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PROSPECTS FOR THE USE OF WILD BERRY PROCESSING PRODUCTS AS FUNCTIONAL FOOD INGREDIENTS

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Abstract. The aim of this study is to substantiate the feasibility of processing wild berries (*Viburnum opulus, Sorbus, Hippophae, Sambucus nigra*) into functional food ingredients. The paper analyses the structure of powders from wild berries *Viburnum opulus, Sorbus, Hippophae, Sambucus nigra*, and investigates the content of micro- and macroelements in the powders; physicochemical parameters of wild berry powders (dry matter, mass fraction of moisture, dispersibility, mass fraction of reducing sugars, solubility, acidity) and dietary fibre content in *Viburnum opulus, Sorbus, Hippophae, Sambucus nigra* powders. The prototypes were made from high-quality fruit and berry raw materials not damaged by diseases and pests. To make the powders, the berries were dehydrated by osmotic dehydration, then dried in infrared dryers for 2 hours at 50°C to a mass fraction of moisture of 6–8%. The dried berries were ground in a laboratory mill LZM-1. The structure of the berry powders was studied by electron microscopy. It was found that the powders have a crystalline porous structure and, accordingly, hydrophilic properties. This makes it possible to use them in food production as structure stabilisers, emulsifiers and moisture retainers. The content of some minerals in the samples was studied using a microscope-based SEM and EDS detector. It was found that the powders contain macronutrients (K, Ca, P, Cl, S, N), essential trace elements (Mg) and the conditionally vital trace element Si, which was found in powders from viburnum and sea buckthorn. The obtained powders from wild berries *Hippophae rhamnoides L., Viburnum opulus, Sambucus nigra* and *Sorbus aucuparia* contain a significant amount of vitamin C. According to all physicochemical parameters, the samples of plant powders from viburnum, elderberry, sea buckthorn, and mountain ash berries meet the requirements of DSTU 8498:2015. These results indicate the feasibility of processing *Viburnum opulus, Sorbus, Hippophae, Sambucus nigra* into functional food ingredients.

Keywords: *Viburnum opulus, Sorbus, Hippophae, Sambucus nigra*, functional food ingredients, dehydration, structure, minerals, vitamins C

Introduction. Formulation of the problem

Wild berries are known to be a source of vitamins, folate, amino acids, carotenoids, bioflavanoids, and dietary fiber. They are combined with various products to increase their biological value and impart certain functional properties. Berries are eaten raw and canned. They are the main and auxiliary raw materials for the manufacture of many food products.

Berry processing products such as powders, purees, and dietary fiber concentrates can be used in the food industry as coloring agents, flavors, and natural preservatives, as well as used to change the composition of products to improve their nutritional properties [1]. Unfortunately, berries have a short shelf life when fresh. Drying is the most rational way of preserving, as microbiological processes slow down in dried products, and the composition of nutrients and biologically valuable substances remains close to natural. During drying, moisture is removed from the raw materials, the concentration of substances in the cell sap increases, and dried fruits, vegetables, and berries have a large amount of carbohydrates, vitamins, pectin and minerals, and organic acids [2].

Analysis of recent research and publications

The food industry is one of the most waste-intensive sectors of the national economy. In terms of waste generation, it is second only to the extractive industries [3]. The reason for waste generation is the use of imperfect processing technologies and the lack of proper logistics. It is known that 40–50% of root vegetables, fruits and vegetables turn into waste. The processing of plant materials produces by-products such as peels, seeds, pomace, and others [4]. Since they are not used in the production process, they are classified as waste. The accumulation of waste worsens the environment and leads to a shortage of natural resources due to the irrational use of raw materials [5]. At the same time, they can be additional sources of useful nutrients, so the study of their composition and properties is an extremely relevant issue.

Recent studies have shown the potential health effects of biologically active compounds present in fruits and their products: they slow down the aging process [6] and have antioxidant properties [7]. It is assumed that antioxidants of plant origin have antimicrobial, antiviral, anti-inflammatory, hypotensive, hepatoprotective, neuroprotective, antidiabetic, and antitumor properties [8,9,10]. These beneficial properties of berry fruits can make them valuable ingredients in the production of functional foods.

It has been proven that the stability and functional properties of plant materials before their use are best maintained in powder form [11].

