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NUTRITIONAL VALUE AND QUALITY OF QUICK-FROZEN FRUITS AND BERRIES USING CRYOPROTECTANTS

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Abstract. Fruits and berries (both cultivated and wild) serve as rich sources of vitamins, minerals, organic acids, macronutrients, and more. Their value as medicinal and food raw materials is determined by a complex of biologically active substances, including their qualitative and quantitative composition, the synergy of their actions, and a high degree of assimilation by living organisms. A significant portion of these biologically active substances possesses immunomodulatory, adaptogenic, anti atherosclerotic, hypotensive, and antioxidant properties..

Keywords: dietary value, freezing fruit and berry, cryoprotectants, vitamin C, nutrients, organoleptic characteristics .

For a comprehensive assessment of frozen semi-finished products, qualitative and quantitative ratios of the main nutrients found in fruits and berries were determined. Well-known methodologies were employed for this purpose. The evaluation of the nutritional value of frozen products, as an indicator reflecting the full spectrum of beneficial properties of a food product, including meeting the physiological needs of the human body in essential nutrients, energy, and organoleptic characteristics, began with the determination of pectin content. Today, the undisputed fact is the extraordinarily significant role of pectin substances in the functioning of the human body.

Furthermore, pectin substances present in the cell walls of the objects protect them from the negative effects of low temperatures during the freezing of raw materials, significantly influencing the quality of frozen and, especially, thawed

semi-finished products. The highest amount of pectin substances is found in viburnum berries (3% by product mass). Moreover, 55.4% of this quantity accounts for soluble pectin, characterized by high biological activity and easy assimilation by the human body. All examined types of fruits and berries (black chokeberry, blackberry, raspberry, blueberry) in these indicators approach viburnum.

Further detailed research has revealed that protopectin is primarily present in the skin of aronia berries and viburnum, giving it a dense structure that effectively isolates the inner soft tissues from external influences. As a result, metabolic processes in the berries proceed more slowly, leading to better preservation. Additionally, when frozen, the formed ice crystals are less likely to disrupt the texture of the berries.

Wild and cultivated fruits and berries serve as efficient sources of various carbohydrates, including sugars, polyols, pectin substances, cellulose, and hemicellulose. Carbohydrates constitute a crucial group of organic compounds within plant organisms, representing their primary source of energy and the main structural material of plant cells. Sugars, in combination with acids and other substances, contribute to the characteristic taste of fruits and berries, as well as their technological properties.

Table 1 presents the results of our experimental studies on the carbohydrate composition of the examined fruits and berries

Table 1

Carbohydrate Composition of Frozen Fruits and Berries, g per 100g of Product

The names of the berries	Sugars		Pectin substances
	Total	Sucrose	
Viburnum	7,0...7,6	0,1...0,2	2,4...3,5
Black Chokeberry	5,2...7,9	0,2…0,3	1,9...2,6
Raspberry	4,6...8,4	0,5…0,6	1,6…2,5
Blackberry	7,8...8,8	0,2…0,3	1,9...2,1
Blueberry	4,8...7,5	0,4…0,5	1,1...2,0

The obtained results indicate the valuable carbohydrate composition of frozen fruits and berries: over 90% of the total sugar mass consists of a mixture of glucose

and fructose, highlighting their suitability for dietary consumption. The content of pectin substances is notable.

An important characteristic of quick-frozen semi-finished products is the presence of organic acids. Due to their pH value, they inhibit the development of mold and other microorganisms. Specific acids, such as malic acid, exhibit radio-protective properties. In specific ratios with sugars, organic acids contribute to the taste qualities of both raw and finished products, characterized by the glucose-acidometric index.

All frozen materials contain almost identical amounts of organic acids, with raspberries and blueberries having the highest sugar content. This ratio serves as an objective characteristic of the taste of the products, reflecting the combination of sweetness and acidity. After prolonged storage, optimal glucose-acidometric index values (6...7:1) were maintained in viburnum and raspberry, while in other berry types, these values were slightly higher.

Table 2, alongside data on ascorbic acid content, presents the results of the total amount of polyphenolic compounds, taking into account the synergism of their interaction.

Table 2

Content of Ascorbic Acid and Polyphenolic Compounds in Frozen Fruits and Berries using Improved Technology, mg/100g of Product

Type of berries	Carotenoids, mg/100g	Ascorbic Acid, mg/100g	Polyphenolic Compounds, mg/100g	Anthocyanins, mg/100g
Aronia	3,76	139,5	1345,0	990,0
Viburnum	2,05	49,7	1215,0	785,0
Blackberry	3,27	75,9	1858,0	898,0
Raspberry	2,18	55,4	1344,0	446,0
Blueberry	1,94	57,3	2095,0	1654,0

Therefore, the obtained frozen materials are natural rich sources of both ascorbic acid and polyphenolic compounds, as well as anthocyanins, underscoring the necessity of their extensive utilization in the production of health-promoting products and semi-finished goods. It is known that phenolic compounds accumulate in the form of glycosides in those parts of plants where metabolic processes are most

efficient, and this is particularly characteristic of wild berries.

In the next stage of the research, changes in the main bio-components of frozen fruits and berries during refrigerated storage (-18°C) for 3 and 9 months were investigated. The results are presented in Table 3.

