

THE DEVELOPMENT OF NEW METHOD OF PRODUCTION OF HEALTHY ICE-CREAM-SORBET OF FRUITS AND VEGETABLES WITH A RECORD BAS CONTENT

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Abstract

The aim of the work is to develop a new type of producing healthy fruit-vegetable ice-cream-sorbet with the record BAS content using fresh vegetables and fruits as raw materials (especially, berries: blackberry, cherry, apricots, sea buckthorn, fruits – apples, lemons with zest, vegetables – spinach, olives, pumpkin) and innovative technological methods, such as cryogenic “shock freezing” and low temperature comminution.

There was offered and developed a new way of preparing healthy fruit-vegetable ice-cream-sorbet, based on using cryogenic “shock” freezing and fine-dispersed comminution of vegetables and fruits as an innovative method of structure creation and getting sorbets with the record BAS content. The complex effect of these methods results in activation and extraction of hidden BAS from fruits and vegetables in the free form, and also in pectin transformation from the inactive form into the active one. A peculiarity of producing sorbets is the use of only natural ingredients (fruits, berries, vegetables) and also the absence of artificial food supplements (stabilizers, stiffeners, emulsifiers, synthetic coloring agents and so on). The new method allows to preserve vitamins and other BAS of initial raw materials completely in sorbets. At the same time it gives a possibility to extract from raw materials hidden inactive BAS forms, bound in nanocomplexes with biopolymers and mineral substances, into the free, easily-assimilated nanoform.

The mass share of BAS in sorbets is 2,5...3,5 times more than in fresh fruits and vegetables that is controlled by standard chemical methods. At the same time the new method allows to extract and transform into the soluble form pectin substances that are in fruits and vegetables in the inactive hidden form more completely (by 70 %). The mass share of soluble pectin in sorbets is 3,0...5,0 times more than in fresh raw materials.

The following fruits and vegetables were chosen at preparing sorbets: apples, blackberry, cherry, apricots, sea buckthorn, pumpkin, spinach, olives, lemon with zest. They are known for their treating-prophylactic properties and first of all favor strengthening of the human organism's immunity.

The recipes of healthy sorbets were developed – 3 types of fruit-vegetable ice-cream with chlorophyll-containing, carotene-containing and anthocyan-containing fruits and vegetables. Natural fruit-vegetable raw materials at preparing ice-cream-sorbets act as five in one: a source of BAS, stiffeners, structure-creators, coloring agents and aromatizers. New types of sorbets are in the nanosize form and exceed analogues by BAS. Technological regimes of producing ice-cream-sorbets are developed at the stand semi-industrial equipment.

Keywords: cryogenic processing, BAS, fruits and vegetables, fine-dyspersated comminution, healthy products, sorbets, extraction of hidden BAS, pectin activation.

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1. Introduction

Among healthy products of fruits, berries vegetables, an important place is occupied by sorbets that are one of ice-cream types, popular among the population of different world countries [1–3]. Sorbets are traditionally produced of fresh fruit-vegetable raw materials and also puree, juices without using milk [1–3]. A shortcoming at producing sorbets is the use of artificial food supplements (stabilizers, stiffeners, emulsifiers, synthetic coloring agents and so on) [4–6]. Freezing and storage of sorbets take place at –18 °C. This method allows to get high-quality sorbets, which storage term is 10 months [6, 7]. But the essential amount of BAS (20–50 %) is lost at defrost and storage. That is why a shortcoming of sorbets is a low content of vitamins and other BAS and also the presence of artificial components, negatively influencing the human organism. So, international practice in the last 10 years changed requirements to ice-cream of both consumers and companies that produce and realize it. The main requirement to ice-cream is the maximal naturalness and also the presence of components, favoring health strengthening, in its composition [8, 9].

It is known, that one of prospective directions of processing fruits, berries, vegetables and other products is cryogenic processing of raw materials using cryogenic “shock” freezing and cryogenic comminution [10]. This method provides the highest degree of preserving vitamins and other BAS [11]. It was established, that the higher speed of freezing vegetable products, the better vitamins and other BAS are preserved, and also the less losses of cellular juice at freezing and keeping the structure are [12].

But in Ukraine the cryogenic method didn't find the proper use for today. Cryogenic technologies are not developed, and biochemical, physical-chemical processes at freezing fruits, berries vegetables and at producing sorbets without using food admixtures, synthetic coloring agents and aromatizers are not studied. Results of fundamental and applied studies of the influence of cryogenic “shock” freezing and low-temperature fine-dyspersated comminution of fruits, berries and vegetables, obtained in Kharkiv state university of food and trade are an exclusion [12–14].

