RESEARCH ARTICLE

# Research of Biochemical Composition and Antioxidant Activity of Freeze-dried Cranberry Powder Obtained on the Basis of Enzymatically Processed Berry Pulp

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## Abstract

**Aim:** An important indicator of the quality of fruit and berry powder products, which determines the suitability of their use in the preparation of food products, is the chemical composition. Complex studies were conducted to study the chemical composition and antioxidant activity (AOA) of the freeze-dried cranberry berries obtained from the pulp of berries pre-treated with a piece of enzymatic preparations of pectolytic and cellulolytic action (Rapidase CR and Laminex BG2). The profile of flavonoids, qualitative composition of organic including phenolic acids, catechins, and minerals, has been studied. **Results and Discussion:** In the flavonoids, quercetin and its glycosides have been identified: Quercitrin, hyperoside, and avicularyin. Among the catechin compounds, epicatechin (more than 65%) is detected in the most considerable amounts; the epigallocatechin (about 18%) is the second in the quantitative series of catechins. Gallates are present in smaller amounts: Epicatechin gallate, gallocatechin gallate, and epigallocatechin gallate with a predominance of the latter (9%). In the composition of fruit acids, citric acid is present in the most significant amounts, and in the spectrum of hydroxycinnamic acids, chlorogenic acid (~45%) and 4-caffeolic acid (~22%) predominate; ferulic, coffee, p-coumaric, and caftaric acids have also been identified. A diverse range of mineral substances has been defined: Potassium, phosphorus, and calcium are leading, substantially magnesium content. From trace elements in significant quantities, there are manganese, iron, aluminum, silicon, and zinc. The high AOA of the sublimed cranberry berries powder is established. **Conclusion**: The obtained data convincingly demonstrate that the berry powder contains a wide range of natural biologically active and minor components useful for human health: Sugars, organic acids including natural preservative - benzoic acid, dietary fibers, protein, minerals, and Vitamin C, and polyphenolic compounds including flavones, flavonols, anthocyanins, catechins, proanthocyanidins, and tannins, as well as natural dyes and preservatives, which opens the prospect of using a freeze-dried powder berries cranberries in the preparation of foods and functional foods and therapeutic and prophylactic purposes.

**Key words:** Antioxidant activity, biochemical composition, cranberry berries, enzymatic treatment, vacuum freeze drying

## INTRODUCTION

In connection with the growing interest of the population in healthy food products, researchers and food manufacturers are increasingly turning to the modification of traditional formulations using products of processing of fruit and berry raw materials, which contain a wide range of healthy functional food ingredients, as well as natural dyes and flavors. From this point of view,

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the cranberry berries deserve particular attention thanks to the high content of vitamins, antioxidants, a wide range of flavonoid compounds, minerals, and organic acids including benzoic and salicylic, having antimicrobial properties.[1-6] Particular attention to cranberries is due to the presence of proanthocyanidins in berries, which have a unique effect in preventing urinary tract infections, which is characteristic only of seeds belonging to the species of cranberry (blueberry and cranberry).[7]

Analysis of modern trends in the development of technologies for processing fruits and berries shows that at the present stage the production of fruit and berry powders is developing dynamically as technological semi-finished products that are convenient in application, storage, and transportation.[8-11] In recent years, there has been a noticeable increase in interest in vacuum freeze drying as a method of dehydration and canning of forest and garden berries. The use makes possible to obtain powder products with maximum preservation of the natural components of raw materials,[12-17] which opens up prospects for their use in food for enrichment useful for human health biologically active substances of berries and partial replacement or in some cases. Complete elimination of synthetic food additives intended for the consumer properties of the product such as appearance, taste, aroma, and conditional on the relevant shelf life.[18-21] The advantages of freeze-dried berry powders are small mass. Chemical and microbiological stability under prolonged storage, the unique properties in rapid rehydration, and restoration of the original quality characteristics of the berries, and above all, the attribute inherent ripe berries (saturation flavor, aroma, and color), and a high concentration biologically active compounds of the original natural raw materials. The latter factor is crucial in assessing the efficiency of processing berries and realizing their resource potential.

