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DEVELOPMENT OF NATURAL NANOPRODUCTS FROM BEAN AND SPICY VEGETABLES FOR RESTAURANT BUSINESS ENTERPRISES FOR HEALTHY FOOD

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The work is devoted to the study of the influence of processes of steam-thermal treatment, fine-dispersid grinding. They are accompanied by processes of mechanodestruction, mechanoactivation, with the use of modern equipment for the preserration of bean protein molecules, their destruction, activation and transformation of bound amino acids into the free form and the development of a new generation of healthful nanoproducts on their basis, for enterprises of the restaurant business (soups - puree, sandwich spreads, snacks, protein pastes, fillings, sauces-dip, etc.) enriched with cryoadditives, from spicy vegetables.

Keywords: *steam-thermal processing, fine dispersed grinding, mechanodestruction, mechanoactivation, destruction, activation, transformation, health the nanoproducts, cryoadditives, spicy vegetables.*

РОЗРОБКА НАТУРАЛЬНИХ НАНОПРОДУКТІВ ІЗ КВАСОЛІ ТА ПРЯНИХ ОВОЧІВ ДЛЯ ПІДПРИЄМСТВ РЕСТОРАННОГО БІЗНЕСУ ДЛЯ ЗДОРОВОГО ХАРЧУВАННЯ

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Вивчено вплив процесів паротермічної обробки, дрібнодисперсного подрібнення, що супроводжуються процесами механо-деструкції, механоактивації, із застосуванням сучасного обладнання на збереження молекул білка квасолі, їх деструкцію, активацію і трансформацію зв'язаних амінокислот у вільну форму та розроблено на їх основі нове покоління оздоровчих нанопродуктів, збагачених кріодобавками з пряних овочів для підприємств ресторанного бізнесу (супів-пюре, бутербродних намазок, закусок, білкових паст, начинок, соусів-дипів та ін.).

Ключові слова: *паротермічна обробка, дрібнодисперсне подрібнення, механодеструкція, механоактивація, деструкція, активація, трансформація, оздоровчі нанопродукти, кріодобавки, пряні овочі.*

РАЗРАБОТКА НАТУРАЛЬНИХ НАНОПРОДУКТОВ ИЗ ФАСОЛИ И ПРЯНЫХ ОВОЩЕЙ ДЛЯ ПРЕДПРИЯТИЙ РЕСТОРАННОГО БИЗНЕСА ДЛЯ ОЗДОРОВИТЕЛЬНОГО ПИТАНИЯ

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Изучено влияние процессов паротермической обработки, мелкодисперсного измельчения, которые сопровождаются процессами механодеструкции, механоактивации, с применением современного оборудования на сохранность молекул белка фасоли, их деструкцию, активацию и трансформацию аминокислот из связанного состояния в свободную форму и разработано на их основе новое поколение оздоровительных нанопродуктов, обогащенных криодобавками из пряных овощей для предприятий ресторанного бизнеса (супов-пюре, бутербродных намазок, закусок, белковых паст, начинок, соусов-дипов и др.).

Ключевые слова: *паротермическая обработка, мелкодисперсное измельчение, механодеструкция, механоактивация, деструкция, активация, трансформация, оздоровительные нанопродукты, криодобавки, пряные овощи.*

Statement of the problem. Today, the global problem in international practice is the deficiency of protein in diets of the population. In the Ukraine according to statistics the need for proteins is satisfied by 50% [1; 2]. In this connection it is actual to search the promising sources of protein (including the protein of plant origin) and to widen the range of dishes and products of healthful effect on the basis.

