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JUSTIFICATION OF THE USE OF CHOKEBERRY POWDER IN THE PRODUCTION OF JELLY CONCENTRATE

M. Samilyk, Doctor of Technical Sciences, Associate Professor
Y. Iliashenko, postgraduate student
Department of Technology and Food Safety
Sumy National Agrarian University
Gerasima Kondratieva St., 160, Sumy, Ukraine, 40021

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Correspondence:

Y. Iliashenko
E-mail: yannulia0911@gmail.com

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Abstract. The study is devoted to substantiating the feasibility of using products of the processing of chokeberry fruits (Aronia melanocarpa) in food concentrates, using the example of jelly. The structure and mineral composition of chokeberry fruit powder were analyzed, and a recipe for a food jelly concentrate based on it was proposed. Fruit dehydration occurred in two stages: preliminary, by osmotic dehydration (τ=1 h), and the main, by drying in an infrared dryer (τ=6 h). The dried fruits were ground using a laboratory mill to a size that ensures complete passage of the material through a sieve No. 010. It was established that the rowan powder has a crystalline porous structure and hydrophilic properties, which allows it to be used as a functional food additive. It was found that the powder from the fruits of chokeberry contains several trace elements necessary for the human body (K, Ca, Mg, Si, P), among which the share of potassium (7.34%) and calcium (1.38%) was the highest. The use of rowan powder in the production of food products can contribute to increasing the overall nutritional value of finished products, especially in the diet of people who need increased potassium intake, since even 10 g of powder in the product formulation provides 24.5% of the need for this trace element. A jelly concentrate formulation based on rowan powder was developed. The sensory analysis of the jelly, according to the Likert scale, showed that the finished product had excellent indicators, provided that the content of rowan powder in the formulation was 77%, according to the weight of the concentrate mixture. Pre-treatment of the fruits in a sugar solution, with osmotic dehydration, improved their taste properties and allowed the exclusion of sugar from the concentrate formulation.

Keywords: chokeberry, powder, food concentrate, jelly, minerals, fiber.

Introduction. Formulation of the problem

In times of war, ready-to-eat food is especially relevant; however, it is important to pay attention to its composition and impact on the human body. Most food concentrates contain cheap, non-beneficial ingredients and artificial flavoring additives.

In the search for new ideas, technologies, and raw materials with beneficial properties, the use of wild plant materials is gaining popularity and widespread application. In this context, *Aronia melanocarpa* (black chokeberry) deserves particular attention, as it is increasingly attracting researchers due to its rich chemical composition and valuable biologically active substances.

The fruits of black chokeberry are a source of vitamins, minerals, polyphenols, and other nutrients that have a positive effect on human health. Moreover, black chokeberry is well known for its antioxidant properties [1], owing to its high content of polyphenols [2]. Chokeberry powder is used as a colorant and flavoring additive in the production of food products and beverages [3]. Due to its high anthocyanin content, it provides stable shades, which are especially valued in the manufacture of drinks, confectionery, dairy products, as well as in baking and frozen desserts [3,4].

In addition, the use of black chokeberry as a natural colorant helps reduce the need for synthetic additives, aligning with the demands of the modern healthy food market and environmental standards. However, despite all its advantages, there is an almost complete absence of industrially manufactured food products based on black chokeberry processing derivatives.

Considering the current challenges faced by Ukraine, including the war and energy resource shortages, the development of naturally-based food concentrates is a relevant task for scientists and industry specialists.

Analysis of recent research and publications

Wild plants play an essential role in the development of medicinal products. It has been scientifically proven that adding chokeberry to the diet improves the general well-being of people, especially the elderly, and reduces the risk of cardiovascular diseases [5]. Chokeberry contains vitamin C, as well as minerals, including magnesium (Mg), copper (Cu), iron (Fe), manganese (Mn), selenium (Se), and zinc (Zn) [6].

