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Editorial office
«EUREKA: Life Sciences»
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THE DEVELOPMENT OF CRYOGENIC METHOD OF DEEP TREATMENT OF INULIN-CONTAINING VEGETABLES (TOPINAMBOUR) AND OBTAINING OF PREBIOTICS IN THE NANOPOWDERS FORM

Raisa Pavlyuk
Department of Technology Processing of Fruits, Vegetables and Milk
Kharkov State University of Food Technology and Trade
333 Klochkivska str., Kharkov, Ukraine, 61051
ktppom@mail.ru

Viktoriya Pogarska
Department of Technology Processing of Fruits, Vegetables and Milk
Kharkov State University of Food Technology and Trade
333 Klochkivska str., Kharkov, Ukraine, 61051

Vadim Pavlyuk
Department of Technology and Organization of Restaurant Business
Kharkov Trade and Economics Institute of Kyiv National University of Trade and Economics
8 Otakara Jarosha alley, Kharkov, Ukraine, 61045

Katerina Balabai
Department of Technology Processing of Fruits, Vegetables and Milk
Kharkov State University of Food Technology and Trade
333 Klochkivska str., Kharkov, Ukraine, 61051

Svetlana Loseva
Department of Technology Processing of Fruits, Vegetables and Milk
Kharkov State University of Food Technology and Trade
333 Klochkivska str., Kharkov, Ukraine, 61051

Abstract

The aim of the work is elaboration of the principally new cryogenic method of deep processing of inulin-containing vegetables (topinambour) using cryogenic "shock" freezing and fine-dispersed comminution and getting of it nanopowders (prebiotics).

There was elaborated principally new cryogenic method of deep processing of topinambour for getting nanopowders – prebiotics. This method differs from traditional ones by the full exclusion of thermal processing of the raw material. Method is based on the use of complex effect of cryogenic "shock" freezing on the raw material using liquid nitrogen, fine-dispersed comminution and sublimation drying. It allows not only preserve biological potential of vegetables but also reveal it more fully and extract the hidden (associated) forms of the low molecular biologically active substances and polymers and transform them into soluble, easily assimilated nanoform.

It was established, that cryogenic method allows more fully extract the low molecular biologically active substances from the state associated with biopolymers in nanocomplexes into free one (1,8…2,3 times more than in initial raw material). There was revealed mechanism of process, connected with cryomechanodestruction, non-enzymatic catalysis and mechanocracking.

It was revealed, that cryogenic methods allows more fully extract heteropulysaccharides – pectin substances, cellulose and proteins from the form associated in nanocomplexes with other biopolymers (1,3…3 times more).

It was established, that cryogenic method of topinambour processing allows partially (by 45…55 %) destruct the difficultly soluble biopolymers such as inulin, pectin substances, cellulose and proteins to their separate monomers in soluble nanoform. There were also revealed conformational changes of molecules of topinambour proteins. It was demonstrated, that form changes and the protein molecule, size of its kernel, coat and ratio of hydrophobic and hydrophilic amino acids remains decrease.

It was demonstrated, that topinambour nanopowders outgo the known analogues of traditional topinambour powders by chemical and disperse composition. It was established that their assimilability is 3 times higher than in traditional ones.

Keywords: cryogenic method, inulin, prebiotics, fine-dispersed, cryogenic freezing, nanopowders, nanocomplexes.

DOI: 10.21303/2504-5695.2016.00145 *© Raisa Pavlyuk, Viktoriya Pogarska, Vadim Pavlyuk, Katerina Balabai, Svetlana Loseva*

1. Introduction

The aim of the work is elaboration of the principally new cryogenic method of deep processing of inulin-containing vegetables (topinambour) using cryogenic "shock" freezing and fine-dispersed comminution and getting of it nanopowders (prebiotics).

In Kharkov state university of food technology and trade (Kharkov, Ukraine) at the department of technology processing of fruits and vegetables in laboratory of innovative cryo- and nanotechnologies of vegetable additives and wellness products together with Kharkov trade and economic Institute of Kyiv national university of trade and economics (Kharkov, Ukraine) was elaborated cryogenic method of the deep processing of topinambour and getting of it nanopowders – prebiotics.

This method differs from traditional ones by the full exclusion of thermal processing of the raw material [1–5]. Method is based on the use of complex effect of cryogenic "shock" freezing on the raw material using liquid nitrogen, fine-dispersed comminution and sublimation drying [6]. It allows not only preserve biological potential of vegetables but also reveal it more fully and extract the hidden (associated) forms of both the low molecular biologically active substances (BAS) and polymers and transform them into soluble, easily assimilated nanoform.

2. Materials and methods of the study of the low molecular BAS and biopolymers content at elaboration of cryogenic method of deep processing of inulin-containing vegetables

2. 1. Studied material and equipment used in experimental procedures

The study was carried out in Kharkov state university of food technology and trade at the department of technology processing of fruits and vegetables and milk (Kharkov, Ukraine).

