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USE OF FOOD COMBINATORICS IN THE VEGETABLE DISHES DEVELOPMENT OF THE IMPROVED AMINO ACID COMPOSITION

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The topicality. To date, the structure of the population's diet has significant deviations from the formula of a balanced diet in terms of protein intake, including sulfur-containing, which causes the formation of risk factors for the development alimentary and alimentary-dependent diseases. For the prevention of diseases caused by protein deficiency, it is promising to increase its content in vegetable dishes due to the integrated use of raw materials and dietary supplements of high biological value. It is advisable to use food combinatorics in the innovative technologies development for vegetable dishes of improved amino acid composition. **The purpose of the study** is food combinatorics of amino acid composition of potato croquettes with soy flour, wheat germ; natural shrimp powder "Rieber Food Ingredients" and lentil-spirulina filling in terms of content and balance of essential and substitute amino acids and the degree of their assimilation by the human body. **Research methods.** Physicochemical, mathematical and statistical methods of experimental data processing with the use of information technologies, methods of ion exchange liquid column chromatography and qualimetric methods have been used. **Results.** Research is aimed at the use of food combinatorics and scientific substantiation of the amino acid composition of potato croquettes with the use of protein vegetable and non-fish water raw materials and dietary supplements. As a result of scientific researches the food combinatorics at development of technology of vegetable dishes has been carried out, the amino acid structure has been proved and experimentally generalized, the amino acid score and balance of sulfur-containing amino acids in the complex use of potato mass with wheat germ, soy flour, natural shrimp powder "Rieber Food Ingredients" and lentil-spirulina filling in culinary products have been analyzed. The social effect of fuller use of vegetable, non-fish water raw materials, expansion of the range of vegetable dishes with improved amino acid composition and consumer properties of potato dishes in restaurants, preservation and protection of public health has been confirmed. **Conclusions and discussions.** Food combinatorics was carried out during the potato croquet technology development with the use of protein vegetable and non-fish water raw materials, which contributed to the improvement of the amino acid composition of vegetable dishes and, in particular, to the increase of their biological value.

Key words: food combinatorics, amino acid composition, potato croquettes, dietary supplements.

The topicality of the problem

Formulation of the problem. Strengthening the physical and mental health of the population in the face of deteriorating medical and demographic situations is a priority for maintaining the reproductive power of society and national security. To ensure a healthy lifestyle and high efficiency in modern conditions, it is important to pay attention to the quality of food (World Health Organization, 2007, p. 87).

The food problem is significant in many countries of the world and in Ukraine. One of the main issues is the lack of complete protein in the human diet. Improving the nutrition structure of the population involves increasing food production by improving existing and developing functional culinary products obtained by the latest technologies.

The main criteria for the quality of food products are their biological value, which is largely determined by the amino acid composition, the balance of amino acids, especially essential, and the degree of assimilation by the body (Peresichnyi et al., 2012).

To solve the problem of providing the population with cheap and high-quality food, the rational use of plant products as cheap and less labor-intensive raw materials in the production of animal products, dietary supplements and the creation of functional culinary products based on them is becoming increasingly important.

Among the products of everyday food the second place after bread is occupied by potatoes, and in terms of production it is second only to cereals (wheat, rice and corn) (Shtantsova & Samokhvalova, 2008) and is characterized by high taste. In terms of gross potato production, Ukraine ranks fourth in the world (after China, India and Russia). Ukraine produces 25-30 thousand tons of potato products (dried, canned, fried) in demand of 150 thousand tons. Depending on the place of cultivation and variety, the tubers contain 11–25% of starch, about 2% of protein, 0.3% of fat (Vermenko et al., 2016, p. 66). In terms of biological value, potato proteins exceed the proteins of many cereals. Especially potato tubers are rich in amino acids: lysine and leucine. Of the minerals, potatoes are the richest in potassium (568 mg / 100 g), which corresponds to 20% of the recommended intake (RNS), phosphorus (58 mg / 100 g – 7% RNS), vitamin C (20 mg / 100 g) and B6, which plays an important role in energy metabolism, breaking down carbohydrates and proteins into glucose and amino acids. Carbohydrates are represented mainly by potato starch (10% of carbohydrates from RNS). Potatoes contain dietary antioxidants, which play an important role in disease prevention, as well as dietary fiber, having a beneficial effect on health (Mikheeva et al., 2013). In terms of calories, potatoes are 3-5 times higher than other vegetables. Therefore, there is a need to increase the nutritional value of potato dishes and reduce their energy value.

It is known that potatoes can be used to make more than 500 delicious dishes. It is used in boiled, fried, stewed, baked, as well as frozen and used in the processing industry ("Potatoes: History", 2021).