The healing properties of chokeberry are mainly due to the high content of antioxidants, especially polyphenols, such as anthocyanins, procyanidins, phenolic acids, and flavonoids. The main contribution to the overall antioxidant capacity of chokeberry, namely about 60%, is provided by anthocyanins, flavonols, and hydroxycinnamic acid derivatives. Among polyphenolic compounds, the most potent antioxidant activity is distinguished by quercetin, cyanidin-3-glucoside, and chlorogenic acid [7]. Another approximately 40% of the total antioxidant potential is accounted for by proanthocyanidins, essential polyphenolic components of chokeberry [8]. Chokeberry anthocyanins demonstrate a high ability to neutralize free radicals and significantly surpass other phenolic compounds in this property [9]. It has been determined that chokeberry juices and fibers, in addition to polyphenols and anthocyanins, also have a high content of trace elements (Mg, Fe, Cu, Mn, Zn) [10]. Due to the high concentration of biologically active substances, chokeberry fruits have various pharmacological effects, including antioxidant, anti-inflammatory, and gastroprotective [11]. Regular consumption of chokeberry and its processed products prevents chronic diseases, particularly metabolic disorders, diabetes, and pathologies of the cardiovascular system [5].

Chokeberry fruits are consumed fresh or dried. Dried fruits are often used as an additive in the production of bread. It has been established that adding rowan improves its appearance, taste, and aroma and positively affects physicochemical parameters [12,13]. It has been established that adding chokeberry cake to shortbread significantly increases the content of polyphenols, anthocyanins, and antioxidant activity of products, while maintaining acceptable sensory properties [14]. Chokeberry is also widely used to produce functional beverages (juices, nectars, teas) [15]. However, such processing of fruits leaves a significant part of the waste that must be disposed of.

It is known that fresh berries have a high water content, and therefore, they are prone to mechanical damage during transportation or storage, enzymatic reactions, and microbial spoilage. Removing water from these products by various processes prevents undesirable physicochemical responses, ensuring a longer shelf life. Based on this, pre-treatment of fruits by drying them is one of the methods used to remove water from products. Drying can significantly reduce or completely neutralize physiological, microbial, and enzymatic degradation [16]. However, when drying, it is essential to consider that this process can cause specific adverse effects, such as the loss of bioactive components and a change in the product's texture. Excessive temperature or drying duration can lead to the degradation of vitamins, antioxidants, and aromatic compounds, which, in turn, will affect the final product's nutritional value and organoleptic characteristics. Optimization of drying parameters is critical to ensure a balance between effective water removal and product quality preservation [17].

Several methods for dehydrating plant raw materials are used for food processing. First of all, convective drying is widely used. Among the advantages of convective drying are simple operation of the equipment, precise control of temperature and air flow rate, low cost, and simple design [18]. However, this method has several disadvantages, which are associated with the lengthy drying process, increased temperature, which leads to the degradation of some essential compounds in the product, enzymatic and non-enzymatic roasting reactions, and visible shrinkage. It has been established that, compared with traditional convective drying (CD), the FBJD method provides significantly lower vitamin C losses and better powder microstructure [19].

Freeze drying has a milder effect on the products to be dried. Products dried by this method retain color, aroma, and nutrients such as vitamins and antioxidants. The freeze-drying method causes slight shrinkage and destruction of the product structure, thereby ensuring its high porosity and low density [20]. It has been proposed that freeze-dried elderberries and chokeberries be used as natural colorants for gluten-free wafers. It was found that the prepared wafers had a significantly higher content of minerals, in particular iron, potassium, calcium, magnesium, and sodium [21]. However, freeze-drying requires preliminary preparation of the raw materials in the form of freezing and has a high level of energy consumption.

Some researchers compared changes in the quality characteristics of chokeberry (Aronia melanocarpa) powders obtained by freeze-drying and convective drying methods. The moisture (%) values and water activity of the powders obtained by these drying methods were within 9.29% and 10.86%, 0.2373 and 0.2963, respectively. Both drying procedures caused significant changes in the color properties of the powders. The total content of phenols and flavonoids in the methanol and aqueous powder extracts obtained by freeze-drying was higher than that obtained by convective drying [22]. However, both methods are quite energy-intensive.

