UDC 664.8.014/.019:602.3:633/635
DOI: 10.15587/2706-5448.2026.352898

Sevinj Maharramova,
Ilhama Kazimova,
Mikail Maharramov

JUSTIFICATION OF THE PRELIMINARY ENZYMATIC TREATMENT OF BERRIES OF DOGWOOD, BLACK ELDERBERRY, HAWTHORN, BARBERRY AND RASPBERRY, GROWN IN THE TERRITORY OF THE REPUBLIC OF AZERBAIJAN

The research shows the results of the effect of preliminary enzymatic treatment of dogwood berries, black elderberry, hawthorn, barberry and raspberry on juice yield and extraction of valuable chemical compounds and nutrients into juice. The objects of the research were the technology for enzymatic extraction of dogwood berries, black elderberries, hawthorn berries, barberries, and raspberries. Enzyme preparations with pectolytic and gluconolytic activity were also investigated. The enzymes included Pectinex BE XXL, Pectinex Yieldash Extra, Amylase AG 300 L, and Fructozym P. Additional preparations used in the research were Rapidaza CR, Bryuzaym BGX, Laminex Super, Selloviridin Q20X, Sellokyuks-A Extra, and Enzerzim XT. The experiment used modern photometric, thermogravimetric, refractometric, potentiometric, chromatographic and other methods of analysis. It was established that the use of a composition of enzyme preparations with pectolytic and glucanolytic action Pectinex BE XXL, Amylase AG 300 L, Rapidaza CR, Sellokyuks-A contributes to an increase in the yield of unclarified juices by an average of 6.8–9.4% compared to the control samples. In this case, the most effective are the use of Fructosym P, Pectinex BE XXL and Amylase AG300L, and when using multienzyme complexes, MFK-I and MFK-II turned out to be more effective, each consisting of a mixture of two enzymes, the juice yield increased by an average of 11.0–14.4% or 1.19–1.29 times compared to the control. The use of the enzyme preparation composition allows to increase the yield of valuable natural components and functional food ingredients in the juice – total sugars by 1.05–1.23 times, organic acids by 1.04–1.24 times, pectin substances by 1.06–1.31 times, ash substances by 1.19–1.33 times, vitamin C by 1.18–1.38 times. The extraction of natural antioxidants and preservatives increases the nutritional value of the juice and improves its technological properties.

Keywords: *berries, enzyme preparations, multi-enzyme composition, juice yield, chemical composition, carbohydrates, pectin.*

Received: 20.12.2025
Received in revised form: 12.02.2026
Accepted: 23.02.2026
Published: 28.02.2026

How to cite
Maharramova, S., Kazimova, I., Maharramov, M. (2026). Justification of the preliminary enzymatic treatment of berries of dogwood, black elderberry, hawthorn, barberry and raspberry, grown in the territory of the Republic of Azerbaijan. Technology Audit and Production Reserves, 1 (3 (87)), 20–28. https://doi.org/10.15587/2706-5448.2026.352898

1. Introduction

The soil and climatic conditions of Azerbaijan allow for the industrial cultivation of many fruits, such as apples, grapes, pomegranates, pears, plums, cherry plums, quince, peaches, apricots, cherries, sweet cherries, etc., as well as vegetables – tomatoes, watermelons, melons, root crops and many others. They are also grown in sufficient quantities in household plots of the population. Numerous species of wild fruit (more than 150 species belonging to 36 genera and 15 families), medicinal, essential oil, spice, ornamental and other plants grow in the forests of the republic. They are used as food products, applied in medicine, serve as raw materials for the vitamin and pharmaceutical industries. The collection of forest fruits, berries and nuts occupies a significant place in the supply of the population with additional food products [1].

From the point of view of the organization of industrial processing, interest in these types of raw materials is due to significant biological reserves, stable annual renewability, and the relative stability of their chemical composition [2]. It is obvious that the development of an effective technology for processing berries opens up prospects for obtaining berry ingredients that can be positioned as sources of natural, healthy, environmentally friendly food products and other biologically active substances of berries [3]. Their use in the production of food products will give them not only an attractive appearance, but also endow them with properties beneficial to human health [4].

In recent years, it has been shown that these berries have valuable antioxidants, great nutritional and therapeutic value. Antioxidants are substances that, when present in low concentrations compared to the concentrations of the oxidizable substrate [5, 6], significantly delay or prevent the oxidation of this substrate.

Along with other nutrients, the berries also contain significant amounts of crude fiber, although little information is available on the total dietary fiber content of berries. The crude fiber content values

obtained in many studies suggest that berries are also potential sources of fiber. Berries are generally low in fat and oil [6, 7]. Due to their low fat and oil content, they are recommended as a good source of nutritional supplement for patients with heart problems or at risk of lipid disorders. An extensive analysis of the current state of berry raw material processing technologies shows that the primary tasks facing the food industry are to increase the yield of finished products. It will also improve their quality, and minimize the loss of valuable natural components of raw materials and the resulting secondary processing products. The solution to these problems is directly related to the development of effective methods for pre-processing berries, allowing for the most complete use of their natural resource [8]. Traditional processed fruit and berry products are juices, extracts, concentrates, etc. [9], which are obtained using the following methods of pre-processing raw materials: mechanical grinding, microwave field action, enzymatic [10], thermal and ultrasonic types of processing [11].

The efficiency of using the specified methods of preliminary treatment of berries to increase juice yield, improve the extractive properties of plant tissue has been demonstrated in several studies. And most complete extraction of valuable nutritional components of berries is described using the example of cranberry [8], hawthorn [12], lingonberry [13], black currant [14], blueberry [15] etc.

It was shown that thermal and microwave treatments had a significant effect on the relative contents of hawthorn anthocyanins, such as cyanidin-3-galactoside (82.9% and 76.9%, respectively) and cyanidin-3-glucoside (9.2% and 11.5%, respectively) [12]. In [13] found that the use of enzymes had a significant effect on the juice yield, increasing it from 70% without enzyme treatment to 81%. Moreover, enzymes significantly increased the content of most phenolic compounds in juices, and thermal treatment without the addition of enzyme also significantly affected the composition. In [16] reported that in terms of antioxidant protection of fats and oils, the average inhibition rate using the solvent extraction method can reach 90%, and the corresponding inhibition rate of anthocyanins obtained using the other two extraction methods is about 80%. They found that the addition of α-amylase and cellulase to blueberry extract could effectively increase the rate of anthocyanin extraction, and that the combination of the two enzymes produced a more significant effect, yielding a higher anthocyanin yield than either enzyme alone. In [14] demonstrated that ultrasonic extraction could increase blackcurrant extraction yields from 63–68% to 74–93% and could be successfully used to extract pigments and produce food coloring. In [15] demonstrated that blueberries are a rich, yet underutilized, source of bioactive polyphenols. For these valuable bioactive molecules, ultrasonic extraction (UE) is an attractive and environmentally friendly alternative to traditional extraction methods, allowing for increased product purity and yield.