Cryogenic "shock" freezing was carried out using the modern experimental equipment, especially, cryogenic program freezer with computer support (**Fig. 1**) that functions using both coolant and inert medium of gaseous nitrogen. Cryogenic program freezer was elaborated in National aerospace university of M. E. Zhukovsky "KAI" (Kharkov, Ukraine) together with joint authors of the article.

Fig. 1. Cryogenic program freezer with computer support

Cryogenic processing of topinambour samples was carried out at temperature – 60 ˚C in the chamber of fast freezing. Topinambour samples were frozen with different speeds (2, 5, 10, 20 ˚C/min) to the final temperature in product –35…–40 ˚C. At that, for freezing of 1 kg of vegetables were used from 0,5 to 1,0 l of liquid nitrogen depending on thickness of frozen product. The volume of working chamber on the raw material load was up to 10 kg.

Sublimation vacuum drying was carried out in vacuum sublimation dryer (**Fig. 2**), produced at the experimental factory of Institute of problems of cryobiology and cryomedicine of National academy of sciences of Ukraine (Kharkov city, Ukraine) and was created for drying of medical preparations, living microorganisms, foodstuff and other biological objects. The drying of samples was carried out at temperature –20 ˚C…–22 ˚C, pressure $–10^{-3}…8{\cdot}10^{-4}$ Pa and additional drying at +50…+55 ˚C (during 30…40 min). Drying was carried out to the final humidity 5 %.

Fine-dispersed comminution was carried out in comminutors (especially, in bedded, vibration-bedded mills, attritors of Ukrainian production and cutter-activator (France)) at temperature not higher than –10 ˚C to the particles size in dozens times less than at traditional comminution.

As objects of the study were used topinambour tubers (**Fig. 3**) and nanopowders of sublimation drying of them (**Fig. 4**).

Fig. 2. Vacuum sublimation dryer

Fig. 3. Initial raw material (topinambour tubers)

Fig. 4. Nanopowder of topinambour sublimation drying

2. 2. Methodologies of determination of parameters of studied samples

Criteria of assessment of cryomechanodestruction processes at elaboration of cryogenic method of topinambour processing into the form of topinambour nanopowders were used at determination of chemical substances in vegetable raw material and ready additives, especially:

– protein of associated and free amino acids, hydrophilic and hydrophobic remains of amino acids, inulin, fructose, general pectin, protopectin, soluble pectin substances, cellulose, organic acids and other;

– L-ascorbic acid, low molecular phenol compounds (oxycinnamic acids), flavonol glycosides, catechins, tanning substances.

At the same time the influence of cryomechanodestruction processes was controlled by determination of conformational changes of protein molecules (especially, radius, volume of kernel

and coat, form of protein molecules and so on) and assimilation degree of additives using bio-testing express-method.

For solving the set problems alongside with commonly used chemical [7–13], physical-chemical [14], spectroscopic [15], chromatographic methods of research [15], were used the original ones, namely: the method of protein structure and conformational changes determination by E. G. Fisher [16, 17] and express-method of biological activity (or assimilability) determination by L. N. Brayenes [18].

As a control sample was used fresh, ripe, washed topinambour of Interest sort, planted in Kharkov region and harvested in autumn (October), stored in the vegetable store house at temperature +2…+4 ˚C. The mean size of topinambour tubers by the largest transversal diameter was 30 mm, and mass – 150 g (tubers). Experimental procedures were carried out with fivefold repetition. The received results are given in units of CI international system.

Mass fraction of the general nitrogen was controlled by Kjeldahl method [7].

Mass fraction of free and associated amino acids was controlled using chromatographic methods of research (ion-exchanged chromatography) on automatic analyzer AAA 339 (Microtechna-Prague-CSSR) on the base of laboratory of assessment of the of forage and animal production quality in Institute of cattle breeding of National academy of agrarian sciences of Ukraine (Kharkov, Ukraine).

Method of determination of protein structure and conformational changes. The structure of initial raw material proteins and their conformational changes at getting nanoadditives were determined using method, elaborated by Nobel prizewinner Fisher E. G. [16, 17]. This method allows by the known ratio of polar and non-polar remains of amino acids in protein molecule calculate its radius, volume and form and also radius of its kernel and index of kernel filling with hydrophobic remains. Method is based on the fact that all amino acid remains, included in polypeptide chain of protein molecule, can be conventionally divided in two groups: non-polar (hydrophobic) and polar (hydrophilic) ones. In water the flexible molecules curls up in globule. Sphere has a minimal area of surface at given volume. Non-polar remains create within protein fraction the certain likeness of spherical drop and the polar ones are concentrated on its surface. It leads to creation of compact body – globule with hydrophobic kernel and hydrophilic coat.