The effect of high-pressure parameters for the production of milkshakes with the addition of chokeberry pomace was investigated. The results showed that this process contributes to the preservation of phenolic compounds and increases the antioxidant activity of the dairy product [23]. However, the effect of osmotic dehydration and IR radiation on preserving the beneficial properties of chokeberry derivatives has not been sufficiently studied. Therefore, it is essential to investigate whether all valuable nutrients are maintained during these processes to assess the effectiveness of these methods in the food industry.

IR drying is widely used for processing various plant products, including fruits, vegetables, and herbs, demonstrating its versatility and efficiency [24,25]. IR drying provides direct thermal impact on the material, which reduces overall energy consumption compared to traditional methods. Infrared radiation transfers heat to the material faster, which reduces drying time. This method is beneficial for processing large quantities of raw materials or in conditions of limited time [26]. The radiation can be tuned to a specific wavelength, which helps preserve bioactive components and vitamins in plant materials better than traditional drying methods. IR drying is carried out without direct contact with the material, which reduces the risk of mechanical damage and preserves the integrity of the fruits [27].

Having analyzed all the advantages and disadvantages of various drying methods, it was proposed to use IR drying with preliminary osmotic dehydration to process chokeberry fruits.

In the process of osmotic dehydration, the cells of the plant raw materials are partially dehydrated by creating excess osmotic pressure with a supersaturated sugar solution [28]. As a result, a partially dehydrated product and an osmotic solution are formed. The solution can be used as a base or additive in preparing non-alcoholic, low-alcohol, and alcoholic beverages, because it has a reasonably high quality and satisfactory physicochemical parameters after osmotic dehydration. It is noted that osmotic dehydration of mountain ash before drying helps maintain a high level of anthocyanins and flavonoids, key components for ensuring human health. It has been demonstrated that osmotic dehydration helps to improve the sensory characteristics of mountain ash, including texture and taste [29]. It has been proven that osmotic dehydration before IR drying saves the plant raw materials ' high quality and nutritional value, reduces drying time, and improves the final product [30]. However, the ways of further use of spent osmotic solutions and dried fruits are not shown.

The most rational way to further process dehydrated products is to grind them into powders that can be used as natural food additives. One of the directions for using plant powders is their introduction into the formulations of food concentrates. It has been determined that fruit concentrates can significantly increase the nutritional value of finished products, particularly jelly, and their shelf life. The use of concentrates improves organoleptic properties, such as texture, color, and aroma, and also positively affects physicochemical properties, such as hardness, acidity, and color of jelly [31]. However, no studies have been found on the impact of adding chokeberry powder obtained by osmotic dehydration on the biological value of food concentrates. Thus, considering modern trends in the food industry and the problem of deficiency of vital micronutrients in the population's diet, it is advisable to study the mineral composition, microstructure of chokeberry powder, and justify the possibility of its use in jelly concentrate formulations.

The purpose of this work is to study the mineral composition, microstructural characteristics of black chokeberry powder and substantiate the feasibility of its use in the jelly concentrate. The use of these products in the production of food helps solve the problem of the deficiency of essential nutrients in the population's diet.

To achieve this goal, the following **research tasks** have been developed:

– to study the microstructure of powder from chokeberry fruits obtained by a combined dehydration method;

– to study the content of minerals in powder from chokeberry fruits obtained by a combined dehydration method;

– to develop a recipe for a food concentrate "jelly" based on rowan powder and conduct its sensory evaluation.

Research materials and methods

Powder samples for the study were prepared from chokeberry fruits (Aronia melanocarpa) of the 2023 harvest, collected in September. Ripe fruits were cleaned of stem residues and other impurities manually, thoroughly washed with warm water to remove dirt and other contaminants. After washing, the rowan berries were dried on a towel to remove excess moisture. The prepared berries were loaded into the working chamber of the osmotic dehydrator, together with a previously prepared concentrated sugar solution (70%) in a ratio of 1:1. Osmotic dehydration was carried out for one hour at a temperature of 50°C [28].