The feasibility of using enzyme preparations at the extraction stage and in juice production was also demonstrated. The studies [13, 16–18] describe and substantiate the technological parameters and modes of preliminary enzymatic treatment of berries. Their use leads to an increase in extract yield by approximately 5.0–15.0%, a decrease in juice viscosity, a reduction in filtration time, and an increase in the extraction of natural components.

Unfortunately, the data presented in the literature do not allow for an objective assessment and comparative analysis of various processing methods for berries grown in the Republic of Azerbaijan. This limitation concerns the effectiveness of these methods in extracting valuable nutrients and biologically active substances, as well as their preservation during processing. To justify the feasibility of berry pretreatment, the authors used a fairly wide range of criteria (yield, reduction in juice viscosity, titratable acidity, dry matter content, sugars, organic and titratable acids, phenolic compounds, tannins, etc.).

It should also be taken into account that the presented data were obtained on raw materials from different years of collection and regions of growth. As is known, the composition and features of the anatomical structure of the plant cell of berries are largely formed under the influence of ecological-geographical and soil-climatic conditions and depend on the timing of collection [9]. And it is these factors that largely determine the effectiveness of pre-treatment of berries when obtaining juice.

There are a number of reports on the composition of nutrients and minerals in some berries grown in the Republic of Azerbaijan. In the work [19] it was shown that black currant has high antioxidant activity, is rich in biologically active compounds and can be used in the production of functional drinks.

Another research work [20] shows that in Azerbaijan, including the Nakhchivan Autonomous Republic, many wild berries grow: barberry (*Berberis L.*), sea buckthorn (*Hippophae rhamnoides L.*), oriental apple (*Malus orientalis*), Caucasian pear (*Pyrus caucasica Fed.*), common cherry (*Padus avium*), rose hips (*Rosa L.*), etc. Due to the richness of their chemical composition and bioavailability, these fruits can be used as raw materials in the production of various types of kvass, beer, berry wine, vodka, vinegar, syrup and soft drinks.

Based on the results of research conducted in [21], it was established that 152 species of wild fruit plants belonging to 23 families and 43 genera are distributed on the territory of the Nakhchivan Autonomous Republic. Of them, 38 species belonging to 7 families and 14 genera are widespread, numerous and promising edible fruit plants.

However, there is virtually no data on the effectiveness of pre-treatment of berries grown in the Republic of Azerbaijan when obtaining juice. Thus, this work is intended to discuss the effect of pre-enzymatic treatment of dogwood, black elderberry, hawthorn, barberry and raspberry berries when obtaining juice and the conditions for its implementation on juice yield and extraction of valuable chemical compounds and nutrients into the juice.

Theoretical justification: In one study, the authors showed that the localization of bioactive compounds in the berry skin is 5.8–10.8 times greater than in the pulp, and only part of them is dissolved in the cell juice. A significant proportion of biologically active compounds are firmly retained by the structural components of the cell wall, the basis of which are non-starch polysaccharides, and do not pass into the juice during berry processing, significantly reducing its nutritional value and biological activity. Therefore, the main goal of preliminary processing of berries when obtaining juice is to damage the cytoplasmic membranes of cells, which, in turn, promotes the release and transition to the juice of additional quantities of valuable chemical compounds and nutrients [9].

The most common technological method used in processing berries is mechanical grinding, which disrupts the balanced biochemical processes occurring in intact living cells. The degree of grinding is of decisive importance for the efficient implementation of the process, and it should be selected depending on the physical properties and geometric shapes of the raw material particles [22]. To increase the juice yield and the extractive capacity of the plant cell, mechanical grinding is often supplemented by the blanching process [9]. The thermal effect is the most common and is used at the stage of preliminary processing of ultra-high-frequency energy (UHF) [23]. It is also possible to increase the intensity of the extraction processes of biologically active compounds and valuable nutrients through the use of ultrasonic vibrations. This leads to an increase in the permeability of plant cells and turbulence of the entire system under the influence of cavitation effects [9].

At the present stage, the biotechnological direction in the processing of fruits and berries is rapidly developing. The use of various specific enzyme preparations allows for a gentle effect on plant tissue and the splitting of structural elements of the cell. This helps improve the processes of juice yield and intensify the extraction of biologically active compounds and valuable nutrients into the juice [16]. The above indicates that the use of various methods of preliminary processing of berries is based on various mechanisms of action on plant tissue and cells, aimed at the destruction of cellular structures. This contributes to a significant intensification of the process of extraction of useful components.

ISSN-L 2664-9969; E-ISSN 2706-5448

However, issues related to the study of the influence of various methods of preliminary treatment of berries growing in the territory of the Republic of Azerbaijan on the extraction of bioactive components into juice have been little studied in the literature. The presented results have not been systematized. To a greater extent, the effectiveness of preliminary treatment of black elderberries, hawthorn, barberry, raspberry, etc. can only be judged on the basis of the results of studies conducted in foreign countries [24].

As a rule, such data are comparable with our results approximately. As noted above, the composition and features of the anatomical structure of the plant cell of berries are largely formed under the influence of the ecological-geographical and soil-climatic conditions of the region of their growth [1].

The objects of research were the technology for enzymatic extraction of dogwood berries (*Cornus mas L.*), black elderberry (*Sambucus nigra L.*), hawthorn (*Crataegus monogyna subsp.*), barberry (*Berberis L.*) and raspberry (*Rubus L.*), growing in various regions of the Republic of Azerbaijan.

The aim of the research is to substantiate the preliminary enzymatic treatment of dogwood berries, black elderberries, hawthorn, barberries and raspberries grown in the territory of the Republic of Azerbaijan.

In accordance with the set aim, the following tasks were solved:

1) to study the effect of preliminary enzymatic treatment of dogwood, black elderberry, hawthorn, barberry and raspberry berries during juice production and the conditions of its implementation on the juice yield;

2) to study the qualitative and quantitative chemical composition of juices obtained from pre-treated berry pulp using various enzymatic preparations.

The implementation of the set goal and objectives of the research will allow to experimentally substantiate the methods and conditions for preliminary processing of dogwood berries, black elderberry, hawthorn, barberry and raspberry, ensuring an increase in juice yield and the most complete extraction of bioactive components into juice. This can be used as a basis for developing technological recommendations for processing dogwood berries, black elderberry, hawthorn, barberry and raspberry, obtaining juices with a high content of natural biologically active substances of berries for use in food product formulations. In addition, the data obtained as a research result will expand current knowledge about the quantitative and qualitative composition of biologically active components of these berries growing in the territory of the Republic of Azerbaijan.

