

DEVELOPMENT OF A METHOD FOR PRODUCING NEW GENERATION OF PROTEIN SNACKS USING THE PROCESSES OF CRYO AND MECHANICAL DISTRUCTION

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Abstract

The aim of research is to develop a method for the production of a new generation of protein snacks using a protein vegetable and milk base and vegetable fortifiers from spicy and carotene-containing vegetables using cryo and mechanical destruction processes. The method is based on the use of a deep processing method as an innovation, which consists in a complex effect on vegetable and protein raw materials of cryo and mechanical destruction processes in modern quick-freezing and low-temperature crushing equipment. The proposed method allows to get new protein snacks with a high content of protein, BAS and phytochemicals in an easily digestible form.

A new generation of protein snacks has been developed to strengthen the immune system using cryogenic protein base and vegetable raw materials. Nano-additives from dried peas and specially processed soft brine cheese are used as a protein base. Pea nanoadditives obtained using non-enzymatic catalysis – mechanolysis, mechanical destruction contain 21.5 ... 23.0 % of complete protein, which includes 49 % of amino acids in a bound state and 51 % in a free state. During the special processing of soft brine cheese with the help of mechanical destruction, 50 ... 55 % of the bound amino acids of the protein are transformed into free α -amino acids in an easily digestible form.

The proposed method makes it possible to more fully reveal the biological potential of vegetable and protein raw materials, to transform protein, BAS and phytochemicals in a bound form into easily digestible nanocomponents into a free easily digestible form. In addition, the processed protein base and raw materials acquire new properties – structure formation, gelation, coloring ability.

The obtained protein snacks are natural, differ from the traditional ones by their high content of complete protein and the absence of synthetic impurities (preservatives, thickeners, colorants, etc.). In addition, 100 g of new products can satisfy the daily requirement for biologically active substances (β -carotene, L-ascorbic acid, phenolic compounds).

Keywords: vegetable processing, protein snacks, vegetable fortifiers, health products, pea nano-additives.

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1. Introduction

The relevance of the studies presented in the work is associated with the need to solve the problem of reducing the immunity of the population [1–3]. It can be increased by including in the daily diet of combined dairy and vegetable products containing a significant amount of biologically active substances (BAS) and phytochemicals of plant raw materials [4–5], and also have a significant content of complete protein [6, 7]. Powdered milk and milk whey have traditionally been used as a dairy base in the manufacture of such products [8]. Recently, legume flour has been used as a milk base and a

source of protein [9, 10]. Powders, pastes, frozen additives, concentrates from various types of fruit and vegetable raw materials are used as enrichment of recipe components [11]. Among the combined dairy and vegetable products that are popular among the population, one can distinguish protein snacks – spreads, the protein base of which is made up of additives from legumes, as well as processed fermented milk cheeses [12]. The main disadvantages of such combined products are the low content of complete protein, biologically active substances [13], high fat content and the presence of harmful food additives in the composition (structure-formers, transgenic fats, flavors, dyes, etc.) [14, 15], which correspond in organoleptic attractiveness, and short shelf life of the product [11, 16, 17]. The low content of biologically active substances is associated with the use in the manufacture of enriching prescription components in the form of powders, pastes, frozen additives from fruit and vegetable raw materials of traditional technologies [18]. Losses of BAS when receiving additives from fruit and vegetable raw materials using traditional technologies range from 20 to 80 % [19].

A promising raw material for enriching herbal supplements is spicy, carotene-containing vegetables (sweet peppers, carrots, pumpkin, tomatoes, parsley root, garlic) and natural spices, the therapeutic and prophylactic properties of which are well known [13, 14].