Today, plant powders made from fruits, vegetables, wild berries and derivatives of their processing are widely used in the food industry as functional food additives.

In addition, powders from fruit and vegetable by-products have important technological functionalities and can be used as food ingredients, namely as thickeners, gelling agents, fillers and water retention agents, as well as in the production of food films [12].

There are studies on the possibility of using berry powders in the production of confectionery, dairy, bakery, pasta and other products not only to enrich them with functional ingredients, but also to impart new technological properties. Powders can improve the structural and mechanical properties of dough and the appearance of finished products. The antioxidant properties of berries remain after heat treatment.

Traditionally, apple pomace is used as animal feed [13]. Apple pomace does not contain phytic acid and is able to restore minerals, so it has an advantage over grain bran [14]. There are studies on the introduction of apple pomace powder into bakery [15-17] and confectionery flour products [18].

In the dairy industry, a study was conducted in which pomegranate powder was added before the fermentation operation to produce yogurt. The study showed that the powder increases the pH during gelation and reduces the fermentation time, while the yogurt has a firmer and more uniform texture during storage. These effects are due to the structure-forming effect of pectins, insoluble fibers released in milk [19].

In the meat industry, apple powder has been added to meat mixes for hamburgers [20] and chicken sausages [21]. During cooking, a decrease in water-holding capacity was observed.

There is a study on replacing 15%, 25%, 30% of wheat flour with pitahaya powder, which increases the content of proteins, dietary fibre and ash in the final products [22]. In the dairy industry, this powder was used as a fat substitute in strawberry ice cream. The rheological properties and melting point were not affected and were accepted by consumers from an organoleptic point of view. It was also added to pasteurized milk to determine its antioxidant effect [23].

Dietary fiber derived from citrus by-products has a high water retention capacity due to its viscosity and the possibility of multiple uses in food products. They play an important role in glucose homeostasis, reducing total lipid levels in the liver and maintaining intestinal health [24]. Pectin, derived from citrus powder, is used in the pharmaceutical industry as it accelerates the release of drugs [25].

Food additives can be added to raw materials and food products at different stages of production. Powders from wild berry processing derivatives can be used as a variety of food additives. Recently, natural colorants have been gaining special attention in the food industry as an alternative to synthetic ones. The available sources of anthocyanin dyes are unconventional raw materials – wild fruits and berries: currants, blueberries, chokecherries, black elderberries, cherries, dark grapes and their waste.

It is known that the waste of wild-grown raw materials is rich in fiber, biologically active substances, polyphenols, antioxidant compounds, and vitamins [26]. The chemical composition depends on the type of berry [27] and the drying method [28].

The use of non-traditional raw materials and food additives in food production is the subject of research by domestic and foreign scientists: A.M. Dorokhovych, M.M. Kalakuri, R.Y. Pavliuk, I.V. Syrokhmana, B.Sullivan, H.Kramer, Anna-Marja Aura, T.õnu Püssa, R.Pällin, Ul. Holopainen-Mantila and others. It has been shown that products from sprouted legumes (peas, beans), sunflower seeds, vegetable and fruit powders, algae, malt extracts, pumpkin and onion puree, Jerusalem artichoke, nettle powder, mountain ash, blueberry, coffee, rose hips, chicory, chokeberry, hawthorn, viburnum fruits, etc. are promising [29-31].

There are recent developments in the field of spray drying of berry juices, such as blueberries, blackberries, chokecherries, and maca berries.

Berries are known to accumulate a large number of different biologically active compounds, including polyphenolic antioxidants. Strawberries, raspberries, viburnum, and blackberries are the most popular berries in the world and are considered an important source of dietary antioxidants [32]. However, a large number of berry species remain poorly understood, especially wild berries.

The technology of powders rich in antioxidants and pigments from two wild berries – Chilean grape berry (*Aristotelia chilensis*) and Mediterranean blackberry (*Rubus ulmifolius*) – has already been developed [33].

It has been shown that fruit pomace has strong antioxidant properties and is a source of dietary fiber. It can be used as an effective functional ingredient for the development of fiber-enriched bakery and pasta products [34].

