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DEVELOPMENT OF BERRY DRINKS WITH A HIGH CONTENT OF ASCORBIC ACID

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Abstract. This work is devoted to the development of innovative soft drinks based on raw materials from wild and cultivated plants characterized by high organoleptic quality and a high content of ascorbic acid (vitamin C). Strawberries, bilberries, blackberries, and black currants were taken as berry raw materials. Using these berries is due to their chemical composition. According to the results of the experimental studies, the optimum ratio of the recipe components has been established, which allows achieving the research objectives. As a result, the recipes of the fizzy drinks *Zdorovya* and *Vesnyany*, sbitens *Vitaminka* and *Yahidny Kokteyl*, fruit drink *Syla* have been developed. At the first stage, the organoleptic analysis of the samples was carried out, since the taste is a major factor in the consumer's perception of an innovative product. The sensory evaluation of the beverages developed was conducted by five independent tasters. The results of the analysis show that the suggested products have high organoleptic quality characteristics. The next step in the research was to determine the ascorbic acid (vitamin C) content, which was done in two stages. First, a qualitative analysis was carried out to confirm the presence of this vitamin in the beverages developed and in the control samples. The quantitative content of ascorbic acid was then determined. The results of the study show that the ascorbic acid content increased on average, compared to that in the control samples, by 44% in the fizzy drink *Zdorovya* and by 20.5% in the fizzy drink *Vesnyany*; by 20% in the sbiten *Vitaminka*; by 11% in the sbiten *Yahidny Kokteyl*; and by 114% in the fruit drink *Syla*. In quantitative terms, it is 50–120 mg/100 ml, which is by 33% more than the daily requirement. The results obtained allow drawing a conclusion that industrial manufacture of the drinks developed will help solve the problem of vitamin C deficiency in the Ukrainian people's diet.

Key words: wild-growing and cultivated berries, alcohol-free drinks, organoleptic quality indicators, ascorbic acid (vitamin C).

Introduction. Formulation of the problem

With increased psycho-emotional stress and deterioration of the ecological state of the environment, a person's need for biologically active substances is significantly increased. Today, the nutrition structure is characterized by a deficiency in a lot of vitamins and minerals. There are several possible ways to solve this problem. One of them is using pharmaceuticals, and the other is consuming food with a chemical composition that can provide the human body with the essential nutrients. At present, the preference is given to the second variant, that is to development of food products with specified characteristics, including general-purpose and functional ones [1,2].

Nowadays, drinks occupy a very important place among the products that provide the human organism with vital substances, since liquids are highly assimilable.

Alcohol-free drinks play an important role in human metabolism, as they maintain the water balance, compensate the loss of moisture and salt, and support

the body's thermoregulation. It is impossible to provide these processes only with fresh water due to the loss of a certain amount of mineral substances [3,4].

Analysis of recent research and publications

Most restaurant industry establishments use recipes of beverages that do not always meet people's current needs in essential nutrients. Besides, the existing range of beverages is not wide, so it cannot fully meet consumers' significant demand. The use of wild-growing and cultivated plants as raw materials is not only able to expand the beverage range, but also provide people with vital substances. Today, a number of national scientists are involved in developing technologies using this raw material, which is widespread in Ukraine. The greatest contribution was made by O. Vetryak, T. Kaplina, L. Malysh, D. Mironov, N. Osiptchuk, L. Osipova, N. Penkin, G. Simakhina, L. Tatar, P. Khomitch, and others [5-8]. However, the main directions of studying the use of wild-growing and cultivated raw materials in beverage technologies are mostly reduced to developing tea technologies [5], while there is almost no research of alcohol-free beverages, for which the demand is the greatest. It is necessary to pay attention to the fact that this raw material is rich in vitamin C, which is currently deficient in the Ukrainian people's diet. Studies of changes in the ascorbic acid content after introduction of the suggested raw materials are not adequately reflected either.

The article is devoted to developing technologies for innovative alcohol-free drinks based on wild and cultivated plant raw materials and characterized by high organoleptic quality and a high vitamin C content.