So, the aim of this work is to develop a new method of producing healthy fruit-vegetable ice-cream-sorbets with the record BAS content, using fresh vegetables and fruits as raw materials and innovative technological methods, such as cryogenic “shock freezing” and low temperature comminution. It allows to get sorbets of the healthy effect with the record content of biologically active substances without using different artificial food admixtures.

2. Materials and Methods

Fresh and frozen fruits and vegetables (blackberry Vernisazh), cherry (Griot Seridko), apple (Simirenko), lemon with zest (Lisbon), apricot (Chervonoschoky), sea buckthorn (Azhurna), spinach (Victoria), olives (Greek), pumpkin (Mustatny)) and new nanosorbets of fruit-vegetable raw materials were used in the work as research objects (Fig. 1, 2).

For attaining this aim, the complex influence of cryodestruction and mechanoactivation on raw materials at fine-dyspersated comminution was used as an innovation at producing fruit-vegetable ice-cream-sorbet using the modern equipment for cryogenic “shock” freezing and fine-dyspersated comminution for activation and extraction of hidden Bas forms in the free easily-assimilated one [3].

Specialists of the department of technologies of processing fruits vegetables and milk of Kharkiv state university of food and trade (Ukraine) together with co-workers of Putyvl agrarian college (Ukraine) developed a new way of producing fruit-vegetable healthy nanosorbets of chlorophyll-containing, carotene-containing and anthocyan-containing vegetable raw materials using the method of deep cryogenic processing of vegetable raw materials, offered by the authors.

The experimental studies were conducted at Kharkiv state university of food and trade (KSUFT, Ukraine) at the department of technologies of processing fruits, vegetables and milk, in the experimental-research laboratory of “Innovative cryo- and nanotechnologies of vegetable supplements and healthy products” using the modern equipment (cryogenic fast-freezing apparatus, comminutor «Robot Coupe» (France), Low-temperature comminutor-activator «SIRMAN» (Italy)) for cryogenic “shock” freezing and fine-dyspersated comminution.



Fig. 1. Research objects: *a* – fresh blackberry, *b* – frozen blackberry, *c* – nanosorbet of blackberry; *d* – fresh cherry, *e* – frozen cherry, *f* – nanosorbet of cherry; *g* – fresh apples, *h* – frozen apples, *i* – nanosorbet of apples; *j* – fresh lemons, *k* – frozen lemons, *l* – nanosorbets of lemons with zest; *m* – fresh apricots, *n* – frozen apricots, *o* – nanosorbet of apricots



Fig. 2. Research objects: *a* – fresh sea buckthorn, *b* – frozen sea buckthorn, *c* – nanosorbet of sea buckthorn, *d* – fresh spinach, *e* – frozen spinach, *f* – nanosorbet of spinach; *g* – olives, *h* – frozen olives, *i* – nanosorbet of olives; *j* – fresh pumpkin, *k* – frozen pumpkin, *l* – nanosorbet of pumpkin

The model studies of the influence of cryogenic “shock” freezing were conducted in the fast-freezing experimental apparatus using the gas-like nitrogen as a cooling agent and inert liquid medium [13, 14]. The apparatus is intended for freezing products with a solid surface and liquid products, placed in a special package. The fast-freezing apparatus allows to vary a temperature within a freezing chamber within the diapason from -5°C to -100°C .

The work was realized the modern original equipment from the department of KSUFT for cryogenic freezing – program cryogenic “shock” freezer with liquid nitrogen as a cooling agent and liquid medium. At that the temperature in the freezing chamber was from -60°C to -100°C . Fruits, vegetables, berries were frozen with different high speeds to different temperatures in epy product.

The use of this equipment allows to model technological processes for revealing methods of the maximal preservation of BAS and biopolymers of the vegetable raw materials. The obtained research results were used at developing nanotechnologies of producing new types of supplements and products of fruits, berries and vegetables, which quality by the BAS content exceeds the quality of the initial raw materials and one of products and supplements – analogues.

2. 1. Experimental procedures

The quality by the content of main BAS (low-molecular phenol compounds, polyphenols, L-ascorbic acid, anthocyanins, β -carotene, chlorophylls a and b, pectin, including soluble organic

acids, protein) was determined in fresh and frozen vegetables and fruits (blackberry, cherry, apples, lemons with zest, apricots, sea buckthorn, spinach, olives, pumpkin) and new nonosorbets of the fruit-vegetable raw materials.

