The use of ultrasonic extraction in the technology of functional drinks based on plant raw materials

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Abstract. The development of targeted drinks is a priority in the field of healthy eating. For their production, plant raw materials are actively used, containing a wide variety of biologically active substances. The presence of these ingredients helps to improve many physiological processes in the body, as well as to increase its immune status. Numerous studies have confirmed the high efficiency of ultrasonic effects on various technological processes. Ultrasonic extraction was carried out at t = 20 °C and an ultrasonic wave frequency of 22 kHz. As a result of research, it was found that with ultrasound exposure, an equilibrium state is achieved within 15 minutes. In order to develop new recipes for drinks, natural raw materials, their chemical composition and the effects on the human body have been studied. The selected ingredients in a certain quantitative ratio made it possible to obtain drinks with improved bio-corrective properties, which allows satisfying the daily requirement of the human body for biologically active substances. Ultrasonic exposure has a positive effect on the organoleptic characteristics of the drink and the aftertaste, as evidenced by the comparative organoleptic evaluation of the samples. The functional properties of the developed drinks have been confirmed experimentally. In the drinks, the following were determined: the content of macronutrients, antioxidant activity, the content of vitamin C, the duration of the shelf life. The use of the method of ultrasonic extraction in the technology of preparing drinks allows one: to reduce the preparation time by half, to reduce the amount of raw materials by 15 %, to increase the content of macronutrients by 45 %, to increase the content of vitamin C by 35 %, to increase stability during storage by 50 – 60 %, increase organoleptic characteristics. The results obtained prove the intensifying effect of ultrasonic exposure in the production of functional drinks.

1. Introduction

According to research, one of the priority areas in the field of healthy nutrition is the development of targeted products of various assortments. Today, for their production, plant raw materials are actively used, containing a vast diverse complex of biologically active substances. The presence of these ingredients helps to improve many physiological processes in the body, as well as increase its immune status [1, 2].

The most promising direction is the development of beverage recipes based on plant biological resources, enriched with biologically active substances of plant origin, which have a tonic effect.
Scientific research and development of scientists are aimed at expanding the range of functional drinks with increased 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. At the moment, a wide range of such drinks is already presented on the Russian market [3–5].

2. Problem Statement
The concept of state policy in the field of healthy nutrition of the population of Russia sets the task of creating functional products in order to improve health and reduce the impact of environmental factors on the body. In the modern world, due to the deteriorating environmental conditions, it is difficult to provide the human body with the optimal amount of essential nutrients from traditional food products. Therefore, it seems expedient to develop special food products that have a beneficial medico-biological effect on the human body. Drinks are one of the most technologically advanced products to meet this challenge.

3. Research Questions
3.1. Study of the properties of functional drinks
For the development of beverage formulations, the introduction of components in various percentages and in comparison with a control sample was studied, while the organoleptic and physicochemical indicators of the quality of the beverage were determined. The use of ultrasonic extraction made it possible to improve the technology of their production.

In the course of the studies, taking into account the results obtained, for all prototypes, the optimal value of the hydronic modulus was established - sample 2, in comparison with the control: the initial raw material was reduced by 15%, the color intensity increased from 15% to 20%, the vitamin C content increased from 35% to 50%.

Ultrasonic exposure has a positive effect on the organoleptic characteristics of the drink and the aftertaste, as evidenced by the comparative organoleptic evaluation of the samples.

Innovative technologies have made it possible to develop a range of directional beverages, since they contain biologically active substances, vitamins, macronutrients in an amount that meets the daily need of the human body and improve their production technologies. These drinks, in accordance with the chemical composition of the main feedstock, have a number of beneficial properties for the human body [2, 6]. The functional properties of the developed drinks were confirmed experimentally. The following were determined in the drinks: the content of macronutrients, antioxidant activity, the content of vitamin C, and the shelf life [7].

3.2. Study of the quality of functional drinks
In the development of beverage formulations, sugar has been replaced by stevia extract. The population of developed countries, including Russia, suffers from a violation of carbohydrate metabolism, which in the human body is a risk factor for the development of diabetes mellitus, cardiovascular; oncological stevia extract is a calorie-free product and helps to normalize metabolism. Therefore it is included in the diet of many diets, has hypotensive the effect of diseases, atherosclerosis and obesity. Also, the extract has the ability to slow down the multiplication of many microbes. When enriching food products with vitamins and minerals, extracts of plant raw materials, pectins and other additives, it is necessary to take into account the harmonization with each other and with the components of the product itself. Therefore, when choosing raw materials, we were guided by their combination with each other, the method and stage of application, which will ensure maximum safety in the process of production and storage.