2. Materials and Methods

In this work, the following enzyme preparations with pectolytic and gluconolytic action were used: *Pectinex BE XXL, Pectinex Yieldash Extra, Amylase AG 300 L, Fructosym P, Rapidaza CR, Sellokyuks-A, Bryuzaym BGX, Laminex super, Selloviridin Q20X, S Extra, Enzerzim XT.* At the same time, their compositions were also used in the following combinations: *Pectinex BE XXL-Fructosym P (MFK-I), Amylase AG 300 L-Sellokyuks-A (MFK-II) and Pectinex Yieldash Extra – Bryuzaym BGX (MFK-III).*

Our previous studies monitored the efficiency of using enzyme preparations of different substrate specificity for processing dogwood berries, black elderberry, hawthorn, barberry and raspberry during juice production. Taking into account the data on the chemical composition of the said berries, a fairly wide range of enzyme preparations of pectolytic and glucanolytic action of imported production were used in the studies, which were used both individually and as part of a composition.

During preliminary experiments it was established that the most effective enzyme preparations from the above-mentioned ones in terms of juice yield were Fructosym P for dogwood berries, Pectinex BE XXL for black elderberry and barberry, Amylase AG300L for hawthorn, Pectinex Yieldash Extra *(production Novozymes, Denmark),* for raspberries. The best results were obtained using the compositions Pectinex BE XXL *(production Novozymes, Denmark)* – Fructosym P *(produced by DSM-Food-Specialties, France)* (MFK-1) and Amylase AG300L *(production Novozymes, Denmark)* – Sellokyuks-A *(manufacturer – Sibbiopharm, Russia)* (MFK-2), the use of which at the stage of preliminary processing of berries helps to increase the juice yield by 14.4% and 13.2%, respectively [17, 18].

Research methods: In the course of the work, standard and special research methods were used:

- determination of the total content of dry substances and moisture – by the thermogravimetric method by drying the test samples to a constant weight (GOST 33977-2016);
- determination of soluble dry substances – by the refractometric method, based on determining the refractive index of the test solution using a refractometer and the mass fraction of soluble dry substances (GOST ISO 2173-2013);
- determination of sugars – according to Bertrand (GOST 8756.13-87);
- determination of titratable acids (total acidity) – by the potentiometric titration method (GOST 51434-99);
- determination of pectin substances – by the photometric method (GOST 32223-2013);
- the mass fraction of ash was determined by the generally accepted gravimetric method, after mineralization of the product sample to a constant mass in a muffle furnace at a temperature of 525 + 25°C (GOST 25555.4-91);
- determination of ascorbic acid (vitamin C) – using high-performance liquid chromatography (GOST 34151-2017).

Research procedure: The research was carried out in the period from 2018 to 2024, in the educational and research laboratory of the Department of Engineering and Applied Sciences of the Azerbaijan State University of Economics. The results are average values for these years.

Data analysis: The studies were carried out in 3 parallel determinations, the results of the quantitative analysis of the chemical composition are presented as the mean result and ± standard deviation.

3. Result and Discussion

3.1. Effect of preliminary enzymatic treatment of berry pomace on juice yield

At the initial stage of the experiment, various enzyme preparations with pectolytic and gluconolytic action were used: Pectinex BE XXL, Pectinex Yieldash Extra, Amylase AG 300 L, Fructosym P, Rapidaza CR, Bryuzaym BGX, Laminex super, Selloviridin Q20X, Sellokyuks-A, Extra, Enzerzim XT.

During preliminary experiments on the yield of juice from dogwood berries, black elderberries, hawthorn, barberries and raspberries, the most effective enzyme preparations and optimal processing modes were established.

To carry out the enzymatic treatment, the berries were subjected to mechanical grinding, after which the enzyme preparations were added individually in the amount of 0.005–0.015% of the berry pulp weight or as part of a composition (MFK) in the amount of 0.005–0.01% (each) of the berry pulp weight, and hydrolysis was carried out for 60–120 min at a temperature of 30–75°C. Upon completion of the hydrolysis process, the FP was inactivated by heating and pressing, and the juice was squeezed out. Juice obtained from crushed berries that had not been pre-treated was used as a control. In this case, the optimal processing modes depending on the type of berries were: the amount of enzyme preparations – 0.0075–0.01% of the berry pulp weight; hydrolysis time – 75–120 min, processing temperature – 45–60°C.

The results of the research on the effect of treatment with enzyme preparations on the yield of juice from dogwood berries, black elderberries, hawthorn, barberry and raspberries growing in the territory of the Republic of Azerbaijan are shown in Fig. 1.

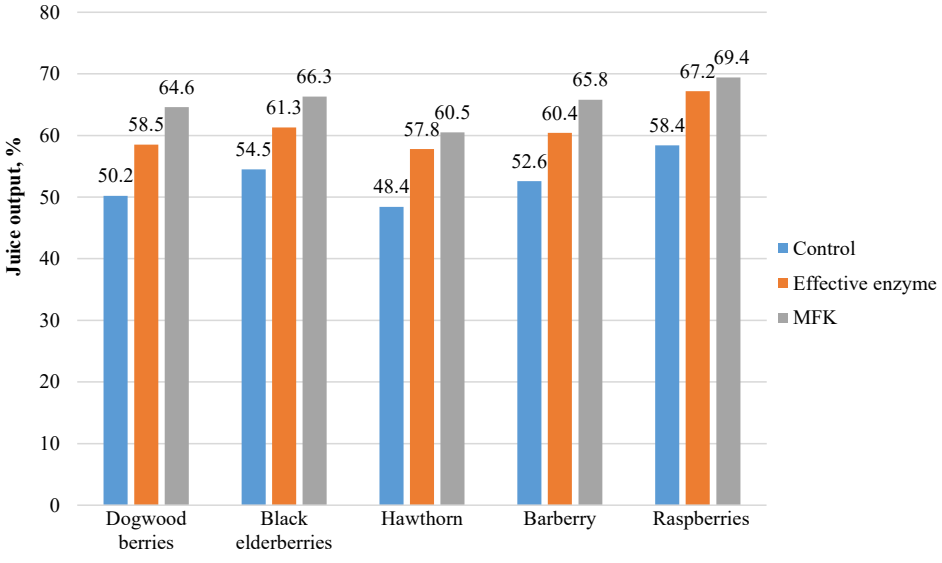


Fig. 1. Histogram of the effect of enzymatic treatment of dogwood berries, black elderberries, hawthorn, barberry and raspberries on juice yield

As shown by the results of our experiments and the histogram of the effect of enzymatic treatment of dogwood berries, black elderberry, hawthorn, barberry and raspberry on juice yield (Fig. 1), the most effective of the studied enzymes for dogwood berries was the Fructosym P enzyme, with which the juice yield increased from 50.2 ± 1.34 to 58.5 ± 0.78%, for black elderberry and barberry the Pectinex BE XXL enzyme, with which the juice yield increased from 54.5 ± 0.87% and 52.6 ± 2.24% to 61.3 ± 1.74 and 60.4 ± 3.08%, respectively, when treating hawthorn the most effective enzyme was Amylase AG300L, compared with the control samples, the juice yield increased from 48.4 ± 1.06% to 57.8 ± 1.56%, and when raspberries were treated with the Pectinex Yieldash Extra enzyme, the juice yield increased compared to the control samples from 58.4 ± 1.46% to 67.2 ± 3.23%.