However, when receiving powder semi-finished products from natural berry raw materials, it should be borne in mind that a significant part of the berries components useful for human health is not able to assimilate the human body and displays its physiological activity due to the natural organization of plant tissue. Sorption of proteins and structural components of the cell wall, based on non-starch polysaccharides, significantly reduces the digestibility of biologically active substances. Only a fraction of them is dissolved in the cell sap and therefore bioavailable. Therefore, important and promising direction in the development of powder products technology is the use of biocatalytic methods preprocessing berries that enhance plant tissue extractive capacity by carrying out partial enzymatic hydrolysis of non-starch polysaccharides berries. It destroys the cell walls, and as a consequence, the enrichment juice fraction (soluble part of the powder product) additional quantities of natural components of berries that have biological the activity and forming a bouquet of color, taste, and aroma.[22-26] Currently, in the industrial processing of fruit and berry raw materials, enzyme preparations are increasingly being involved as technological auxiliaries, the use of which makes it possible to develop and introduce qualitatively new, environmentally safe technologies, to increase the yield of finished products, to improve its quality, and to reduce losses of biologically active substances processing of raw materials.[27-31]

Currently, little attention is paid to the use of enzymes in the pre-treatment of raw materials in the production of berry powders and their characteristics from the position of nutritional value and the manifestation of antioxidant properties useful for human health. Based on experience, the successful application of enzymes in food technology rational combination of biocatalytic methods of pretreatment berries and modern methods of drying may be the key to a productive and successful implementation of intensive technologies of processing of vegetable biological resources, focused on preservation and the most complete use of the unique natural composition of the berries and obtaining powder semi-finished products increased nutritional value and antioxidant activity (AOA) for use in septum food.

The purpose of the present studies was to study the biochemical composition and AOA of the sublimed cranberry powder obtained by the enzyme.

## METHODS OF RESEARCH

We used berries cranberries, crop 2013, growing in the Tver region of the Russian Federation, and enzyme preparations (FP) pectolytic and cellulolyticus action Rapidash CR (strain producer - *Aspergillus niger*, the manufacturer - DSM-Food-Specialties, France) and Laminex BG2 (the producer strain is *Trichoderma reesei*, manufacturer, Danisco, Denmark).

## ENZYMATIC TREATMENT OF PULP OF THE BERRIES CRANBERRIES

For hydrolysis, the berries were crushed, the resulting pulp was introduced FP in the composition in concentrations: 3.4 units. Polygalacturonic acid (PGA)/g pectin for pectolytic drug Rapidase CM 21.3 units. Congenital adrenal hyperplasia/g cellulose for glucanolytic drug Laminex BG2 and hydrolysis conducted at a temperature of 45°C for 1.5 h. After hydrolysis, enzymes were inactivated by heating. Dosages of FP and the duration of hydrolysis were chosen based on the analysis of the obtained dependences illustrating the dynamics of the juice fraction yield in the berry pulp under the influence of individual FP [Figures 1 and 2].[32] The output of the cell SAP was an indirect measure by which to judge the degree of degradation of the structural polysaccharides under the influence of FP.

The production of freeze-dried cranberry powder on the basis of enzymatically processed pulp was carried out at

the experimental stand of SVP-0.36 (a stand of vacuum processes).[33] Drying parameters: The temperature at the stage of moisture removal by the "ice-steam" phase transition was −20–−22°C; the maximum temperature at the drying stage is 36–38°C (with radiation energy supply); the average pressure in the chamber is 100 Pa; the total drying time is 12 h; the moisture content in the final product is 5%. The dried product was a fairly dense layer with a brittle consistency; when unloading from the baking tray, it was easily crushed. After unloading, the resulting product was further crushed with a mixer designed to work with V-Type Kewei Mechanical Manufacturing Co., Ltd., powder products, model VH-0.1.[34] The freeze-dried product was a finely dispersed crumbly powder of characteristic cranberry color with a pronounced aroma [Figure 3].

## METHODS FOR DETERMINING THE ACTIVITY OF ENZYME PREPARATIONS

Endoglucanase activity was established by the viscometric method based on a determination of the rate of viscosity decrease of 0.3% Na-CMC solution after the action of cellulase.[35]

The pectinase PGA of the enzyme preparation was determined by the colorimetric method by the procedure described in Polygalina *et al*.[35]

### Methods for studying the chemical composition

The mass fraction of moisture was determined by the Karl Fischer method by the procedure[36] in the "701-KF Titrino" installation of the firm "Metrohm" (Switzerland).