Method allows determine the molecule form by the general number of amino acid remains in kernel and polar and non-polar remains ratio. Using the method at work the forms of protein molecules of the fresh raw material and topinambour nanoadditives were determined. Methodology of determination of the protein structure and conformational changes of studied samples is presented in the works [16, 17].

Biological activity (or assimilability) of samples was determined by original express-method of L. N. Brayenes. The assessment of substances (or product) biological activity was carried out by generative activity (or increase of young forms) of biological test-objects (unicellular infusoria Paramecium caudatum), that is by stimulation of reproduction [9]. The essence of method of control of biological activity (or assimilability) of the different products and substances using infusoria is based on straightening of absorbing and digestive ability of elementary organism – infusoria and activation of their reproduction in the case if studied product includes substances that stimulate their growth and development. At presence of toxic or other harmful substances in tested product there is observed deceleration of development or death of infusoria. Methodology of determination of biological activity of studied samples is presented in the work [18].

Inulin content was determined according to methodical instructions of biochemical analysis. Method is based on inulin property to hydrolyze at presence of hydrochloric or oxalic acid with creation of fructose and also on inulin ability to be dissolved in hot water and not to be dissolved in alcohol. After conducting reaction of neutralization by alkali hydroxide to slightly acid reaction the sugar determination is carried out by the method of Bertran [8]. The difference between percent content of sugars, found after hot extraction with water and 82-percent alcohol will be the sugar, received of inulin.

Mass fraction of pectin substances (general, soluble and protopectin) was measured by the standard weight calcium-pectate method (SSTU 8756.11-70), based on determination of pectin acid content by the mass of calcium pectate, created at interaction of calcium chloride with pectin acid [13].

Mass fraction of cellulose was determined by the standard method, based on creation of furfurol of pentosans at cellulose processing by the solution with 13 % mass fraction of hydrochloric acid at heating and determination of skimmed furfurol by spectrofotometric method (SSTU 10820-75) [9].

Vitamin C content was determined by iodometric method, based on oxidizing-renewing reaction that takes place between ascorbic acid and indicator 2,6 – dichlorphenollindophenol (Tillmans paint) (SSTU 24556-89) [10].

Phenol substances content was determined by the method of Folin-Denis in recalculation on chlorogenic acid (SSTU 4373:2005). Method is based on creation of blue complexes at renewal of tungsten acid under effect of polyphenols with Folin-Denis reagent in alkali medium [11].

Polyphenol (tanning substances) content was determined by titrimetic method by tannin (SSTU 24027.2-80). Method is based on the property of tanning substances to oxidize at presence of indigo carmine indicator [12].

Mass fraction of titrated (organic) acids was determined by the method of volume titration (SSTU 25555.0-82). Method is based on neutralization of acids extracts of the studied sample by the alkali solution to the appearance of pink coloration that testifies to the end of reaction [14].

3. Results of research

At elaboration of cryogenic method of topinambour processing and getting nanopowders of it using cryogenic "shock" freezing and fine-dispersed comminution it was important to increase the degree of extraction of the hidden forms of BAS associated with biopolymers into free state from the raw material. At the same time it was necessary to partially transform the difficultly soluble polysaccharides, oligosaccharides and proteins into soluble form. It becomes possible at the expense of cryodestruction and cryomechamodestruction and also mechanolysis. It was also important to reveal mechanisms of aforesaid processes and assimilability by the living organisms.

For the first time in international practice authors revealed and demonstrated that at complex action of cryogenic "shock" freezing and fine-dispersed low-temperature comminution on the raw material takes place not also the full preservation of all BAS but also their more full extraction from the raw material. It was demonstrated, that they are in hidden associated forms with biopolymers (proteins, heteropolysaccharides), nanocomplexes and nanoassociates. It was established, that extraction and transformation of BAS into the free state (1,8…2,3 times more than in the raw material) is connected with mechanocracking. In parallel it was revealed, that at cryoprocessing and fine-dispersed comminution of topinambour takes place destruction of inulin into the separate monomers – fructose by 45…55 %, protein – into free acids, cellulose in sugars – by 43…55 % at the expense of non-enzymatic biocatalysis – cryomechanolysis [19, 20]. So, there takes place destruction of the difficultly soluble biopolymers and their transformation in easily assimilated nanosized form. The conformational changes of proteins globules were studied. It was shown, that the forms of protein molecule changes, the size of its kernel, coat and ratio of hydrophobic and hydrophilic remains of amino acids and so on decrease. There was also studied the transformation of difficultly soluble heteropolysaccharides, their nanocomplexes together with proteins into soluble easily assimilated form.