As for the use of multienzyme complexes (MEC), MEC-I consisting of the enzyme Pectinex BE XXL – Fructosym P proved to be effective in processing dogwood and hawthorn, where the juice yield increased from 50.2 ± 1.34 and 48.4 ± 1.06% to 64.6 ± 3.04 and 60.5 ± 2.54%, respectively, and MEC-II consisting of Amylase AG300L-Sellolyuks-A proved to be effective for black elderberry, barberry and raspberry, where the juice yield increased from 54.5 ± 0.87%, 52.6 ± 2.24% and 58.4 ± 1.46% to 66.3 ± 1.73%, 65.8 ± 3.18% and 69.4 ± 1.35%, respectively.

As a result of the experiments, it was found that preliminary enzymatic treatment with various enzyme preparations of crushed dogwood berries, black elderberry, hawthorn, barberry and raspberry, contributes to an increase in the yield of unclarified juices by an average of 6.8–9.4% compared to the control samples. The most effective are the use of Fructosym P, Pectinex BE XXL and Amylase AG300L. And when using multienzyme complexes, MFK-I and MFK-II, each consisting of a mixture of two enzymes, turned out to be more effective, the juice yield increased by an average of 11.0–14.4% compared to the control samples or 2.2–6.1% compared to the use of effective enzymes. It was found that the use of MFK-I was more effective in processing dogwood, the increase in juice yield was 6.1%, and when processing black elderberry and barberry with MFK-II, here the increase in juice yield was 5.0 and 5.4%, respectively. The use of MFK-I, MFK-II turned out to be relatively less effective for hawthorn and raspberry, since the juice yield increased by only 2.7% and 2.2%, respectively.

3.2. Qualitative and quantitative characterization of the chemical composition of juices obtained by enzymatic extraction of cornelian cherry, elderberry, hawthorn, barberry, and raspberry

It is known that the nutritional value of juices depends on their chemical composition [1]. According to the obtained results, preliminary enzymatic treatment of dogwood, black elder, hawthorn, barberry and raspberry berries contribute to a significant increase in the yield of berry extractive substances in the juice fraction compared to the juice obtained without the use of enzyme preparations. The histogram of the dynamics of the mass fraction of soluble dry substances and sugars during preliminary treatment of dogwood berries with enzyme preparations (Fig. 2) shows a significant increase in the yield of soluble dry substances in the juice by 1.11–1.16 times, total sugars by 1.14–1.19 times, reducing sugars by 1.14–1.17 times and sucrose by 1.12–1.58 times (Fig. 2, Tables 1, 2).

As can be seen from Fig. 2, when using the enzyme preparation Fructosym P, the increase in sucrose is only 12.0%, and when using MFK-1, the increase in sucrose content was already 1.58 times. In our opinion, this is due to the effect of multienzyme complexes containing Pectinex BE XXL-Fructosym P and Amylase AG300L-Sellolyuks-A. Apparently, under the influence of multienzyme complexes, insoluble complex carbohydrates are broken down into simpler and soluble carbohydrates, including sucrose.

A significant increase in the yield of valuable natural components and functional food ingredients in dogwood and hawthorn juice was found: organic acids by 1.17–1.24 times, pectin substances by 1.06–1.12 times, ash substances by 1.13–1.24 times, vitamin C (by 1.22–1.43 times) (Table 1 and 2).

Enhancement of the extractive properties of plant tissue is noted under the influence of MEK-1 and MEK-2, but still more preferable from this point of view is the composition based on the enzyme preparations Pectinex BE XXL-Fructosym P (MFK-1) (Tables 1, 2). The choice of this composition is also supported by the fact that its use at the stage of preliminary processing of berries contributes to an increase in juice yield by 12.1–14.4%.

The original taste of the berry juice is formed by organic acids in combination with sugars. Organic acids participate in the alkalization of the body; reduce the risk of synthesis of carcinogenic nitrosamines in the body, and therefore the risk of developing oncological pathology [13]. Of the fruit acids in the composition of the juice from dogwood berries, black elderberry, hawthorn, barberry and raspberry, citric and malic acids were identified with a clear dominance of citric acid [6, 21]. A special feature of dogwood, black elder, hawthorn and barberry berries is the presence of a natural preservative in their composition – benzoic acid, which has antiseptic properties, which determines the ability of processed berry products for long-term storage. In addition to citric, malic and benzoic acids, the composition of juices from these berries contains tartaric, salicylic and other acids in small quantities.

ISSN-L 2664-9969; E-ISSN 2706-5448

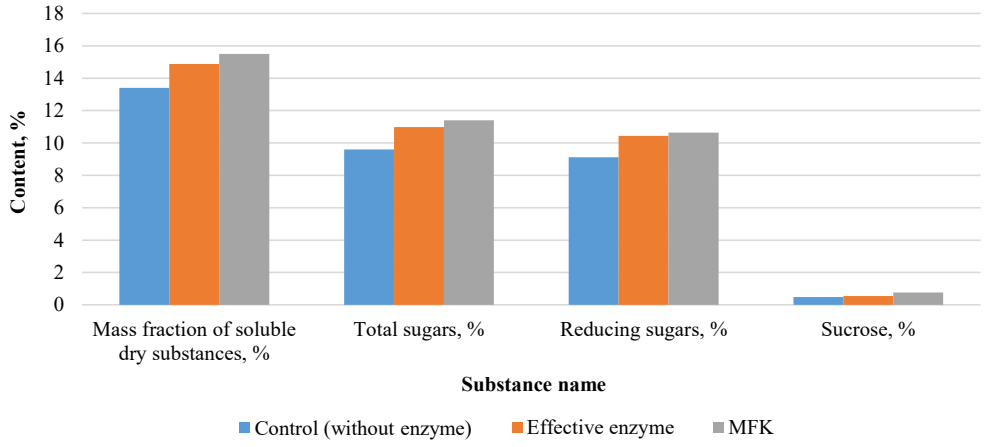


Fig. 2. Histogram of the dynamics of the content of the mass fraction of soluble dry substances and sugars during preliminary treatment of dogwood berries with enzyme preparations

Table 1

The effect of preliminary enzymatic treatment of dogwood berries on the yield of extractive substances in juice