Table 3

Content of main bio-components in frozen fruits and berries after prolonged storage, mg/100g of product

Type of berries	Ascorbic Acid				Polyphenolic Compounds			
	Original content	Post-Freezing	After storage, months		Original content	Post-Freezing	After storage, months	
			3	9			3	9
Aronia	143,4	139,5	130,4	125,5	1367,0	1345,0	1340,0	1329,0
Viburnum	55,2	49,6	50,8	49,0	1245,0	1215,0	1206,0	1192,0
Blackberry	78,8	75,9	72,4	68,8	1885,0	1858,0	1826,0	1804,0
Raspberry	59,6	55,4	52,2	46,4	1362,0	1344,0	1331,0	1311,0
Blueberry	60,4	57,3	55,8	49,2	2118,0	2095,0	2070,0	2050,0

Thus, after freezing, all berries contained ascorbic acid within the range of 55.4 mg/100g to 139.5 mg/100g, depending on the culture. This constituted 92% to 97% of the content of vitamin C in fresh berries. Losses during 3 months of storage were, for example, 9.4% for aronia berries and 7.7% for blueberries. After 9 months of storage, these figures were only 12.6% and 18.6%, respectively. For comparison, with traditional freezing technologies (without cryoprotectors), after 3 months of storage, aronia berries lose up to 58% of vitamin C, and blueberries - 71%.

As expected, the preservation of polyphenolic compounds with high antioxidant activity was even higher. After 9 months of storage, blueberries lost only 3.2% of these compounds, and aronia berries lost 2.8%.

It is worth noting the high content of anthocyanins in the examined berries, especially in blueberries (1654 mg/100g of product), which is associated with a powerful antioxidant effect, capillary-strengthening, cardiotropic, spasmolytic, hypotensive, anti-inflammatory, and other actions. This suggests that the consumption of frozen berries, either directly or as enriched diets, will contribute to

strengthening the health of consumers, ultimately determining the level of national security.

Changes in the qualitative indicators of fruits and berries during freezing and prolonged storage occur strictly individually. Therefore, in addition to the obtained data, it is essential to determine the organoleptic indicators of berries and fruits before and after technological processing.

A sensory evaluation showed that fruits (cherries, viburnum) and berries (blackcurrants) frozen using the improved technology with cryoprotectors for 9 months of refrigerated storage (-18±1°C) have a pleasant taste, aroma, natural color, and a fresh appearance. Only blackcurrants showed a slight decrease in organoleptic properties and an overall rating from 5 points decreased to 4.88 after freezing and to 4.64 after storage. The reason for this is likely that blackcurrants have delicate skin tissue, less resistant to the damaging action of ice crystals during freezing compared to viburnum.

The highly praised aromas and colors of frozen fruits and berries are preserved even after 9 months, maintaining the varietal nuances of scents and color characteristics.

A comparison of the taste evaluation of cherries frozen after cryoprotector treatment and without such treatment emphasizes the effectiveness of the improved technology compared to traditional freezing methods.

All fruits and berries contain a wide range of macro- and microelements, although the quantity can significantly differ for different types. During freezing and prolonged storage, the concentration of mineral compounds does not change significantly, and the main losses may occur during the defrosting of frozen materials along with the loss of cell sap.

All examined fruits and berries, both fresh and after freezing and prolonged storage, contain essential biogenic mineral substances. Raspberry berries have the highest calcium content (38.6 mg/100g) with a daily requirement of 800–1200 mg. Blackcurrant berries have the highest potassium content, actively participating in various biochemical processes, including maintaining the osmotic properties of cells

and blood plasma (355.4 mg/100g) with a daily requirement of 2500 mg. This culture also contains the highest magnesium content (40.4 mg/100g), which is part of most enzymes, participates in ATP metabolism, and reduces the risk of atherosclerosis.

The share of trace elements is much smaller, and their daily requirement is insignificant. For example, the concentration of iron in raspberry berries is 1.01 mg/100g with a daily requirement of 10-15 mg. Cherries have the highest zinc content among other cultures (0.172 mg/100g) with a daily requirement of 10-12 mg. This trace element is particularly popular during the current pandemic conditions, as it, along with vitamin B6, is involved in the synthesis of unsaturated acids and is necessary for maintaining immunity, ensuring normal blood formation, and other physiological functions of the body. Cherries also contain the highest manganese content (0.081 mg/100g) among other cultures. This trace element participates in the synthesis of proteins and nucleic acids, with a daily requirement of 2 mg.

And in terms of copper content, raspberry berries prevail (0.1 mg/100g), with a daily requirement of 1-2 mg. Copper, as known, is part of the structure of various proteins and enzymes, participating in the synthesis of collagen and elastin.

Thus, frozen fruits and berries can be effectively used to overcome and prevent micronutrient deficiencies.

Overall, our developed advanced technology for fast-frozen fruit-berry semi-finished products does not reduce their nutritional value compared to fresh raw materials, and organoleptic indicators only slightly deteriorate after prolonged storage. The preservation of the content of ascorbic acid, polyphenolic compounds, carotenoids, organic acids, carbohydrates (including pectin substances), and mineral compounds is 75-90%. This amount is sufficient to satisfy 10-50% of the average daily need for them in the human body with normal consumption levels (300 g of fruits and berries). Regarding the content of ascorbic acid, polyphenolic compounds, and carotenoids, this need is exceeded by 150-300%. Thus, from the perspective of daily vitamin intake, 100 g of fruits or berries is sufficient.