The content of total sugar (the full content of sucrose and reducing sugars) was determined by a photocolorimetric method based on the oxidation of total sugar by potassium dichromate in a strongly acid medium. Colorimetry was carried out on a KFK-3 photoelectric colorimeter at a wavelength λ = 670 nm and a cell thickness of 5 cm.[37]

Reducing sugars were determined by the accelerated iodometric method by the procedure.[38]

Pectic substances were determined by the carbazole method, based on obtaining specific violet-pink staining of uronic acids with carbazole in a sulfuric medium. Colorimetry was carried out on an SF-26 spectrophotometer at λ = 535 nm and a cell layer thickness of 10 mm. The number of uronic acids was calculated from the calibration chart plotted for galacturonic acid.[39]

The determination of cellulose was carried out according to the method of Kushner and Ganek, based on the oxidation, degradation, and dissolution of various chemical compounds

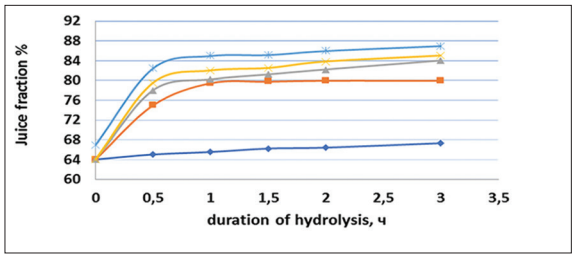


**Figure 1:** Change in the share of the juice fraction in the mash of berries cranberries under the action of the OP Rapidase CR at various concentrations of 6.8–27.2 units (polygalacturonic acid/g pectin)

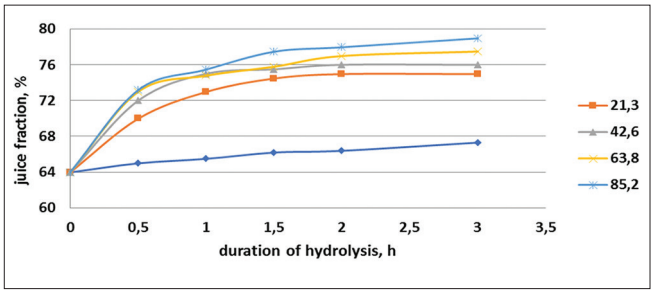


**Figure 2:** Change in the proportion of juice fraction in the mash of berries cranberries under the action of OP Laminex BG2 at various dosages of 21.3–85.2 units (CAA/g cellulose)

**Figure 3:** Sublimated cranberry powder obtained by fermented mashed berries in an experimental sublimation unit SVP-0.36, after grinding

that make up plants, with a mixture of acetic and nitric acids. At the same time, cellulose (cellulose) practically does not dissolve, is filtered out and weighed.[39]

Determination of dietary fibers was carried out in accordance with the methodology described in Russian Ministry of Health.[40]

The content of total protein was determined by the Kjeldahl method.[38]

The content of soluble protein was determined by the colorimetric method (according to Lowry), based on the

reaction of proteins with Folin reagent, giving blue staining. Colorimetry was carried out on an SF-26 spectrophotometer at λ = 750 nm and a cell layer thickness of 10 mm. The protein content of the product was calculated using a preconstructed calibration curve (albumin).[38]

The determination of the content of titrated acids was carried out by the potentiometric method by GOST ISO 750-2013 on the pH meter-ionomer "Agilent 3200P."

The qualitative composition of organic acids was investigated by high-performance liquid chromatography (HPLC).[41] Chromatographic analysis conditions: Kromasil C18 column 5 mm, 250 mm × 4.6 mm; mobile phase 0.2 M phosphate buffer pH 2.6; speed 1.0 ml/min; and UV, λ = 254 nm. The volume of the injected sample: 5 µl.

The determination of benzoic acid was carried out by RP-HPLC with spectrophotometric detection.[41] Chromatographic analysis conditions: column:octadecylsilica gel 250 mm × 4.6 mm, 5 µm (Phenomenex Luna 5 µm C18 (2)); mobile phase: 0.025 M CH3COONa, pH 4, 5 - 82%: acetonitrile - 18%; mobile phase feeding rate: 1.0 ml/min, and detection: UV, λ = 272 nm. The volume of the sample is 10 µl.

The determination of hydroxycinnamic acids was carried out using the HPLC method.[41]

Chromatography conditions: Octadecylsilica-silica column 5 m km, 250 × 4.6 (Hypersil Gold C18); mobile phase feeding rate: 0.9 ml/min; column temperature: 25°C; and detection: UV, λ = 330 nm. The volume of the sample is 10 µl. Mobile phase: (A) 0.05% trifluoroacetic acid and (B) acetonitrile.

| Time, min | 0 | 18 | 30 | 35 |
|---|---|---|---|---|
| A, % | 95 | 77 | 70 | 50 |
| B, % | 5 | 23 | 30 | 50 |

The total content of polyphenolic compounds was determined by the modified Folin–Ciocalteu method. The absorption of the solution at 750 nm is proportional to the content of phenolic compounds. The value of the mass concentration of phenolic substances in mg/l was determined from a graduated graph plotted against gallic acid.[40]

The total content of anthocyanins was determined by differential spectrophotometry.[40]

The content of proanthocyanidins was determined by the Beit-Smith method followed by a photometric determination.[41] The measurement was carried out on an SF-26 spectrophotometer at λ = 550 nm in cuvettes with a layer thickness of 0.5 cm. The content of proanthocyanidins was calculated using a preconstructed calibration curve (using a standardized extract). The solution of the comparison is a solution based on the grape seed extract.