Red berry fruits are a good source for anthocyanin-rich powders. Rowan fruits (*Sorbus aucuparia L.*) contain procyanidin B1, carotenoids, catechin and epicatechin, ferulic acid methyl ester, and organic acids [35]. The antioxidant components of sea buckthorn (*Hippophae rhamnoides L.*) are flavonoids, such as kaempferol, catechin, epicatechin and isorhamnetin, phenolic acids, including p-coumaric, gallic and caffeic acids, as well as tocopherols [36].

Viburnum fruit is a natural source of various compounds with antioxidant properties, such as ascorbic acid (vitamin C), α-tocopherol (vitamin E), carotenoids, chlorophylls and phenolic compound [37].

Sambucus nigra berries are characterised by high antioxidant activity, as they contain natural polyphenolic compounds, primarily flavonols, phenolic acids and anthocyanins. *Sambucus nigra* has a high content of bioflavonoids, which has radioprotective, antioxidant and anti-inflammatory properties [38]. Elderberry powder is a good source of carbohydrates, calcium and magnesium, and is low in fat, making it a low-calorie product. Elderberry powder can be a potential alternative source of vegetable protein and fibre.

Also, processed plant products can add colour and stabilising properties to food products due to the presence of carotenoids and polyphenols. The degree of ripeness of the fruit affects the content of anthocyanins (ripe fruits have higher content), especially the amount of cyanidin-3-sambiobioside-5-glucoside, cyanidin-3-sambiobioside and cyanidin-3-glucoside [39]. Since anthocyanins are unstable compounds, the processing conditions of elderberry products are important, especially the temperature used [40].

Anthocyanins are found in significant quantities in black elderberry fruit and are natural colouring agents belonging to the flavonoid group [41].

Powders from viburnum derivatives can be used as antioxidant-rich flavour enhancers for bakery [42], confectionery [43] and meat products [44].

An analysis of scientific studies has shown that berry and fruit powders have functional properties and can be used as food additives in various food industries. As raw materials for the production of plant powders, it is advisable to use wild berries that grow well in the Ukrainian climate and are widely used in the production of food and culinary products: sea buckthorn, viburnum, elderberry, mountain ash, rose hips, hawthorn, chokeberry, etc.

In view of the above, it is advisable to produce powders from derivatives of wild berries processing. However, there are no studies on the content of micro and macronutrients in powders of some wild berries of regional importance. Such a study will allow to substantiate the need to process wild berry derivatives into powders and expand the areas of their application in food production.

The fruits of wild plants are food plant raw materials and a source of many biologically active components. They are often used for medicinal purposes, but there are practically no technologies for processing and using derivatives of processing wild berries in food production. This work is devoted to the study of the properties of powders made from the fruits of wild plants as functional food ingredients. The proposed method for processing the fruits of wild plants makes it possible to preserve their biological value and certain functional properties, knowing which areas of application can be formulated in food technologies.

The purpose of this work is to substantiate the feasibility of processing the fruits of wild plants V*iburnum opulus*, *Sorbus*, *Hippophae*, *Sambucus nigra* into functional food ingredients.

To achieve this goal, the following research **objectives** were developed:

1. to analyze the microstructure of berry powders;
2. to investigate and compare the mass content of micro- and macroelements in powders of *Viburnum opulus, Sorbus, Hippophae, Sambucus nigra;*
3. to study the physicochemical parameters of wild berry powders (dry matter, sucrose, solubility, acidity);
4. to study the content of dietary fiber in powders of *Viburnum opulus, Sorbus, Hippophae, Sambucus nigra.*

Research materials and methods

The powders were made from high-quality fruit and berry raw materials that were not damaged by diseases and pests. Wild fruits were thoroughly washed, disinfected and sorted. The washed fruits were pre-frozen at (-18±2)°C, and immediately before processing they were defrosted at (4±2)°C to improve their taste. The peculiarity of the developed technology for the production of powders from wild plant fruits is the use of osmotic dehydration. The dehydration apparatus is first fed with granulated sugar and drinking water in a ratio of 7:10. The mixture is thoroughly mixed and heated until the sugar crystals are completely dissolved. The mass fraction of sucrose in the sugar solution is not less than 70.0%. The resulting sugar solution was pasteurized at a temperature of (65±1)°C for 10 min. after which the berry fruits were added to it. The fruits were kept in a sugar solution with a mass fraction of sucrose of 70.0% at a temperature of (50±1)°C for 1 hour. Partially dehydrated fruits are separated from the osmotic solution and sent for drying in an infrared dryer at a temperature of (50±1)°C for 1 hour. Drying at a temperature not exceeding (50±1)°C is based on the fact that a significant amount of moisture is removed from the product and unfavorable conditions for the development of microorganisms are created, while the biological value of the fruit is preserved. The dried material is ground to a powdered structure using a laboratory disc mill LZM-1 and sieved using a set of brass sieves No. 045, No. 035 and No. 016. The 0.16 fraction can be used as natural coloring and flavoring agents, and the larger fraction can be used as an additive to increase the content of dietary fiber in food products.

