



Development of Protein-Enriched Vegetable Product Technology and Its Quality Assessment

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Abstract

Nutritional basics of pupils of general educational institutions are considered in the article. As proposals on improvement of food ration of pupils, it is proposed to use developed innovative vegetable casseroles, for enrichment of which the innovative products have been applied: aubergines, marrows, pumpkin and apples. A protein complex dry blend has been utilized to enrich the casseroles with protein. Determination of functional parameters of developed vegetable casseroles has shown that the casseroles prepared according to the technology are protein-enriched. The developed products may be recommended for use in nutrition of pupils in general educational institutions.

Keywords: promising vegetable raw materials, protein complex dry blends, vegetable casseroles, food functional parameters, nutrition of pupils, level of requirement.

INTRODUCTION

Health of the rising generation depends on right, well-organized nutrition. Furthermore, a balanced meal must meet body's needs not only in terms of quantity but also in terms of quality.

The nutrition of children and juveniles may be designated as a problem of great social significance. During most of the time pupils stay in general educational institutions, sometimes even within 12 hours (taking into account after-school centers and also facultative studies). Therefore the well-formed nutrition builds healthy habits and lays the foundations of food culture.

Vegetables are in widespread use in feeding all the year round. However for the present their consumption is countrywide behind on established reference intakes. Vegetables are consumed fresh, as side and separate dishes, as recipe components in manufacture of production for children and juveniles.

Vegetables as well as fruits are the most important source of vitamins C, PP, carotenoids, mineral salts, a number of micronutrients, carbohydrates, phytoncides, which are conducive to the elimination of pathogenic microorganisms. Vegetables increase significantly the absorption and promote better digestion of protein and carbohydrate food and also favour the recovery of gastrointestinal tract, liver and pancreas secretory and motoric activity.

Vegetables take on greater and greater importance in control of overweight, prevention and treatment of cardiovascular and other diseases [1, 2].

Consumption of vegetables by children and juveniles is not sufficient while vegetable products are manufactured in a narrow range and characterized by a lack of variety.

It is advisable to use seasonal vegetables more often, in the first place these include such vegetables as: green peas, kidney bean, aubergines, marrows, pumpkin and etc.

Vegetable mass dishes take on particular importance in the balanced meal: patty cakes and casseroles.

Casseroles are the most popular dish. A range of casseroles in the public catering is insignificant: potato, cabbage and carrot ones. Their range in the home nutrition is much wider.

The following raw materials are used to prepare casseroles in traditional technologies: white cabbage, carrot, bulb onion, potato, manna-croup, egg, table margarine, salt, sugar, bread crumbs, sour cream [3, 4].

According to consumer evaluation these casseroles are not particularly attractive and are in a limited demand. Vegetable casseroles are prepared very seldom in school and preschool nutrition.

The modern life requires that the production meets the demands of healthy eating.

Preferences of choices in children and juveniles have been taken into consideration in the development of new assortment of casseroles, the following promising raw materials differing from traditional casseroles have been used as the recipe components: marrows, aubergines, bulb onion, white cabbage, carrot, potato, apples.

An enrichment of vegetable casseroles has been provided for raising their biological value.

METHODS

Protein complex dry blends have been applied to enrich the casseroles according to the National Russian Federation Standard GOST R 53861-2010 (Products for healthful and dietetic purposes. Protein complex dry blends. General specifications).

The blends may be used as the separate dishes and also as component for preparation of dishes and addition to casseroles, porridges, soups and beverages.

The "Nutrinor" special purpose blend is recommended as a dietotherapy in medical treatment and preventive care institutions for optimization of recovery process and prevention of diseases and also may be used in case of protein deficiency.

The blend ingredient composition is as follows: soy protein isolate, lecithin, dietary fibers (soy polysaccharides, xanthan gum), maltodextrin, aspartame, flavouring agent (cream, oil, honey), vitamin-mineral premix in daily requirement [5, 6].

The studies have been conducted according to selected food analysis methods.