The most selective for ascorbic acid is its reaction with the 11-molybdobismutho (III)phosphoric heteropoly complex [9,10]. Unfortunately, the use of this reaction to determine ascorbic acid in fruit drinks can be hindered by a high content of organic acids that can destroy Keggin heteropoly compounds. Molybdenum heteropoly complexes of the Dawson structure are resistant to the action of hydroxy acids [11]. But in this case, too, anthocyanins and other polyphenolic compounds have a slight interfering effect, when determining the vitamin C content in highly-coloured juices [12]. This effect disappears in strongly acidic solutions. However, in such conditions, the reduction of 18-molybdophosphate is very slow. The use of bismuth (III) salts together with the reagent can greatly accelerate the reaction [13,14]. This method is quite sensitive, simple, uses easily available instruments, and is more selective than other visual or spectrophotometric methods.

The purpose of this study was to obtain a product of high organoleptic quality and with a higher ascorbic acid content compared to existing analogues. Thus, the problem of vitamin C deficiency in a person's daily diet will be largely solved.

To achieve this goal, the following **objectives** were specified:

- to justify the choice of wild and cultivated raw materials;
- to analyse and identify the prototypes of technologies most suitable for rationalization;
- to develop beverages from the selected types of raw materials, taking into account their effect on the organoleptic parameters of the quality of the finished product;
- to conduct experiments proving a high increase in the vitamin C content in drinks made using the technologies developed, in comparison with similar products.

Research materials and methods

The preparation of the samples and the analysis of drinks were carried out at the Department of Food Technologies of the Oles Honchar Dnipro National University. The sampling and sample preparation for analysis were carried out according to the requirements of DSTU 7040: 2009.

The raw material used (fresh-frozen bilberries, blackberries, black currants, and strawberries) met the requirements of the Expert Review and Declarations of Conformity of the State Health Laboratory.

The sensory evaluation of the quality of beverages was carried out in accordance with DSTU 4096: 2016 by a five-point grading scale and taking into account the weight coefficient (product rating coefficient) [15,16]. The analysis was conducted by five independent experts. In order to eliminate the possibility of falsifying the data, the product samples to be examined were numbered without indicating their real names.

Qualitative and quantitative determination of ascorbic acid was carried out in accordance with the analytical methods developed at the Department of Analytical Chemistry of the Oles Honchar Dnipro National University. These procedures are based on the use of bismuth-containing 18-molybdophosphate heteropoly complexes.

Procedure for determination of ascorbic acid using an 18-molybdobismuthophosphate heteropoly complex (18-MBPC).

Preparation of the reagent. 5 ml of 0.01 mol/L solution of an 18-MBPC, 10 ml of 0.01 mol/L of bismuth (III) nitrate, and 10 ml of 0.5 mol/L sulphuric acid are mixed in a 50 ml volumetric flask and diluted with distilled water up to the mark.

Construction of a calibration graph. 1 mL of the reagent solution is added to a 25 ml volumetric flask, the volume is diluted to approximately 15–20 ml with distilled water, and an aliquot of the ascorbic acid solution is added. After 1 min, 1 ml of the 0.5 mol/L H_2SO_4 solution is added, and the solution is diluted to the mark with distilled water. The absorbance (optical density) is measured in a cuvette with an optical path length of 1 cm at 690 nm. The vitamin C content is

determined by the calibration graph (Fig. 1), constructed using standard ascorbic acid solutions. The calibration graph is linear in the range of concentrations from 6 to 120 μmol/L, R^2=0.996.

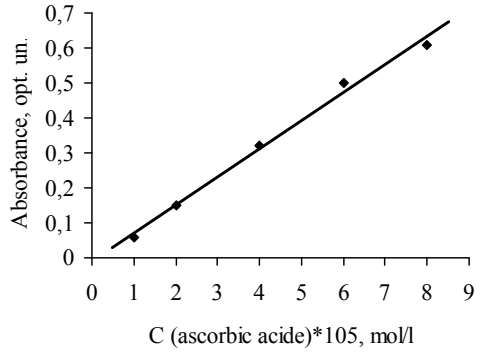

Fig. 1. Calibration graph for determining the ascorbic acid content

Semi-quantification of the vitamin C content was carried out using paper test strips made by impregnating filter paper with low-soluble tetraethylammonium salt of an 18-molybdodiphosphate heteropoly complex [14]. The colour of the test strips changed from yellow to blue-green or blue, depending on the ascorbic acid concentration.