One of the promising directions of processing raw fruits and vegetables is “shock” freezing with subsequent storage at a temperature of 18 °C [20, 21]. The analysis of literature data on the study of the effect of freezing temperature regimes on the quality of the product in terms of the content of biologically active substances, organoleptic, thermophysical indicators. It has been established that the disadvantage of the most common method of “shock” freezing by a flow of cold air is the loss of vitamins and other biologically active substances, as well as the loss of cell sap during thawing [22]. It has been shown that the loss of BAS and cell sap during thawing of the product depends on the freezing rate [23, 24]. The higher the speed, the less the violation of the cellular structure of fruit and vegetable raw materials and the less the loss of BAS [25] and cell juice [26] during defrosting [27, 28]. In leading countries, to obtain high-quality frozen products, “shock” freezing is used using cryogenic liquids (nitrogen, carbon dioxide). The analysis of the data showed that there is little information in the scientific literature about the effect of cryogenic “shock” freezing and fine grinding [29] of fruit and vegetable raw materials when receiving additives for biochemical, physicochemical, microbiological processes, cryo and mechanical destruction processes [30]. The exception is the results of fundamental and applied research obtained by the authors of this work for some types of fruit and vegetable raw materials [13].

The aim of research is to develop a method for obtaining a new generation of protein snacks to strengthen immunity using a specially processed protein base and vegetable fortifiers with a high content of amino acids, BAS and phytocomponents in an easily digestible nanoscale form. The new method is based on the use as an innovation of a complex effect on the protein and raw materials of cryoprocessing and the processes of cryo and mechanical destruction. They occur in modern quick-freezing and low-temperature crushing equipment (at a temperature of 35 °C), which makes it possible to obtain a new generation of protein snacks to increase immunity.

2. Materials and Methods

The study was carried out at the Kharkiv State University of Food Technology and Trade (KSUFTT, Ukraine) on the basis of the research laboratory “Innovative cryo and nanotechnologies of herbal supplements and health products” of the Department of Food Technologies of Products from Fruit, Vegetables and Milk and Innovations in Health Nutrition.

As research materials, when developing a new method for the production of protein snacks, the following were chosen: nano-additives from peas and specially processed soft brine cheese in an easily digestible form as a protein base; sweet pepper, parsley root, garlic, carrots, pumpkin, tomatoes and vegetable cryo-frozen fortifiers obtained from them; a new generation of natural protein snacks to strengthen the immune system “Bogatyr”, “Carotone”, “Svitliachok” (Fig. 1).

Cryogenic freezing was carried out using a cryogenic freezer using liquid and gaseous nitrogen as a refrigerant [9]. For fine grinding, let's use homogenizer-grinders made in France “Robot Couper” and an innovative food processor “ThermoMix” (France) [13]. Steam-thermal processing in the manufacture of protein snacks was carried out using modern Italian-made equipment a UNOX vapor convection oven of the XVC series [9].

