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SUBSTANTIATION OF THE EFFICIENCY OF THE METHOD FOR PROCESSING VIBURNUM BY THE METHOD OF OSMOTIC DEHYDRATION

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Abstract

In the process of any food production, it is important not only to obtain a high quality product, but also to minimize industrial waste, reduce energy costs for the process. Recently, buyers are also paying special attention to the biological value, the popularity of organic and natural products is growing. The search for new types of non-traditional raw materials and the choice of a rational way of processing it is an important task for scientists and manufacturers. The subject of the study was the viburnum fruits (Viburnum opulus). The object is the process of osmotic dehydration. The purpose of the study is to substantiate the effectiveness of the method of processing Viburnum opulus fruits by the method of osmotic dehydration. The process of processing viburnum fruits provides for mandatory pre-freezing, defrosting, osmotic dehydration and drying. A method was developed for waste-free processing of viburnum fruits using the process of osmotic dehydration. Products of viburnum processing (osmotic solution and powders) were studied. Analysis of the mineral composition of powders of their derivatives from the processing of viburnum showed the highest content of potassium (5.74 %). In addition, vitamin C was found in the products of viburnum processing: in powders – 8.28 mg/100 g, in an osmotic solution − 1.12 mg/100 ml. Given that wild berries were used for the study, a study of powders for the presence of microorganisms and heavy metals was carried out. Mesophilic aerobic, facultative anaerobic microorganisms, yeasts and molds were not detected. The content of heavy metals is less than 10 ppm Pb. Thus, viburnum fruits are safe raw materials. When using osmotic dehydration, their biological value and organoleptic properties are preserved.

Keywords: osmotic dehydration, drying, crushing, Viburnum opulus, processing derivatives, fortified products

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1. Introduction

Food production affects the environment. This fact is increasingly of interest to consumers, especially in rapidly developing countries. This mainly concerns the indicators of CO_2 emissions from the production, delivery of raw materials and finished food products. Therefore, the development of eco-centric technologies in the industry is an extremely topical issue.

In order to maintain the environmental safety of food products, refining, mineralization and other processes that reduce their nutritional properties, as well as the addition of artificial flavors, dyes, etc., are prohibited. Ecological products are produced without the use of pesticides, synthetic mineral fertilizers, growth regulators, artificial food additives and GMOs.

Wild berries are a promising raw material for eco-products. They are grown without the use of various plant protection products, pesticides and other chemicals, therefore they are safe [1]. The growth area of this culture extends to many regions, which makes it possible to locally process it in any European country. Among the wild berries that grow in large numbers in many European countries and, in particular, in Ukraine, it is worth highlighting the viburnum (Viburnum opulus).

Viburnum opulus is a valuable medicinal and food plant. Viburnum opulus berries contain vitamin C, phenolic compounds, carotenoids, and essential oils [2–4]. They are characterized by high antioxidant activity. The total amount of phenolic compounds in viburnum berries is 1168 mg/100 g [5]. The content of chlorogenic acid is 0.54–6.93 mg/ ml. Epicatechins and catechins (the main antioxidants) make up 40 % and 23 % of viburnum juice, respectively [6].

The color of viburnum fruits is due to colorful anthocyanins, which showed the best stability at a temperature of 75°C and pH – 7 [7]. Anthocyanins make up 3–5 % of the total amount of phenolic substances [5].

Fresh viburnum berries have an unpleasant aroma, bitter taste associated with the content of saponin, glycosides and vinburnine. To improve the organoleptic properties of viburnum berries, they need to be pre-frozen [8]. In viburnum berries, 41 compounds were found, 10 of which form the smell of fruits [9].

Also, the viburnum fruits contain a large amount of organic acids: citric, tartaric, malic, quinic included in the viburnum and sugar: fructose, glucose and sucrose [10].

27 minerals were found in viburnum berries (Al, mg, Na, Ba, Ca, Ni, Cd, P, Cr, Pb, S, Cu, Se, Fe, K, Sr, Li, Z, V, Ag, Bi, Co, Mn, B, Ga, In, Ti). Most of all – K, P, Ca, S [11].

The main fatty acids in viburnum are oleic, linoleic, and palmitic [12].

For the use of viburnum in the food industry, the method of its processing is important. Quite often, extracts are made from it, into which most of the biologically active components contained in cells pass [13]. Ethanol and aqueous solutions are usually used, which due to their properties cannot be used for food production. In addition, the pomace formed after the extraction of viburnum processing products is utilized, which negatively affects the ecosystem [14].