Procedure for the qualitative or semi-quantitative determination of ascorbic acid. The test strips were immersed into the sample solution for 5 min. Then, the ascorbic acid concentration was evaluated using a specially prepared test scale. The range of ascorbic acid concentrations determined by this method is 10 to 450 mg/L [13,14]. The advantage of this method is that the natural colour of the samples due to the anthocyanin content, does not interfere with the determination, since such polyphenols are not adsorbed on paper [17].

Results of the research and their discussion

It is well known that the vitamin C content depends on a complex of factors, including the type of a plant, the pomological variety, the cultivation area, the climate, etc. However, the highest ascorbic acid content has been found in the following fruits: black currant berries – 265 mg, blackberries – 20 mg, bilberries – 15 mg, and strawberries – 60 mg. In addition, these berries include a significant amount of flavonoids, vitamins A, E, B1, B2, B3, B6, B9, K, PP, micro and macroelements, organic acids, fibre (including dietary fibre), etc. These substances have immunomodulatory, adaptogenic, anti-atherosclerotic, hypotensive, and anti-radical effects [18-20]. So, based on the above, the use of this raw material can allow solving the research tasks.

Using berry raw materials is more acceptable technologically in the production of fizzy drinks, spiced honey tea called sbiten, and fruit drinks. That is why, these technologies were chosen as prototypes. However, the existing technologies lead to poor taste and low vitamin C.

On the first stage of the research, the sensory evaluation of the samples was carried out, as the taste is the main factor in a consumer's perception of an innovative product. It is important to note that the best results were obtained when combining two types of raw materials. Thus, the following beverages have been developed: the fizzy drink *Zdorovya* (a combination of bilberries and blackberries), the fizzy drink *Vesnyany* (a combination of black currants and strawberries), the sbiten *Vitaminka* (a combination of bilberries and strawberries), the sbiten *Yahidny Kokteyl* (a combination of blackberries and strawberries), the fruit drink *Syla* (a combination of black currants and strawberries).

Manufacture of alcohol-free drinks involves a standard set of technological operations, such as preparation of water and raw materials, grinding, juice squeezing or heat treatment, adding ingredients according to the recipe, cooling the ready drinks, and storing them [21,22]. To manufacture fizzy drinks, berries are washed, and the juice is squeezed. Next, the sifted sugar is added into the water, and the solution is boiled to obtain a syrup at the temperature 100–110 °C. After that, the juice and the syrup are mixed, ice and carbonated water are added, the mixture obtained is beaten up with a shaker for 3–5 min, and served cooled to a temperature of 10–15°C. The recipes of the fizzy drinks developed are shown in Table 1.

Table 1 – Norms of raw materials used for to prepare fizzy drinks *Zdorovya* and *Vesnyany*

Raw material	Weight of raw materials, g			
	Fizzy drink *Zdorovya*		Fizzy drink *Vesnyany*	
	Gross weight, g	Net weight, g	Gross weight, g	Net weight, g
Drinking water	50	50	50	50
Sugar	50	50	50	50
Carbonated water	80	80	80	80
Bilberry	50	49	–	–
Blackberry	50	49	–	–
Black currant	–	–	50	49
Strawberry	–	–	100	85
Consumer ice	20	20	20	20

When preparing the fruit drink, the berries are washed, the sugar is sieved, water is added and boiled for 10–15 min at the temperature 95–100 °C. Next, the resulting product is ground and cooled to a temperature of 10–15 °C. Table 2 shows the norms of the raw materials for the fruit drink developed. For the manufacture of sbiten, cinnamon, cloves, and cardamom are covered with water and boiled for 5–10 min, then cooled to the temperature 30–40°C, and finally, honey is added. The berries are washed, and the juice is squeezed. Then all components are mixed and heated at the temperature 40–60°C for 10–15 min. The sbiten is served warm. Table 3 shows the norms of the raw materials used for sbitens.

Table 2 – Norms of raw materials used for the preparation of fruit drink *Syla*

Raw material	Weight of raw materials, g	
	Gross weight, g	Net weight, g
Water	250	250
Black currant	50	49
Strawberry	50	35
Sugar	60	60

Table 3 – Norms of raw materials used to prepare the sbiten *Vitaminka* and The sbiten *Yahidny Kokteyl*

Raw material	Weight of raw materials, g			
	Sbiten *Vitaminka*		Sbiten *Yahidny Kokteyl*	
	Gross weight, g	Net weight, g	Gross weight, g	Net weight, g
Water	250	250	250	250
Honey	37.5	37.5	37.5	37.5
Bilberry	50	49	–	–
Strawberry	50	35	50	35
Blackberry	–	–	50	49
Clove	3	3	3	3
Cinnamon	4	4	4	4
Cardamom	2	2	2	2