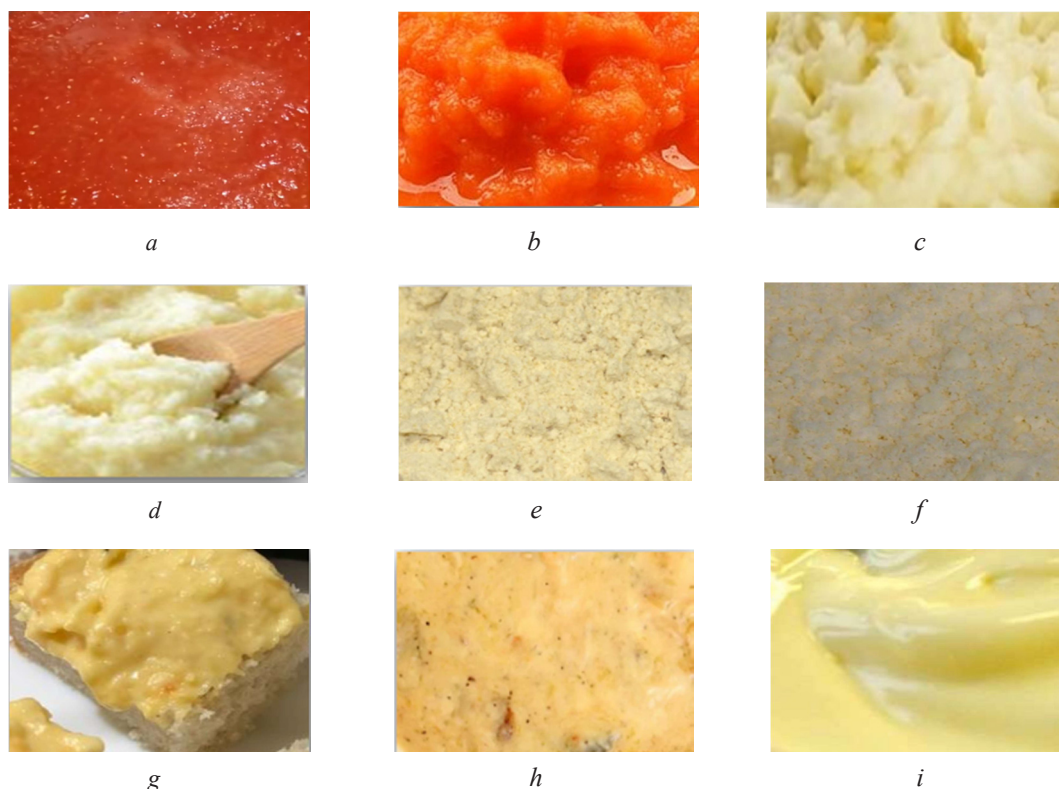


Fig. 1. Materials of research in the development of a method for obtaining a new generation of protein snacks using a protein base and vegetable fortifiers: a, b, c, d – cryo-enrichers from sweet pepper (a), carotene-containing vegetables “Multicarotin” (b), parsley root (c), garlic (d); e – Nanoadditives from peas, there f – soft brine cheese after special processing, g, h, i – protein snacks “Bogatyr” (g), “Carotone” (h), “Sviliachok” (i) (and)

A new generation of natural protein snacks has been developed to strengthen the immune system, it is recommended for implementation in large and small food industry enterprises, in restaurant business establishments.

3. Experiment procedures

In vegetable raw materials and additives from spicy and carotene-containing vegetables and natural spices, the quality was determined by the content of biologically active substances, in particular:

- L-ascorbic acid, by the method of visual and potentiometric titration with a solution of 2,6-dichlorophenolindophenate Na;
- β -carotene, by the colorimetric method of Moore after extraction of carotene from the product with an organic solvent and purification of carotene from accompanying colored substances using column chromatography;
- low molecular weight phenolic compounds (for rutin and chlorogenic acids separately), by the colorimetric method of Folin-Denis in terms of rutin and separately for chlorogenic acid;
- polyphenolic compounds, by a titrimetric method based on the properties of polyphenolic compounds to oxidize in the presence of the indicator indigo carmine, the calculation of tannins was carried out in terms of tannin.

The processing of the results of experimental studies was carried out using methods of mathematical processing using computer programs MathCad and Microsoft Excel.

4. Results

A new method has been developed for obtaining a new generation of protein snacks to strengthen immunity using a protein base and cryo-frozen vegetable fortifiers from spicy and car-

otene-containing vegetables. The new method is based on the use as an innovation of the method of deep processing of raw materials, which consists in a complex effect on vegetable and protein raw materials of cryo and mechanical destruction processes in modern quick-freezing and low-temperature crushing equipment (at a temperature of -35°C).

The proposed method allows to preserve, additionally remove and transform into a free easily digestible form of protein, BAS and phytocomponents. So, when receiving cryo-frozen vegetable fortifiers from spicy and carotene-containing vegetables, the mass fraction of BAS and phytocomponents increases 5.0 ... 5.7 times compared to the original fresh raw material. When a protein plant base is obtained from peas in the form of a nanopowder, the amino acids of the protein are transformed into a free, easily digestible form, the percentage of which in the powder is 51 %. When a protein milk base is obtained from soft brine cheese, 50 ... 55 % of the amino acids bound in the protein molecule are transformed into α -amino acids, which are in a free easily digestible form. In addition, it allows the protein base and vegetable enrichment to be provided with new functions of structure formation, gelling, coloring ability, and the like. This makes it possible to obtain new natural protein health-improving snacks with a high content of biologically active substances, phytocomponents, protein and without the use of artificial food additives. The proposed method makes it possible to more fully reveal and use the biological potential of these types of protein and vegetable raw materials, significantly increase the efficiency of the resulting product when consumed by the human body.