Development of formulation and preparation technology has been carried out by means of simulation technique defined in the Interstate Standard GOST 32691-2014 "Public catering service. Method of elaborating and approving of house specialties at public catering enterprises". The organoleptic evaluation has been made according to the Interstate Standard GOST 31986-2012 "Public catering service. Method of sensory evaluation of catering products". Physical and chemical parameters have been determined in compliance with "Guideline for food quality and safety analysis methods" [7], "Methods of Analysis of Food Components and Additives" [8], "Foods: requirements to their quality and their safety control according to international and European standards"[9]. The structural and mechanical evaluation and analytical assessment has been made using developed empirical formulae.

The assortment of protein-enriched vegetable casseroles has been elaborated by a method of trial of recipe components. Aubergines have been added to a cabbage casserole, marrows to a vegetable one, apples to a carrot one, pumpkin to a potato one. The introduction of new kinds of vegetables and fruits has increased significantly gustatory characteristics and in the whole organoleptic parameters of the vegetable casseroles. As control

samples vegetable casseroles of traditional preparation technology have been used [3, 4].

RESULTS AND EXAMINATION

Chemical composition, nutritional and energy value of promising raw materials have been studied for its use in preparation of vegetable mass production and given in Table 1.

It has been established that these raw materials contained protein within limits of 0,62 ... 1,13%, fat - 0,12 ... 0,41%, carbohydrates - 4,63 ... 10,21%, of them mono- and disaccharides - 0,24 ... 1,05%, except marrows, dietary fibers - 1,1 ... 2,6%. The amount of potassium in mineral substances was 235 ... 278 mg. Besides that they contained sodium, calcium, magnesium, phosphorus, and iron in the quantity of 0,39 ... 0,45 mg; in vegetables and apples their amount was 2,23 mg. There was the highest amount of vitamin C equal to 5 - 32 mg, and β -carotene - 20 - 150 mg, among vitamins. The energy values of these raw materials was the following: aubergines - 28 kcal, marrows - 25 kcal, pumpkin - 24 kcal, and apples - 46 kcal.

It has been found that the promising raw materials may be used in making of vegetable mince production because of their nutritional value.

The protein complex dry blend has been applied to enrich vegetable casseroles with protein according to the National Russian Federation Standard GOST R 53861-2010 [5, 6, 10].

The blends contain complete protein, dietary fibers, some of which comprise vitamin-mineral complexes. They surpass in their value proteins of animal and plant-based food.

The following health-promoting properties of blends have been demonstrated:

- normalize metabolism;
- bring blood cholesterol and sugar levels into conformity with normal values;
- show antioxidant activity;
- promote gastrointestinal tract function;
- use of these blends is a preventive measure of contraction of bronchopulmonary diseases in enterprises with high gas content in the air and in coal mines;
- favour prevention of nervous diseases and mental illnesses;
- improve function of articulations, are prophylactic remedy of musculoskeletal system diseases;
- activate body immune protection in case of tumors of various stages and aetiology.

In conformity with definition of the term specified in the Technical Regulation of the Customs Union 021/2011, "enriched food" is production, to which one or more dietary fibers and (or) biologically active substances or probiotic microorganisms have been added; with that guaranteed by manufacturer content of each feedstuff or biologically active substance used for its enrichment is brought up to a level meeting criteria for foods.

The enriched food has a distinguishing feature concerned with specific character of its ingredients and properties, doesn't carry personalization signs and is a production of general purpose (for public consumption). Content of indispensable nutrient materials in daily ration of these goods may reach 100-300% of daily requirement.

Protein-enriched vegetable casseroles have been developed. Their nutritional and energy values have been studied [11].

Table 1. Chemical composition, nutritional value of promising raw materials (g/100 g).