It was suggested to use bean, as a promising source of protein of plant origin. It is a source of valuable protein that is biologically close to the animal protein. But at the present time the beans have not been properly used in the food industry of Ukraine [1; 3]. The analysis of literary sources has shown that the assortment of canned bean products is limited to several types of products manufactured in Ukraine: "Canned Beans", "Beans in tomato", "Beans with Meat". The range of the products from beans at the enterprises of restaurant business usually includes 2 to 3 dishes with whole beans (not milled beans). What about the protein additives from beans at the enterprises of the processing industry and in restaurant enterprises practically are not produced [4; 5]. The difficulties in processing and using beans are connected the fact that with protein consists of high-protein protein-cellulosic-mineral complexes (associatives). Their presence in processing complicates the process of obtaining homogeneous mass [3–6]. In the addition, beans have a dense shell that is difficult to break and grind

[3–8]. It should be noted that bean-based products contain protein-cellulose-mineral complexes that are difficult to digest by the human body [3–9]. The coagulation factor of bean protein is 50–60% [3; 4; 10; 11]. In this regard, it is relevant to search the new technological techniques and new types of modern equipment, which will allow destroying the protein complexes of the beans, transformation of the proteins into a more easily digestible form and obtaining of homogeneous puree, protein additives and protein-rich foods and health-improving foods [3–8; 12].

Review of the latest research and publications. One of the perspective directions of the development of science, technique and technologes in international practice is the application of promising methods of grinding. These methods lead to the processes of mechanodestruction, mechanoactivation. They are especially manifested in increasing the degree of dispersion of shredded materials. The result of the above product acquires new properties and is in a nanosized light-digestible form. [3–8; 13; 14]. At present, fine-dispersed grinding particles with a few micrometers are widely used in chemical, textile, metallurgical, aviation, construction and other industries.

At present, the fine-dispersed grinding milling particles with a few micrometers are widely used in chemical, textile, metallurgical, aviation, construction and other industries [3–8; 15; 16]. in the food industry, these processes are practically not studied [3–8; 17; 18]. The exception is the research work carried out the within scientific schools prof. R. Pavlyuk and prof. V. Pogarskaya at the department of technology of processing of fruits, vegetables and milk at the Kharkiv State University of Nutrition and Trade, [3–8]. It is offered to use as an innovation in the processing of various types of raw materials fine dispersed grinding in a complex with freezing or steam-thermal treatment [3–8]. When receiving puree, including frozen ones, the complex action of steam-thermal treatment and fine-dispersed grinding. This allows to almost completely preserve the quality of the raw material by the content of carotenoids, ascorbic acid, phenolic compounds [3–8; 19]. The quality of the obtained mashed potatoes from carotene-containing vegetables, chlorophyll-containing vegetables, mushrooms, peas exceeds the quality of the analogues. Which are made using traditional equipment [3–8; 20]. In the scientific literature, the processing of beans using these methods is practically absent [3–8; 21].

In this regard, it is important to apply the complex action of processes of steam-thermal treatment and fine-dispersed grinding in the processing of beans to obtain protein additives in the form puree. Which are used in the manufacture of health nanoproducts for enterprises of restaurant business.

The objective of the research is study of the influence of processes steam-thermal treatment, fine-dispersed grinding with the use of modern equipment. Which are accompanied by processes of mechanodestruction, mechanoactivation to preserve the bean protein molecules. Their destruction, activation and transformation of bound amino acids into the free form. Developing on the basis of them and using cryoadditives from spiced vegetables a new generation of health-improving nanoproducts for restaurant business enterprises (soups-puree, sandwich spreads, snacks, protein pastes, fillings, sauces-dip, etc.).

To achieve the goal, it was necessary to solve the following tasks:

– to study the chemical composition and quality of beans as raw materials in the development of protein additives in the nanostructured form and to study the amino acidic skore of beans' proteins and the influence on it of processes of steam-thermal treatment and fine-dispersed grinding;

– to study the complex influence of the processes of steam-thermal treatment and fine-dispersed grinding on the content of amino acids of beans protein; which are in bound and in free form;

– to study the quality of additives in the form of frozen nanostructured puree from natural spices (garlic and roots of celery and ginger) on the content of BAS (L-ascorbic acid, aromatic substances, tannins);

– on the basis of fine-dispersed protein beans with the use of nanostructured frozen spices additives to develop a wide range of new generation of health-improving nanoproducts and dishes for restaurant business.