Determination of the total content of flavones and flavonols (in terms of routine) was performed by spectrophotometric method.[40] Optical density measurements were carried out at a wavelength of 415 nm. For quantitative calculations, a preconstructed calibration curve was prepared using a standard solution of rutin (Routine Trihydrate, 95%, (Sigma), CAS: 207671-50-9).

The flavonoid profile was analyzed by HPLC with the sequential use of a diode-array detector (DMD) and a mass spectrophotometric detector (MS).[34] The studies were carried out on an Agilent 1200 chromatograph. As an extractant, a 50% methanol solution was used. Chromatography conditions: ProteCol C18 HPH125 column 250 × 4.6 mm, 5 µm; mobile phase: A - 0.1% solution of formic acid, B - acetonitrile (040 min, 10–60% B). Column temperature 30° C, mobile phase speed of 0.5 ml/min, sample volume 10 µl, analytical wavelengths: 360, 330, and 290 nm. Mass scanning - in the mode of registration of positive ions in the range of m/z 150–1000. Operating parameters of the ionization source: the voltage on the capillary is 3500 V, the gas-dryer stream (nitrogen) is 9 L/min, the temperature is 325°C, and the pressure on the nebulizer is 0.27 MPa.

The group composition and quantitative content of catechins and gallic acid were determined by RP-HPLC with spectrophotometric detection at λ = 275 nm.[41] Chromatographic analysis conditions: Octadecylsilica-column column 250 × 4.6 mm, 5 µm (Phenomenex Luna 5 µm C18 (2)); the mobile phase feeding rate is 1.0 ml/min; and the volume of the injected sample is 10 µl. Mobile phase: (A) - trichloroacetic acid, pH = 2.5 and (B) -acetonitrile;

| Time, min | A, % | B, % |
|---|---|---|
| 0 | 96 | 4 |
| 25 | 80 | 20 |
| 30 | 80 | 20 |
| 50 | 50 | 50 |

The content of tannins and Vitamin C was determined in accordance with the methods described in Russian Ministry of Health.[40]

Determination of the ash content was carried out in accordance with the procedure.[39] The determination of the content of macro- and micro-elements was carried out using atomic emission spectroscopy with inductively coupled plasma on the iCAP 6300 Duo (Thermo Fisher Scientific, USA).[42,43] The samples were preliminarily cleared on the tile by the "wet ashing" method, then burned in a muffle furnace at 600°C, the ash was dissolved in 50 $cm^3$ of a 2% solution of $H_2SO_4$ with heating. For analysis, a solution was prepared with a mass fraction of the elements corresponding to the calibration curve.

## METHOD FOR DETERMINATION OF AOA

AOA was determined with respect to the 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical.[44] The kinetics of optical density loss at λ = 517 nm of the DPPH solution was recorded in the presence of antioxidants of the test sample and the standard solution (Trolox analog of Vitamin E) after preliminary incubation.

The optical density was measured on a Shimadzu spectrophotometer Model UV 1800.

## STATISTICAL PROCESSING OF EXPERIMENTAL DATA

To process the results of the studies, a statistical method for processing experimental data was used, during which the mean values of the determined value were determined from 3 to 6 replicas, the standard deviation and the confidence interval.[45]

## RESULTS AND ITS DISCUSSION

An important indicator of the quality of fruit and berry powder products, which determines the expediency of their use in the preparation of food products, is the chemical composition. The results of studies carried out to study the effect of enzymatic processing of the cranberries pulp on the juice fraction composition, and its antioxidant properties made it possible to evaluate the effectiveness of the use of OP in the stage of preliminary treatment of cranberry berries in the preparation of a powder product. An increase in the extractive capacity of plant tissue by biologically active substances, natural dyes, and preservatives and AOA of the juice fraction by 40% has been established (by 1.2–2 times).[46,47] Qualitative transformations of the composition of the juice fraction of enzymatically processed pulp of berries have been identified. Epigallocatechin has been recognized with high antiradical properties, the presence of which has not been found in juice obtained without the use of PTs.[47] The obtained results give the basis for assuming an increase in the nutritional value of the soluble (juice) part of the cranberry powder obtained by fermented mashed berries by additional extraction of natural berry components into the juice. Moreover, the use of the vacuum freeze-drying method, according to the literature data, will preserve biologically active, minor, and technologically significant elements of berries.