Parameters	Aubergines	Marrows	Pumpkin	Apples
Moisture, g	90,2±2,51	93,6±2,38	90,9±1,12	89,6±2,11
Protein, g	1,13±0,16	0,62±0,09	1,11±0,09	0,41±0,07
Fat, g	0,12±0,02	0,41±0,08	0,13±0,02	0,38±0,05
Common carbohydrates, g	4,63±0,81	4,81±0,95	4,65±1,12	10,21±2,62
incl. mono- and disaccharides, g	3,68±0,92	4,81±0,95	4,41±0,83	9,16±0,15
Starch, g	0,95±0,16	-	0,24±0,12	1,05±0,14
Dietary fibers, g	2,6±0,23	1,1±0,23	2,2±0,4	1,9±0,33
Organic acids, g	0,22±0,05	0,15±0,06	0,11±0,06	0,82±0,12
Ash, g	0,5±0,06	0,36±0,08	0,62±0,13	0,59±0,09
Mineral substances, mg				
Na	8±2	3±2	5±1	28±3
K	241±6	235±12	214±10	278±11
Ca	13±3	16±2	25±5	16±2
Mg	10±2	11±3	14±3	11±3
P	36±5	15±2	23±5	12±2
Fe	0,42±0,11	0,39±0,04	0,45±0,06	2,23±0,14
Vitamins, mg				
β -carotene	20±3,3	30±4,2	150±10,2	30±5,3
B ₁	0,09±0,01	0,03±0,01	0,05±0,02	0,04±0,01
B ₂	0,06±0,02	0,03±0,01	0,06±0,01	0,02±0,01
PP	0,61±0,11	0,65±0,13	0,52±0,03	0,32±0,08
C	5±2,1	32±3,1	8±3,1	11±2,6
	Properties: - regulate mineral metabolism - have a hypoglycemic effect - increase heartbeat - gentle fibers	Properties: - facilitate excretion of excess fluid; - prevent obesity and cholesterol accumulation - have good influence on haematopoiesis	Properties: - increases biliation; - intensifies an intestinal motility - reinforces an immune system - promotes an absorption	Properties: - increase digestion and raise an appetite - phytoncides have active influence on causative microorganisms
	Used: - in liver and kidney diseases; - in cardiovascular diseases;	Used: - in case of cardiac edemae; - in kidney, liver and bladder diseases; - in obesity; - in gerontological nutrition;	Used: - in liver and gall bladder diseases; - in colitis; - in neoplasms and inflammatory processes	Used: - in iron-deficiency anemia; - in deficiency of blood; - in obesity; - in cardiovascular insufficiency; - in kidney and bladder diseases; - in edemae
Energy value, kcal	29	27	25	50

Table 2. Nutritional and energy value of vegetable casseroles, 100 g.

Names of parameters	Control				New development			
	Casseroles				Casseroles			
	Vegetable	Cabbage	Carrot	Potato	Vegetable	Cabbage	Carrot	Potato
Moisture, g	70,42	67,14	75,56	78,37	66,34	60,33	52,59	55,20
Protein, g	3,20	3,85	2,78	2,30	9,19	9,09	10,39	10,38
incl. animal	0,22	1,35	0,06	0,26	7,4	7,93	9,03	7,79
Fat, g	1,64	5,26	2,11	2,05	5,22	9,75	9,38	8,02
incl. vegetable	1,12	2,59	1,75	0,89	0,90	3,35	1,14	6,42
Common carbohydrates, g	11,88	19,67	14,48	14,01	16,86	15,05	22,34	19,81
incl. mono- and disaccharides, g	3,20	3,74	7,58	1,20	5,17	5,56	10,23	3,75
Starch, g	8,68	15,93	6,90	12,81	11,69	9,49	12,10	16,06
Dietary fibers, g	1,82	2,93	2,13	1,21	1,01	4,12	2,70	2,10
Organic acids, g	0,22	0,14	0,27	0,25	0,16	0,19	0,38	0,26
Ash, g	1,82	1,01	1,87	1,81	1,22	1,47	2,22	4,13
Mineral substances, mg								
Na	221	191	350	412	327	231	300	1030
K	289	242	216	408	660	618	635	723
Ca	21	58	31	30	197	216	205	200
Mg	25	22	40	20	99	102	112	101
P	48	45	65	56	184	187	213	209
Fe	0,73	0,69	1,00	0,56	3,08	2,84	4,11	2,68
Vitamins, mg								
β-carotene	3630,8	28,26	1190,4	19,47	3095,2	8,02	7150,5	418,1
B ₁	0,04	0,04	0,03	0,09	0,32	0,36	0,35	0,37
B ₂	0,11	0,14	0,10	0,07	0,39	0,40	0,47	0,49
PP	0,82	0,64	0,88	0,82	0,82	0,75	0,82	0,96
C	6,2	10,0	1,1	0,7	16,2	11,6	18,4	4,4
Energy value, kcal	75	141	88	84	151	184	215	193
Losses in cooking, %	22,84	20,89	20	14,97	23,14	20,32	24,70	23,61