However, to ensure a balanced diet, it is advisable to develop culinary products based on potato mass with high biological value. An effective way to solve this problem is to create with the help of food combinatorics scientifically based technology of potato croquettes, which are popular with people of different ages, with improved biological

value. The possibility of modeling the consumer characteristics of finished products, forecasting their biological safety, quality and functional and technological properties, taking into account the phenomenon of synergism, plays a significant role in the food design of multicomponent products.

In order to use food combinatorics in the development of technology of culinary products for functional purposes, enriched with proteins and amino acids, dietary fiber, macro- and micronutrients, vitamins, it is advisable to use different types of grains, flour, dietary supplements, as traditional products are mainly made from using flour of the highest and first grades.

Among the most important nutrients that have a positive effect on intellectual abilities and mental activity, proteins are distinguished and primarily as a source of essential amino acids (World Health Organization, 2007, p. 87).

Promising protein raw materials are soy flour, wheat germ, lentils, as well as dietary supplements: spirulina, natural shrimp powder “Rieber Food Ingredients”.

In developing culinary products took into account the biological value of protein proteins, dietary supplements and the principle of mutual complementarity of limiting amino acids. The biological value of food proteins depends not only on their amino acid composition, but also on the availability of enzymes of the gastrointestinal tract and the degree of digestibility (Studenikin, 2012).

State study of the problem. An important way to rationalize the quality of protein nutrition is to improve the amino acid composition of food. Of plant products, protein contains a significant amount of legumes (up to 30%), cereals (10... 18%). Vegetables and fruits are poor in protein (1.5... 2%). However, many proteins from these groups of products have a very valuable amino acid composition (Tutelyan, 2004).

The work of OI Cherevko et al. is devoted to the study of the development of multi-component food products using biologically active substances. (2017), S. Gonzalez-Perez (2003); using potato mass S.K. Ildirova, O.O. Simakova, S. Yu. Popova (2014), L.P. Malyuk, L.O. Kasilova (2010), V.A. Koltunova, N.I. Wojciechina, S.P. Shevchenko (2007), J. Lachman, K. Homouz (2005) and others. The use of food combinatorics in the development of technology of potato dishes using biologically active substances of plant origin and dietary supplements with a given amino acid composition and their inclusion in the diet are relevant in solving the problem of health nutrition.

Unresolved issues. In world practice, potato processing is quite common. In the United States, more than 54% of the gross collection is processed annually, in the United Kingdom – 20%, in Germany – 38% (Furdyga, 2010).

Quick-frozen potato products are in the greatest demand about 60% of the total production volume. The share of edible fried potato products is 22%, dried – 15% and canned – 3% (Kushnaryov et al., 2015). Increasingly popular in Ukraine is the processing of potatoes primarily into chips, crispy potatoes, frozen fries, mashed potatoes, dumplings, potato buns.

Mass and regular population of Ukraine consumes potato dishes, and they meet the criteria for food products to be enriched with essential nutrients and there is a possibility of their centralized production, even distribution of additives by weight of the product, the technological process of enrichment that ensures appropriate quality of the finished product.

In connection with the above, scientists pay great attention to the development of technology for culinary products with improved amino acid composition, which will significantly affect the process of growth and the body formation.

When developing culinary products it is necessary to take into account the biological value of proteins and the principle of mutual complementarity of limiting amino acids. Amino acids play a leading role in the regulation of metabolism in the brain, among them sulfur-containing amino acids, in particular methionine, is especially important. Essential amino acids methionine, lysine, tryptophan has a significant impact on the growth and the body formation; methionine + cystine increases the body's resistance; tyrosine + phenylalanine – protein metabolism. Deficiency of any amino acid is manifested by diseases with characteristic features of each of them. For example, tryptophan deficiency results in cardiac dysfunction and lens opacity; reduction of methionine levels leads to damage to the pancreas and fatty infiltration of the liver; lysine is to change the processes of inhibition in the central nervous system.

In the absence of plant proteins, consisting mainly of essential amino acids, the body less rationally uses essential amino acids. The total number of calories obtained from protein should be 9... 11% of the daily energy value of the diet.

Proteins of some cereals, especially wheat, have insufficient biological value, as their amino acid rate is 50%, and the limited amino acids are lysine and threonine. Thus, wheat flour of the first grade has a lysine rate of 5.2%, threonine is 8.3%, and the combination of cereals with legumes, legumes with vegetables provides culinary products with the optimal amino gram. The source of protein can be a dietary supplement of spirulina with all essential amino acids, especially rich in leucine (5.4%) and valine (4.0%). It contains more lysine (2.9%) than vegetables. Therefore, it is appropriate to use spirulina in the development of culinary products from potatoes.

Soy products are included in FAO / WHO international programs to improve the nutrition of the world's population. Soy full-fat flour maintains a natural balance between highly dispersed proteins, soybean oil, lecithin, minerals and fat-soluble vitamins.

The quality of culinary products can be improved with the help of protein-containing raw materials: wheat germ, soybean meal, and lentils, natural shrimp powder “Rieber Food Ingredients”.