It is well-known, that in vegetable raw material (including topinambour) pectin substances are in non-active form and that is why they have the low jelly and absorptive properties [21, 22]. In this connection were carried out scientific researches when topinambour was frozen using high (2, 5, 10, 20 ˚C/min) and low (0,1; 0,2; 0,5 ˚C/min) freezing speeds. The cut tubers were frozen to the different final temperatures in product (especially –18…–20 ˚C) and to the lower temperatures in product (–32…–35 ˚C) and sublimation drying and fine-dispersed comminution were carried out. In the process of freezing and comminution take place cryomechanodestruction and cryomechanoactivation. It was established, that at complex effect of aforesaid processes on topinambour takes place the more full extraction of pectin from associated state with other biopolymers and nanocomplexes into free active (soluble) form. It was revealed, that there takes place essential degradation and cryodestruction of protopectin and its transformation from non-active form into active (soluble) one. Thus, it was established, that at getting nanopowders of tominambour takes place the more full extraction of pectin substances mass fraction from nano-

complexes, 3,0…3,4 times more that in initial raw material, including protopectin (2 times) and its destruction to the soluble pectin (4,5 times more). In general in topinambour nanopowders 70 % of pectin substances are in soluble form. Mechanism of the more full extraction of pectin substances from nanocomplexes and nanoassociates of the vegetable raw material is connected with their cryomechanocracking (destruction) and non-enzymatic biocatalysis – cryomechanolysis.

Using the method of biotesting of infusoria test-cultures (by generative activity of unicellular organisms) was shown that in comparison with coarsely dispersed topinambour the assimilability of its nanopowders is 2,7…3,0 times higher. It is connected with the higher extraction from the raw material of soluble biologically active and food substances that are in nanosoluble form at fine-dispersed comminution.

It was established, that topinambour additives – nanopowders by chemical composition, BAS content and dispense state exceed the known world analogues, received by traditional technologies. Such technologies are realized at thermal drying at temperature +65…+130 ˚C and higher, especially, by convective, convective-vacuum, convective-impulse, conductive, vacuum, spraying and other drying methods [23–25]. The significant part of substances (especially, inulin, protein, cellulose, pectin substances) and BAS (phenol compounds, flavonol glycosides, tanning substances) in 60…70 % are in nanosized form (**Table 1**). Thus, for example, difficultly soluble biopolymers (proteins, inulin, cellulose, pectin substances) of topinambour in 45,0…55,0 % were transformed into soluble form as separate monomers (fructose, free α-amino acids, glucose, galacturonic acids) that have nanosoluble form. It is known, that the last ones have molecules size from 0,8…1,4 nm [26, 27]. Nanopowders differ from analogues by the high fructose content (up to 25,0 %) and fructooligosaccharides [23–25]. At the same time they differ by the high content of low molecular phenol compounds (by chlorogenic acid) (up to 2800 mg in 100 g, flavonol glycosides (by rutin) (up to 1800 mg in 100 g), tanning substances (up to 2160,0 mg in 100 g) (**Table 1**). The cited compounds have potential immune-modeling, antioxidant, detoxifying and anti-tumor properties [29].

Table 1

Content of biologically active and prebiotic substances in topinambour nanopowders comparing with analogues (n=3)

Parameter name	Fresh topinambour	topinambour nanopowder	Analogue – topinambour powder of convective vacuum-impulse (CVI) drying	Analog – topinambour powder of convective drying
Inulin, %	12,8±0,5	25,6±1,5	9,75±0,1	7,46±1,3
Fructose, %	–	25,6±1,5	0,0	0,0
Protein, %	1,2±0,01	9,1±0,2	8,9±0,1	8,7±0,1
Associated amino acids of protein, mg in 100 g	1664,0	3698,0±0,2	–	–
Free amino acids of protein, mg in 100 g	350,0	5415,0±0,2	–	–
General pectin, %	1,9	30,0	9,3±0,1	8,4±0,1
Protopectin, %	1,2	10,4	–	–
Soluble pectin, %	0,7	23,0	–	–
General sugar, %	4,4±0,1	23,7±1,4	70,25±0,2	71, 33±0,2
Vitamin C, mg100 g	10,3±0,1	78,2±2,4	16,4±1,1	12,2±0,3
Phenol compounds (by chlorogenic acid), mg in 100 g	350,0±5,7	2800,0±12,4	–	–
Flavonol glycosides (by rutin), mg in 100 g	240,0±4,8	1800,0±12,4	–	–
Tanning substances, mg in 100g	300,0±6,4	2160,0±14,0	–	–
Ash content, %	1,6±0,1	6,8±0,2	6,0±0,2	5,9±0,1
Organic acids, %	0,3±0,01	2,0±0,1	0,8±0,1	0,65±0,1
Humidity, %	76,4±1,2	5,5±0,1	7,9±0,1	7,3±0,1