Presentation of the research material. The research was conducted at the Kharkiv State University of Nutrition and Trade (Ukraine, Kharkiv) at the department of technology for the processing of fruits, vegetables and milk at the laboratory "The innovative cryo- and nanotechnologies of plant additives and health products" in cooperation with specialists of the Kharkiv Trade and Economic College of Kyiv National Trade and Economics University.

A steam convection UNOX SPA XVC series (Italy) oven was used for the experimental part of the work and for obtaining a new product. It includes 70 programs that differ in the modes of processing (temperature, intensity and amount of steam supply, the presence of circulation or airflow). It includes 70 programs that differ in the modes of processing (temperature, intensity and amount of steam supply, the presence of circulation or blowing air) and allows you to save the useful substances of the product. The activator-shredder-ruber (France) used for fine-dispersed grinding. It allows you to get a product with lobes a dozen times smaller compared to traditional shredding.

The objects of the study were dried beans, steam-thermal treated and beans fine-dispersed puree from it. Besides it, the also used cryopuree from spicy vegetables (celery root, ginger root, garlic).

In the beans, dried, steam-thermal treatment and fine-dispersed puree from it were studied and determined the protein content (total nitrogen) and the amino acids in free and bound form, the fat content, dry matter, and pectin. In the cryopuree from spicy vegetables determined the quality and controlled the aromatic substances (by the number of fragrances), tannins (for tannin), vitamin C. With the methods for determining the indices of the studied samples can be found in detail in the works [3–8].

The main thing in developing the technology of fine-dispersed grinding steam-treated beans additives using the processes of mechanical degradation was to maximally destroy the associates or complexes of "protein-cellulose-mineral substances" biopolymers of raw materials, carry out mechanical degradation of proteins and transform them into easily digestible form (break down into individual amino acids or simple peptides), keep as much as possible the biologically active substances (BAS) of the raw material, obtain protein additives of a stable structure in the form of puree, do not exclude The admissibility of the use of synthetic components that possess the properties of structure-forming and thickeners.

The main thing in the development of technology of fine-dispersed grinding steam-thermal treatment beans from the use of the processes of mechano-destruction was to maximally destroy the associatives or complexes of "protein-cellulose-mineral substances" biopolymers of raw materials; the carry out mechanical degradation of proteins and transform them into an easily digestible form (to break down into individual amino acids or simple peptides); the maximally save biologically active substances (BAS) of raw material; get protein additives of a stable structure in the form of puree; the eliminate the need for the use of synthetic components with the properties of structure-forming and thickeners.

The final result of the work is the development of a new generation of health-improving nano-products from beans and spicy vegetables for restaurant business enterprises (soups-puree, sandwich spreads, snacks, protein paste, sauces-dip, etc.) with using such prescription components as nanostructured beans in the form of fine-dispersed grinding puree. It is obtained using innovative technology, which is based on the integrated application of steam-thermal treatment and fine-dispersed grinding.

The task was to study the chemical composition and quality of beans as raw materials in the development of protein additives in the nanostructured form. It was found that beans are high in total protein (23.8–25.0%), it contains all the essential amino acids.

It was shown that beans dry matter consists predominantly of starch (44.8–46.5%), hard-soluble heteropolysaccharides of cellulose (8.9–10.1%), pectin (3.2–3.8%). The mass fraction of total sugar is 3.0–3.5% and is represented by monosaccharides – fructose (1.2–1.3%) and glucose (1.0–1.4%). It is shown that the mass fraction of ash in dried beans is 2.8–3.0% and is represented by a wide spectrum of trace elements (K, Ca, Mg, P, Na), contains silicon. The vitamins of the beans are represented by vitamin E (9.1–11.2 mg per 100 g), riboflavin (0.15–0.30 mg per 100 g), choline (200–210 mg per 100 g), thiamine (0.8–1.2 mg per 100 g) (table 1).