Chemical component	Component content, mg/100 g dogwood berries		
	Control (juice without FO)	Juice obtained using an effective enzyme	Juice obtained using MFK-1
Mass fraction of soluble dry substances, %	13.4 ± 0.64	14.88 ± 0.56	15.50 ± 0.38
Total sugars, %	9.60 ± 0.31	10.98 ± 0.40	11.40 ± 0.32
Reducing sugars, %	9.12 ± 0.28	10.44 ± 0.11	10.64 ± 0.30
Sucrose, %	0.48 ± 0.21	0.54 ± 0.14	0.76 ± 0.08
Mass fraction of organic acids, %	2.20 ± 0.10	2.46 ± 0.16	2.53 ± 0.11
Sugar-acid index	4.36	4.43	4.51
Pectin substances, %	0.70 ± 0.06	0.81 ± 0.04	0.86 ± 0.06
Mass fraction of ash substances, %	0.65 ± 0.07	0.74 ± 0.06	0.84 ± 0.04
Vitamin C, mg/100 g	75.0 ± 2.24	88.7 ± 2.08	101.20 ± 3.40

Table 2

The effect of preliminary enzymatic treatment of hawthorn berries on the yield of extractive substances in juice

Chemical component	Component content, mg/100 g hawthorn berries		
	Control (juice without FO)	Juice obtained using an effective enzyme	Juice obtained using MFK-1
Mass fraction of soluble dry substances, %	10.6 ± 0.38	11.80 ± 0.27	12.24 ± 0.45
Total sugars, %	8.62 ± 0.26	9.91 ± 0.20	10.06 ± 0.18
Reducing sugars, %	7.14 ± 0.17	8.52 ± 0.11	8.34 ± 0.22
Sucrose, %	1.48 ± 0.21	1.39 ± 0.16	1.72 ± 0.20
Mass fraction of organic acids, %	0.76 ± 0.04	0.89 ± 0.06	0.94 ± 0.017
Sugar-acid index	11.34	11.13	10.70
Pectin substances, %	0.92 ± 0.03	1.03 ± 0.02	0.98 ± 0.04
Mass fraction of ash substances, %	1.04 ± 0.04	1.18 ± 0.34	1.29 ± 0.31
Vitamin C, mg/100 g	39.8 ± 1.58	48.6 ± 1.07	57.0 ± 1.86

The ratio of sugars and acids (sugar-acid index) predetermines the harmony of taste of fruits and berries. The optimal value of the sugar-acid index is 7.0. The results of our experiments show that with preliminary treatment of dogwood, black elder, hawthorn, barberry and raspberry berries with enzyme preparations, the content of the mass fraction of organic acids in the juice increases by 1.15; 1.19; 1.26; 1.07 and 1.07 times, respectively (Tables 1, 2 and Fig. 3). The presence of organic acids in dogwood, barberry and black elder juice determines the low value of active acidity of the environment (pH ~ 2.7–3.0), which contributes to the natural protection of the juice from the action of microorganisms [13].

According to the content of mass fraction of organic acids, the studied berries are arranged in the following order: barberry > dogwood > raspberry > black elderberry > hawthorn.

Compared with hawthorn and barberry juice, dogwood, black elderberry and raspberry juices have a relatively harmonious taste due to the relatively high sugar content (9.84–11.4%); their sugar-acid index fluctuates approximately within the range of 4.36–6.69. Hawthorn juice has a sweet-sour and sweet taste, sugar-acid index of 11.1–11.3, and barberry juice has a sour taste and sugar-acid index of 2.18–2.27. The results of our work (Tables 1, 2 and Fig. 4) show that all the berries studied – dogwood, black elderberry, hawthorn,

barberry and raspberry – contain pectin substances. Pectin substances are not absorbed by the body, but they contribute to the implementation of many positive functions: they remove toxic metals and radionuclides from the body. They suppress the development of putrefactive bacteria, prevent excessive fermentation of carbohydrates, and promote the binding of endogenous and exogenous toxins. Therefore, the berries studied and products based on them have a positive effect in the treatment of the gastrointestinal tract [7].

As the results of the experiments show (Tables 1, 2 and Fig. 4), upon preliminary treatment of dogwood, black elder, hawthorn, barberry and raspberry berries with enzyme preparations, the content of pectin substances in all the berries studied increases compared to the control samples by 1.06–1.31 times, depending on the type of berries. Barberry has the highest content (1.24%) of pectin substances, followed by hawthorn (1.03%), raspberry (0.99%) and dogwood (0.86%). Black elder has the poorest content of pectin substances. According to our data on the content of pectin substances, the berries studied are arranged in the following order: barberry > hawthorn > raspberry > dogwood > black elder. From a physiological point of view, mineral substances are no less important parts of berries. They are associated with the enzymatic system of the cell and ensure the constancy of osmotic pressure in the tissues of a living organism. Salts of organic acids (citric, malic, tartaric, etc.) are characterized by an alkaline reaction.

They neutralize acidic products formed in the body as a result of metabolism, while helping to maintain an active reaction of tissues and fluids. Potassium and phosphorus are the most important components of the skeletal system; potassium salts provide the required level of fluid content, including water in tissues. Iron, copper, cobalt, manganese are involved in the processes of hematopoiesis, chlorine is necessary for the formation of hydrochloric acid in gastric juice. Magnesium is of great importance for the work of the heart and the condition of the entire muscular system, sodium salts regulate water metabolism, and iodine promotes the work of the thyroid gland [9].

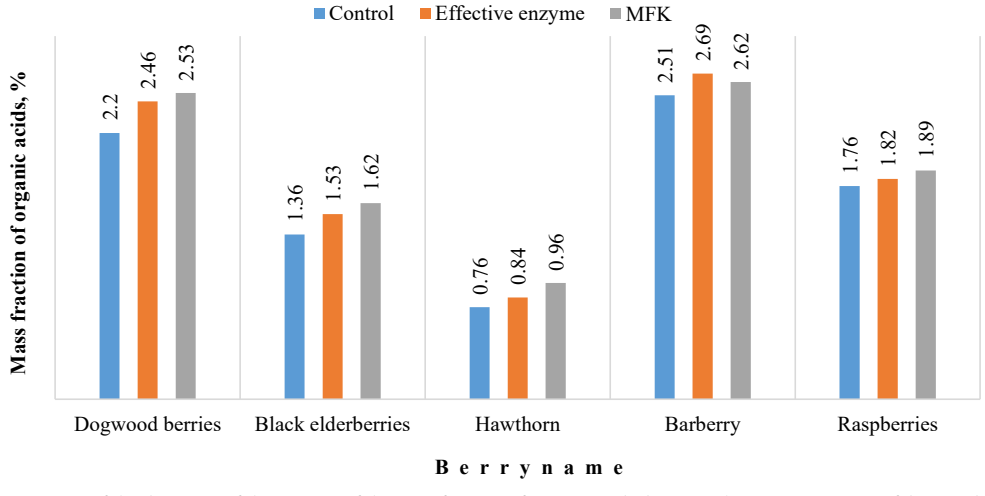
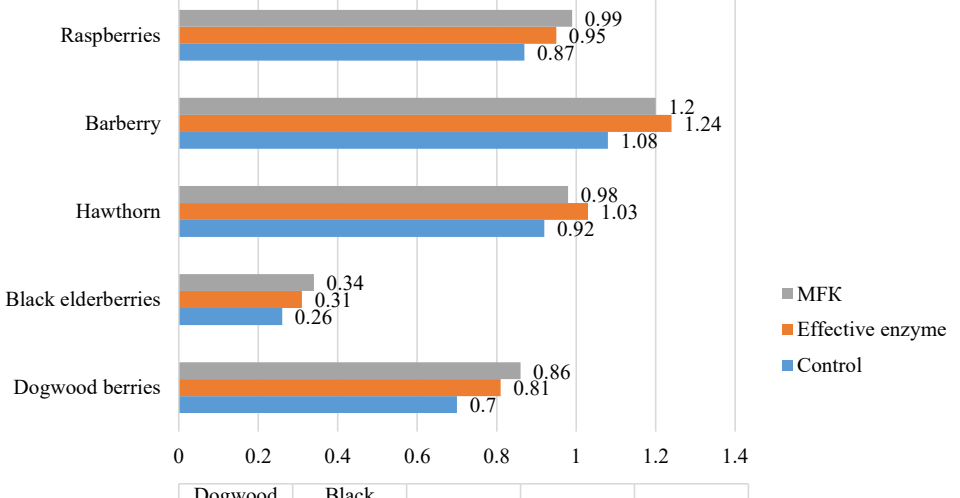