Purpose and research methods

The purpose of the study is the use of food combinatorics in the development of potato croquet technology using vegetable and non-fish water raw materials with high quality amino acid composition.

Research methods are physics-chemical, mathematical and statistical. qualimetric. The biological value of proteins and amino acid content was determined by ion-exchange liquid column chromatography on an automatic amino acid analyzer T-339 manufactured by Microtechna (Czech Republic).

The object of research is food combinatorics in the technology development of vegetable dishes of improved amino acid composition.

On the basis of the analysis of scientific sources the subjects of researches are defined: potatoes of a sort “Miracle”, grown in Borodyanskaya DSS (Kyiv region); wheat germ (TU U 2060869.004-2000), full-fat soybean meal flour (DSTU 4543: 2006) manufactured by “OLEV” LLC, (Kyiv); red lentils (DSTU 6020: 20080) produced by Divo Life,

(Kyiv); spirulina (TU U 20898991.002-2010), manufacturer LLC “Biovit” (Kyiv); natural shrimp powder “Rieber Food Ingredients” (ISO 9001: 2000 certificate), manufactured by Rieber & Son (Norway) from shrimp meat; potato croquettes: “Delis” with wheat germ and stuffing from lentils and spirulina, “Verde” with soy flour and stuffing from lentils and spirulina. Boiled potato croquettes were selected for control according to the Collection of recipes “Foreign cuisine” (Novozhenov & Sopina, 1990).

Information base of research is monitoring of scientific researches, reports of research work, abstracts of dissertations, and scientific articles in professional collections of scientific works, materials of the international congresses and symposiums, scientific and practical conferences, normative and technical documentation, statistical data.

Research results

The problem of using a rational amount of wheat germ, soy flour, lentils, spirulina, natural powder from shrimp “Rieber Food Ingredients”, which are a valuable protein and mineral raw material, in the technology of potato croquettes is solved. Attention is paid to the combination of components and determining the quality of the amino acid composition of potato croquettes.

Previous researchers have found that composite mixtures consisting of legume proteins and cereal proteins (approximately 50:50) are complementary and give the ratio of essential amino acids required in food (Kyrylenko, 2005).

We determined the amino acid composition of three varieties of potatoes by the method of ion exchange liquid column chromatography: “Miracle”, “Temp”, “Vale”; grain raw materials: whole meal rye flour, “ECO” awakened flattened barley; raw flour: wheat flour of the 1st grade, wheat bran «ESO», wheat germ “ECO”, soy flour; non-fish aquatic raw materials: natural shrimp powder “Rieber Food Ingredients”, spirulina; legumes: beans, lentils and analyzed the balance of amino acid composition to the amino acid scale of the FAO / WHO (Table 1).

According to the results of studies of potato varieties “Miracle”, “Temp”, “Vale”, it is among the amino acids of proteins of potato varieties “Miracle” most in the tubers contain leucine, lysine and isoleucine, of the amino acids containing sulfur – cystine.

Significant influence on the process of growth and formation of the human body are essential amino acids lysine, leucine and valine. “ECO” wheat germ proteins are rich in these amino acids – 2.75%, 1.84%, 1.34% and full-fat soy flour – 2.41%, 3.08% and 2.41%, respectively.

It has been proved that the addition of 5% wheat germ to wheat flour increases the content of essential amino acids from 3 to 5%, including lysine from 13 to 16% (Mykhonik, 2009).

It is known from the literature that in the manufacture of culinary products it is appropriate to include lentils due to the high protein content (24%), containing leucine (1.9%) and lysine (1.7%), which are insufficient in potato and cereal tubers, and natural “Rieber Food Ingredients” shrimp powder, treated at a temperature of 54° C to minimize protein denaturation and the least loss of flavoring active ingredients, rich in leucine (4.26%), lysine (4.32%), isoleucine (2.64%)) and valine (2.52%).

We set a task to use in the technology of croquet the maximum number of wheat germ, soy flour, which is valuable protein and mineral raw materials.

Table 1. Comparative amino acid composition of flour, plant products and non-fish aqueous raw materials, mg per 100 g of product