Table 1

The chemical composition of dried beans – raw material for fine-dispersed protein additives in the form of nanostructured puree

Name of indicators	Bean samples		
	№ 1	№ 2	№ 3
Protein, %	24.5	25.0	23.8
Fat, %	1.5	2,0	1.8
Starch, %	46.5	45.0	44.8
Total sugar, %	3.0	3.5	3.2
Pectin, %	3.5	3.2	3.8
Cellulose, %	10.1	8.9	9.2
Glucose, %	1.0	1.2	1.4
Fructose, %	1.21	1.30	1.25
Ash, %	2.8	3.0	2.9
Mineral substances, mg in 100 g: K	890	910	873
Na	35	40	42
Ca	118	125	130
P	330	350	365
Mg	108	115	125
Silicon	83	95	101
Vitamins, mg in 100 g: E	9.1	10.5	11.2
Riboflavin	0,15	0,30	0.25
Thiamin	0,80	1,0	1,2
Choline	165	200	210
Moisture, %	14	13	14.5

The task of the research was to study the amino acidic skore of beans' proteins and the effects of steam-thermal treatment and fine-dispersed grinding on it. It is found that the protein of the dry bean is high-grade. The amino acid skore for all essential amino acids is 103.0–175.7%.

It was determined that the use of processes of steam-thermal treatment and fine-dispersed grinding results to increase of amino acid skore in comparison with dry beans. It includes all the essential amino acids from 120.3 to 236.0. The protein of the obtained fine-dispersed additives exceeds 1.2–2.4 times the "ideal", one according to the FAO/WHO scale from beans (table 2).

Table 2

The content of essential amino acids and the amount of amino acid score in the dried beans and fine-dispersed grinded puree from steam-thermal treatment beans

Amino acid	FAO scale / WHO, mg per 1 g of protein	Content of AA, mg per 1 g of protein dried beans	Amino acid score dried beans, %	Amount of AA mg in 1 g fine-dispersed puree protein beans, %	Amino acid score fine-dispersed grinding puree with beans, %
Protein content, %	24.32				
Essential amino acids					
Tryptophan	10	15.5	155.0	23.6	236.0
Lizin	55	73.8	134.2	79.1	143.8
Throne	40	41.2	103.0	57.2	143.0
Valine	50	77.1	154.2	77.0	154.0
Methionine	35	60.5	172.9	65.2	186.3
Isoleucine	40	48.7	121.8	58.1	145.3
Leicine	70	71.8	102.6	84.2	120.3
Phenylalanine + tyrosine	60	105.4	175.7	128.4	214.0
Total:			1119.4		1342.7

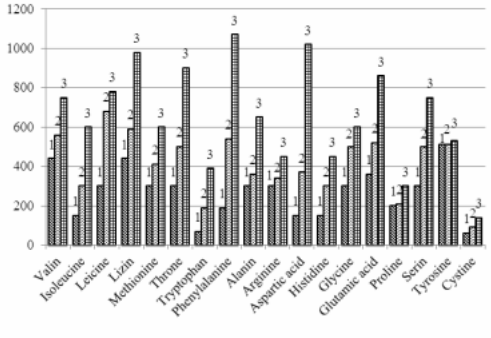
In the parallel, the complex influence of the processes of steam-thermal treatment and fine-dispersed grinding on the content of amino acids of the protein beans, which are in the bound and in free form, has been studied. It is shown that the complex application of these processes leads to the destruction of protein molecules and the transfer of amino acids from the protein bound molecules into the free forms. In fine-dispersed grinding from beans 54–57% remains in the bound state and 43–46 of the protein passes into the free form (table 3)

Table 3

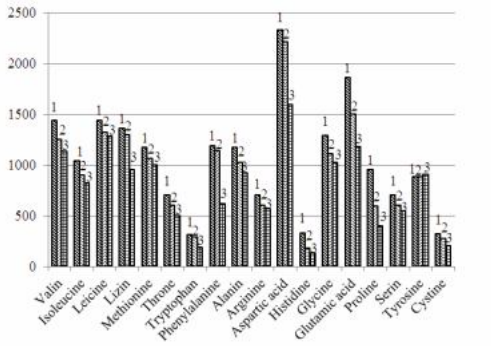
The effect of heat treatment and fine-dispersed grinding in obtaining protein nano-structured bean additives on the weight fraction of amino acids in free and bound form