Fig. 3. Histogram of the dynamics of the content of the mass fraction of organic acids during preliminary treatment of dogwood berries, black elderberries, hawthorn, barberries and raspberries with enzyme preparations



	Dogwood berries	Black elderberries	Hawthorn	Barberry	Raspberries
MFK	0.86	0.34	0.98	1.2	0.99
Effective enzyme	0.81	0.31	1.03	1.24	0.95
Control	0.7	0.26	0.92	1.08	0.87

Pectin substances, %

Fig. 4. Histogram of the dynamics of the content of pectin substances during preliminary treatment of dogwood berries, black elderberry, hawthorn, barberry and raspberry with enzyme preparations

ISSN-L 2664-9969; E-ISSN 2706-5448

As the results of our studies show (Tables 1, 2 and Fig. 5), in all the studied raw materials, with preliminary processing of berries, the content of the mass fraction of ash substances increases compared to the control samples by 1.29; 1.19; 1.24; 1.25 and 1.33 times, respectively. According to the content of the mass fraction of ash substances, the studied berries are arranged in the following order: hawthorn > black elderberry > dogwood > barberry > raspberry. Of the vitamins synthesized in the berries of dogwood, black elderberry, hawthorn, barberry and raspberry, vitamin C (ascorbic acid, which accumulates in the berries in the largest quantities) is of particular interest. Vitamin C is involved in oxidation-reduction processes, tissue respiration, the metabolism of amino acids, carbohydrates, fats and cholesterol; it is necessary for the formation of collagen protein, which binds the cells of blood vessels, bone tissue, skin, and for wound healing. Vitamin C neutralizes the action of free radicals formed during the digestion of food; prevents the conversion of nitrates into nitrosamines, which are strong carcinogens [13]. ing pectin substances (0.7–1.08%), hemicellulose, and cellulose, as well as ash (0.63–1.04%). They also contain organic acids (0.76–2.51%) and vitamins, such as ascorbic acid (38.2–84.5 mg/100 g), which ultimately lead to a wide range of physicochemical properties and health benefits [25].

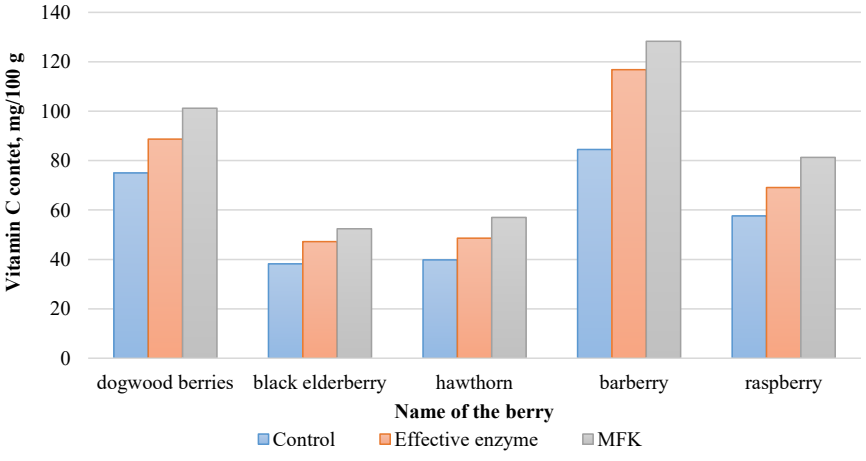
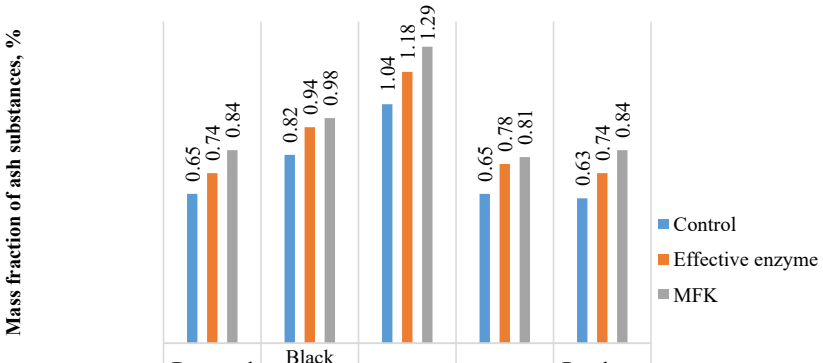


Fig. 6. Histogram of the dynamics of vitamin C content during preliminary treatment of dogwood berries, black elderberry, hawthorn, barberry and raspberry with enzyme preparations



	Dogwood berries	Black elderberries	Hawthorn	Barberry	Raspberries
Control	0.65	0.82	1.04	0.65	0.63
Effective enzyme	0.74	0.94	1.18	0.78	0.74
MFK	0.84	0.98	1.29	0.81	0.84

Fig. 5. Histogram of the dynamics of the content of the mass fraction of ash substances during the preliminary treatment of dogwood berries, black elderberry, hawthorn, barberry and raspberries with enzyme preparations

As shown by the results of our studies (Tables 1, 2 and Fig. 6), the yield of vitamin C in the juice fraction after treating berries with effective enzyme preparations increased in dogwood juice by 1.18 times, in black elderberry juice by 1.23 times, in hawthorn juice by 1.22 times, in barberry juice by 1.38 times, and in raspberry juice by 1.20 times. The increase in vitamin C in the juices of the indicated berries with the use of multienzyme complexes MFK-1 and MFK-2 was 1.35–1.52 times. The increase in the yield of ascorbic acid, in our opinion, is associated with the hydrolytic cleavage of the structural components of the cell wall, and above all, cellulose and hemicellulose. As a result of which bound forms of vitamin C are released and pass into the juices of berries, which is also indicated in [13].