Product name	Amino acids							
	Valine	Isoleucine	Leucine	Lysine	Methionine + cystine	Threonine	Tryptophan	Phenylalanine + tyrosine
FAO / WHO recommendations	5000	4000	7000	5500	3500	4000	1000	6000
<i>The potato variety "Miracle"</i>	410*	620	850	800	750	520	90*	770
Amino acid score, %	8,2	15,5	12,1	14,6	21,4	13,0	9,0	12,8
<i>Potato varieties "Temp"</i>	400*	610±	840	770	360	520	70*	800
Amino acid score, %	8,0	15,3	12,0	14,0	10,3	13,0	7,0	13,3
<i>Potato varieties "Vale"</i>	390*	620	830	780	360	510	80*	760
Amino acid score, %	7,8	15,5	11,9	14,2	10,3	12,8	8,0	12,7
<i>Wheat flour of the 1st sort</i>	510	530	880	290*	400	330*	120	880
Amino acid score, %	10,2	13,3	12,5	5,2	11,4	8,3	12,0	14,7
<i>Whole meal rye flour</i>	410	260	480	280*	360	220*	100	890
Amino acid score, %	8,2	6,5	6,9	5,1	10,3	5,5	10,0	14,8
<i>Wheat bran "ESO"</i>	212*	328	572	273	50*	337	–	710
Amino acid score, %	4,2	8,2	8,7	5,0	1,4	8,4	–	11,8
<i>Barley "ECO" awakened rolled</i>	580	420	750	370*	330	350*	120	950
Amino acid score, %	11,6	10,5	10,7	6,7	9,4	8,8	12,0	15,8
<i>Wheat germ "ECO"</i>	1340*	1060*	1840*	2750	660*	1120	310	4550
Amino acid score, %	26,8	26,5	26,3	50,0	18,9	28,0	31,0	75,8
<i>Whole soy flour</i>	2412	2089	3082	2412	600*	1605	520	1858*
Amino acid score, %	48,2	52,2	44,0	43,9	17,1	40,1	52,0	31,0
<i>Bean</i>	530	490	830	760	210	410	110	730
Amino acid score, %	10,6	12,3	11,9	13,8	6,0	10,3	11,0	12,2
<i>Lentil</i>	1270	1020	1890	1720	510*	960	220	2030
Amino acid score, %	25,4	25,5	27,0	31,3	14,6	24,0	22,0	33,8
<i>Natural shrimp powder</i>	2520*	2640	4260	4320	4130	2100	1860	4620
Amino acid score, %	50,4	66,0	60,9	78,5	118,0	52,5	186	77,0
<i>Spirulina</i>	4000	3500	5400	2900*	2000	3200	900	5800
Amino acid score, %	80,0	87,5	77,1	52,7	57,1	80,0	90,0	96,7

Note: * – limiting amino acids.

Source: own development

To design the component ratio of food compositions with improved amino acid composition, the indicators of rheological properties when adding dietary supplements in the amount of from 4 to 12% of soy flour and from 1 to 20% of wheat germ were determined.

At the initial stage, the effect of replacing wheat flour with soybean (wheat germ) on the rheological properties of potato semi-finished products was studied. To solve

this problem, the process of adhesive strength, which is important for determining the properties of food systems, was considered (Table 2).

Table 2. Indicators of adhesive strength of potato semi-finished products using protein-containing vegetable raw materials (n = 40, p ≤ 0,05)

Nº experiment	The concentration of the additive, %	Adhesion strength, Pa		
1	Control	760,0	±	30,4
Full-fat soy flour "ECO"				
2	4	1100,0	±	44,0*
3	6	801,5	±	40,1
4	8	784,0	±	39,2
5	10	1047,5	±	41,9*
6	12	1592,0	±	63,7*
Wheat germ				
7	1	1100,0	±	44,0*
8	5	801,5	±	40,1
9	10	784,0	±	39,2
10	15	1047,5	±	41,9*
11	20	1592,0	±	63,7*

Note. * – the difference with the control is statistically significant.

Source: own development

In the study of the adhesive strength of the test samples, it was found that the addition of soy flour in the amount of 4% and wheat germ in the amount of 1% provides an excess of the adhesive strength of the control (Table 3). This is due to the fact that the designed process of food system production provides intermolecular interaction of proteins of plant origin, and at the same time increases the contact surface of the particles, which increases the amount of adhesion and "bonding" of potato mass particles. At 8% of soy flour and 10% of wheat germ the adhesive strength approaches the control value, therefore the free moisture is completely bound by proteins of soy flour and wheat germ, and gradually with the addition of additional protein raw materials in the diffusion process mutual penetrations of molecules are formed contact bodies, blurring of the phase boundary and the transition of adhesion to cohesion, which is observed when adding soy flour more than 10%, wheat germ more than 15% to the potato mass.

The dependence of the adhesive strength of the samples on the concentration of the corresponding additive is described by the quadratic function (Fig. 1).

The quota for the introduction of spirulina in the filling of croquettes is limited by its effect on the organoleptic properties of the finished product. Previous experimental studies have shown that the introduction into the recipe of spirulina fillings in amounts of 2% and above (by weight of the semi-finished product) and natural shrimp powder "Rieber Food Ingredients" in the amount of 1.5% and above gave the product an undesirable foreign taste and bright green color (for due to spirulina). Of practical interest is the introduction of the filling: lentils 30%, spirulina 1.5% and 1% natural shrimp powder (by weight of the semi-finished product) in the manufacture of croquettes.