Amino acid	Mass fraction of amino acids							
	in a bound state condition				in a free condition			
	Raw material (dried beans), %	Fine-dispersed puree from beans, %	% to the raw material	Reduction in relation to raw material, times	Raw material (dried beans), %	Fine-dispersed puree from beans, %	% to the raw material	Increase to the raw material, times
Alanin	1.17	0.92	78.6	1.1	0,30	0.65	216.0	2.2
Arginine	0.70	0.57	81.4	1.2	0.30	0.45	150.0	1.5
Aspartic acid	2.33	1.59	68.2	1.5	0.15	1,02	680.0	6.8
Valin	1.44	1.13	78.5	1.2	0.44	0.75	170.5	1.7
Histidine	0.33	0.13	39.4	2.5	0.15	0.45	300.0	3.0
Glycine	1.29	1.02	79.1	1.3	0.30	0.60	200.0	0.2
Glutamic acid	1.86	1.18	63.4	1.6	0.36	0.86	238.9	2.4
Isoleucine	1.04	0.82	78.8	1.0	0.15	0.60	400.0	4.0
Leicine	1.44	1.28	88.9	1.1	0.30	0.78	260.0	2.6
Lizin	1.36	0.95	69.9	1.4	0.44	0.98	222.7	2.2
Methionine	1.17	1.00	85.5	1.1	0.30	0.60	200.0	2.0
Proline	0.95	0.40	42.1	2.4	0.20	0.30	150.0	1.5
Serin	0.70	0.55	78.6	1.3	0.30	0.75	250.0	2.5
Tyrosine	0.88	0.81	92.5	1.1	0.51	0.63	123.5	1.2
Threonine	0.70	0.50	71.4	1.4	0.30	0.90	300.0	3.0
Tryptophan	0.31	0.19	61.3	1.6	0.07	0.39	557.1	5.6
Phenylalanine	1.19	0.62	52.1	1.9	0.19	1.07	563.2	5.6
Cystin	0.32	0.20	62.5	1.6	0.06	0.14	233.3	2.3
∑	20.40	13.12	64.31	1.6	3.92	9.28	236.7	2.4

It was found that in case of steam-thermal treatment and fine-dispersed grinding, disaggregation, destruction and protein mechanolysis to separate amino acids occur (43–46%). In addition, it has been shown that the amount of free amino acids increases in 1.4–6.7 times compared with the raw material (Fig.). This is due to the transformation of bound amino acids into free, which are in a more easily absorbed form of living organisms. That is, the effect of mechanical degradation, activation and mechanolysis of bean protein biopolymers in free amino acids was first detected.



a



b

Fig. Effect of steam-thermal treatment and fine-dispersed grinding on the transformation of amino acids from the bound state to free during the preparation of fine-dispersed additives with beans: a – mass fraction of amino acids in the free state, mg in 100 g; b – mass fraction of amino acids in the bound state, mg in 100 g; when 1, 2, 3 – dried beans (1), after heat treatment and rough dispersed grinding (2), puree with the steam-thermal treatment and fine-dispersed grinding beans (3)

The obtained results of experimental studies became the basis for the development of non-waste technology of fine-dispersed protein additives from beans. From the traditional technologies of receiving mashed form additives, the new technology differs from the use of puree-shaped semi-finished beans. It was obtained using a complex action of steam-thermal treatment and fine-dispersed grinding (together with a shell, without waste) to particle size. These particles are several times smaller in comparison with traditional additives and are in an easily digestible nanoscale form.

On the basis of fine-dispersed protein additives in the form of beet pulp, a wide range of new generation of health-improving nanoproducts for restaurant business has been developed. For the enrichment of new bean products, additives in the form of frozen nanostructured garlic and celery root and ginger with a high content of BAS (L-ascorbic acid, aromatic substances, tannins) were used. Their quality exceeds the fresh raw material (table 4).