After processing the viburnum fruits, 30–35 % of pomace (peel, seeds) remains on the pureed mass. The high content of catechins in the powder obtained from viburnum pomace makes it possible to use it as a stabilizer for the main beet pigment in the preparation of red food coloring. The taste is sweetish tart with a slight bitterness. The dye is resistant to the production of confectionery products with it at any pH value [15].

Viburnum oil is a fraction of neutral lipids, contains 0.015 % vitamin E, 0.005 % carotenoids, of which 0.002 % is β-carotene [16].

The analysis showed that the Viburnum opulus fruits are promising raw materials. However, there is no rational way to process them, which will preserve the biologically active components and organoleptic properties. At the same time, it is important to ensure complex processing without the formation of waste.

The aim of the study is to substantiate the effectiveness of the method of processing Viburnum opulus fruits by osmotic dehydration.

To achieve the aim, the following research objectives are defined:

– to develop an optimal model for processing Viburnum opulus fruits;

– to analyze the mineral composition of derivatives of Viburnum opulus fruits processing;

– to analyze the content of vitamin C in derivatives of Viburnum opulus fruits processing;

– to investigate microbiological indicators of derivatives of Viburnum opulus fruits processing;

– to investigate the safety performance of derivatives of Viburnum opulus fruits processing.

2. Materials and Methods

2. 1. The method of fertilizing the fruiting of Viburnum opulus

Wild berries of Viburnum opulus were thoroughly washed, frozen (–18°C), and defrosted immediately before processing to improve taste properties. Mixed in a ratio of 1:1 with 70 % sucrose solution, heated to 65 °C. Osmotic dehydration of the solution was carried out for 1 hour [17–19]. The mixture was thoroughly stirred at a constant temperature of 50 °C. At the same time, the content of solids in the sucrose solution decreased by 10–12 %. Partially dehydrated berries were separated from the osmotic solution and sent for drying in an infrared laboratory dryer at a temperature of 50 °C.

The dried berry derivatives were ground into powders using a LZM-1 laboratory disk mill to a fineness that ensured the complete passage of the material through a braided brass sieve (0.45 mm).

2. 2. Methodology for the study of the mineral composition of derivatives of the processing of Viburnum opulus fruits

The analysis of the mass content of trace elements in the samples was carried out using a SEM and EDS detector based on an SEO-SEM Inspect S50-B microscope: an AZtecOne microscope with a dispersive spectrometer with an X-MaxN20 detector. Samples for research were pressed into tablets 2 mm in diameter with a polished outer surface. To prevent the accumulation of surface charge in the electron probe experiment, dielectric samples were covered with a thin layer (30–50 nm) of silver.

2. 3. Method for determination of vitamin C content in derivatives of Viburnum opulus fruits processing

The release of vitamin C from experimental samples was studied by HPLC (Agilent Technologies 1200, detector with UV-Vis Abs, detection at =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). An isocratic treatment was used with an elution rate of 1 ml/min and an analytical column temperature of 40°C. The injection volume is 20 μl.

Extraction of samples was carried out by adding a mobile phase (20 ml) to powdered (1 g) and liquid samples (5 ml). The obtained samples were centrifuged three times (centrifuge OPN-12) at 10,000 rpm for 10 min. The extracts were filtered using an Agilent 0.45 μm PTFE filter.

2. 4. Methodology of microbiological analysis

To determine the total number of mesophilic aerobic and facultatively anaerobic microorganisms (MAFAM): 1 ml of samples were sown on 2 Petri dishes and 15–20 ml of soy-casein agar with a temperature of no higher than 45 °C was added. After solidification of the agar, the cups were incubated at a temperature of 30–35ºC for 5 days, checking daily and recording the amount of CFU on the cups.

To determine the total number of yeast and mold fungi: 1 ml of the sample was sown on 2 Petri dishes and 15–20 ml of sabuoraud dextrose agar with a temperature of no higher than 45 °C was added. After solidification of the agar, the cups were incubated at a temperature of 20–25 ºC for 7 days, inspected daily, fixing the amount of CFU on the cups.

The number of CFU in 1 g was calculated according to the formula:

$$\frac{\sum k \cdot x}{n}, \qquad (1)$$

where, $\sum k$ is the number of colonies on cups;

n is the number of cups used in the control (2);

x is the dilution index (for MAFAM – 100, for mushrooms – 100).