The partially dehydrated fruits separated from the solution were dried to 8–10% moisture content. The duration of the infrared drying process in a WetAir WFD-K700BSS laboratory dryer was six hours at a temperature of 50°C [28]. To achieve the required particle size of the working material, the dried fruits were subjected to fragmentation by grinding in a Tekhniko HMG-3060 mill. The mill has three pairs of millstones and a function to adjust the grinding degree, which ensures high efficiency and uniform grinding of the product, resulting in particles of the desired size. The powder was sieved through a woven brass sieve to obtain the desired fraction.

The mass composition of micronutrients in the powder from chokeberry fruits was determined by scanning electron microscopy using an AZtecOne dispersion spectrometer and an X-MaxN20 detector. The powder samples were pre-dried in a vacuum drying oven to a constant mass and applied to aluminum pillars using a carbon conductive tape. To ensure electrical conductivity, the surface of the samples was covered with a thin layer of carbon using cathodic sputtering in a vacuum sputtering device. Scanning was carried out in high vacuum at an accelerating voltage of 15–20 kV. The analysis was performed in the point scanning mode and the form of a mapping of the sample area. The elemental composition was determined based on X-ray peaks from the energy-dispersive spectrum. Quantitative analysis was performed using the built-in microscope software, with correction for background radiation and matrix effects. The results were presented as the mass fraction of the main trace elements in the sample (in particular, K, Ca, Mg, etc.), considering the average values from several measurements.

A REMMA-102 scanning electron microscope was used to study the microstructure of the powders. Sample preparation included the creation of a suspension of the powders in distilled water at a temperature of 30°C for 20 minutes. The resulting suspension was applied to the surface of a silicon single crystal, KEF (111), and dried in a vacuum until the solvent was evaporated entirely. Scanning of the sample surface was carried out with an electron beam with a diameter of up to 5 nanometers, with an electron energy of 20 kV. Images were obtained with a magnification of 80 to 800 times and a resolution of 5 nanometers in the elastically reflected electron (COMRO) mode.

Based on Rowan powders, recipes for food jelly concentrates were developed, which were compared with the industrially produced concentrate. The jelly concentrate "Blueberry and Blackberry" (TM "Mriya") was used as an analogue (Table 1).

To prepare the final jelly dish based on the concentrate, water was heated to a temperature of 40-50°C, avoiding boiling to maintain the activity of the recipe components. Heated water in the amount indicated in the formulation (Table 1) was gradually added to the concentrate. The mixture was thoroughly mixed for 3– minutes until the concentrate was dissolved entirely, ensuring the homogeneity of the mass and preventing the formation of lumps. The resulting homogeneous mixture was cooled to 20 °C for 10–15 minutes, poured into molds to form the finished product, and left to solidify at 4–8°C.

The resulting product was subsequently subject to sensory analysis. Sensory evaluation was performed by a group of non-professional tasters (20 people) with previous experience in organoleptic evaluation of food products, according to pre-defined criteria, using a 5-point Likert scale (Table 2).

Statistical analysis of experimental data on the organoleptic assessment of jelly was carried out using generally accepted methods of mathematical statistics, using Microsoft Excel 2016 software. The probability of differences between the mean values of organoleptic parameters (overall quality, appearance, color, taste, aroma, texture) was assessed using Student's t-test at three levels of statistical significance: $p < 0.05$, $p < 0.01$, and $p < 0.001$.

The results are presented in tabular form as mean ± standard deviation. To indicate statistically significant differences between samples, superscripts were used in various small Latin letters (a, b, c). Values denoted by different letters differed statistically significantly at $p < 0.05$ or higher, while the same letters indicated no statistically significant differences.

Based on the sensory evaluation results, a rational formulation of food concentrate was established.