When developing the technology for preparation of drinks, the optimum ratios of berry raw materials were chosen according to sensory characteristics. For example, for the sbitens *Yahidny Kokteyl* and *Vitaminka*, fizzy drink *Zdorovya*, and fruit drink *Syla*, the ratio of berry raw materials 1:1 was chosen as the most appropriate, while for the fizzy drink *Vesnyany*, the optimum ratio of black currants to strawberries was 1:2.

When developing the technologies, the regular principles of formation of the sensory characteristics were taken into account. The results of the sensory analysis of the drinks developed are shown in Table 4.

Analysing the data obtained allows concluding that drinks made by the suggested technology have the taste characteristics familiar to the consumer. This is very positive, since potential consumers, first of all, evaluate the product by its taste. In order to confirm the improved properties of the drinks developed, they have been studied along with the control samples. The control samples were *Cranberry Drink* (recipe No. 546), *Alcohol-Free Sbiten Drink* (recipe No. 634), and *Alcohol-Free Fizzy Drink* [20, 21].

In the course of the sensory analysis, a five-point grading scale was developed taking into account the rating coefficient, which allowed demonstrating the high quality of the beverages obtained. The summarized average data of this analysis are shown in Table 5.

Table 4 – Organoleptic quality indicators of drinks

Parameter	Characteristics of the parameter				
	Fizzy drink		Sbiten		Fruit drink
	Zdorovya	*Vesnyany*	*Yahidny Kokteyl*	*Vitaminka*	*Syla*
Appearance	Liquid, frothy drink containing berry pulp		Liquid, homogenous, containing berry pulp		Liquid, homogenous, containing berry pulp
Consistency	Thin, with inclusions of berry pulp		Thin, with inclusions of berry pulp		Thin, with inclusions of berry pulp
Colour	Maroon	Dark Red	Dark Red	Burgundy	Light Red
Smell	Pronounced, fragrant, characteristic of bilberries and blackberries	Pronounced, fragrant, characteristic of black currants and strawberries	Pronounced, fragrant, characteristic of strawberries and blackberries	Pronounced, fragrant, characteristic of strawberries and bilberries	Pronounced, fragrant, characteristic of strawberries and black currants
Taste	Sweet-sour, pronounced, characteristic of bilberries and blackberries	Sweet-sour, pronounced, characteristic of black currants and strawberries	Sweet, characteristic of strawberries and blackberries	Sweet, characteristic of strawberries and bilberries	Sweet, characteristic of strawberries and black currants

Table 5 – The results of the sensory analysis of the beverages by the five-point grading scale

Parameter	Rating coefficient	Evaluation with the rating coefficient							
		Fizzy drink			Sbiten			Fruit drink	
		Zdorovya	*Vesnyany*	Control Sample	*Yahidny Kokteyl*	*Vitaminka*	Control Sample	*Syla*	Control Sample
Taste	0.45	2.25	2.25	2.06	2.25	2.25	1.93	2.25	2.12
Colour	0.20	0.94	1.00	0.83	0.91	0.97	1.00	1.00	0.89
Fragrance	0.20	0.94	1.00	0.83	1.00	1.00	0.83	1.00	0.86
Appearance	0.15	0.73	0.75	0.60	0.75	0.73	0.62	0.73	0.58
Overall rating		4.86	5.00	4.31	4.91	4.95	4.38	4.98	4.44

According to the results of the study, it is obvious that the drinks developed are much higher in the sensory quality than the control samples, and have well-pronounced taste properties.

The determination of vitamin C was carried out in two stages. At the first stage, the ascorbic acid content was determined semi-quantitatively. The purpose of this stage was to confirm the presence of ascorbic acid in the developed products and in the control samples, and to remove the samples not containing ascorbic acid. The obtained results showed the presence of quite high concentrations of ascorbic acid in all the samples studied – the colour of the test strips in all samples changed to blue.

At the second stage, the vitamin C content in the product samples was determined as described above. The results of the calculations are given in Table 6.