2. 5. Methods of determination of heavy metals

4 ml of a solution of 250 g/l magnesium sulfate *P* in dilute sulfuric acid *P* (*V* $mgSO_4$) was placed in a quartz crucible and 1,000 g of substance (msubst.) was added. Stirred with a glass stick. The crucible was placed in an ash vessel, carefully evaporated and charred. The crucible with the charred residue was placed in a muffle furnace and burned at a temperature of no more than 800 °C (*T*) until a white or gray residue was obtained. The crucible was cooled. The residue was flavored with a few drops of diluted sulfuric acid and the procedure was repeated. The total burning time should be no more than 2 hours. The residue from the cooled crucible was quantitatively transferred into a test tube with two portions of diluted hydrochloric acid of 5 ml each (*Vk-ti*).

0.1 ml of phenolphthalein (*Vff*) solution was added and alkalized with a concentrated ammonia solution until a pink color appeared. Cooled, glacial acetic acid was carefully added to decolorize the solution, and another 0.5 ml of glacial acetic acid (*Voct.k-ty*) was added. If necessary, the solution was filtered and the filter was washed with water. The volume of the solution was brought up to 20 ml with water (*V flask*) and mixed (solution C). 12 ml of solution C (*Vp-on C*) was placed in a test tube, 2 ml of buffer solution pH 3.5 (*Vbuf.*) was added and mixed. The resulting mixture was poured into a test tube into which 1.2 ml of the thioacetamide reagent (*Vreact.*) was previously placed and immediately mixed (tested solution).

A standard lead solution (10 ppm Pb) was prepared. 0.5 ml of a standard solution of lead (1000 ppm Pb) P (V1000 g) was brought to a volume of 50.0 ml with water (*V* flasks). 4 ml of a solution of 250 g/l of magnesium sulfate in dilute sulfuric acid (*V* mgSO4) was placed in the crucible and 1.0 ml of a standard solution of lead (10 ppm Pb) P (V10 ppm) was added. 10 ml of the resulting solution (*Vad.p-on*) was placed in a test tube, 2 ml of solution C (*Vp-on C*), 2 ml of buffer solution pH 3.5 R (*Vbuf.*) were added and mixed. The resulting mixture was poured into a test tube, into which 1.2 ml of thioacetamide P reagent (*Vreact.*) was first placed and immediately mixed (reference).

10 ml of water *R* (*Vwater R*), 2 ml of solution C (*Vp-on C*), 2 ml of buffer solution pH 3.5 R (*Vbuf*) were poured into a test tube and mixed. The resulting mixture was poured into a test tube, into which 1.2 ml of the thioacetamide reagent (*V*react.) was first placed and immediately stirred (blank solution). After 2 minutes (τ), the color of the test, blank and reference solutions were compared.

The reference solution should be brown when compared to the blank solution. The brown color of the test solution should not be more intense than the color of the reference solution. The content of heavy metals should not exceed 0.001 % (10 g Pb).

3. Results

3. 1. Method for processing Viburnum opulus fruits

The development of a rational way of complex processing of Viburnum opulus fruits, a model of which is shown in **Fig. 1**.

In accordance with the proposed model, peeled berries are subject to mandatory pre-freezing. This will reduce bitterness and ensure the phase transformation of water from a liquid to a solid state. During defrosting, part of the moisture is lost, which leads to a decrease in energy consumption for drying.

Osmotic dehydration performs two functions at once: first of all, 10–15 % of moisture is removed from the cells, as a result, the drying time is reduced; secondly, the treatment with a sugar solution stops the enzymatic oxidation processes, so the organoleptic properties of the berries are preserved. It should be noted that biologically active components pass along with the cell sap in the osmotic solution, which makes it a valuable raw material for product enrichment [20].

Partially dehydrated berries are dried and ground into powders, which can become a natural flavor additive for the production of many food products [21].

The proposed model is non-waste.