Table 1 – Jelly recipe, g

Name of components	Analog	Experimental Samples	
		Sample 1	Sample 2
Concentrate			
Granulated sugar	86.0	–	–
Gelatin	10	17.0	23.0
Acidity regulator (citric acid)	1.5	–	–
Fruit powder “Blueberry and blackberry”	0.01	–	–
Natural red colorant (carmine acid)	1.5	–	–
Antioxidant (ascorbic acid)	0.99	–	–
Chokeberry powder	–	83.0	77.0
Total	100.0	100.0	100.0
Finished product			
Jelly concentrate “Blueberry and blackberry” (TM “Mriya”), g	90.0	–	–
Jelly concentrate “Chokeberry”	–	60.0	60.0
Water, ml	300.0	300.0	300.0
Total	360.00	330.00	330.00

Table 2 – Jelly sensory analysis criteria

Score	Appearance	Color	Taste	Aroma	Texture
Concentrate					
1-3	Heterogeneous mixture with lumps and foreign inclusions				
4-5	Homogeneous mixture without foreign inclusions. A small number of loosely bound lumps are allowed, which disintegrate under slight pressure				
Finished product					
1–3	Unattractive, unstable mass that does not retain its shape	Pinkish-purple, unsaturated or overly intense	Weakly pronounced, with a slight aftertaste of chokeberry or overly concentrated, not quite pleasant	Weak, indistinct or overly concentrated	Non-uniform
4–5	Attractive, stable mass that retains its shape	Purple, saturated	Sweet-sour, well-defined, typical for chokeberry, with no off-flavors	Pleasant, distinct	Dense, elastic, uniform

Results of the research and their discussion

The image of the microstructure of the powder from the chokeberry mountain ash is presented in Figure 1. This image shows that the powder consists of polydisperse particles of various sizes and shapes.

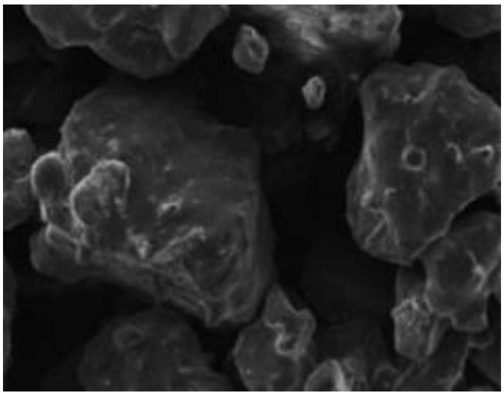

Fig. 1. **Microstructure of black chokeberry powder (increase 500µm)**

Black chokeberry powder particles have a rough texture with distinct contours. Most particles have an irregular, uneven surface with numerous protrusions. Such a microstructure indicates a high specific surface area of the powder, which can positively affect its functional properties, particularly the ability to bind water. The presence of irregularities in the structure can also improve the rheological properties of products based on powder from the fruits of black chokeberry and slow the release of active substances during digestion. The results indicate the potential of using this powder as a functional ingredient in food products, particularly in producing jelly desserts, bars, or drinks [3].

A study of the mineral composition of the powder from the fruits of the chokeberry rowan showed that it contains several micronutrients necessary for the human body. Among them: K, Mg, Ca, P and S (Fig. 2).

The high potassium content (7.34%) emphasizes its importance for the functioning of cells and metabolic processes. Potassium is responsible for the body's water balance and helps maintain normal blood pressure and the nervous and cardiovascular systems. Calcium in the powder (1.38%) is essential for bone tissue and other physiological functions of the human body.

The value of powder from the fruits of chokeberry emphasizes the presence of magnesium. Although it is contained in a small amount (0.11% in dry matter), its content is significant and necessary for many biochemical reactions and processes.

It is worth noting that other researchers found more magnesium, copper, iron, manganese, selenium, and zinc in the composition of powders from chokeberry [6]. Our study sample did not find Manganese, selenium, zinc, or iron. However, it was found that rowan powders also contain phosphorus (0.31%) and sulfur (0.12%).