4. Conclusions

Thus, the use of cryomechanodestruction (cryogenic freezing and fine-dispersed comminution) allows get the qualitatively new feed additives in the form of topinambour nanopowders with record BAS and biopolymers content in easily assimilated nanoform that are impossible to be gotten using traditional methods (convective, convective-vacuum, convective-impulse, conductive, vacuum, spraying and other) of the raw material drying. According to the chemical composition, new feed additives (nanopowders) of topinambour have potential perbiotic, immune-modeling, anti-tumor and detoxifying effects [30]. It is knows, that inulin, pectin substances, cellulose, protein are the indigestive food components, contained in topinambour nanopowders and have prebiotic properties [30]. They stimulate in human organism development and metabolic and biological activity of one or several groups of own bacteria that form intestinal human micriflora, have a positive influence on composition of microbiocenosis. It is also known, that phenol compounds (by chlorogenic acid), flavonol glycosides (by rutin) and tanning substances, contained in topinambour nanopowreds, have potential immune-modeling, antioxidant, detoxifying and anti-tumor effect [28, 30]. In this connection there are reasons to think that nanopowders have the same properties because of containing significant part of these substances.

Experimental data, presented in the article, are the base of elaboration of the cryogenic nanotechnology of topinambour as nanopowders.

New technologies were probated in production conditions of SPE "CRIAS" (Kharkov, Ukraine) and SPE "FIPAR" (Kharkov, Ukraine), the normative documentation was elaborated (TC U 15.3-01566330-304 and TI). On their base were elaborated the new types of wellness products (dry fast soluble fruit nanodrinks «Instant»m dry juices, pastry, new types of nanoicecream, biokefirs, bioyoghurt with prebiotic properties and so on).

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ABSTRACT AND REFERENCES

TECHNOLOGY AND EQUIPMENT OF FOOD PRODUCTION

DEVELOPMENT OF TECHNOLOGY OF USING SUBSTANDARD EGGS IN FARM POULTRY FEEDING (p. 4-14)

Bogdan Iegorov, Nina Vorona, Alla Makarynska, Olena Voietska Tatiana Bordun

Theoretically and experimentally, there was substantiated the expediency of enriching grain raw material in the composition of feed with the protein of animal origin due to a substantial reduction of nutritional and energy value of the grain components that are produced in Ukraine, often with violation of agrotechnology. The possibility to use valuable substandard egg mass for feeding agricultural poultry was proved. This will allow solving the problem of utilizing defective eggs.

A technological way of producing the extruded feed additive was developed, which implies obtaining the preceding mixture of crushed corn and egg mass without shell of substandard chicken eggs in the 1:1 ratio in a frame mixer for 180 s, mixing the preceding mixture with corn grit, which remained in the blade batcher for 120...180 s, and the extrusion of the resulting highly homogeneous mixture. The rational parameters of technological process of the extrusion of the feed additive were established: pressure in the working zone of the extruder is 2...3 MPa, power consumption of the electromotor is 4.0...4.5 kW, product temperature at the outlet of the extruder is 110...120 °C, duration of the process is 60...120 s, diameter of the hole of the matrix is 10 mm. The optimum amount of the egg mass in the mixture is 10 %. The influence of the extrusion process on the quality and nutritional value of the extruded feed additive was defined. During the extrusion process, the 3,1 % loss of crude protein content was observed, the starch content decreased by 26.8 %, in this case, the content of water-soluble carbohydrates increased by 6 times. During the storage of the extruded feed additive for 3 months, bacterial semination decreased by 7 times.

Biological assessment of efficiency of the improved technology of the production of extruded feed additive was defined on laboratory animals, and it was found that the extruded feed additive is characterized by high biological value, so in the tested group the daily average gain of live weight of rats was 25,4 % higher, and the conversion of feed was 20.3 % lower than in the control group.

Keywords: extruded feed additive, production technology, enrichment of grain raw materials, substandard eggs.

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EXPLORING THE COLOR OF PLANT POWDERS USING COMPUTER COLORIMETRY (p. 15-20)

Alexandra Niemirich, Oksana Petrusha, Oksana Vasheka, Lyudmila Trofymchuk, Natalia Myndrul

The question of using a new method of color measurement with the use of contemporary digital computer technology was considered, which implies obtaining, under certain conditions, digital image of the tested sample. The plant powders, explored in the work, contain a number of pigments, which determine both the color of the powder and the color of culinary products, in composition of which they are included.

When measuring color coordinates of the powders, their restoration with water was conducted, in this case, the restored samples have lower lightness in comparison with the native powder. The difference of change in the value of color coordinate L on average decreases by 20 %.

The measurement of color of prepared meals, which was made with the use of plant powders, showed that they have lower saturation in comparison with the powders, since the pigment concentration decreases. In this case, other ingredients of meals shift the magnitudes of color coordinates of lower magnitudes of saturation and lightness towards the lightness of native powder. The exception is the powder from sea buckthorn, the pigments of which are manifested poorly in the restored state.