When receiving cryo-frozen vegetable fortifiers, it was found that the use of cryogenic “shock” freezing at a rate of $2^{\circ}\text{C}/\text{min}$ to a product temperature of $32 \dots 35^{\circ}\text{C}$ leads to inactivation of oxidative enzymes. The mechanism of the process is associated with the denaturation and destruction of the protein part of the enzymes, as well as with the inactivation of the active centers of the enzymes.

In addition, the effect of cryo and mechanical destruction processes on the content of biologically active substances and phytocomponents in the production of cryo-frozen vegetable fortifiers from spicy and carotene-containing vegetables was studied in terms of the mass fraction of L-ascorbic acid, β -picture, phenolic compounds, flavonol glycosides, polyphenols (Table 1).

Table 1

Influence of cryo and mechanical destruction processes on the content of biologically active substances and phytocomponents of spicy and carotene-containing vegetables

Product	Mass fraction of BAS, mg per 100 g				
	L-ascorbic acid	β -carotene	phenolic compounds (by chlorogenic acid)	flavonol glycosides (by rutin)	polyphenolic tannins (by tannin)
<i>Parsley root</i>					
fresh	28,4...30,1	0,2...0,3	305,0...321,4	50,6...56,7	380,2...385,4
cryoprocessed	58,6...62,5	0,3...0,4	506,2...529,2	82,7...90,3	556,0...570,2
A mixture of carotene-containing vegetables (carrots, pumpkin, tomatoes) «Multicarotine»					
mix of fresh KBO*	18,2...20,4	8,2...10,3	170,1...182,3	48,2...51,4	240,3...250,2
cryoprocessed	40,1...45,6	30,5...32,4	295,3...304,2	108,2...125,4	390,1...425,3
Sweet pepper					
fresh	310,0...335,0	5,0...5,4	132,0...150,1	28,5...32,4	118,3...126,2
cryoprocessed	720,2...800,4	12,8...15,5	204,2...210,6	41,0...46,3	190,2...195,4

*CCW – carotene-containing vegetables

It has been established that the use of cryogenic “shock” freezing of spicy and carotene vegetables to a temperature of $32 \dots 35^{\circ}\text{C}$ and further fine grinding leads to additional removal of previously unknown forms of BAS from raw materials into a free form, the mass fraction of which is 5.0 ... 5.7 times more compared to fresh raw materials.

The mechanism of increasing the content of biologically active substances and phytocomponents is associated with the use of cryo and mechanical destruction processes, mechanocracking and transformation of biologically active substances in an easily digestible form.

The obtained vegetable fortifiers were used in the production of protein snacks not only as BAR fortifiers, but also as natural structurants, gelling agents, dyes and flavorings.

Nano-additives from dried peas and specially processed soft brine cheese were used as a protein base in the manufacture of a new generation of protein snacks to strengthen the immune system.

Additives from peas in the form of powder and puree obtained with the use of nanotechnology based on the use of non-enzymatic catalysis – mechanolysis, mechanical destruction, which makes it possible to obtain additives in an easily digestible nano-sized form. It was shown that the obtained nanoadditives from peas contain 21.5 ... 23.0 % of complete protein, of which 51 % of amino acids are in a free state and 49 % are in a bound state.

When using cheese, special processing was carried out using mechanical destruction. It is shown that in soft brine, raw protein for special processing is in a bound form. The use of mechanical destruction leads to the transformation of 50 ... 55 % of the amino acids bound in the protein molecule into α -amino acids, which are in a free easily digestible form.