The control of biologically active substances (BAS) was determined by the following methods:

- Low-molecular phenol compounds (by rutin and chlorogenic acid separately), determined by the colorimetric method of Folin-Denis in recalculation by chlorogenic acid.
- Tanning substances (by tannin), determined by the titrometric method in recalculation by tannin. This method is based on an ability of tanning substances to oxidize in presence of an indigo carmine indicator.
- L-ascorbic acid, determined by the method of visual and potentiometric titration by the solution of 2,6-dichlorophenolindophenolate Na.
- β -carotene, controlled by the colorimetric method of Mouri after extracting carotene from the product by an organic dissolvent and cleaning it from accompanied color substances using column chromatography.
- Anthocyanins, determined by the colorimetric method, based on determining the mass concentration of color substances in coloring agents by comparing the coloration intensity of the control solution, prepared of Cobalt sulphate and the studied solution.
- Chlorophylls a and b, determined by the spectrophotometric method in acetone extracts of experimental samples. The method is based on the difference of maximums in spectrums of chlorophyll absorption in the red zone.
- Pectin, the method is based on hydrolysis of pectin substances and precipitation of polygalacturonic acid as cellulose calcium pectate.
- Organic acids, the method is in removing free acids with water steam and further titration by alkaline. For transforming salts in free acids, orthophosphate acid is used. The amount of titrated volatile acids is recalculated for acetic acid.
- Protein, determine by the nitrogen-metric method (Kjeldahl) method, based on determining the amount of protein nitrogen, formed at destructing amino acids, included in the protein composition.

3. Results

The authors in this work offered to use cryogenic “shock” freezing and low-temperature fine-dyspersated comminution as a innovation at developing the new way of producing healthy nano-products «NatureSuperFood» (at the stage of introduction in production) – fruit-vegetable ice-cream-sorbets of fruits, berries, vegetables. It gave a possibility to get new types of ice-cream-sorbets in the nanosize form with the record BAS content (2...3,5 times more than in the initial raw materials) and to exclude a necessity of using food supplements, traditionally included to the composition of sorbets.

There was offered and developed the new method of getting healthy products – fruit-vegetable ice-cream-sorbets of fruits, vegetables, berries - that allows to get products «NatureSuperFood» with unique characteristics. New types of products are in the easily-assimilated nanosize form and are remarkable for the high content of natural biologically active substances (L – ascorbic acid, β -carotene, chlorophylls a and b, phenol compounds, anthocyanins, aromatic substances and other). The new method and nanotechnologies of producing sorbets differ from traditional ones by using cryogenic “shock” freezing and fine-dyspersated comminution as an innovation, which complex effect results in activation and extraction of hidden BAS from raw materials in the free form. The model experiments demonstrated that the new way and technologies result in transformation of a stiffener and structure creator of fruit pectin from the inactive form into the active soluble one. The obtained new types of sorbets are prepared by only natural ingredients (fruits, berries, vegetables) and don't contain different food supplements (stabilizers, stiffeners, emulsifiers, synthetic coloring agents and other) in their composition. It was established, that the new method allows not only to preserve vitamins and other BAS of the fresh vegetable raw materials completely, but also gives a possibility to extract hidden inactive forms (bound in nanocomplexes with biopolymers and mineral substances) from them into the free, easily-assimilated form. Thus the mass share of BAS in

sorbets is 2,5...3,5 times more than in fresh fruits and vegetables. The effect of BAS increase is observed in all sorbets of different fruits, vegetables and berries in 2,5...3,5 times, depending on a raw material, its architecture, chemical composition, type (**Table 1**). At the same time nanotechnologies of sorbets allowed to extract pectin substances that are in the fruit-vegetable raw materials in the inactive hidden form more completely in 3,0...5,0 times and to transform 70 % of pectin substances in the soluble form (**Table 1**).

Table 1

The influence of cryogenic “shock” freezing and mechanolysis on BAS and pectin at getting one-component nanosorbets of fruits, vegetables, berries (n=3, P≥0,95)

Product	Mass share, mg in 100 g					Mass share, %		
	L-ascorbic acid	Phenol compounds (by chlorogenic acid)	Phenol compounds (by rutin)	tanning substances (by tannin)	β-carotene	Chlorophylls a and b	Anthocyanins	Soluble pectin
Fresh apples	55,0	580,1	160,3	380,2	0,1	0	0,2	1,5
Apple sorbet	135,1	980,2	390,1	720,4	0,2	0	0,5	7,2
Fresh blackberry	280,5	720,5	175,2	602,1	4,8	0	4,0	1,6
Sorbet of blackberry	840,0	1330,0	280,1	1000,1	13,8	0	8,0	7,4
Fresh cherry	68,1	670,1	142,1	420,1	0,2	0	2,5	1,4
Sorbet of cherry	150,2	1102,0	280,1	740,2	0,3	0	5,0	6,5
Fresh apricot	49,2	320,5	70,2	250,2	9,5	0	0	1,4
Sorbet of apricot	140,1	560,4	120,6	480,4	32,5	0	0	7,2
Sea buckthorn	95,2	570,2	95,1	420,0	11,5	0	0	1,2
Sorbet of sea buckthorn	250,1	940,6	170,2	780,1	40,2	0	0	6,8
Fresh pumpkin	40,2	260,2	60,2	215,1	9,8	0	0	1,0
Sorbet of pumpkin	108,1	480,6	105,2	401,2	41,2	0	0	4,5
Fresh spinach	60,2	320,6	105,0	380,5	6,8	810,1	0	0,7
Sorbet of spinach	178,6	560,0	175,2	720,1	21,0	1650,2	0	5,2
Frozen olives	38,5	280,1	50,4	250,1	3,5	350,1	0	0,5
Sorbet of olives	75,2	460,2	75,6	400,1	7,5	700,2	0	3,8
Fresh lemons	80,2	101,1	75,0	300,4	0,2	0	0	1,8
Sorbet of lemons with zest	200,1	180,2	135,1	560,2	0,4	0	0	7,8