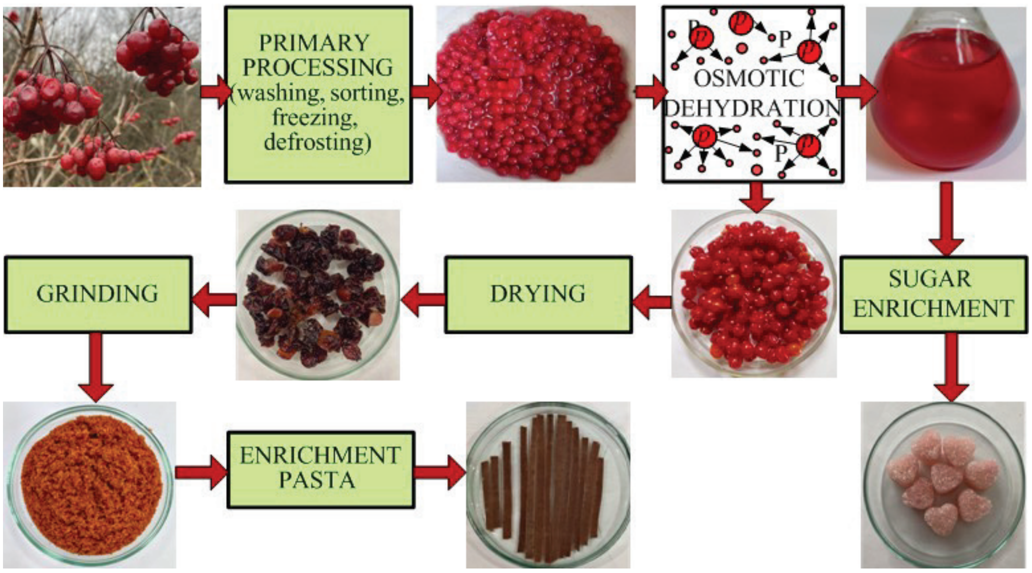


Fig. 1. Model of the method of complex processing of Viburnum opulus fruits

3. 2. Results of the study of the mineral composition of powders derived from the processing of Viburnum opulus fruits

Potassium, calcium, and phosphorus were found in the powders derived from the processing of viburnum fruits (**Fig. 2**).

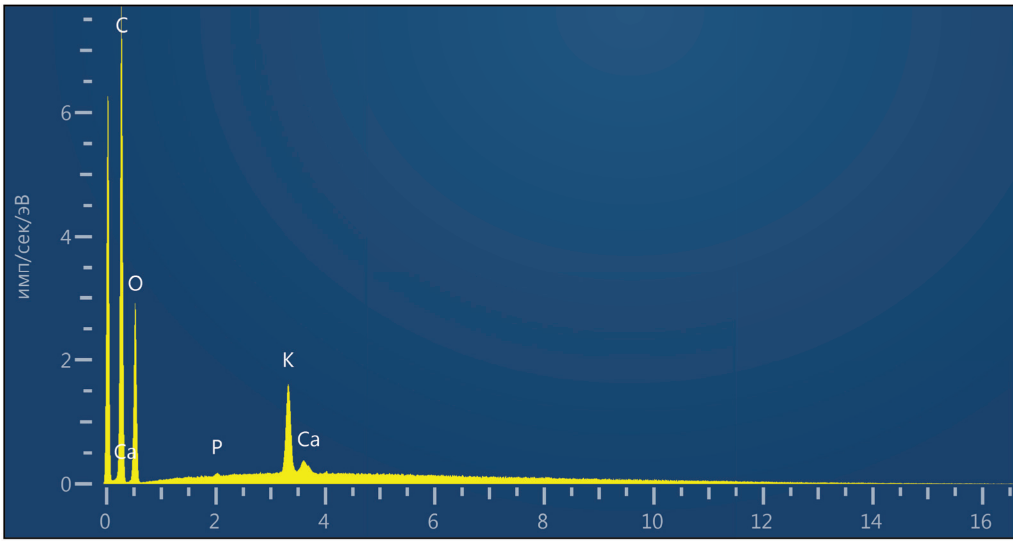


Fig. 2. Mineral composition of powders derived from the processing of Viburnum opulus fruits

The largest amount of K was found in the samples − 5.74 %. The content of Ca was 0.4 %, and P – 0.14 %.

3. 3. The results of the study of the content of vitamin C in the derivatives of Viburnum opulus fruits processing

As a result of osmotic dehydration, vitamin C is preserved in the derivatives of Viburnum opulus fruits processing. The results of chromatographic analysis of powders and syrups are presented in **Fig. 3, *a*, *b***.

The yield of vitamin C in powders from viburnum fruits is 4.16 µg/ ml, which corresponds to 8.28 mg/100 g. While the yield of vitamin C in syrups obtained as a result of osmotic dehydration of viburnum fruits is 2.8 µg/ ml (1.12 mg/100 ml).

