value mg/dm³ |
|-------------------------------------------|------------------|
| Raspberry fruit drink (traditional technology) | 0,41             |
| Raspberry fruit drink (ultrasonic extraction) | 0,77             |
| Cranberry juice (traditional technology)  | 0,35             |
| Cranberry juice (ultrasonic extraction)   | 0,66             |

Drinks prepared using the ultrasonic extraction method (I) are superior to drinks obtained by traditional technology (II) in some indicators: there is a more pronounced taste of the raw materials, a long aftertaste, a rich aroma of raw berries, intense colour.
Figure 2. Profilograms: A - fruit drink from raspberries (I - ultrasonic extraction II - traditional technology), B - fruit drink from cranberries (I - ultrasonic extraction II - traditional technology).

6. Conclusion
The results obtained indicate that the use of the ultrasonic extraction method helps to reduce the saturation time of the extractant, double the antioxidant activity and increase the organoleptic characteristics. This result helps to ensure higher functional indicators of drinks and proves the feasibility of using ultrasonic extraction in the technology of drinks functionally directed action production.

References
[1] Dobrynina E S and Lomovsky O I 2010 Creation of new recipes for sauces and dressings of functional nutrition Food Industry 8 16–18
[2] Manukovskaya M V and Serchenya M V 2015 The use of modern technology in the preparation of tinctures Economics. Innovation. Quality control. 2 130-133
[3] Perkins J M et al 2016 Adult height, nutrition, and population health Nutrition reviews 74.3 149 - 165
[4] Mayurnikova L A et al 2008 Scientific rationale and practical aspects of the development and evaluation of consumer properties of functional soft drinks
[5] Bugayets N A 2004 Functional food products, their therapeutic and prophylactic effect News of higher educational institutions Food technology 2-3
[6] Fatkullin R I 2013 Prospects for the use of ultrasonic exposure as a factor in the formation of consumer properties of drinks based on natural raw materials Proceedings of the South Ural State University. Series: Economics and Management 7 (4)
[7] Rodionova N S, Manukovskaya M V, Nebol'sin A E and Serchenya M V 2016 Application of ultrasonic extraction method in the preparation of the directive action beverage from black currant Proceedings of the Voronezh State University of Engineering Technologies 2 162-169 (In Russ.) https://doi.org/10.20914/2310-1202-2016-2-162-169
[8] Choi JWJ et al 2008 Sugar-sweetened soft drinks, diet soft drinks, and serum uric acid level: The third national health and nutrition examination survey Arthritis Care & Research: Official Journal of the American College of Rheumatology 59.1 109-116
[9] Yashin A Y and Yashin Y I 2009 The use of TsvevYauza liquid chromatographs with electrochemical detectors in medicine, ecology, and for food control Devices
[10] Rodionova N S, Manukovskaya M V, Kolomnikova J P and Serchenya M V 2015 Investigation of antioxidant activity of blackberry and cranberry liqueurs, prepared by the method of ultrasonic extraction Proceedings of the Voronezh State University of Engineering Technologies 4 98-103 (In Russ.) https://doi.org/10.20914/2310-1202-2015-4-98-103
[11] Mateyev Y Z, Shalginbayev D B, Mateyeva S Z, Kopylov M V, Ostrikov A N and Vasilenko V N
2019 Mathematical modeling of the extracting process of vegetable oil on auger equipment 
EurAsian Journal of BioSciences 13 (2) 1875-1880

[12] Kairbayeva A, Vasilenko V, Dzhinguilbayev S, Baibolova L, Frolova L 2017 Development of the mathematical model for the process of oil raw materials pressing Journal of Engineering and Applied Sciences 12 (6) 7836-7842 DOI: 10.3923/jeasci.2017.7836.7842

[13] Drannikov A V, Derkanosova A A, Korotaeva A A, Orinicheva A A and Pribytkov A V 2020 Study of feed protein supplement with the properties of phytobiotics IOP Conference Series: Earth and Environmental Science DOI: 10.1088/1755-1315/422/1/012086

[14] Mushtaq B S, Pasha I, Omer R, Hussain M B, Tufail T, Shariati M A, Derkanosova A A, Shchetilina I P, Popova N N, Popov E S, Oseneva O V, Kharitonov D V 2018 Characterization of Moringa oleifera leaves and its utilization as value added ingredient in unleavened flat bread (chapatti). Journal of Microbiology, Biotechnology and Food Sciences DOI: 10.15414/jmbfs.2018.8.1.751-755