Table 3. Potato croquettes with composite mixtures

Name of croquettes	The concentration of additives in the composite mixture,% by weight of the semi-finished product	Concentration of additives in fillings,%
Control	Wheat flour – 14	–
“Verde”:		
I variant	Wheat flour – 8 Soy flour – 6	Lentil – 31 Spirulina – 1 Natural shrimp powder “Rieber Food Ingredients” – 0,5
II variant	Wheat flour – 4 Soy flour – 8	Lentil – 30 Spirulina – 1,5 Natural shrimp powder “Rieber Food Ingredients” – 1
III variant	Soy flour – 14	Lentil – 29 Spirulina – 2 Natural shrimp powder “Rieber Food Ingredients” – 1,5
“Delis”:		
I variant	Wheat flour – 4 Wheat germ – 8	Lentil – 31 Spirulina – 1 Natural shrimp powder “Rieber Food Ingredients” – 0,5
II variant	Wheat flour – 2 Wheat germ – 10	Lentil – 30 Spirulina – 1,5 Natural shrimp powder “Rieber Food Ingredients” – 1
III variant	Wheat germ – 12	Lentil – 29 Spirulina – 2 Natural shrimp powder “Rieber Food Ingredients” – 1,5

Source: own development

Thus, by a preliminary experiment, there is a limit on the quantitative composition of ingredients for potato croquettes and developed composite mixtures.

To determine the rational concentrations of wheat germ, soy flour in potato croquettes were guided by organoleptic quality indicators (appearance, sectional view, consistency, odor, taste). The upper limit of concentration at which the organoleptic evaluation of the product is higher than the control sample was chosen as the optimal one (Table 3).

Thus, the appearance, taste, smell and consistency of croquettes “Delis” and “Verde” I variant and control products have almost the same number of points, a slight difference is observed only in the appearance of minced meat in the cut (in the control sample is missing). Exceptions are samples with maximum substitution of wheat flour for wheat germ and soy flour (variant III). According to the tasters, the taste of the potatoes in the provided samples weakens; the color of the semi-finished product becomes slightly yellower due to wheat germ and soy flour, as well as the appearance of a faint odor and taste of wheat germ and soy flour. Experimental products become less juicy

and their consistency more elastic. Delis and Verde II croquettes had the highest score in terms of appearance, taste, smell, minced cut and consistency, receiving an average organoleptic score of 4.84 and 4.83 points, respectively, while the control sample – 4, 51 points (Table 4).

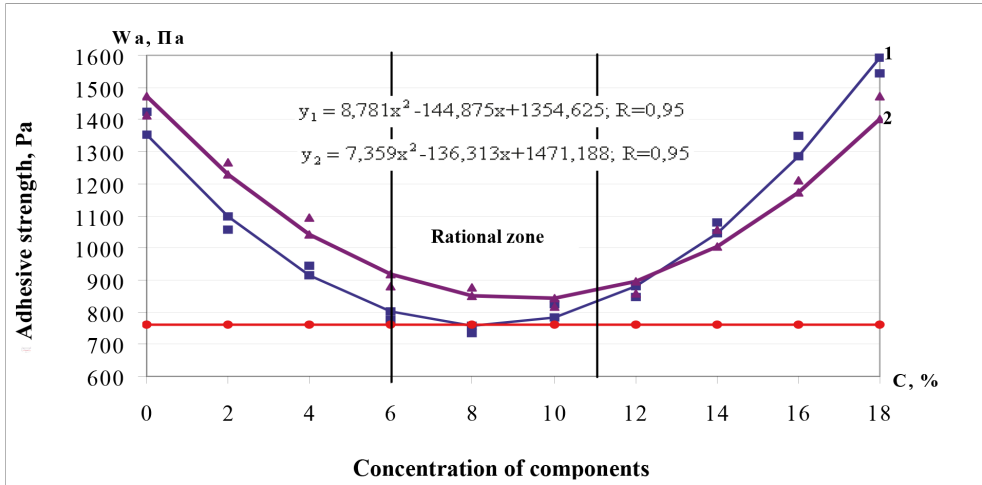


Fig. 1. Indicators of adhesive strength of food compositions depending on the concentration of the additive:

- 1– food composition with the addition of whole soy flour;
- 2– food composition with the addition of wheat germ;
- 3– control; $U_k = 880$ Pa.