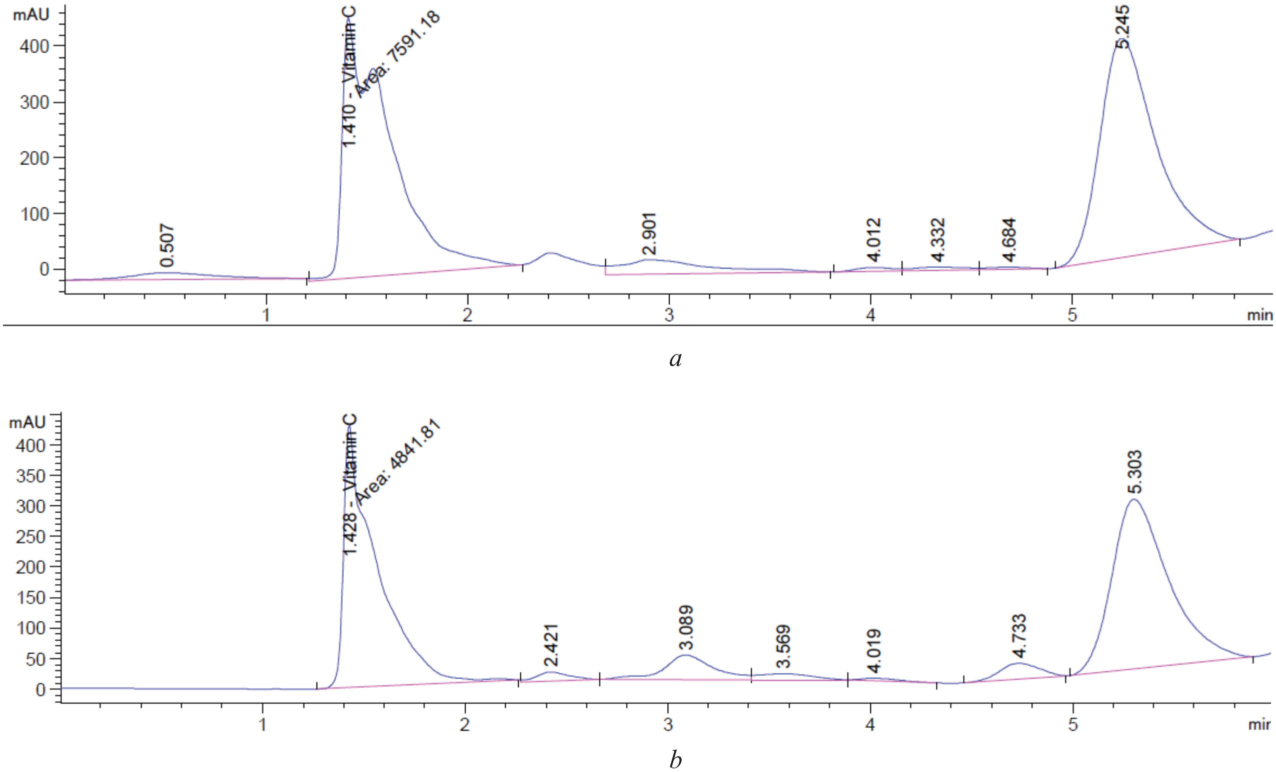
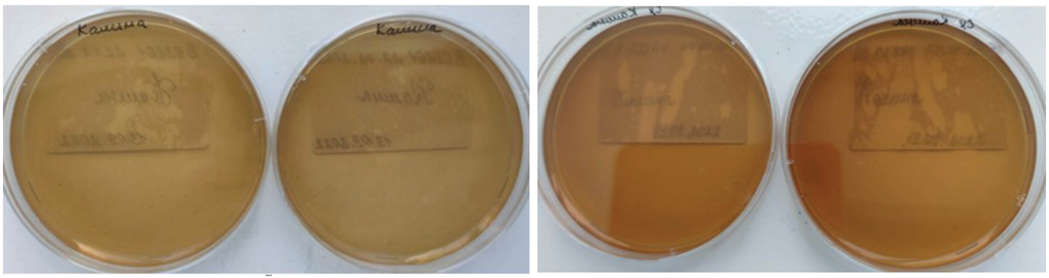


Fig. 3. The content of vitamin C in the derivatives of Viburnum opulus fruits processing:
a – powders; *b* – syrups

3. 4. Results of microbiological analysis of powders of recent processing of viburnum berries

According to the results of the control, it was found that in powders from a similar treatment of elderberry, the growth of microorganisms per day (**Fig. 4**): MAFAM<100 KUO; dryliv<100 CRF; mold fungi <100 CFU.



a *b*

Fig. 4. The results of the microbiological study of powders for derivatives of viburnum processing:
a – the total number of MAFAM; *b* – the total number of yeast and mold fungi

It should be noted that the study of the microbiological purity of the powders was carried out after 6 months of their storage in a paper dip bag at room temperature without direct sunlight.