The results of our studies show that some berries growing in the Republic of Azerbaijan, including dogwood, black elderberry, hawthorn, barberry, and raspberry, are characterized by a relatively high content of soluble solids (10.6 ± 0.38–13.4 ± 0.64%). The total sugar content ranges from 8.62 ± 0.26 to 9.60 ± 0.31%. These sugars are mainly represented by reducing sugars (7.14 ± 0.17–9.12 ± 0.28%) and sucrose (0.48 ± 0.21–1.48 ± 0.21%). At the same time, the berries are rich in dietary fiber, including pectin substances (0.7–1.08%), hemicellulose, and cellulose, as well as ash (0.63–1.04%). They also contain organic acids (0.76–2.51%) and vitamins, such as ascorbic acid (38.2–84.5 mg/100 g), which ultimately lead to a wide range of physicochemical properties and health benefits [25].

It has been established that enzymatic extraction of dogwood, black elderberry, hawthorn, barberry, and raspberry berries increases juice yield. In addition, it reduces raw material consumption per unit of product and production waste by approximately 6.8–14.4%. Besides, the extraction of nutritional components and natural antioxidants and preservatives, such as carbohydrates, organic acids, pectic substances, ash components, and vitamin C, is also enhanced. The increase in these components improves the nutritional value of the juices and enhances their technological properties. The data obtained are consistent with the results reported by other researchers [6, 7, 19–21, 23, 26].

The obtained results are of practical significance for producers and the food industry. This indicates that adjusting product formulations, including non-alcoholic beverages, according to the origin and composition of berries with unique flavor characteristics can optimize product quality. Such an approach can also enhance consumer satisfaction and market potential.

This work lays the foundation for future studies focused on investigating the biological activity of individual phytochemical compounds present in juices from dogwood, black elderberry, hawthorn, barberry, and raspberry berries. Compared with other fruit juices, Azerbaijani berry juices generally contain higher levels of bioactive compounds. It makes them valuable functional food products with health-promoting properties. The results of this research should be considered preliminary. Further research is required to confirm the underlying biological mechanisms and to substantiate the potential of Azerbaijani juices from dogwood, black elderberry, hawthorn, barberry, and raspberry berries as functional dietary components.

4. Conclusions

1. It was established that preliminary treatment of dogwood, black elder, hawthorn, barberry and raspberry berries during juice extraction with enzyme preparations has a significant effect on juice yield, with the most effective of the studied enzymes for dogwood

berries being Fructozym P, with which the juice yield increased from 50.2 ± 1.34 to 58.5 ± 0.78%, for black elder and barberry Pectinex BE XXL, with which the juice yield increased from 54.5 ± 0.87% and 52.6 ± 2.24% to 61.3 ± 1.74% and 60.4 ± 3.08%, respectively, while Amylase AG300L was the most effective for hawthorn treatment, with the juice yield increasing from 48.4 ± 1.06% to 57.8 ± 1.56% compared to the control, and when raspberries were treated with Pectinex Yieldash Extra, the juice yield increased compared to the control from 58.4 ± 1.46% to 67.0 ± 3.23%. It has been established that enzymatic extraction of dogwood, black elderberry, hawthorn, barberry, and raspberry berries increases juice yield. In addition, it reduces raw material consumption per unit of product and production waste by approximately 6.8–14.4%.

2. The conditions of preliminary processing of dogwood, black elderberry, hawthorn, barberry and raspberry berries during juice production using various enzyme preparations have been experimentally substantiated. They ensure an increase in juice yield and the most complete extraction of valuable natural components and functional food ingredients into juice: total sugars by 1.05–1.23 times, organic acid by 1.04–1.24 times. Pectin substances by 1.06–1.31 times, ash substances by 1.19–1.33 times, vitamin C by 1.18–1.38 times compounds. Using dogwood berries as an example, it was shown that under the influence of multienzyme complexes MFC-I, insoluble complex carbohydrates are broken down into simpler and more soluble carbohydrates, including sucrose, the content of which increases by 1.58 times compared to control samples. This increases the extraction of nutrients and natural antioxidants. Increasing the content of these components improves the nutritional value of the juices.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

Financing

The research was performed without financial support.

Data availability

Manuscript has no associated data.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies in creating the submitted paper.

Authors' contributions

Sevinj Maharramova: Conceptualization, Investigation, Resources, Visualization, Data curation, Project administration, Writing – original draft; ***Ilhama Kazimova***: Investigation, Visualization, Writing – review and editing; ***Mikail Maharramov***: Conceptualization, Methodology, Writing – review and editing.