The results of studies of the biochemical composition of the freeze-dried cranberry berries powder obtained by fermented mashed berries are presented in Table 1.

As shown by the data presented in Table 1, the sublimed cranberry powder is characterized by the high content of sugars and organic acids. In their powder, their content is 39.2 ± 0.9 g/100 g and 24.4 ± 0.7 g/100 g [Table 1].

As shown by chromatographic data, the dominant role in the spectrum of organic acids belongs to citric acid; its content is 16.22 g/100 g [Table 2].[48] The citric acid in the food industry is used as a regulator of acidity, to protect against the flow of destructive processes. The most typical of fruits and berries is malic acid, which is present in the cranberry powder in the amount of 1.86 g/100 g. Of the others, a quinic acid in the amount of 5.61 g/100 g is determined [Table 2].

The spectrum of hydroxycinnamic acids is dominated by chlorogenic acid (≈45% of the total number of acids detected) and its structural isomer 4-caffeolic acid (≈22%) [Table 3 and Figure 4].

Ferulic and p-coumaric acids are found in one concentration range (89.04 and 94.29 mg/kg); in almost half the quantity, coffee acid (48.32 mg/kg) is present and the content of kaftar acid (7.77 mg/kg) is insignificant [Table 3].

Identified acids have high antioxidant properties. It has been established that the AOA of chlorogenic acid is 27 times higher than the AOA of naringenin (the main grapefruit flavonoid). Moreover, for AOA, they can be arranged in a row: Coffee> ferulic> chlorogenic >> naringenin.[49] For chlorogenic and caffeic acids, hypoglycemic action is shown.[49] In the literature, data are given that chlorogenic, coffee, and ferulic acids have a mild hypocholesterolemic

**Table 1:** Biochemical composition of freeze-dried cranberry powder

| Component name | Content, in 100 g | Component name | Content, in 100 g |
|---|---|---|---|
| Water, g | 5.0 | Polyphenol compounds, mg | 3330±270 |
| Total ash, g | 1.1 | Anthocyanins, mg | 1237±28 |
| Total sugar, g | 39.2±0.9 | Proanthocyanidins, mg | 28.5±1.7 |
| Protein, g | 4.2±0.3 | Tannins, mg | 1208 90 |
| Organic acids (titrated) in terms of apple), g | 24.4±0.7 | Flavones and flavonols (in terms of rutin), mg | 711.3±8.5 |
| Alimentary fiber | 20.3±1.5 | Vitamin C, mg | 139.6±2.5 |

effect, reduce the risk of developing cholelithiasis.[50,51] Data are reported that ferulic and p-coumaric acids prevent the development of colorectal cancer.[52]

The unique natural acid contained in cranberry berries is benzoic acid. Berry berries occupy a leading position in the content of benzoic acid among other fruits and berries (up to 0.2%).[1,2] The antimicrobial action of benzoic acid is widely used in the food industry.[48] The preservative effect, which is achieved by the use of benzoic acid (salts) in the preparation of food products, is due to the manifestation of the antimicrobial properties of benzoic acid, which are based on the inhibition of enzyme activity in the cells of the infecting microflora.[48] Using reversed-phase-HPLC, the content of benzoic acid in the freeze-dried cranberry powder was determined, which was 238 mg/100 g.

**Table 2:** Content of some organic acids in freeze-dried cranberry powder

| Name of acid | Content, г/100 г |
|---|---|
| Quinic acid | 5.61 |
| Malic acid | 1.86 |
| Citric acid | 16.22 |

**Table 3:** Composition and content of hydroxycinnamic acids in freeze-dried cranberry powder

| Name of acid | Content, mg/kg |
|---|---|
| Caftaric acid | 7.77 |
| Chlorogenic acid | 333.27 |
| 4-Caffeolic acid | 160.23 |
| Caffeic acid | 48.32 |
| p-coumaric acid | 94.29 |
| Ferulic acid | 89.04 |
| Sum of hydroxycinnamic acids | 732.92 |

Sublimated cranberry powder is a carrier of components of non-alimental nature of natural origin - dietary fiber, which is given great importance in the prevention of a number of diseases of the gastrointestinal tract, diabetes, metabolic disorders, etc.[53,54] The content of dietary fiber in the powder product is significant and amounts to 20.3 ± 1.5 g/100 g, which indicates the prospects of its use for the enrichment of food products [Table 1].