Table 3. Functional and process parameters of innovative vegetable casseroles

Names of samples	Moisture content kg/kg	Chemical composition criterion	Static yield stress value, Pa	Dynamic yield stress value, Pa	Water activity	Cryoscopic point, °C
Control						
Vegetable	3,86	7,53	1963	2365	0,9841	-2,0
Cabbage	2,04	1,15	1580	1886	0,9894	-1,4
Carrot	3,09	4,07	1758	2105	0,9763	-2,9
Potato	3,62	4,07	1758	2105	0,9875	-1,61
Developed product						
Vegetable	1,97	3,47	1721	2060	0,9774	-2,78
Cabbage	1,52	1,42	1595	1907	0,9815	-2,29
Carrot	1,11	1,23	1584	1892	0,9687	-3,83
Potato	1,23	1,59	1606	1919	0,9815	-2,79

Table 4. Daily requirement satisfaction level by enriched vegetable casserole for two age groups

Names of nutrient materials	Average requirement in nutrient materials for pupils of two age groups		Vegetable casserole (100 g)									
			Control				Developed product				Daily requirement rate deviation (+/-)	
					% of daily requirement				% of daily requirement			
From 7 to 11 years	From 11 years and upwards	From 7 to 11 years	From 11 years and upwards	From 7 to 11 years	From 11 years and upwards	From 7 to 11 years	From 11 years and upwards	From 7 to 11 years	From 11 years and upwards			
Proteins	77	90	3,2	4,16	3,56	9,19	11,94	10,21	2,87	2,87		
Fats	79	92	1,64	2,08	1,78	5,22	6,61	5,67	3,18	3,19		
Carbohydrates	335	383	11,88	3,55	3,1	16,86	5,03	4,4	1,42	1,42		
Energy value	2350	2713	75	3,19	2,76	184	7,83	6,78	2,45	2,46		
Thiamine (vitamin B ₁)	1,2	1,4	0,04	3,33	2,86	0,32	26,67	22,86	8,01	7,99		
Riboflavin (vitamin B ₂)	1,4	1,6	0,11	7,86	6,87	0,39	27,86	24,38	3,54	3,55		
Vitamin C	60	70	6,2	10,33	8,86	16,2	27	23,14	2,61	2,61		
Vitamin A (mg retinol equivalent)	0,7	0,9	0,60513	86,45	67,24	0,51587	73,7	57,32	0,85	0,85		
Calcium	1100	1200	21	1,91	1,75	197	17,91	16,42	9,38	9,38		
Phosphorus	1650	1800	48	2,91	2,67	184	11,15	10,22	3,83	3,83		
Magnesium	250	300	25	10	8,33	99	39,6	33	3,96	3,96		
Iron	12	17	0,73	6,08	4,29	3,08	25,67	18,12	4,22	4,22		

Table 5. Daily requirement satisfaction level by enriched cabbage casserole for two age groups

Names of nutrient materials	Average requirement in nutrient materials for pupils of two age groups		Cabbage casserole (100 g)							
			Control			Developed product			Daily requirement rate deviation (+/-)	
	From 7 to 11 years	From 11 years and upwards	From 7 to 11 years	% of daily requirement	From 7 to 11 years	% of daily requirement	From 7 to 11 years	From 11 years and upwards		
Proteins	77	90	3,85	5	4,28	9,09	11,81	10,1	2,36	2,36
Fats	79	92	5,26	6,66	5,72	9,75	12,34	10,6	1,85	1,85
Carbohyd-rates	335	383	19,67	5,87	5,14	15,05	4,49	3,93	0,76	0,76
Energy value	2350	2713	141	6	5,2	184	7,83	6,78	1,31	1,3
Thiamine (vitamin B ₁)	1,2	1,4	0,04	3,33	2,86	0,36	30	25,71	9,01	8,99
Riboflavin (vitamin B ₂)	1,4	1,6	0,14	10	8,75	0,4	28,57	25	2,86	2,86
Vitamin C	60	70	10	16,67	14,29	11,6	19,33	16,57	1,16	1,16
Vitamin A (mg retinol equivalent)	0,7	0,9	0,00471	0,67	0,52	0,00134	0,19	0,15	0,28	0,29
Calcium	1100	1200	58	5,27	4,83	216	19,64	18	3,73	3,73
Phosphorus	1650	1800	45	2,73	2,5	187	11,33	10,39	4,15	4,16
Mag-nesium	250	300	22	8,8	7,33	102	40,8	34	4,64	4,64
Iron	12	17	0,69	5,75	4,06	2,84	23,67	16,71	4,12	4,12