Table 6 – Vitamin C content in the drinks developed

Name of the drink	Vitamin C content, mg/100cm^3
Fizzy drink *Zdorovya*	120±0.4
Fizzy drink *Vesnyany*	100±0.6
Control sample *Alcohol-Free Fizzy drink*	83±0.2
Sbiten *Yahidny Kokteyl*	53.8±1.4
Sbiten *Vitaminka*	50±0.2
Control sample *Sbiten*	45±0.1
Fruit drink *Syla*	110±2.4
Control sample *Fruit drink Cranberry*	45±0.1

It can be concluded from the data given in Table 6, that in the drinks developed, the vitamin C content increased for the fizzy drinks *Zdorovya* and *Vesnyany* by 44% and 20.5%, respectively; for the sbitens *Yahidny Kokteyl* and *Vitaminka*, by 20% and 11%, respectively; and for the fruit drink *Syla*, by 144%.

Such a change in the amount of vitamin C is due to the fact that the raw materials used, namely fresh-frozen black currants, strawberries, and bilberries, contain more ascorbic acid compared to, for example, lemon juice (which was used to make the control fizzy drink sample), and do not lack berry raw materials (as it was with the control sample of sbiten).

The results of scientific research are supposed to be introduced at food industry and public catering enterprises, as well as in the educational process of higher educational institutions of the food profile.

Conclusions

1. During the research, the feasibility of combining wild and cultivated berries in the technology of making alcohol-free drinks was proved. The berries of black currant, blackberry, bilberry, and strawberry were selected as berry raw materials.

2. The technology of the fizzy drinks *Zdorovya* and *Vesnyany*, sbitens *Yahidny Kokteyl* and *Vitaminka*, fruit drink *Syla* using the above types of berry raw materials have been developed. The technologies developed are simple, and the recipe components available.

3. The drinks developed have high taste properties confirmed by the results of the sensory analysis.

4. It has been experimentally proved that the vitamin C content in the drinks developed varies from 50 to 120 mg per 100 mL. Taking into consideration that the weighed average of the physiological need for vitamin C is 60–100 mg per day, it can be concluded that drinking one glass of one of the suggested beverages can fully satisfy a person's daily need for ascorbic acid.

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РОЗРОБКА ЯГІДНИХ НАПОЇВ З ВИСОКИМ ВМІСТОМ АСКОРБІНОВОЇ КИСЛОТИ

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Анотація. Дану роботу присвячено розробці інноваційних безалкогольних напоїв на основі дикорослої та культивованої сировини, які характеризуються високими органолептичними показниками якості та підвищеним вмістом аскорбінової кислоти (вітаміну С). В якості ягідної основи було обрано плоди ягід полуниці, чорниці, ожини та чорної смородини. Використання цих ягід обумовлено їхнім хімічним складом. У результаті експериментальних досліджень було встановлено оптимальне співвідношення рецептурних компонентів, що дозволяє досягти поставлених задач дослідження. Розроблено рецептури фізів «Здоров'я» та «Весняний», збитнів «Вітамінка» та «Ягідний коктейль», морсу «Сила».–На першому етапі проводили органолептичний аналіз зразків, адже смакові властивості є головним чинником при сприйняття інноваційного продукту споживачем. Сенсорна оцінка розроблених напоїв проводилась п'ятьма незалежними дегустаторами. Результати аналізу свідчать, що запропонована продукція має високі органолептичні показники якості. Наступним етапом дослідження стало визначення вмісту аскорбінової кислоти (вітаміну С), який складався з двох стадій.–Спочатку проведено якісний аналіз, який підтвердив наявність зазначеного вітаміну у розроблених напоях та контрольних зразках. Далі проведено визначення кількісного вмісту аскорбінової кислоти. Результати дослідження показали, що вміст аскорбінової кислоти у порівнянні з контрольними зразками в середньому збільшився на: фіз «Здоров'я» – 44 %, фіз «Весняний» – 20,5%, збитень «Вітамінка» – 20%, «Ягідний коктейль» – 11%, морс «Сила» – 144%. У кількісному еквіваленті це складає 50– 120 мг/100 мл, що на 33% більше за добову потребу. Виходячи з отриманих результатів можна зробити висновок, що впровадження у виробництво розроблених напоїв дозволить вирішити проблему дефіциту вітаміну С в харчових раціонах населення країни.

Ключові слова: дикорослі та культивовані ягоди, безалкогольні напої, органолептичні показники якості, аскорбінова кислота (вітамін С).

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