The analysis of the mass content of trace elements in the studied samples was carried out using a SEM and EDS detector based on a SEO-SEM Inspect S50-B microscope.

The microstructure of the powders was studied using a scanning electron microscope REMMA-102 (OJSC "SELMI", Sumy).

The release of vitamin C from the experimental samples was studied by HPLC (Agilent Technologies 1200, UV-Vis Abs detector, detection at λ=240 and 300 nm, C18 column (Zorbax SB-C18 4.6 × 150 mm, 5 μm)). The following mobile phase was used: methanol and 0.02M KH_2PO^4 solution (20:80). Isocratic treatment was applied with an elution rate of 1 cm^3/min and an analytical column temperature of 40°C. The injection volume was 20 μL.

Samples were extracted by adding mobile phase (20 cm^3) to powdered (1 g) and liquid samples (5 cm^3). The samples were centrifuged three times (OPN-12 centrifuge) at 10,000 rpm for 10 minutes. The extracts were filtered using an Agilent 0.45 μm PTFE filter.

To determine the physico-chemical indicators, generally accepted standard research methods were used according to DSTU 6045:2008, GOST 30648.6-99, DSTU 4957:2008, GOST 13340.1-77 (Ukrainian State Standarts). To determine the mass fraction of moisture, a crushed 5 g powder was weighed in a pre-dried and weighed batch with a glass rod, lid, and sand.

The mass fraction of total sugar was determined by the permanganate method according to DSTU 4954:2008. Before determining the total sugar content, sucrose inversion was performed.

The final results were expressed as the mean ± standard deviation of the measurements from three separate extracts, and the measurements were made in three different studies. Comparisons of group means and the significance of differences between groups were tested by Student's t test. Statistical significance was set at $p \leq 0.05$.

Results of the research and their discussion

The microstructure analysis (Fig. 1–4) showed the presence of dietary fiber, which is characterized by high hydrophilicity and the ability to swell and structure formation. This microstructure indicates the possibility of using the powders as stabilizers.

It can be seen from the figures that all samples consist of polydisperse systems with different shapes and sizes of crystalline particles. Each particle is presented in the form of cells of mechanical and conductive tubular fabrics. Due to the sieve tubes formed by the conductive fabric, liquid media can freely pass through them and be retained inside the cells. Despite the same grinding conditions, the particle diameter differed significantly, which can be explained by the different structure of the seedless fraction of the dried powders.

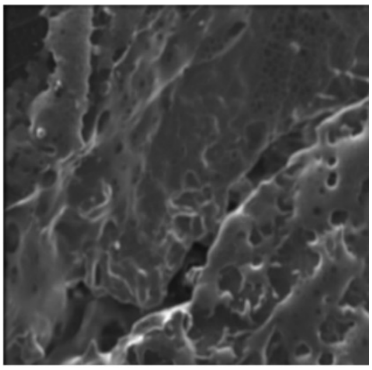

Fig. 1. Microstructure of elderberry powder (magnification 500μm)

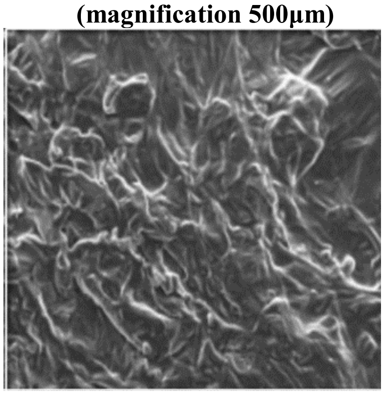

Fig. 2. Microstructure of rowan powder (magnification of 500 μm)