Table 4. Organoleptic evaluation of potato croquettes with vegetable additives and lentil and spirulina filling, points
 $p < 0,05$

Options for potato croquettes	Evaluation by quality indicators					General organoleptic evaluation taking into account the weighting factor
	Appearance	Taste	Smell	View in the cut	Consistence	
	weight ratio					
	2	3	2	1	2	
Control	4,75 ± 0,22	4,54 ± 0,19	4,47 ± 0,18	4,40 ± 0,19	4,43 ± 0,19	4,51 ± 0,19
“Delis”:						
variant I (8 % wheat germ)	4,75 ± 0,21	4,54 ± 0,18	4,54 ± 0,19	4,47 ± 0,17	4,45 ± 0,19	4,54 ± 0,21
variant II (10 % wheat germ)	4,79 ± 0,18	4,86 ± 0,20	4,84 ± 0,16	4,84 ± 0,22	4,88 ± 0,22	4,84 ± 0,20
variant III (12 % wheat germ)	4,40 ± 0,19	4,20 ± 0,20	4,24 ± 0,20	4,80 ± 0,22	4,23 ± 0,18	4,31 ± 0,19

Continuation of the table 4

"Verde":						
variant I (6 % soy flour)	4,73 ± 0,22	4,55 ± 0,19	4,50 ± 0,19	4,49 ± 0,18	4,45 ± 0,19	4,54 ± 0,19
variant II (8 % soy flour)	4,84 ± 0,21	4,89 ± 0,23	4,79 ± 0,22	4,77 ± 0,19	4,84 ± 0,20	4,83 ± 0,21
variant III (10 % soy flour)	4,30 ± 0,20	4,20 ± 0,18	4,20 ± 0,18	4,75 ± 0,22	4,10 ± 0,19	4,26 ± 0,18

Source: own development

We have developed a technology for the production of potato croquettes, which replaced wheat flour in potato semi-finished products with a rational amount of dietary supplements – wheat germ 10% (croquettes "Delis"), soy flour is 8% (croquettes "Verde"), in which the ratio of potato mass and fillings was 60: 40%, respectively. A lentil is 30%; spirulina is 1.5% and natural shrimp powder "Rieber Food Ingredients" is 1.0% (instead of boiled potatoes) was used as fillings (Peresichnyi et al., 2012).

Studies of the amino acid composition of croquettes (Table 5) show that the amount of essential amino acids in the control is 1725 mg / 100 g, in the experimental samples it increased by 342.2% in croquettes "Verde" and 331.3% – in croquettes "Delis".

Table 5. Amino acid composition of potato croquettes

Name of indicators	Control	Potato croquettes			
		"Verde"		"Delis"	
		Experi- ment	Experiment / control, %	Experi- ment	Experiment / control, %
Proteins, g	4,66	14,04	301,3	14,23	305,4
Essential amino acids, mg:	1725	5903	342,2	5716	331,3
Valine	238	699	1293,6	630	264,7
Isoleucine	196	589	300,5	518	264,2
Leucine	320	908	283,7	829	259,0
Lysine	219	1571	717,3	1166	532,4
Methionine + cystine	136	396	291,1	344	252,9
Threonine	178	534	300,0	512	287,6
Tryptophan	56	157	280,3	145	258,9
Phenylalanine + tyrosine	382	1049	274,6	1572	411,5
Substitute amino acids, mg:	2505	8032	320,6	7590	302,9
Alanine	188	668	355,3	658	350,0
Arginine	216	1051	486,6	1419	656,9
Asparagine to-that	384	1577	410,6	1368	356,2
Histidine	82	365	445,1	554	675,6
Glycine	187	614	328,3	589	314,9
Glutamic-ta	894	2312	258,6	1741	194,7
Proline	293	664	226,6	538	183,6
Serine	261	781	299,2	723	277,0
Total amino acids, mg	4230	13 935	329,4	13 306	314,5

Source: own development

Analysis of culinary products are potato croquettes from selected raw materials showed that the ratio of the amount of essential amino acids to their total content in the test samples is higher and is 42.04% – croquettes “Verde”, 40.2% – croquettes “Delis” against 37.0 % in control. This increases the content of valine, isoleucine, lysine, tryptophan, threonine, methionine + cystine.

The amount of substituted amino acids (alanine, arginine, aspartic acid, histidine, glycine, glutamic acid, proline and serine) is also higher in the experimental samples by 320.6% in Verde croquettes and by 302.9% in “Delis” croquettes (Table 5). The total number of amino acids in the experimental samples, compared with the control, increased by 329.4% in “Verde” croquettes and by 314.5% in “Delis” croquettes.

In the croquettes “Delis” in quantitative terms of essential amino acids are dominated by valine, isoleucine, leucine, tryptophan (2.6 times), phenylalanine + tyrosine (4.1 times), lysine (5.3 times) in relation to the control sample.

In “Verde” croquettes, threonine, isoleucine (5.3 and 5.8 times), valine (7 times), leucine (9 times), phenylalanine + tyrosine (10.4 times) predominate in the quantitative ratio of essential amino acids, lysine (15.7 times) relative to the control sample.

An important indicator of the protein component is the balance of sulfur-containing amino acids. In the considered variants of experimental samples of potato croquettes the maximum approximation of this indicator to the requirements of nutrition is indicated. The ratio of amino acids is tryptophan: lysine: methionine + cystine, tryptophan: threonine, tryptophan: leucine is close to the recommended FAO / WHO, and for tryptophan: threonine, tryptophan: leucine meets the standards of nutrition (Table 6).