The accessibility of the method makes it possible to use it for evaluating quality, controlling technological process of preparing meals and culinary products using traditional and innovative ingredients, including vegetable and fruit-and-berry powders.

Keywords: color coordinates, computer colorimetry, index of yellowness, plant powders, digital image, color.

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THE EFFECT OF CRYOMECHANODESTRUCTION ON ACTIVATION OF HETEROPOLYSACCARIDE-PROTEIN NANOCOMPLEXES WHEN DEVELOPING NANOTECHNOLOGIES OF PLANT SUPPLEMENTS (p. 20-28)

Raisa Pavlyuk, Viktoriya Pogarska, Katerina Balabai, Vadim Pavlyuk, Tatyana Kotuyk

The regularities and mechanisms of the effect of deep processing of plant raw materials were established, such as finely dispersed grinding in developing nanotechnology of obtaining frozen nanopuree and nanopowders on the transformation of bound amino acids of protein to free soluble form by мechanolysis of molecules of protein (by 45...55 % to separate α-amino acids). We discovered the mechanism of mechanodestruction of protein molecules and its nanocomplexes with other biopolymers and BAS, which is linked to mechanocracking.

In the deep processing of plant raw materials, in particular, Jerusalem artichoke, which is based on the comprehensive action of cryogenic «shock» freezing, freeze drying and finely dispersed grinding processes when obtaining nanopowders, the processes of cryodestruction, mechanodestruction and mechanochemistry occur that lead to the fuller extraction of BAS from the raw material (by 1.8...2.3 times more than is in the original raw material) and destruction of biopolymers (inulin, proteins) to their monomers.

It was found that the freezing and cryomechanodestruction lead to the transformation of chemical substances of Jerusalem artichoke (cryomechanochemistry) and transformation, in particular, conformational changes of protein molecules: reduction of radius of the volume of a protein molecule, radius of its nucleus, and also to a decrease in the indicator of filling the nucleaus with hydrophobic remains of amino acids. In addition, the shape of protein molecules changes.

We proposed and designed cryogenic nanotechnology of finely dispersed frozen nanopuree and nanopowders from Jerusalem artichoke with prebiotic properties. It was shown that nanosupplements exceed the known world analogues in the content of BAS and dispersed composition. In addition, a large part of the substances (both BAS and biopolymers) is in the nanodimensional form.

Keywords: deep processing of raw materials, cryomechanodestruction, finely dispersed grinding, Jerusalem artichoke, nanocomplexes, nanopowders, nanopuree.

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THE STUDY OF BIOLOGICALLY ACTIVE SUBSTANCES OF CHAENOMELESAND THE PRODUCTS OF ITS PROCESSING (p. 29-35)

Galyna Khomych, Yuliia Levchenko, Aleksandra Horobetc, Anzhela Boroday, Nataliia Ishchenko

The importance of developing food products of improved biological value to ensure the healthy nourishment of the population was analyzed. The prospects of using plant raw materials as a source of biologically active components were shown. The chemical composition of chaenomeles fruit and of the products of its processing was determined. The biological value of the components of the fruit was explored, and it was found that maximum amount of L-ascorbic acid is contained in the pulp of the fruit and that maximum amount of phenolic substances is contained in the peels of the fruit. With the help of chromatographic studies, it was established that the products of chaenomeles processing have significant content of organic acids, among which malic, quinic, citric and succinic acids were identified, malic acid is dominant amomg them. The sugars, found in the fruit of chaenomeles, are represented by fructose, glucose and saccharose, among them fructose and glucose prevail. The raw material contains procyanidins, hydroxycinnamic acids, flavones and flavan-3-ols, among them procyanidin trimmer, chlorogenic acid, rutin and epicatechine dominate, which have high antioxidant properties. In the products of chaenomeles processing, 48 types of aromatic compounds were identified, among which prevail alcohols, acids, ethers and unsaturated carbohydrates that give products of chaenomeles processing unique aroma and predetermine their antibacterial properties.

The products of chaenomeles processing (juice, puree) are a valuable source of organic acids; they were used as a natural regulator of acidity and as an antioxidant in manufacturing products from flour yeast dough. Puree fromchaenomeles contains a significant amount of pectic substances and was used in the production of fruit sauces as a structuring agent. An increase in the organoleptic and physical and chemical indicators in fruit sauces and flour products with the use of products of chaenomeles processing was established.

Keywords: chaenomeles, chemical composition, chromatograms, procyanidin, aromatic substances, sauce, flour products.