Table 4

Comparative characteristics of BAS content in fresh spiced vegetables (garlic, roots of celery and ginger) and in frozen nanostructured puree on their basis

Product	Mass fraction					
	L-ascorbic acid		aromatic substances (by the number of flavors)		tannins (for tannins)	
	mg per 100 g	% to the raw material	мл $Na_2S_2O_3$ per 100 г	% to the raw material	mg per 100 g	% to the raw material
1	2	3	4	5	6	7
Ginger root fresh	11.9±0.5	100	85.3±1.5	100	191.2±2.5	100
nanostructured puree	14.8±0.5	124	167.1±2.5	196	246.8±2.5	129

Continue of table 4

1	2	3	4	5	6	7
The root of celery is fresh	7.7±0.5	100	52.9±1.5	100	212.2±4	100
nanostructured puree	13.9±0.5	181	118.1±1.5	223	286.2±4	135
Garlic is fresh	9.9±0.4	100	142.2±2.3	100	201.9±4.5	100
nanostructured puree	15.9±0.4	161	183.2±4	129	312.1±5	155

Nanostructured frozen garlic, celery root and ginger additives have fundamentally new consumer properties. Due to rapid freezing and low-temperature grinding, processes of cryodestruction and mechanoactivation are taking place and a more complete removal of BAS from a state bound to biopolymers into free (L-ascorbic acid, aromatics, tannins) occurs. The increase, depending on the type of BAS, ranges from 1.3 to 2.2 times relative to the original fresh raw material. Thus, the mass fraction of L-ascorbic acid increases from 124–181%, aromatic substances from 129–223%, tannins by 129–155%.

On the basis of fine-dispersed beet protein additives with the use of nanostructured frozen spices vegetable additives, a wide range of new generation of health nannoproducts and dishes for restaurant business enterprises has been developed: soup-puree, sandwich spreads, sauce-dipes, snacks, fillings, protein paste and others.

The rational technological parameters of the technology have been experimentally determined and substantiated, and testing has been carried out in production conditions.

Conclusion. The chemical composition and quality of beans are studied. It was established that beans, as a raw material in the development of protein additives in nanostructured form, are characterized by a high content of complete protein (from 23.8 to 25.0%), which includes all essential amino acids. It was also found that the application of the processes of steam-thermal treatment and fine-dispersed grinding in comparison with dry beans leads to an increase in amino acid scor, which by all indispensable amino acids is from 120.3 to 236.0. The protein in the obtained fine-dispersed additives from beans is 1.2–2.4 times the «perfect». It was also found that the beans contain high content of starch – 44.8–46.5%, difficult soluble heteropolysaccharides, cellulose (8.9–10.1%), pectin (3.2–3.8%). It has been established that in case of steam-thermal treatment and fine-dispersed grinding, there is disaggregation, destruction and protein mechanolysis to individual amino acids (43–46%). In addition, it has been shown that the amount of free amino acids increases in 1.4–6.7

times compared with the raw material. This is due to the transformation of bound amino acids into free, which are in a more easily absorbed form of living organisms. That is, the effect of mechanical degradation, activation and mechanolysis of bean protein biopolymers in free amino acids was first detected.

The quality of nanostructured frozen additives from spiced vegetables (garlic, roots of celery and ginger) was studied. It is shown that additives have fundamentally new consumer properties. Due to the rapid freezing and low-temperature grinding of spicy vegetables accompanied by processes of cryodestruction and mechanoactivation, the complete removal of BAS from a state bound to biopolymers occurs in free (L-ascorbic acid, aromatic substances, tannins) (1.3–2.2 times) relative to the source of fresh raw materials.

On the basis of fine-dispersed beet protein additives with the use of nanostructured frozen spices vegetable additives, a wide range of new generation of health nanoproducts and dishes for restaurant business enterprises has been developed: soup-puree, sandwich spreads, sauce-dipes, snacks, fillings, protein paste and others. The experimental defined and substantiated rational technological parameters of the technology, tested in production conditions.

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