4. Purpose of the Study
At the moment, a number of enterprises produce a wide range of functional foods and beverages. After analyzing the assortment and their target audience, the goal was set to develop beverage recipes for people involved in fitness and leading a healthy lifestyle [8].
In order to develop new recipes for drinks, natural raw materials, their chemical composition and effects on the human body have been studied. As a result, the following were selected: black currant berries, cranberries, raspberries, cherries, beets, lemon, lime, grapefruit, rose hips, spices (ginger, cinnamon), amla extract. These ingredients in a certain quantitative ratio make it possible to obtain drinks with improved bio-corrective properties, which allows satisfying the daily requirement of the human body for biologically active substances [9].

5. Research Methods

After analyzing the technologies already used in production, a choice was made in favor of the ultrasonic extraction method. Today, at a number of enterprises in various industries, numerous studies have confirmed the high efficiency of ultrasonic effects on various technological processes [6, 10].

The technology of making drinks consists of the following stages: preparation of raw materials, preparation of a drink, filtration of the finished drink and its filling. At the stage of preparation of raw materials, the berries are sorted out and washed (if the fruits and berries are frozen, then they are defrosted beforehand). Then the prepared raw material is crushed and loaded into the mixing bowl of the ultrasonic installation. Also, additional components are added to the mixing glass: sugar and water.

The contents of the beaker are mixed and the beaker is fixed in the chuck of the installation. Then the timer is set (15 minutes) and the unit is turned on. Ultrasonic extraction is carried out at \( t = 20 \, ^\circ \text{C} \) and an ultrasonic wave frequency of 22 kHz. After the extraction time has elapsed, the unit turns off, the glass with the finished drink is removed, the drink is filtered and poured into the container for dispensing.

6. Findings

In the course of the experiments, the dependences of changes in the content of dry substances in drinks and optical density were obtained depending on the duration of the extraction process (Figures 1–7).

![Figure 1](image1.png)  ![Figure 2](image2.png)

**Figure 1.** Change in the content of dry substances depending on the extraction time in the drink "Blackcurrant with beets" (I - traditional method, II - uz - extraction).

**Figure 2.** Change in the content of dry substances depending on the time of extraction in the drink "Vigor" (I - traditional method, II - uz - extraction).

Graphical dependencies (Figures 1–2) prove that ultrasonic exposure makes it possible to obtain a product with a high content of biologically active substances in a shorter period of time, this is explained by the ability of ultrasound to cause cavitation in liquid media. This phenomenon leads to disruption of the diffuse layer, fast and high-quality mixing of the components of the medium [6, 10].
Figure 3. Change in optical density depending on the time of extraction in the drink «Blackcurrant with beets» (I – traditional method, II – uz-extraction).

Figure 4. Change in optical density depending on the time of extraction in the drink «Vigor» (I – traditional method, II – uz-extraction).

Figure 5. Change in optical density depending on the time of extraction in the drink «Tonus» (I - traditional method, II - uz-extraction).

Figure 6. Change in optical density depending on the time of extraction in the drink «Berry Mix» (I - traditional method, II - uz-extraction).

Figure 7. Change in optical density depending on the time of extraction in the drink «Berry fresh» (I - traditional method, II - uz-extraction).
As a result of research, it was found that with ultrasound exposure, an equilibrium state is achieved within 15 minutes. During this period of time, there is a more complete depletion of raw materials and maximum saturation of the extractant than in the control sample (Figures 3–7).

The study found that:

— with prolonged exposure to ultrasound (21 - 33 minutes), a decrease in the content of optical density of dry substances is observed, that is, in the studied extracts, the extractable component is destroyed under the influence of cavitation and redox reactions;

— the fastest and most complete extraction of components from raw materials takes place in the interval from the beginning of extraction to 15 minutes;

— the optimal time for processing raw materials with ultrasound can be considered the interval from 15 to 18 minutes, when the maximum amount of the component passes into the extract without its destruction under the influence of ultrasonic waves.

7. Conclusion

As a result of research using the method of ultrasonic extraction, new types of drinks from natural raw materials have been developed. Application of the method of ultrasonic extraction in beverage preparation technology allows one to:

— halve the cooking time;
— reduce the amount of feedstock by 15 %;
— increase the content of macronutrients by 45 %;
— increase the content of vitamin C by 35 %;
— increase antioxidant activity by 45-50 %;
— increase the storage stability by 50-60 %;
— improve organoleptic characteristics.

The results obtained prove the intensifying effect of ultrasonic exposure in the production of functional drinks. As a result of the research, the possibility of obtaining drinks with improved indicators of functionality (antioxidant activity, content of macronutrients, organic acids) and quality (mass fraction of dry substances) from natural raw materials has been substantiated.

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