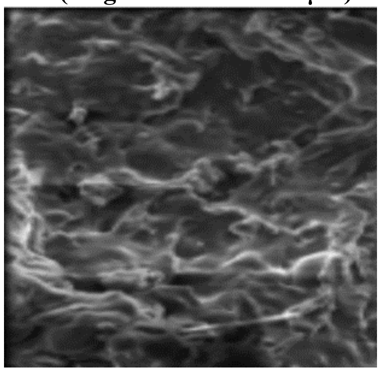

Fig. 3. Microstructure of the powder of viburnum powder (magnification 500 μm)

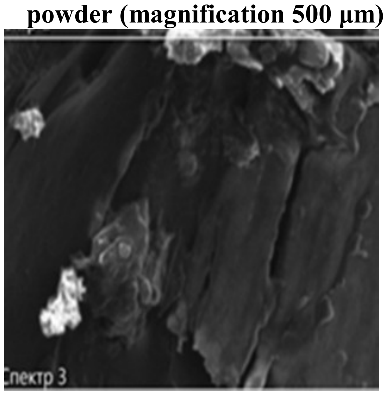

Fig. 4. Microstructure of sea buckthorn powder (magnification 500 μm)

The conductive tissue of sea buckthorn powders is partially destroyed during drying. We assume that this is due to the fact that partial denaturation of tissues occurs during heat treatment. Therefore, we chose a drying mode in which this process is not so intense (t=45-50°C, duration 2 hour).

The porosity of the powders obtained (the volume of free space between the powder particles) is slightly different. Voids in the powders occupy from 50 to 80% of the volume. The highest porosity is observed in sea buckthorn powder, and the lowest in rowan powder. The lower the density and the higher the porosity, the greater the degree of compression of the powder. This should be taken into account when setting the technological regime for adding powders to product formulations. It can be concluded that powders from wild berries have good hydrophilic properties and can be used as structure stabilizers, emulsifiers, moisture retainers and thickeners in the production of various food products.

The ability to swell depends on the surface characteristics of the particles, with elderberry powder showing pronounced porous particles. These particles showed lower electrostatic properties compared to the rowan powder particles, resulting in a noticeable swelling ability between the two powders.

Wild berries contain a large amount of minerals. Minerals play an important role in water, mineral, protein, fat and carbohydrate metabolism.

A comparative analysis of the content of macro- and microelements in powders made from wild berries is presented in Figures 5-8.

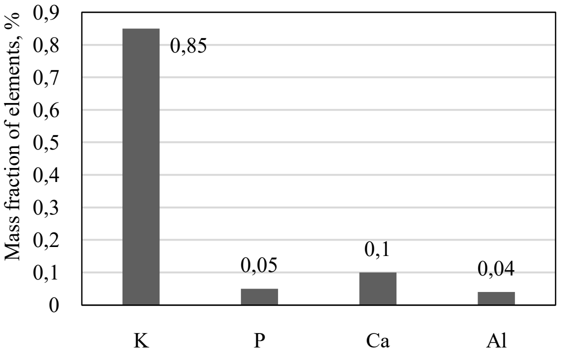

Fig. 5 Content of macro- and microelements in *Sorbus aucuparia powder*

Powders from rowan derivatives contain K, P, Ca and Al. The largest amount of potassium, which is necessary for the proper functioning of the heart and circulatory system, helps to maintain adequate blood pressure and muscle tone. Calcium affects the strength of bones and teeth, muscle tone, blood vessel function, and the activity of the nervous system Phosphorus is involved in most metabolic processes in the body, and is an indispensable element in the formation of nervous tissue. Aluminum is involved in the formation of epithelial cells and connective tissue, and phosphate metabolism [45].

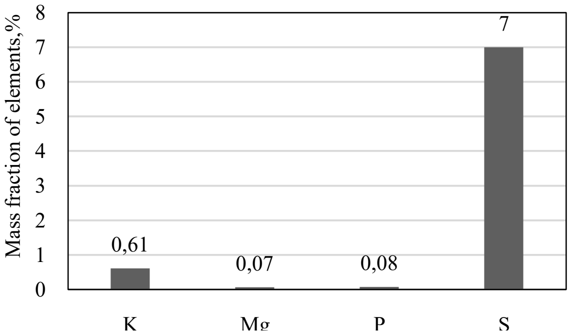

Fig. 6. Content of macro- and microelements in *Sambucus nigra powders*

Powders obtained from elderberry pomace are an important source of mineral elements. K, S, P, Mg were found in our samples. *Sambucus nigra* powder, according to our data, contains the highest amount of sulfur (7%), which is necessary for the functioning of the brain, blood vessels and liver [46].