A large group of biologically active substances are compounds of polyphenolic nature, which are represented quite extensively in the sublimed cranberry powder. The total content of phenolic compounds is 3330 ± 270 mg/100 g; flavones and flavonols (in terms of routine) - 711.3 ± 8.5 mg/100 g [Table 1].

The high content (1237 ± 28 mg/100 g) of natural pigments - anthocyanins, which determine the characteristic cranberry color of the powder product [Table 1] is revealed, which allows to view cranberry powder as a source of natural dyes in the production of food products. The prophylactic effect of anthocyanins is shown: When present in the diet, they reduce the risk of developing cardiovascular and cancer diseases.[55-57]

Of the unique flavonoid compounds inherent in cranberry berries, proanthocyanidins are defined in the powder product. Their content is 28.5 ± 1.7 mg/100 g [Table 1]. For proanthocyanidins, onco- and cardio-protective effects have been identified.[58,59]

The most famous group of flavonoids is catechins. The content of catechins in sublimed cranberry powder is 556.5 mg/kg [Table 4 and Figure 5].

Analysis of chromatographic data shows that more than 65% of all detected catechins account for the share of epicatechin [Table 4]. The second in the quantitative

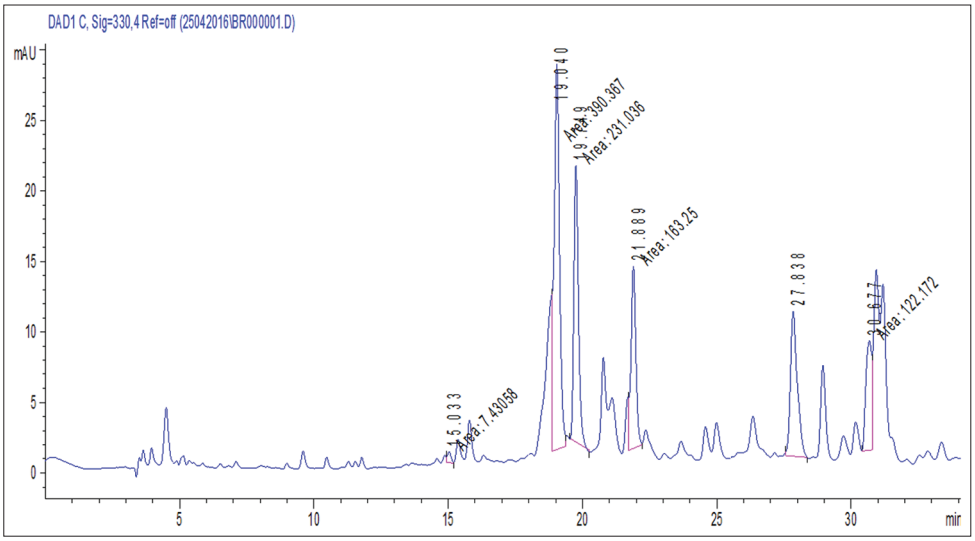


**Figure 4:** Chromatogram of hydroxycinnamic acids of freeze-dried cranberry powder

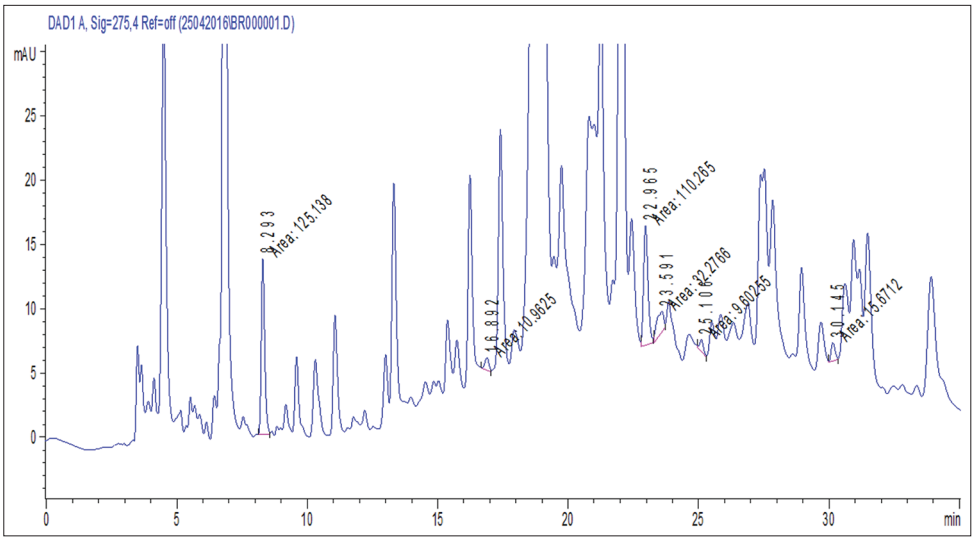


**Figure 5:** Chromatogram of catechins and gallic acid of freeze-dried cranberry powder

**Table 4:** Composition and content of catechins and gallic acid in freeze-dried cranberry powder

| Name | Content, mg/kg |
|---|---|
| Gallic acid | 61.11 |
| Epigallocatechin | 99.12 |
| Epicatechin | 366.87 |
| Epigallocatechin gallate | 49.56 |
| Gallocatechin gallate | 25.41 |
| Epicatechin gallate | 15.54 |
| Sum of catechins (excluding gallic acid) | 556.50 |

series of catechins is epigallocatechin - 99.12 mg/kg (≈18%). As a second quantitative significance among catechin compounds, lingonberry berries, namely epigallocatechin could be identified as part of the pulp fruit juice fraction cranberries after enzymatic pre-treatment.[47] Complement set catechin compounds esters with gallic acid, which have a higher antiradical activity compared to the baseline catechins - epigallocatechin gallate - 49.56 mg/kg, gallocatechin gallate - 25.41 mg/kg, and epicatechin gallate - 15.54 mg/kg [Table 5]. The resulting chromatograms identify gallic acid. Its content in the freeze-dried cranberry powder is 61.11 mg/kg [Table 4]. Gallic acid has antibacterial, antiviral, hypoglycemic, and antioxidant action accelerates the healing of wounds and burns.[60,61]