Table 6. Daily requirement satisfaction level by enriched carrot casserole for two age groups

Names of nutrient materials	Average requirement in nutrient materials for pupils of two age groups		Carrot casserole (100 g)							
			Control			Developed product			Daily requirement rate deviation (+/-)	
	From 7 to 11 years	From 11 years and upwards	From 7 to 11 years	% of daily requirement	From 7 to 11 years	% of daily requirement	From 7 to 11 years	From 11 years and upwards		
Proteins	77	90	2,78	3,61	3,09	10,38	13,48	11,53	3,73	3,73
Fats	79	92	2,11	2,67	2,29	8,02	10,15	8,72	3,8	3,81
Carbohyd-rates	335	383	14,48	4,32	3,78	19,81	5,91	5,17	1,37	1,37
Energy value	2350	2713	88	3,74	3,24	193	8,21	7,11	2,2	2,19
Thiamine (vitamin B ₁)	1,2	1,4	0,03	2,5	2,14	0,35	29,17	25	11,67	11,68
Riboflavin (vitamin B ₂)	1,4	1,6	0,10	7,14	6,25	0,47	33,57	29,37	4,7	4,7
Vitamin C	60	70	1,1	1,83	1,57	18,4	30,67	26,29	16,76	16,75
Vitamin A (mg retinol equivalent)	0,7	0,9	0,1984	28,34	22,04	1,19175	170,25	132,42	6,01	6,01
Calcium	1100	1200	31	2,82	2,58	205	18,64	17,08	6,61	6,62
Phosphorus	1650	1800	65	3,94	3,61	213	12,91	11,83	3,28	3,28
Mag-nesium	250	300	40	16	13,33	112	44,8	37,33	2,8	2,8
Iron	12	17	1,00	8,33	5,88	4,11	34,25	24,18	4,11	4,11

The data presented in the Table 2 show that vegetable masses of developed casseroles have higher values of protein by 169,9...295,22%, of fat – by 85,4...218,0%; of carbohydrates – by 13,57...26,68%. In these conditions the ratio of proteins and fats in developed casseroles promotes better lipid digestion. The formulated vegetable casseroles have increased content of mineral substances: potassium, calcium, magnesium, phosphorus and iron; vitamins: carotene, thiamine, riboflavin, ascorbic acid, in comparison with control samples. The energy value of developed vegetable casseroles amounts to 151 – 215 kcal, while of control samples – to 75 – 141 kcal.

Addition of protein complex dry blend has tightened a stuffing mixture. As a result, moisture of innovative vegetable casseroles has decreased within the following limits: vegetable – by 16,47%, cabbage – by 10,14%, carrot – by 30,40%, potato – by 29,56%, that has influence on the shelf life of the developed production.

Functional and process parameters of culinary production – vegetable casseroles - have been examined (Table 3).

The studies have shown that control samples were imbalanced in moisture content and chemical composition

criterion, structural and mechanical parameters, cryoscopic point. The development of vegetable casseroles according to the innovation technology with the use of promising raw materials made it possible to stabilize the moisture content within the range of 1,11...1,97 kg/kg, chemical composition criterion - within the range of 1,23...3,47, structural and mechanical parameters, cryoscopic point - within the range of -2,29...-3,83 °C.