Table 6. The ratio of essential amino acids in potato croquettes

The ratio of amino acids	FAO / WHO recommendations	Control	Potato croquettes	
			“Verde”	“Delis”
Tryptophan: lysine: methionine + cystine	1 : (3-5) : (2-4)	1 : 3,9 : 2,4	1 : 5 : 2,5	1 : 4 : 2,4
Tryptophan: threonine	1 : (2-3)	1 : 3,1	1 : 3,4	1 : 3,5
Tryptophan: leucine	1 : (4-6)	1 : 5,7	1 : 5,8	1 : 5,7

Source: own development

Studies have shown that in the protein of the control sample the amount of essential amino acids per 100 g of protein is 33.6 g, and in the experiments – 43.0 g per 100 g of protein (“Verde” croquettes) and 42.8 g per 100 g of protein (croquettes) “Delis”) (Table 7). Thus, this total figure indicates the increased biological value of proteins of the studied foods.

A better understanding of the biological value of croquet protein with protein components is provided by the amino acid score, which allows the detection of limited amino acids.

In this case, the limiting essential amino acid is methionine + cystine, the amino acid rate of which in Verde croquettes is 82.5%.

Table 7. Amino acid speed of potato croquettes

Amino acids	Recom. FAO / WHO, g / 100 g	Potato croquettes						Deviation of amino acid score, experiment / control, ± %	
		Control		"Verde"		"Delis"		"Verde"	"Delis"
		Amino acid lots, g per 100 g of protein	Amino acid lot rate, %	Amino acid lots, g per 100 g of protein	Amino acid lot rate, %	Amino acid lots, g per 100 g of protein	Amino acid lot rate, %		
Valine	5,0	4,4	88,0	4,9	98,0	5,0	100,0	+11,4	+13,6
Isoleucine	4,0	3,6	90,0	4,1	102,5	4,2	105,0	+13,9	+16,7
Leucine	7,0	5,8	82,9	6,8	97,1	6,5	92,9	+17,1	+12,1
Lysine	5,5	4,7	85,4	11,1	201,8	8,1	147,2	+136,3	+72,4
Methionine + cystine	3,5	2,8	80,0	2,9	82,5	3,4	97,1	+3,1	+21,4
Threonine	4,0	3,8	95,0	3,8	95,0	3,6	90,0	-	-5,3
Tryptophan	1,0	1,1	110,0	1,2	120,0	1,0	100,0	+9,1	-9,1
Phenylalanine + tyrosine	6,0	7,4	123,3	8,2	136,6	11,0	183,3	+10,8	+48,7
The sum of essential amino acids	36,0	53,6	95,3	43,0	119,4	42,8	118,9	+28,0	+27,4

Source: own development

Essential amino acids of croquettes “Verde” and “Delis” are used by the body by 82.5% and 92.9% respectively. In the experimental samples, the content of cortical amino acids, except for threonine, increased in comparison with the control sample: in “Verde” croquettes it is at the level of the control sample, in “Delis” croquettes it decreased by 5.3%, and the amount of threonine decreased by 9.1%.

Conclusions and discussion of results

The scientific novelty of the obtained results is to establish the regularity of the influence of soy flour, wheat germ and lentils and spirulina fillings, natural shrimp powder “Rieber Food Ingredients” to improve the quality amino acid composition of food compositions based on potato mass.

Studies of the amino acid composition of culinary products show that the body’s daily protein requirement is 14% when consuming potato croquettes with biologically active ingredients and fillings, the number of essential amino acids in the test samples increased by 342.2% in “Verde” croquettes and 331.3% – in croquettes “Delis” in comparison with control.

Summarizing the above, we can conclude that the use of food combinatorics of protein vegetable and non-fish water raw materials in the technology of potato croquettes allows obtaining products with high protein content and high-quality amino acid composition, which will improve the nutritional structure of Ukraine and strengthen the human body.

Prospects for further development in this direction are the further use of developed food compositions in the technology of vegetable dishes in order to implement them in restaurant business.