A new generation of natural protein snacks has been developed that help to strengthen the immune system using vegetable fortifiers from spicy and carotene vegetables in combination with a protein base (from legumes and soft brine cheese) as recipe components. Natural spice additives in the form of powders and extracts were used as natural preservatives. New types of protein snacks differ from the traditional ones in their high content of biologically active substances, complete protein (more than 18 %) and the absence of synthetic impurities (preservatives, thickeners, dyes, etc.). In addition, 100 g of new products can satisfy the daily requirement for biologically active substances (β -carotene, L-ascorbic acid, phenolic compounds). New types of protein snacks are unique in chemical composition, natural products, superior in quality to analogues and are recommended for immunoprophylaxis of all segments of the population. In terms of BAS content, the new snacks meet the recommended FAO/WHO criteria for foods for a healthy diet. The obtained protein base and vegetable fortifiers are recommended for use in the manufacture of a wide range of products for a healthy diet.

Health-improving protein snacks have been tested in production conditions at the enterprises of Kharkiv, in particular in LLC "Lisova Kazka", LLC "KHPK", UE "Baby food combine", received a positive assessment and are waiting for their consumer and investor.

5. Conclusions

A method for obtaining a new generation of protein snacks for strengthening immunity using a protein vegetable and dairy base and vegetable cryo-frozen fortifiers from spicy and carotene vegetables has been proposed and developed. The new method is based on the use of the method of deep processing of raw materials as an innovation, which consists in the complex effect of cryo and mechanical destruction processes on vegetable and protein raw materials.

The proposed method allows to preserve, additionally remove and transform into a free easily digestible form of protein, BAR and phytocomponents. So, when receiving cryo-frozen vegetable fortifiers from spicy and carotene vegetables, the mass fraction of BAR and phytocomponents increases 5.0 ... 5.7 times compared to the original fresh raw material. When a protein plant base is obtained from peas in the form of a nanopowder, the amino acids of the protein are transformed into a free, easily digestible form, the percentage of which in the powder is 51 %. When a protein milk base is obtained from soft brine cheese, 50 ... 55 % of the amino acids bound in the protein molecule are transformed into α -amino acids, which are in a free easily digestible form. In addition, it allows the protein base and vegetable enrichment to be provided with new functions of structure formation, gelling, coloring ability, and the like. This makes it possible to obtain new natural protein health-improving snacks with a high content of biologically active substances, phytocomponents, protein and without the use of artificial food additives. The proposed method makes it possible to more fully reveal and use the biological potential of these types of protein and vegetable raw materials, significantly increase the efficiency of the resulting product when consumed by the human body.

When receiving cryo-frozen vegetable fortifiers, it was found that the use of cryogenic "shock" freezing using high speeds (including 2 °C/min) up to a temperature inside the product 32...35 °C leads

to complete inactivation of oxidative enzymes. The mechanism of the process is associated with denaturation and destruction of the protein part of enzymes and inactivation of active centers of enzymes.

It has been established that the use of cryogenic “shock” freezing of spicy and carotene vegetables to a temperature of 32 ... 35 °C and further fine grinding of cryo-frozen vegetables leads to additional withdrawal from raw materials of previously hidden unknown forms of BAS into a free form, the mass fraction of which is 5,0 ... 5.7 times more compared to fresh raw materials. The mechanism of the processes is associated with the use of cryoprocessing processes, cryomechanical destruction, mechanocracking and transformation in an easily digestible form.

A new generation of natural protein snacks has been developed to strengthen the immune system using vegetable fortifiers from spicy and carotene vegetables in combination with a protein base (from legumes, soft brine cheese). The obtained protein snacks differ from the traditional ones in their high content of biologically active substances, complete protein (more than 18 %), the absence of synthetic impurities (preservatives, thickeners, dyes, etc.) and an extended shelf life. Consumption of 100 g of new products can satisfy the daily requirement for biologically active substances (β -carotene, L-ascorbic acid, phenolic compounds). New types of protein snacks are unique in chemical composition, natural products, superior in quality to world analogues and are recommended for immunoprophylaxis of all segments of the population.

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