There were developed the recipes and studied the quality and content of BAS of three types of fruit-vegetable ice-cream of the different colors (green, yellow-green, pink) of chlorophyll-containing, carotene-containing and anthocyan-containing fruits, berries, vegetables. There was developed the wide assortment of healthy products «NatureSuperFood» – fruit-vegetable ice-cream-sorbet – green line, named «Green pleasure», «Green power», «Green pro», yellow-orange line – «Orange lime», «Carotene», «Caroton» and pink line, named «Purple», «Cherry», «Berries». The names of sorbets and sorbets themselves are at the stage of introduction in production. Natural coloring agents-BAS in the green line are chlorophylls of spinach and

olives, in yellow-orange one – β -carotene and other carotenoids of apricots, sea buckthorn and pumpkin, in the pink one – anthocyanins of blackberries and cherries.

Based on the aforesaid results of the experimental studies, there was developed the new way of producing fruit-vegetable ice-cream-sorbets of fruits, vegetables, berries, differing from traditional ones by using the high freezing speed (from 1 to 20 °C/min). At that the temperature in the cooling chamber is –60...–100 °C and the final freezing temperature in the product must be lower than conventional one –18 °C. At the same time the new method of producing sorbets includes using fine-dispersed comminution of frozen mixtures of fruits berries and vegetables to particles, which size is tens times less than ones of traditional sorbets and frozen puree of fruit-vegetable raw materials. The offered fine-dispersed fruit-vegetable mixtures are cut, packed and directed for tempering and refrigeratory storage at temperature –18 °C.

There was studied the quality of new types of ice-cream-sorbets. They have an original taste and smell of the natural product. At the same time sorbets differ from the initial raw materials that they are based on by the record content of natural BAS (L-ascorbic acid, phenol compounds, tanning substances, anthocyanins, β -carotene, chlorophylls) and also prebiotic substances, included in the product in the soluble easily-assimilated form.

New types of fruit-vegetable ice-cream-sorbets are stored during 12 months without BAS losses that is provided by complete inactivation of oxidizing enzymes at their production.

The new method and nanotechnologies of healthy products «NatureSuperFood» – fruit-vegetable ice-cream-sorbets were probated under production conditions at enterprises of city Kharkiv (SPE “Krias plus”, LTD “ICF “Khladoprom”, LTD CUIC “Plus”).

4. Conclusions

For the first time in international practice there was developed the unique method of getting natural fruit-vegetable ice-cream in the sorbet form for healthy nutrition with the record content of BAS that favor strengthening of the immune system of the population and have detoxifying, antioxidant properties. New products have no analogues in the world.

The new method differs from traditional ones by using fine-dispersed comminution and cryo-processing using liquid and gas-like nitrogen at processing fruits and vegetables, by high speeds of freezing and lower temperatures than ones, accepted in international practice (at –50...–100 °C). At the same time the use of low-temperature fine-dispersed comminution, accompanied by the processes of low-enzymatic catalysis of mechanolysis, allows to get sorbets in the nanosize form and to use the biological potential of natural raw materials as fully as possible.

The advantages of this work are in fact that at developing the new way of preparing sorbets, there was made a discovery that hidden forms of BAS and biopolymers were revealed in the natural raw materials.

It was established, that at this method of preparing sorbets the mass share of BAS extracted from the raw materials is 2,5...3,5 more than the one in the initially raw materials, and soluble pectin – 3,0...5,0 times.

The authors hope that the results, presented in the article, will have an essential practical value for both Ukrainian and international community, because the deficit of natural products is observed in the world, and each eighth dweller of the Earth suffers from hunger. At processing fruits and vegetables using traditional methods, the essential BAS losses are observed (from 20 to 80 %). At the same time the essential share of healing vegetable substances is assimilated by the human organism in 30...50 %. That is there are essential losses of the biological potential both at processing and consumption that are hundreds millions of tons within the Planet.

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