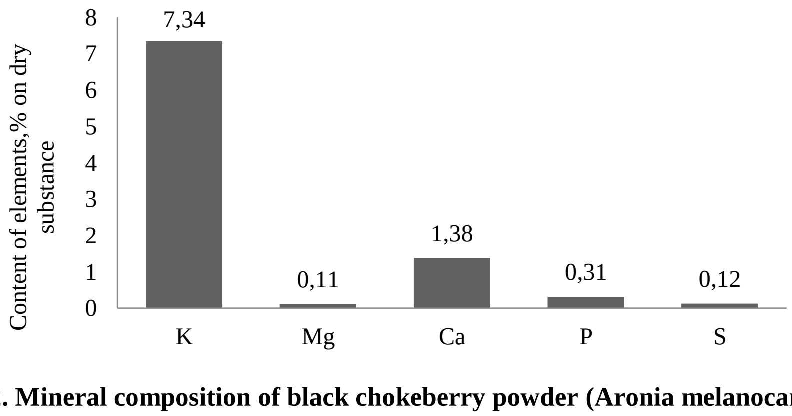

Fig. 2. Mineral composition of black chokeberry powder (Aronia melanocarpa)

To prepare jelly based on black chokeberry powder, several options for different amounts of recipe ingredients were considered. Based on the sensory evaluation results, there were a few jelly samples with black chokeberry powder. Both samples were scored on five key indicators: appearance, color, taste, aroma, and texture. For each sample, mean values of estimates and standard deviations were calculated, which allows for the assessment of the variability of the perception of the product by tasters (Table 3). The overall quality indicators were significantly higher in the analogue compared to sample 1 by 0.20 points or 4.17% (p<0.05), and compared to sample 2, only a tendency to a slight excess of 0.10 points was established. Both test samples did not have significant differences in the overall quality indicator.

The analogue sample was rated higher in appearance than sample 1 by 0.80 points or 16.67%, and when compared with sample 2, tasters did not find any noticeable differences. At the same time, sample 1 was inferior to sample 2 in appearance by 0.70 points or 17.50% (p<0.001).

The color study allowed the tasters to note the best value for the analogue - 4.9 points, which significantly exceeded the score of the first experimental sample by 1.00 points or 20.41% (p<0.001). Still, it was equal to the score of the second sample. Comparison of experimental samples 1 and 2 resulted in 3.9 and 4.8 points, respectively, but with a significant difference in favor of the second, which was 0.90 points or 23.08% (p<0.001). The highest score for the best taste qualities of 4.8 points was received by sample 2, exceeding the evaluation results of both experimental sample 1 by 1.00 points or 20.83% (p<0.001) and the results of the analogue by 1.60 points or 33.33% (p<0.001). It should be added that the analogue was inferior to the experimental sample 1 in terms of taste score by 0.60 points or 15.79% (p<0.001).

It can be stated that the tasters noted the analogue concentrate's aroma was too saturated, which is not characteristic of a natural product. Therefore, the latter received the lowest score of 3.00 points. At the same time, the second experimental sample (4.7 points) was noted for better aromatic properties, which surpassed both the first experimental sample by 0.60 points or 12.77% (p<0.001) and the analogue by 1.70 points or 36.17% (p<0.001). Also, the aroma of the experimental sample 1 (4.1 points) was significantly higher than the analogue by 1.70 points or 36.17% (p<0.001).

In terms of texture, tasters' preferences were distributed in favor of the analogue with a total of 4.9 points, which was higher by 1.10 or 28.95% (p<0.001) and 0.20 or 4.26% (p<0.02) compared to samples 1 and 2, which received 3.8 and 4.7 points, respectively. Of the two experimental samples, the second sample 2 (4.7 points) had a higher evaluated texture compared to the first by 0.690 points or 19.15% (p<0.001). Therefore, according to organoleptic indicators, the optimal option for making jelly from chokeberry powder was the recipe component of Sample 2.

Compared to the analogue recipe (Table 1), the experimental samples do not contain additional artificial sweeteners and preservatives, which increases their naturalness and promotes healthy eating. The high sugar content in the analogue recipe makes this product unacceptable for consumption by people with different stages of diabetes, as this can lead to a significant increase in blood glucose levels.

Red carminic acid, which is used in commercial products to achieve intense color, is a synthetic dye that can cause allergic reactions in consumers. The developed jelly based on chokeberry powder provides natural color and the absence of artificial additives, which meets modern requirements for food products. As a result, the resulting product met all quality requirements, providing an attractive appearance, pleasant taste and aroma, and a homogeneous texture, which adds to the consumer's positive perception of the product.