We did not detect calcium, unlike the results presented in the study [47], where the content of minerals in elderberry fruits in elderberry fruits is 0.90-1.55% of their weight: K 391.33 mg/100 g; P 54.00 mg/100 g; Ca 28.06 mg/100 g; magnesium 25.99 mg/100 g, iron 1.86 mg/100 g; zinc 0.36 mg/100 g; manganese 0.27 mg/100 g; copper 0.14 mg/100 g. According to the research of Portuguese scientists [48], Ca, Mg, Fe, and Se were found in elderberry pomace powders.

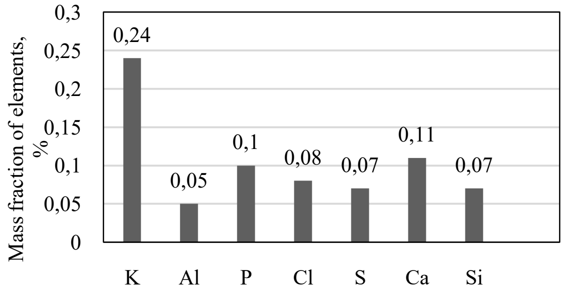

Fig. 7. Content of macro- and microelements in powders of *Hippophae rhamnoides L.*

Powders from sea buckthorn derivatives contain K, Ca, P, Al, S, Cl and Si. According to a study, Fe, Ca, P, and K [49] and 35 other elements were found in sea buckthorn. Potassium is the most abundant of all the identified trace elements [50,51] The content of the 4 main metals and phosphorus decreased in turn: potassium > calcium > phosphorus > magnesium > sodium [52].

The published data of sea buckthorn samples from different countries have large differences in the concentration of individual elements.

At the same time, the content of elements in plant material depends on many factors, including variety or species, plant parts, planting area, soil composition, fertilization, ripening period, etc. [53]. All of these samples from different sources and our studies of powders from sea buckthorn processing demonstrate these factors.

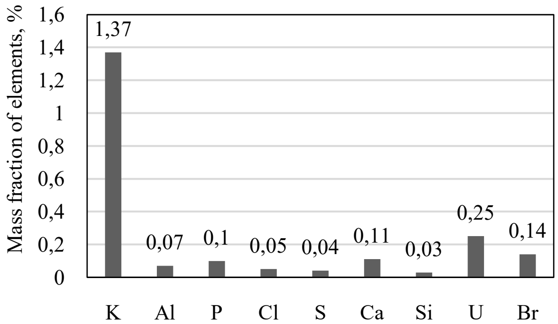

Fig. 8. Content of macro- and microelements in *Viburnum opulus powders*

In powders made from viburnum fruit derivatives, K, U, Br, Al, P, Cl, S, Ca, Si were found (Fig. 8). The highest amount of K was found in the samples – 1.37%. The content of Ca was 0.11%, and P 0.10%, Br 0.14 and U 0.25. Other researchers [54,55] also found the highest amounts of K, P, Ca, and 27 other minerals.

Bromine affects the proper activity of the thyroid gland, participates in the functioning of the central nervous system, and enhances inhibition processes.

By enriching food products with powders from wild berries, you can give them additional functional properties.

Vitamin C stimulates the launch of immune processes and also has antioxidant properties, so its content in powders from the derivatives of wild berries *Hippophae rhamnoides L., Viburnum opulus, Sambucus nigra* and *Sorbus aucuparia* was studied (Table 1).

A large number of studies have confirmed the important role of dietary fiber in human nutrition, health promotion, and prevention of lifestyle-related non-communicable diseases [56]. It has been shown that dietary fiber has a moisture-retaining ability, prevents bread from staling, and extends the shelf life of the product [57].