References

1. Magerramov, M. A. (2020). *Nauchnye osnovy proizvodstva, teplo i elektrofizicheskie svoistva plodoovoshchnykh sokov.* Liankaran: LGU, 321.
2. Rajendran, P., Nandakumar, N., Rengarajan, T., Palaniswami, R., Gnanadhas, E. N., Lakshminarasaiah, U. et al. (2014). Antioxidants and human diseases. *Clinica Chimica Acta, 436,* 332–347. https://doi.org/10.1016/j.cca.2014.06.004
3. Loi, M., Paciolla, C. (2021). Plant Antioxidants for Food Safety and Quality: Exploring New Trends of Research. *Antioxidants, 10 (6),* 972. https://doi.org/10.3390/antiox10060972
4. Olas, B. (2018). Berry Phenolic Antioxidants – Implications for Human Health? *Frontiers in Pharmacology, 9.* https://doi.org/10.3389/fphar.2018.00078
5. Lourenço, S. C., Moldão-Martins, M., Alves, V. D. (2019). Antioxidants of Natural Plant Origins: From Sources to Food Industry Applications. *Molecules, 24 (22),* 4132. https://doi.org/10.3390/molecules24224132
6. Novruzov, E. N., Mustafaeva, L. A., Zeynalli, A. Z. (2019). Comparative study of the chemical composition and antioxidant properties of extracts of various cornel (*Cornus mas L.*) organs. *Plant & Fungal Research, 2 (2),* 41–48. https://doi.org/10.29228/plantfungalres.23
7. Məhərrəmov, M. Ə., Məhərrəmova, S. İ., Kazımova, İ. H. (2019). *Xammal və qida məhsullarının təhlükəsizliyi.* Bakı: "İqtisad Universiteti" Nəşriyyatı, 270. Available at: https://mek.org.az/e-kitabxana/kitab.php?id=22902
8. Sharma, H. P., Patel, H., Sugandha. (2016). Enzymatic added extraction and clarification of fruit juices – A review. *Critical Reviews in Food Science and Nutrition, 57 (6),* 1215–1227. https://doi.org/10.1080/10408398.2014.977434
9. Məhərrəmov, M. Ə. (2017). *Qida məhsulları texnologiyasının nəzəri əsasları.* Bakı: "İqtisad Universiteti" Nəşriyyatı, 384. Available at: https://www.preslib.az/az/book/vyhYX3HmJrLlGIk
10. Aït-Kaddour, A., Hassoun, A., Tarchi, I., Loudiyi, M., Boukria, O., Cahyana, Y. et al. (2024). Transforming plant-based waste and by-products into valuable products using various "Food Industry 4.0" enabling technologies: A literature review. *Science of The Total Environment, 955,* 176872. https://doi.org/10.1016/j.scitotenv.2024.176872
11. Koponen, J. M., Buchert, J., Poutanen, K. S., Törrönen, A. R. (2007). Effect of pectinolytic juice production on the extractability and fate of bilberry and black currant anthocyanins. *European Food Research and Technology, 227 (2),* 485–494. https://doi.org/10.1007/s00217-007-0745-2
12. Liu, S., Chang, X., Liu, X., Shen, Z. (2016). Effects of pretreatments on anthocyanin composition, phenolics contents and antioxidant capacities during fermentation of hawthorn (*Crataegus pinnatifida*) drink. *Food Chemistry, 212,* 87–95. https://doi.org/10.1016/j.foodchem.2016.05.146
13. Marsol-Vall, A., Kelanne, N., Nuutinen, A., Yang, B., Laaksonen, O. (2021). Influence of enzymatic treatment on the chemical composition of lingonberry (Vaccinium vitis-idaea) juice. *Food Chemistry, 339,* 128052. https://doi.org/10.1016/j.foodchem.2020.128052
14. Kruszewski, B., Boselli, E. (2024). Blackcurrant Pomace as a Rich Source of Anthocyanins: Ultrasound-Assisted Extraction under Different Parameters. *Applied Sciences, 14 (2),* 821. https://doi.org/10.3390/app14020821
15. Bamba, B. S. B., Shi, J., Tranchant, C. C., Xue, S. J., Forney, C. F., Lim, L.-T. (2018). Influence of Extraction Conditions on Ultrasound-Assisted Recovery of Bioactive Phenolics from Blueberry Pomace and Their Antioxidant Activity. *Molecules, 23 (7),* 1685. https://doi.org/10.3390/molecules23071685
16. Li, X., Zhu, F., Zeng, Z. (2021). Effects of different extraction methods on antioxidant properties of blueberry anthocyanins. *Open Chemistry, 19 (1),* 138–148. https://doi.org/10.1515/chem-2020-0052
17. Maharramova, S. (2023). Changes in the chemical composition of extracts of wild berries growing in the Republic of Azerbaijan during enzimatic pretreatment of their pulp. *Ukrainian Food Journal, 12,* 542–555. https://doi.org/10.24263/2304-974x-2023-12-4-5
18. Magerramova, S. I. (2022). Vliianie predvaritelnoi fermentativnoi obrabotki na biologicheski aktivnye soedienie i antioksidantnye svoistva nekotorykh iagod. *Technical and Agrarian sciences, 1,* 46–51. Available at: https://lsu.edu.az/new/imgg/aqrar-2023/tex_aqr_1_2022.pdf
19. Qədimova, N. S. (2025). *Bitki mənşəli bioloji fəal əlavələrin tətbiqi ilə içkilərin texnologıyasının təkmilləşdirilməsi.* [Extended abstract of Doctoral dissertation]. Available at: https://adau.edu.az/images/files/2025-05/1748261455_avtoreferat-az-qdimova-natvan-a5-3.pdf
20. Qasımov, H. (2017). Naxçıvan Muxtar Respublikası florasının alkoqollu içki və sirkə alınan bitkiləri. *Elmi Əsərlər, 3 (84),* 33–40. Available at: https://ndu.edu.az/wp-content/uploads/Elmi%20Eserler/84%20tebiet%202017.pdf
21. İbrahimov, Ə., İbrahimov, Ə., Qurbanov, Ə. (2017). Naxçıvan Muxtar Respublikasının bəzi perspektivli yabanı qida meyvə bitkilərinin xalq təsərrüfatı əhəmiyyəti. *Elmi Əsərlər, 7,* 33–39. Available at: https://ndu.edu.az/wp-content/uploads/Elmi%20Eserler/88%20t%E2%95%94%D0%A9bi%E2%95%94%D0%A9t%202017.pdf
22. Ionsecu, A.-D., Voicu, G., Ferdes, M., Ipate, G., Constantin, G.-A., Stefan, E.-M., Begea, M. (2024). *Effect of Grinding and Successive Sieving on Active Biological Compounds in the Obtained Fractions of Blackthorn Berries.* https://doi.org/10.20944/preprints202406.1934.v1
23. Bastos, K. V. L. da S., de Souza, A. B., Tomé, A. C., Souza, F. de M. (2025). New Strategies for the Extraction of Antioxidants from Fruits and Their By-Products: A Systematic Review. *Plants, 14 (5),* 755. https://doi.org/10.3390/plants14050755
24. Nicolescu, A., Babotă, M., Zhang, L., Bunea, C. I., Gavrilaș, L., Vodnar, D. C. et al. (2022). Optimized Ultrasound-Assisted Enzymatic Extraction of Phenolic Compounds from Rosa canina L. Pseudo-Fruits (Rosehip) and Their Biological Activity. *Antioxidants, 11 (6),* 1123. https://doi.org/10.3390/antiox11061123

ISSN-L 2664-9969; E-ISSN 2706-5448

25. Al-Khayri, J. M., Rashmi, R., Toppo, V., Chole, P. B., Banadka, A., Sudheer, W. N. et al. (2023). Plant Secondary Metabolites: The Weapons for Biotic Stress Management. *Metabolites, 13 (6),* 716. https://doi.org/10.3390/metabo13060716

26. Cavdar Dincturk, H., Can Karaca, A., Capanoglu, E. (2025). Development of novel processing technologies for sustainable production of berries. *Berry Fruits,* 325–341. https://doi.org/10.1016/b978-0-443-16011-0.00009-2

Sevinj Maharramova, *PhD in Biology, Associate Professor, Department of Engineering and Applied Sciences (UNEC), Azerbaijan State University of Economics, Baku, Azerbaijan, ORCID: https://orcid.org/0000-0002-1599-7013*

Ilhama Kazimova, *PhD in Engineering, Associate Professor, Department of Engineering and Applied Sciences, Azerbaijan State University of Economics (UNEC), Baku, Azerbaijan, ORCID: https://orcid.org/0000-0003-3857-9575*

✉***Mikail Maharramov,*** *Doctor of Technical Sciences, Professor, Department of Technology and Technical Disciplines, Lankaran State University, Lankaran, Azerbaijan, e-mail: mikailbyst@mail.ru, ORCID: https://orcid.org/0000-0002-4688-5823*

✉*Corresponding author*