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DEEP PROCESSING OF CAROTENE-CONTAINING VEGETABLES AND OBTAINING NANOFOOD WITH THE USE OF EQUIPMENT OF NEW GENERATION (p. 36-43)

Raisa Pavlyuk, Viktoriya Pogarskaya, Ludmila Radchenko, Roman Tauber, Nadiya Timofeeva

We proposed and designed a new method of deep processing of carotene-containing vegetables – alternative to cryogenic treatment, based on the comprehensive action of steam thermal treatment and finely dispersed grinding on raw materials using a new generation of equipment that is applied in restaurant business, which makes it possible to more fully utilize biological potential (2...3 times higher than in the original raw materials).

It was found that during deep (steam convection) processing of carotene-containing vegetables (carrot and pumpkin) with the use of modern steam convection equipment, the fermentative processes proceed with less intensity than during traditional method of thermal treatment – blanching by immersion in boiling water. The quantitative indicator of the maximum fermentative activity during treatment of the carotene-containing vegetables in a combi steamer, compared to blanching, is 2–4,5 times less for polyphenol oxidase, by 3 times for peroxidase. It was demonstrated that the complete inactivation of oxidative enzymes during thermal treatment of carotene-containing vegetables in a combi steamer occurs earlier than during blanching and takes place in 20 minutes, which is 10–15 minutes faster than at blanching. The complete inactivation of oxidative enzymes during blanching of carotene-containing vegetables occurs in 30–35 minutes.

It was demonstrated that, compared with fresh raw materials, during thermal treatment of carotene-containing vegetables (carrot, pumpkin) in a combi steamer (under the abovementioned modes), not only the preservation of β-carotene is achieved in 10 minutes, but also the increase in its mass by 2...2,3 times that occurs due to the release from the hidden state (forms, associated with biopolymers) to free form that is registered by the chemical methods of research. It was found that the loss of vitamin C during thermal treatment of carotene-containing vegetables in a combi steamer is much lower than at blanching. Thus, after 20 minutes of thermal treatment in the combi steamer, the mass fraction of L-ascorbic acid remained by 65...80 %, while after blanching by 40...50 %.

It was also demonstrated that after steam thermal treatment and finely dispersed grinding of carotene-containing vegetables when making puree, a significant increase in the extraction of L-ascorbic acid and β-carotene occurs in comparison to the original raw materials, which is 2 and 3 times larger for pumpkin, respectively, and for carrot – 1,7 and 2,5 times, respectively.

It was found that the comprehensive application of steam thermal treatment of vegetable raw materials in a combi steamer with finely dispersed grinding makes it possible to obtain puree, the quality of which is close to the quality of the puree, obtained using the cryogenic product treatment (in particular, the content of β-carotene is 2,5...3 times during steam thermal treatment and is 2,8...3,5 times during cryogenic treatment).

Keywords: deep processing, carotene-containing vegetables, steam thermal treatment, finely dispersed grinding, steam convection furnace, products in the nanoform.

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DETERMINATION OF TOTAL ANTIOXIDANT CAPACITY IN MARMALADE AND MARSHMALLOW (p. 43-50)

Sergey Gubsky, Maiia Artamonova, Natalia Shmatchenko, Inna Piliugina, Elena Aksenova

Creation of functional foods with various plant additives as a preventive means of population antioxidant protection programs is an important task, the solution of which is impossible without a preliminary assessment of antioxidant properties of food components – plant material. For this purpose, the antioxidant capacity of plant additives of apples, quince, grapes, pumpkins, carrots, rose hips, sea buckthorn, Sudanese rose, black chokeberry, obtained by cryogenic technologies and products with them – fruit jelly and marshmallow was investigated by galvanostatic coulometry. It was found that the TAC of cryopastes increases in the row: pumpkins<carrots<quince<apples<grapes from 25 to 550 C/100 g. The TAC of cryopowders increases in the row: grapes<black chokeberry<Sudanese rose<sea buckthorn<rose hips from 663 to 4400 C/100 g. The values correlate with the content of the main classes of antioxidants in these cryoadditives. It was determined that marmalade with the addition of carrot and pumpkin cryopastes has the lowest bromine TAC. Additional introduction of cryopowders in marmalade samples with cryopastes in an amount 1.5 % increases the TAC of marmalade by 3.5–10 times. It is shown that the use of water-alcohol extracts as additives with the addition of 1 % citric acid provides the samples of marshmallow with more pronounced antioxidant properties.

The calculations, based on the additive scheme show that the functional properties of the products are due to the antioxidant properties of the additives.

Keywords: antioxidant, coulometry, plant additive, cryogenic technology, cryopaste, cryopowder, marmalade, marshmallow.