Table 1 – Vitamin C and fibre content in samples of powders from wild berry processing derivatives

Name	Value			
	Hippophae rhamnoides L.	***Viburnum opulus***	***Sambucus nigra***	***Sorbus aucuparia***
Vitamin C, mg/100 g	3.81	8.38	3.05	1.72
Crude fiber content, g/100 g	7.34	10.92	18.2	6.7

It was found that most of the vitamin C is retained in *Viburnum opulus* powders, the least of it remains in Sorbus aucuparia.

According to some scientists [58,59], the vitamin C content in fresh rowan fruits and their processed products is approximately 0.10–0.42 mg/g (10–42 mg/100g). The recommended dietary intake of ascorbic acid is 60 mg per day, and 5–7 mg per day prevents scurvy. Using osmotic dehydration and drying, the vitamin C content is reduced. But consuming 100 g of rowan powder can largely meet the vitamin requirement to prevent scurvy. The content of vitamin C in ethanol extracts of mountain ash [60] is 2.08 mg/100 g, which is significantly less than in powders obtained by the proposed method. When storing fresh frozen rowan fruits in a starch-sugar mixture, the vitamin C content decreases by 33-40% [61], however, the shelf life of such berries is only 6 days. Using the processing method proposed by us, the shelf life of the powders is 12 months.

The content of vitamins in *Hippophae rhamnoides L* is very high, among which the content of vitamin C is the highest, reaching 800–3909 mg/100 g of sea buckthorn fruit is 2–10 times higher than in kiwi [62].

Viburnum opulus contains 70% more vitamin C more vitamin C than lemon [63]. According to recent studies [64,65], natural carotenoids and ascorbic acid (vitamin C) contained in viburnum protect the body from cancer, have a significant antioxidant effect and prevent premature ageing. Thus, the addition of viburnum powders or extracts to food products can increase their nutritional value, and due to the presence of antioxidants in the powders, increases the shelf life and expands the raw material base of the food industry industry.

The highest content of crude fibre is found in powders made from Sambucus nigra, and the lowest in powders made from Sorbus aucuparia. Thus, all types of powders can be used for enriching foods with dietary fibre or increasing their moisture retention capacity.

The recommended level of dietary fibre intake is about 20–25 g per day. Thus, consuming 100 g of viburnum and elderberry powders can provide more than 50% of the daily requirement. This indicates the effectiveness of the use of the presented plant powders for food enrichment.

In terms of physicochemical parameters, plant powders from berry processing derivatives (viburnum, elderberry, sea buckthorn, mountain ash) correspond to the indicators presented in Table 2.

An important indicator of the quality of plant powders is the mass fraction of moisture, as it affects their storage capacity [66]. The mass fraction of total sugar in powders from wild berry derivatives affects their nutritional value and the nutritional value of products made on their basis. Sucrose is a kind of preservative and gives the powders the properties of sweeteners. However, it is worth noting that the content of of sucrose in some food products is limited, especially in baby food.

Powders with a mass fraction of moisture less than 8% can be stored for a long time without deterioration in quality with almost complete preservation of the original nutritional value and can be used in food technologies wide range of products.

Table 2 – Physicochemical quality indicators of plant powders

Name	Value, mg/100 g			
	Hippophae rhamnoides L.	Viburnum opulus	Sambucus nigra	Sorbus aucuparia
Mass fraction of moisture, %	7.46	6.14	4.44	5.77
Dispersibility, mm	<0.5	<0.5	<0.5	<0.5
Active acidity, units pH	4.15	4.23	4.71	4.65
Titratable acidity (in terms of malic acid), %	0.58	0.46	0.33	0.21
Solubility, %	77.0	77.8	79.5	80.1
Mass fraction of reducing sugars, %, not more than	29.9	37.1	50.0	37.9

In terms of physicochemical parameters, all samples of plant powders from berry processing derivatives (*viburnum, elderberry, sea buckthorn, mountain ash*) meet the requirements of DSTU 8498:2015.

Vegetable powders from berry processing derivatives are intended for use in bakery and confectionery production as acid- and sugar-containing raw materials rich in pectin, vitamins and minerals.

A formulation of pasta (noodles) with the addition of powders from derivatives of wild berries *Sambucus nigra, Viburnum opulus, Hippophae rhamnoides L*. has been developed [67]. There are already studies on the use of sea buckthorn derivatives in the production of butter buns [68], elderberry in the production of yogurt [69], and rowan in the production of bread [70].