3. 5. Results of the Study of the Capacity of Important Metals in Potassium Recycling

The results of the study of the amount of important metals in the chemical processing of viburnum fruits are presented in **Fig. 5**.

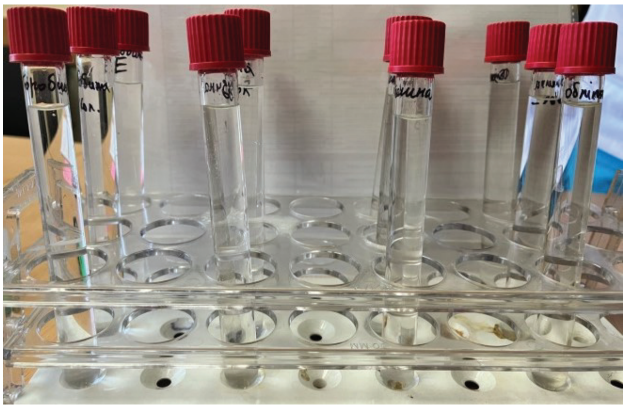


Fig. 5. The results of the study of the capacity of important metals in powders and from the secondary processing of wild berries

According to the results of testing the analysis of all the colors, they were not intensive for the standard, which indicates that there are significant metals in powders from similar processing of wild plants, Pb becomes less than 10 rpm.

4. Discussion

A model (**Fig. 1**) of non-waste processing of fruits has been developed, which includes several mandatory processes: freezing, defrosting, osmotic dehydration, drying, grinding. Each process is justified and performs a specific function (or several functions). Freezing reduces bitterness, and other researchers have obtained similar results [8]. In the process of osmotic dehydration, the color and smell of fruits are preserved (**Fig. 1**), enzymatic processes slow down, and part of the water is lost. Similar results were obtained by other scientists in the study of dehydration of vegetables and fruits [17–19]. The drying time is reduced, which is also confirmed by other researchers [22].

Three main mineral elements were found in viburnum powders (K, Ca, P). Other researchers [11, 23] also found the largest amount of K, P, Ca, as well as 27 more minerals. Potassium is essential for the proper functioning of the heart and circulation, and helps maintain adequate blood pressure and muscle tone. Calcium affects the strength of bones and teeth, muscle tone, the functioning of blood vessels 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. Enriching food products with viburnum powders can give them additional functional properties.

The study showed that vitamin C is preserved in derivatives of viburnum processing. The content of vitamin C in powders was 8.28 mg/100 g, in syrup – 1.12 mg/100 ml. Other studies have shown that fresh fruits contain 39 mg/100 g of vitamin C [8]. The proposed method is effective from the point of view of preserving the biological value. Preliminary studies have already shown that derivatives of viburnum processed by osmotic dehydration also contain amino acids [20]. Thus, viburnum powders and syrups can be used as natural flavor additives in the production of many fortified food products.

Considering that wild-growing viburnum fruits were used for the study, an analysis of safety indicators was carried out. It has been established that powders from derivatives of viburnum fruit processing do not contain heavy metals and can be stored for at least 6 months.

The problem of introducing this method into production may be the need for complex processing within one enterprise. The proposed method is most effectively implemented at sugar beet factories, which will solve the problem of the seasonality of this production.

The disadvantage of this method is that the pre-treatment of viburnum fruits requires manual labor.

In further studies, it is planned to investigate the transition of organic acids and carbohydrates into derivatives of the processing of wild berries processed by the osmotic dehydration method.

5. Conclusions

A rational model for the processing of Viburnum opulus fruits has been developed, which provides for the waste-free production of natural flavoring additives (powder and liquid).

The mineral composition of powders based on derivatives of Viburnum opulus fruits processing has been analyzed. It has been established that they contain trace elements vital for the body – potassium, calcium and phosphorus.

It has been established that the content of vitamin C in powders from derivatives of Viburnum opulus fruits processing is higher than in sugar solutions obtained as a result of osmotic dehydration. Thus, they can be used in the production of fortified foods.

Microbiological analysis showed that viburnum powders obtained by the proposed method are well preserved, do not contain mold, yeast and MAFAM.

Despite the fact that wild berries grow in the field, without human control, they are safe and do not contain heavy metals.

Conflict of interest

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

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Data availability

Manuscript has no associated data.

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