A characteristic astringent, astringent taste of cranberry berries and products of its processing are given by tannins (tannins) belonging to the group of phenolic compounds. By their nature, tannins are phenolic acid esters, preferably ellagic and gallic acids or formed by condensing phenolic compounds - flavonols, mainly of flavan-3-ols (catechins), or flavan-3,4-diols (leucoanthocyanins).[6] Representatives of both classes of tannins are present in vegetable raw materials including cranberries in berries.[1,2,6] As shown by the data of the conducted studies, the content of tannins in cranberry powder was 1208 ± 90 mg/100 g [Table 1]. In the food industry, tannin-containing raw materials are used to impart to the products a tart taste, a specific color, and aroma (brewing and winemaking).[48,62] Anti-inflammatory properties of tannins have found application in medicine.[61]

Using the HPLC-DMD-MS, the profile of flavonoids in the freeze-dried cranberry powder was studied and the content of their individual representatives was determined [Table 5, Figures 6 and 7].

According to the results obtained, quercetin is present in cranberry powder (15.6% of the flavonoid compounds detected), but in its overwhelming amounts, its glycosides: Quercitrin, avicularyin, and hyperoside (65.3%). Two more representatives of quercetin glycosides, acylated for carbohydrate residues, were not identified [Table 5].

Of vitamins, the content of Vitamin C was determined, which was 139.6 ± 2.5 mg/100 g [Table 1].

Supplementing the nutritional value of freeze-dried cranberry powder is available in a wide range of macro- and micro-elements [Table 6]. Mineral substances are the most important group of natural compounds, which are a necessary component of the normal life.

In the sublimed powder of cranberry, potassium, phosphorus, and calcium are leading (4363.8 mg/kg, 2134.4 mg/kg, and 1058.8 mg/kg, respectively) [Table 6]. Significant amounts of magnesium are 568.9 mg/kg. In comparison with other macro elements, the sodium content is insignificant (72.8 mg/kg) [Table 6].

From trace elements in significant quantities revealed manganese, iron, aluminum, silicon, and zinc. The presence