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ВИКОРИСТАННЯ ХАРЧОВОЇ КОМБІНАТОРИКИ ПРИ РОЗРОБЛЕННІ ОВОЧЕВИХ СТРАВ ПОКРАЩЕНОГО АМІНОКИСЛОТНОГО СКЛАДУ

Актуальність. На сьогоднішній день структура харчування населення має суттєві відхилення від формули збалансованого харчування за рівнем споживання білків, у тому числі сірковмісних, що обумовлює формування факторів ризику для розвитку аліментарних і аліментарнозалежних захворювань. Для профілактики захворювань, обумовлених дефіцитом білка, перспективним є підвищення його вмісту в овочевих стравах внаслідок комплексного використання харчової сировини та дієтичних добавок підвищеної біологічної цінності. Доцільним є використання харчової комбінаторики при розробленні інноваційних технологій овочевих страв покращеного амінокислотного складу. **Мета дослідження** – харчова комбінаторика амінокислотного складу крокетів картопляних із соєвим борошном, зародками пшениці, натуральним порошком із креветок «RieberFoodIngredients» та сочевично-спіруліновою начинкою за вмістом і збалансованістю незамінних і замінних амінокислот та ступенем їх засвоюваності організмом людини. **Методи дослідження.** Використані фізико-хімічні, математично-статистичні методи оброблення експериментальних даних із застосуванням інформаційних технологій, методи іонообмінної рідинно-колонтчатої хроматографії та кваліметричні. **Результати.** Дослідження спрямовані на використання харчової комбінаторики та наукове обґрунтування якості амінокислотного складу крокетів картопляних із використанням білкової рослинної і нерибної водної сировини та дієтичних добавок. У результаті наукових досліджень здійснено харчову комбінаторику при розробленні технології овочевих страв, обґрунтовано і експериментально узагальнено амінокислотний склад, проаналізовано амінокислотний скор та збалансованість за сірковмісними амінокислотами при комплексному використанні картопляної маси з зародками пшениці, соєвим борошном, натуральним порошком із креветок «RieberFoodIngredients» та сочевично-спіруліновою начинкою в кулінарній продукції. Підтверджено соціальний ефект, який полягає у більш повному використанні рослинної, нерибної водної сировини, розширенні асортименту овочевих страв покращеного аміно-

кислотного складу та споживчих властивостей страв із картоплі у закладах ресторанного господарства, збереженні та захисті здоров'я населення. **Висновки та обговорення.** Здійснено харчову комбінаторику при розробленні технології крокетів картопляних із використанням білкової рослинної і нерибної водної сировини, що сприяло покращенню амінокислотного складу овочевих страв і, зокрема, підвищенню їх біологічної цінності.

Ключові слова: харчова комбінаторика, амінокислотний склад, крокети картопляні, дієтичні добавки.

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ИСПОЛЬЗОВАНИЕ ПИЩЕВОЙ КОМБИНАТОРИКИ ПРИ РАЗРАБОТКЕ ОВОЩНЫХ БЛЮД УЛУЧШЕННОГО АМИНОКИСЛОТНОГО СОСТАВА

Актуальность. На сегодняшний день структура питания населения имеет существенные отклонения от формулы сбалансированного питания по уровню потребления белков, в том числе серосодержащих, что обуславливает формирование факторов риска для развития алиментарных и алиментарнозависимых заболеваний. Для профилактики заболеваний, обусловленных дефицитом белка, перспективным является повышение его содержания в овощных блюдах за счет комплексного использования пищевого сырья и диетических добавок повышенной биологической ценности. Целесообразно использовать пищевую комбінаторику при разработці інноваційних технологій овочевих страв покращеного амінокислотного складу. **Цель исследований** – пищевая комбінаторика амінокислотного складу крокетів картофельних с соєвою мукою, зародками пшениці, натуральним порошком із креветок «RieberFoodIngredients» і чечевично-спируліновою начинкою с содержанием и сбалансированностью незаменимых и заменимых аминокислот и степенью их усвояемости организмом человека. **Методы исследования.** Используются физико-химические, математическо-статистические методы обработки экспериментальных данных с применением информационных технологий, методы ио-

нообменной жидкостно-коллончастой хроматографии и квалиметрические. **Результаты.** Исследования направлены на использование пищевой комбинаторики и научное обоснование качества аминокислотного состава крокетов картофельных с растительным белковым и нерыбным сырьем и диетическими добавками. В результате научных исследований осуществлена пищевая комбинаторика при разработке технологии овощных блюд. Обоснованно и экспериментально определен аминокислотный состав, проанализированы аминокислотный скор и сбалансированность по серосодержащим аминокислотам при комплексном использовании картофельной массы с зародышами пшеницы, соевой мукой, натуральным порошком из креветок «RieberFoodIngredients» и чечевично-спиреулиновой начинкой в кулинарной продукции. Подтвержден социальный эффект, который заключается в более полном использовании растительного, нерыбного водного сырья, расширении ассортимента овощных блюд улучшенного аминокислотного состава и потребительских свойств блюд из картофеля в заведениях ресторанного хозяйства, сохранении и защите здоровья населения. **Выводы и обсуждения.** Осуществлена пищевая комбинаторика при разработке технологии крокетов картофельных с использованием белкового растительного и нерыбного водного сырья, что способствовало улучшению аминокислотного состава овощных блюд и, в частности, повышению их биологической ценности.

Ключевые слова: пищевая комбинаторика, аминокислотный состав, крокеты картофельные, диетические добавки.