Daily satisfaction of ration of children and juveniles has been estimated by basic nutrient materials, specific vitamins and mineral substances for two age groups studying in general educational institutions (Table 4).

In the course of analysis of data presented in Tables 4-7, it has been found that the vegetable casseroles developed using innovation technologies are production of higher nutritional value, protein-enriched. Thus a satisfaction level of daily requirement has made: in protein from 11,81% to 13,48% for the first age group and from 10,1 to 11,53% for the second age group, in fat – from 6,61% to 12,34% and from 5,67% to 10,6%; and in carbohydrates from 4,95% to 5,91% and from 3,93 to 5,17% according to the age groups.

Table 7. Daily requirement satisfaction level by enriched potato casserole for two age groups

Names of nutrient materials	Average requirement in nutrient materials for pupils of two age groups		Potato casserole (100 g)							
			Control				Developed product			
	From 7 to 11 years	From 11 years and upwards	% of daily requirement		% of daily requirement		From 7 to 11 years	From 11 years and upwards	From 7 to 11 years	From 11 years and upwards
Proteins	77	90	2,30	2,99	2,56	10,38	13,48	11,53	4,51	4,5
Fats	79	92	2,05	2,59	2,23	8,02	10,15	8,72	3,92	3,91
Carbohydrates	335	383	14,01	4,18	3,66	19,81	5,91	5,17	1,41	1,41
Energy value	2350	2713	84	3,57	3,1	193	8,21	7,11	2,3	2,29
Thiamine (vitamin B ₁)	1,2	1,4	0,04	3,33	2,86	0,37	30,83	26,43	9,26	9,24
Riboflavin (vitamin B ₂)	1,4	1,6	0,07	5	4,38	0,49	35	30,62	7	6,99
Vitamin C	60	70	0,7	1,17	1	4,4	7,33	6,29	6,26	6,29
Vitamin A (mg retinol equivalent)	0,7	0,9	0,0032	0,46	0,36	0,0697	9,96	7,74	21,65	21,5
Calcium	1100	1200	30	2,73	2,5	200	18,18	16,67	6,66	6,67
Phosphorus	1650	1800	56	3,39	3,11	209	12,67	11,61	3,74	3,73
Mag-nesium	250	300	20	8	6,67	101	40,4	33,67	5,05	5,05
Iron	12	17	0,56	4,67	3,29	2,68	22,33	15,76	4,78	4,79

Table 8. Level of breakfast provision with protein of vegetable casseroles

Names of casseroles	Control sample, protein				Developed product, protein			
	Cont ent, %	% of food ration		Cont ent, %	% of food ration			
		From 7 to 11 years	From 11 years and upwards		From 7 to 11 years	From 11 years and upwards		
Vegetable	3,2	15,58	14,2	9,19	47,74	40,84		
Cabbage	3,85	20,0	17,1	9,09	47,22	40,4		
Carrot	2,78	14,44	12,36	10,38	53,92	46,13		
Potato	2,30	11,95	10,22	10,38	53,92	46,13		

The energy value of vegetable casseroles, where the daily requirement had been satisfied, amounted to from 7,83 to 8,21% for the first age group and from 6,78 to 7,11% for the second one.

The protein-fat ratio in developed vegetable casseroles equaled from 0,93 to 1,76% in comparison with the control samples being in the range from 0,7 to 1,95%. In these formulated casseroles the ratio is in condition to make an absorption of proteins possible.

The content of vitamins and mineral substances in developed vegetable casseroles is higher as compared to traditional technologies (control).

CONCLUSION

It is mostly recommended to use the vegetable casseroles for breakfast or supper. A level of breakfast provision with protein of vegetable casseroles is presented in Table 8.

This protein provision level has amounted for control samples to: 10,22 - 20% for the first age group and 10,22 - 17,1% for the second age group.

A level of breakfast provision with protein for developed casseroles has made: 47,22 - 53,92% for the first age group, 40,4 - 46,13% for the second age group, depending on casserole kind.

Therefore the vegetable casseroles prepared according to innovation technologies are protein-enriched. The developed products may be recommended for use in nutrition of pupils in general education institutions, balanced diet and in case of protein deficiency.

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