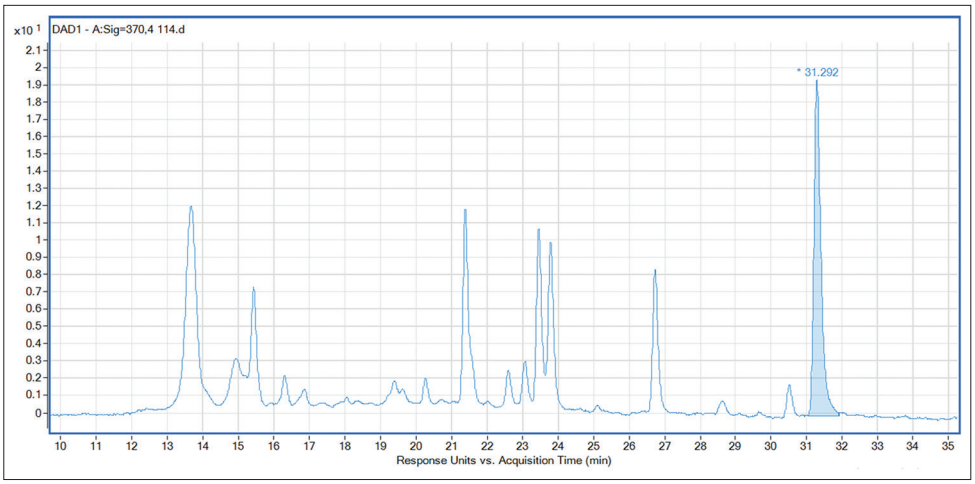


**Figure 6:** Chromatogram of flavonoids of sublimated cranberry powder, λ = 370 nm (quercetin)

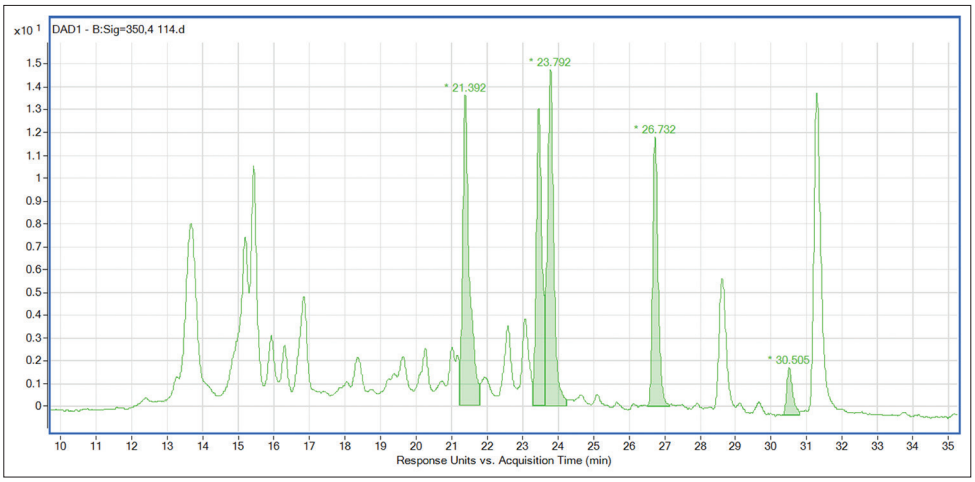


**Figure 7:** Chromatogram of flavonoids of sublimated cranberry powder, λ = 350 nm (quercetin glycosides)

**Table 5:** Content of individual flavonoids in freeze-dried cranberry powder, mg/100 g

| Flavonoid | Content | Flavonoid | Content |
|---|---|---|---|
| Hyperoside | 20.8 | Quercetin | 14.0 |
| Avicularyin | 16.9 | Unidentified acylated glycoside of quercetin | 14.4 |
| Quercitrine | 21.2 | Unidentified acylated glycoside of quercetin | 2.8 |

**Table 6:** The content of some minerals in the freeze-dried cranberry powder

| Name of the element | Content, mg/kg | Name of the element | Content, Мг/кг |
|---|---|---|---|
| Potassium | 4363.8 | Phosphorus | 2134.4 |
| Calcium | 1058.8 | Magnesium | 568.9 |
| Aluminum | 31.5 | Manganese | 211.1 |
| Zinc | 12.1 | Sodium | 72.8 |
| Iron | 40.9 | Nickel | 0.83 |
| Silicon | 23.3 | Lithium | 0.79 |
| Silver | 0.11 | Chromium | 0.65 |

of lithium, nickel, chromium, and silver supplements and the range of mineral substances of cranberry powder are shown in Table 6.

The final stage of the study was the determination of the AOA of the sublimated cranberry powder about the DPRN radical, which was 5370 mg/100 g (in TEAS units).

## CONCLUSION

The results of the conducted studies indicate that the freeze-dried cranberry powder obtained by fermented mashed berries contains a wide range of natural berries compounds, functional food ingredients, minor, and biologically active substances and is a source of natural dyes and preservatives. The combination of elements with antioxidant properties in freeze-dried cranberry powder causes its manifestation of a high AOA, which is the result of a synergistic effect due to the joint action of the complex of recognized antioxidants present in the berry powder. All this in aggregate gives grounds to talk about the prospects of using freeze-dried cranberry powder in obtaining traditional food products to increase nutritional value for the content of essential and minor micronutrients, as well as products of functional and therapeutic and prophylactic purposes.

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