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THE STUDY OF NANOPARTICLES OF MAGNITITE OF THE LIPID-MAGNETITE SUSPENSIONS BY METHODS OF PHOTOMETRY AND ELECTRONIC MICROSCOPY (p. 51-61)

Alexandr Alexandrov, Iryna Tsykhanovska, Tatyana Gontar, Nicholas Kokodiy, Natalia Dotsenko

With the aid of the methods of photometry and electronic microscopy, we studied the sedimentation and aggregative stability of the lipid-magnetite suspensions (LMS). Different LMS were obtained. All suspensions are sufficiently stable over time. The best results in stability were displayed by suspensions, in which the ratio Fe_3O_4:SAS=0,02:0,35 g or 0,04 mass %:0,70 mass % and 0,025:0,35 g or 0,05 mass %:0,70 mass %. We determined size of the particles of magnetite with SAS. The order of mean particle size is defined – it amounts to <d>~76 nm.

It was found that in the course of time (0–48,0 h) and with an increase in the wavelength (210–1000 nm), a gradual increase in the coefficient of transmission is observed from 25 % (210 nm) to 71,9 % (1000 nm) at 0 hours of exposure of the suspension: from 27,5 % (210 nm) to 81,2 % (1000 nm) at the maximum period of exposure of the suspension (48 hours).

The indices of LMS are determined: concentration of the particles – N=1,43 1012 cm^{-3}, in 48 hours the concentration decreased by 20 % (N=1,19·1012 cm^{-3}); r=38 nm, n=1,48, κ=0,01. The distribution function of the particles by size is rather narrow and symmetrical, which indicates that the system of the synthesized nanoparticles is homogenous with a low degree of polydispersity.

The UV spectra of LMS and their components were taken and analyzed. The comparison of the spectra of transmission of suspensions with different degree of dilution testifies to chemical identity of the samples.

The kinetic dependences of the coefficient of transmission for the suspensions with different concentration of magnetite (Fe(ov.).), were examined, based on which we calculated the effective mean radius of the particles of the stabilized magnetite: 76–168 nm. The mean radius of the particles in the lipid suspension of magnetite without stabilizer (r_{eff})=400 nm. Visually, LMS manifested high aggregation stability at the total time of sedimentation reaching several tens of hours.

It was established that LMS can be used as the biologically-active and food supplements, which possess the comprehensive action: beneficial biological effect on the human organism; due to the presence of bivalent iron in magnetite and capacity to form transition complexes with oxygen and peroxide radicals (and hydroperoxides), they manifest antioxidant activity, which leads to improvement in the quality and lengthening of the period of storage of the products that contain fat. Furthermore, LMS due to Fe^{2+} of magnetite can be recommended as the source of easily assimilated iron and as the anti-anemic means. Therefore, the introduction of LMS to the food products increases its quality, nutritional and biological value.

Keywords: magnetite, photometry, electron microscopy, dispersibility, size and effective mean radius of particles, stabilization, magnetite suspension, surface active substance (SAS), sedimentation and aggregative stability.

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SUBSTANTIATON OF SELECTING THE METHOD OF PRE-COOLING OF FRUITS (p. 62-68)

Marina Serdyuk, Dmitrij Stepanenko, Svitlana Baiberova, Nonna Gaprindashvili, Alina Kulik

The research is devoted to the scientific substantiation of the feasibility of combination of pre-cooling the fruits and their treatment by antioxidant compositions before prolonged storage, as well as determining the optimal modes and methods of carrying out the given technological operation. The objects of research were the fruits of apple varieties Aydared, Golden Delicious, Simirenko Renet, Florin, the fruits of pear varieties Izyuminka Crimea and Conference, the fruits of plum varieties Voloshka and Stenley. Pre-cooling was conducted in three ways: by cold air in conventional storing chambers, by cold air in the chambers of intensive cooling and hydro-cooling in the solutions of antioxidant compositions. As a result of the studies, it was found that the most intensive method of pre-cooling is cooling by air at temperature minus 2...minus 4 °C and airflow velocity 3 m/s. Under such circumstances, general period of cooling to a temperature 0 °C of the apple fruits and pear fruits is about 2 hours and the plum fruits – slightly longer than 1 hour. The velocity constant of reduction in the intensity of breathing and heat release of fruits during intensive cooling exceeded the velocity constant of the analyzed indices during slow cooling by 4.3...6.6 times and during hydro-cooling by 1.2...1.6 depending on the type of fruit. Along with this, high speed of air motion increased the natural weight loss of fruits during cooling. The quantitative value of this indicator during intensive method was maximum and varied in the range of 0.56 % for the pear fruits to 0.44 % for the plum fruits. Combined method, which implies initial pre-cooling in the working solutions of antioxidant compositions and further cooling by the intensive method, was characterized by high velocity constant of reduction in the intensity of breathing and heat release of the fruits and low level of the natural loss weight. In this case, the quantitative value of the weight loss varied in the range from 0.005 % for plum fruits to 0.014 % for the apple and pear fruits.

Keywords: pre-cooling, antioxidants, hydro-cooling, intensity of breathing, heat release of fruits, weight loss.

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