Thus, jelly made based on chokeberry concentrate demonstrated several advantages compared to its analogue, making it more suitable for a wide range of consumers, including those seeking to avoid excessive sugar and artificial components. This emphasizes the potential of the new product for integration into the diet of people who adhere to the principles of a healthy lifestyle. This jelly can be used as an independent dessert or a component of other confectionery products.

The daily need of the human body in micronutrients and its provision when consuming 100g of jelly based on chokeberry powder are given in Table 4 [32].

Table 3 – Results of sensory evaluation of jelly based on chokeberry powder

Sample	Analog	Sample 1	Sample 2
Concentrate			
General quality indicators	$4.8±0.05^a$	$4.6±0.05^b$	$4.7±0.08^{ab}$
Finished product			
Appearance	$4.8±0.08^a$	$4.0±0.06^b$	$4.7±0.08^a$
Color	$4.9±0.05^a$	$3.9±0.05^b$	$4.8±0.07^a$
Taste	$3.2±0.06^c$	$3.8±0.05^b$	$4.8±0.07^a$
Aroma	$3.0±0.11^c$	$4.1±0.05^b$	$4.7±0.08^a$
Texture	$4.9±0.05^a$	$3.8±0.05^c$	$4.7±0.08^b$

Notes: different small letters (a, b, c) denote statistical differences between groups at p < 0.05 and above; identical letters indicate no statistically significant difference between samples

Table 4 – Ensuring the daily requirement of the human body for micronutrients when consuming jelly from chokeberry

Micronutrient	Daily requirement, g	Micronutrient content in chokeberry powder, g/100g	Daily requirement met when consuming 100 g of powder,%	Daily requirement met when consuming 100 g of jelly,%
K	3.00	7.34	245	34.3
Mg	0.40	0.11	28	3.9
Ca	1.10	1.38	125	17.5
P	0.70	0.31	44	6.2
S	50.00	0.12	0.2	0.03

The results confirm that the powder from the chokeberry fruits obtained by the proposed method is a rich source of important mineral elements necessary for the human body's normal functioning. The level of enrichment with micronutrients should be 20–50% of the daily requirement for the micronutrient in the case of the usual level of product consumption. According to the obtained consumption data, the introduction of 50–100 g of rowan powder into the formulation of finished products will give it functional properties and provide the daily requirement of the body in such essential minerals as K and Ca to a significant extent (15–35%) and provide the daily requirement for magnesium and phosphorus. The high potassium and calcium content make rowan powder a promising ingredient for enriching food products to increase their nutritional value and improve public health. The use of rowan powder in the production of food products can help increase the overall mineral value of finished products, especially in the diet of people who need increased potassium intake, since even 10 g of powder in the product formulation will provide 24.5% of the need for this trace element.

Potassium performs several essential bodily functions, including regulating fluid balance, promoting proper muscle and nervous system function, and controlling blood pressure. It also participates in carbohydrate metabolism and maintaining normal heart function, which makes it extremely important for overall health.

The high calcium content in the powder will help strengthen bones and teeth, especially for children, adolescents, and older people. Calcium also plays a vital role in hematopoiesis, regulating muscle contractions, and transmitting nerve impulses.

The body needs magnesium and phosphorus for many vital processes. Magnesium promotes energy metabolism, supports muscle function, and is also involved in forming human bones. Phosphorus, in turn, is the main component of cell membranes and DNA. It is also essential for creating energy as ATP, making it indispensable for metabolic processes.

Thus, including chokeberry powder in the diet can significantly improve the nutritional value of products and provide the body with necessary micronutrients, contributing to the general strengthening of the population's health.

Approval of research results. To enable the use of chokeberry powder in producing food products, technical conditions "Chokeberry Powder" TU U 10.8-04718013-012:2024 have been developed.