Conclusions

1. The development of new generation products from environmentally safe and biologically valuable plant materials is a topical area of food industry development. This includes wild-grown raw materials. It is known that the fruits of wild plants contain a balanced complex of vitamins, minerals, proteins, lipids and have high nutritional, flavour and therapeutic and preventive properties.

2. Powders from wild berry derivatives (Hippophae rhamnoides L, Viburnum opulus, Sambucus nigra, Sorbus aucuparia) have been found to contain essential macro- and microelements.

3. Wild berries are rich in vitamin C, the highest amount of which is contained in powders from Viburnum opulus.

4. The analysis of the microstructure of berry powders made from wild berries showed that all powders have a polydisperse, crystalline, porous structure. This structure and form gives them hydrophilic properties. This makes it possible to use them as functional food additives to improve the structure and moisture retention capacity of foods, as well as to increase the content of dietary fibre in them.The highest crude fibre content was found in powders from Sambucus nigra, and the lowest in powders from Sorbus aucuparia.Thus, all types of powders can be used to enrich foods with dietary fibre or increase their moisture retention capacity.

5. The results obtained indicate the feasibility of processing berry products (viburnum, elderberry, sea buckthorn, mountain ash) into functional food powders.

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ПЕРСПЕКТИВИ ВИКОРИСТАННЯ ПРОДУКТІВ ПЕРЕРОБКИ ДИКОРОСЛИХ ЯГІД ЯК ФУНКЦІОНАЛЬНИХ ХАРЧОВИХ ІНГРЕДІЄНТІВ

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Анотація. Метою даного дослідження є обгрунтування доцільності переробки плодів дикорослих рослин (*Viburnum opulus*, *Sorbus*, *Hippophae*, *Sambucus nigra*) у функціональні харчові інгредієнти. В статті проаналізовано структуру порошків з дикорослих ягід *Viburnum opulus*, *Sorbus*, *Hippophae*, *Sambucus nigra*, досліджено вміст мікро- та макроелементів у порошках; фізико-хімічні показники порошків із дикорослих ягід (сухі речовини, масова чатка вологи, дисперсність, масова частка редукувальних цукрів,озчинність, кислотність) та вміст харчових волокон у порошках *Viburnum opulus*, *Sorbus*, *Hippophae*, *Sambucus nigra.* Дослідні зразки були виготовлені із якісної плодово-ягідної сировини не пошкодженої хворобами та шкідниками. Для виготовлення порошків ягоди зневоднювали методом осмотичної дегідратацію, потім висушували у інфрачервоних сушарках протягом 2 годин за температури 50°С до масової частки вологи 6–8%. Висушені ягоди подрібнювали на лабораторному млині ЛЗМ-1. Методом електронної мікроскопії досліджено структуру ягідних порошків. Встановлено, що порошки мають кристалічну пористу структуру, а відповідно гідрофільні властивості. Це дає можливість їх використання при виробництві харчових продуктів в якості стабілізаторів структури, емульгаторів та вологоутримувачів. Дослідження вмісту деяких мінеральних речовин в зразках проводили за допомогою детектора SEM та EDS на основі мікроскопа. Встановлено, що порошки містять макроелементи (K, Ca, P, Cl, S, N), незамінні мікроелементи (Mg) та умовно життєво необхідний мікроелемент Si, який виявлено в порошках з калини та обліпихи. Отримані порошки з дикорослих ягід *Hippophae rhamnoides L.*, *Viburnum opulus*, *Sambucus nigra* та *Sorbus aucuparia* містять значну кількість вітаміну С. За всіма фізико-хімічними показниками зразки рослинних порошків із ягід калини, бузини, обліпихи, горобини відповідають вимогам ДСТУ 8498:2015. Такі результати свідчать про доцільність переробки *Viburnum opulus*, *Sorbus*, *Hippophae*, *Sambucus nigra* у функціональні харчові інгредієнти.

Ключові слова: *Viburnum opulus*, *Sorbus*, *Hippophae*, *Sambucus nigra*, функціональні харчові інгредієнти, зневоднення, структура, мінеральні речовини, вітамін С