Conclusions

1. Analysis of the microstructure of the powder produced by a complex processing method from chokeberry fruits showed that this powder has a polydisperse, crystalline structure. Accordingly, it can be used to improve the texture and moisture-holding capacity of products and increase the content of dietary fiber, which is especially important in the production of functional food products.

2. It was found that chokeberry powder contains many essential micronutrients, such as potassium, calcium, magnesium, phosphorus, and others. According to the data obtained, the introduction of 50–100 g of chokeberry powder into the formulation of finished products will give it functional properties and provide 15–35% of the body's daily requirement for K and Ca, as well as significantly provide the daily requirement for magnesium and phosphorus. The use of rowan powder in the production of food products can contribute to increasing the overall mineral value of finished products, especially in the diet of people who need increased potassium intake, since even 10g of powder in the product formulation will provide 24.5% of the need for this microelement.

3. Based on the data obtained, a food concentrate "jelly" recipe was developed using chokeberry powder. A product with satisfactory organoleptic properties was created. The results of the organoleptic evaluation showed that the optimal proportion of rowan powder in the recipe for a food concentrate jelly is 77%. At the same time, the finished product has a pleasant sweet-sour taste and a rich purple color, which indicates the presence of natural pigments characteristic of chokeberry fruits. The texture of the jelly is dense, elastic, and homogeneous, which means the correct balance of ingredients and cooking technology. Tests have shown that the resulting jelly has good organoleptic properties and is enriched with minerals necessary for the human body.

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ОБҐРУНТУВАННЯ ДОЦІЛЬНОСТІ ЗАСТОСУВАННЯ ПОРОШКУ ГОРОБИНИ ЧОРНОПЛІДНОЇ У ВИРОБНИЦТВІ КОНЦЕНТРАТУ ЖЕЛЕ

М. Самілик, доктор технічних наук, доцент, *E-mail*: maryna.samilyk@snau.edu.ua
Я. Ілляшенко, аспірант, *E-mail*: yannulia0911@gmail.com
Кафедра технологій та безпечності харчових продуктів
Сумський національний аграрний університет
вул. Герасима Кондратьєва, 160, м.Суми, Україна, 40021

Анотація. Дослідження присвячено обґрунтуванню доцільності застосування продуктів перероблення плодів чорноплідної горобини (*Aronia melanocarpa*) у виробництві харчових концентратів на прикладі желе. Проаналізовано структуру та мінеральний склад порошку із плодів чорноплідної горобини та запропоновано рецептуру харчового концентрату желе на його основі. Зневоднення плодів відбувалося у два етапи: попереднє – осмотичною дегідратацією (τ=1 год) та основне – сушінням у інфрачервоній сушарці (τ=6 год). Висушені плоди подрібнювали за допомогою лабораторного млина до крупності, яка забезпечує повний прохід матеріалу через сито №010. Встановлено, що горобиновий порошок має кристалічну пористу структуру та гідрофільні властивості, що дозволяє застосовувати його в якості харчової добавки функціонального призначення. Виявлено, що порошок з плодів горобини чорноплідної в своєму складі містить ряд необхідних організму людини мікронутрієнтів (K, Ca, Mg, Si, P), серед яких частка калію (7,34%) та кальцію (1,38%) була найвищою. Використання горобинового порошку у виробництві харчових продуктів може сприяти підвищенню загальної харчової цінності готових виробів, особливо в раціоні людей, які потребують підвищеного споживання калію, оскільки навіть 10 г порошку у рецептурі продукту на 24,5% забезпечує потребу в даному мікроелементі. Розроблено рецептуру концентрату желе на основі горобинового порошку. Результат сенсорного аналізу желе відповідно до шкали Лайкерта показав, що готовий продукт має відмінні показники за умови, що вміст горобинового порошку у рецептурі складає 77% до маси суміші концентрату. Попередня обробка плодів у цукровому розчині, при осмотичній дегідратації, забезпечила покращення їх смакових властивостей і дозволила виключити цукор із рецептури концентрату.

Ключові слова: горобина чорноплідна, порошок, харчовий концентрат, желе, мінеральні речовини, клітковина.