Improving Technology of Biscuit Semi-Finished Products Using Pumpkin Derived Products

Timoshenkova Irina Alekseevna
Peter the Great St. Petersburg Polytechnic University
St. Petersburg, Russia
itimoshenkova@spbstu.ru

Moscvicheva Elena Vladimirovna
Peter the Great St. Petersburg Polytechnic University
St. Petersburg, Russia
moskvicheva_ev@spbstu.ru

Bernavskaya Maya Vladimirovna
Peter the Great St. Petersburg Polytechnic University
St. Petersburg, Russia
bernavskaya@mail.ru

Chernikova Dariya Alekseevna
Peter the Great St. Petersburg Polytechnic University
St. Petersburg, Russia
dasha511997@yandex.ru

Fedinishina Yekaterina Yurievna
Peter the Great St. Petersburg Polytechnic University
St. Petersburg, Russia
71311@mail.ru

***Abstract*— A possibility and expediency of pumpkin seeds flour utilization for production of biscuit semi-finished product was studied; the influence of the flour on consumer properties of the product was investigated. Studies were conducted on organoleptic and physicochemical indicators of the finished biscuit semi-finished products. Grounding on the implemented studies a new production technology of pumpkin seeds flour based biscuits was developed, shelf life, biological, and nutrition value were identified. It was established that the optimal ratio of pumpkin seeds flour and starch is 90.5±0.5% to 9.5±0.5%. It was established that after consuming 100 g of the biscuit with a complete substitution of wheat flour to the gluten-free mixture 44% of daily need in magnesium, 50% - in selenium, 39% - in copper, 48% - in phosphorus, 46% - in manganese, 36% - in vitamin B9, and 36% - in linoleic acid is satisfied.**

***Keywords*— pumpkin seeds flour, biscuit, nutrition value, biological value**

I. Introduction

Flour confectionery remains an integral part of any cuisine and plays a great role in nutrition of humanity.

Amongst the whole variety of baked semi-finished products intended for cake production, biscuits characterized by the puffy and light structure gained the most distribution. However, from the point of a nutrition value, biscuits cooked according to traditional recipes lack stability in their chemical contents. The ratio of the main nutritional substances (protein, lipids, and assimilable carbohydrates) in biscuit #1 in a collection of flour confectionery and bun goods makes 1:0.75:5.85 [1]. Most flour confectionery is characterized by poor contents of protein, essential amino acids, macro- and microelements, vitamins, and other vital nutrients, as well as by a high caloric content. Within modern requirements on the part of consumers, flour confectionery does not need to be a vacuous calories carrier, but to provide a specific functionality.

A substantial part of food products is taken by products devoid of grain crop protein, which causes an autoimmune chronic Gee's disease [2].

The search for raw materials, which could allow creating quality gluten-free products possessing a balanced chemical content and high nutrition value, comes to the forefront. Ways of production of gluten-free confectionery were developed with the use of various flour types, such as triticale, rice, buckwheat, corn, fat-free flour from grape, watermelon, thistle fruit seeds; vegetable, fruit and vegetable and berry purees, pastes and powders; grain and groats conversion products [3-14]. Currently pumpkin flour, which is produced during the processing of its seeds, is of special interest. Chemical contents of pumpkin seeds are characterized by a high composition of vitamins, macro- and microelements, essential amino acids and polyunsaturated fat acids.

The aim of this paper is to develop a technology for a biscuit semi-finished product with a complete substitution of wheat flour by pumpkin seeds flour.

Due to the set aim, the following tasks were identified:

- to investigate technological characteristics of pumpkin seeds flour;
- to investigate organoleptic and physicochemical indicators of biscuit baked products with a complete substitution of wheat flour to pumpkin seeds flour with

varying ratio of starch from a dry mixture mass and to identify optimal ratio of pumpkin seeds flour and starch from dry mixture mass;

- to develop a technology of a biscuit with a complete substitution of wheat flour to a gluten-free mixture;
- to conduct a complex evaluation of the quality of new biscuit baked products.
- Pumpkin seeds flour and biscuit of recipe #1 according to a collection of flour confectionery and bun products [15] were chosen as the object of investigation.

II. METHODS OF INVESTIGATION

Sampling and their preparation for analysis were conducted in compliance with State Standard 5904; pumpkin seeds flour humidity – State Standard 9404; autolytic activity – State Standard 27495; amount and quality of gluten – State Standard 27839; acidity of the flour - State Standard 27493; mass fraction of moisture in biscuit semi-finished products – State Standard 21094; organoleptic indicators – State Standard 50763; porosity of biscuit semi-finished products – State Standard 5669.

According to commonly known methods, the following physicochemical indicators were identified:

- Gelation temperature – by heating the flour suspension to the temperature of 55-95°C with a 10°C step and subsequent centrifuging of a cooled sample during 10 minutes with 3000 revolutions per minute speed.
- Density of baked gluten-free products – as a ratio of mass to the volume of a baked semi-finished product's fragment.
- Baking losses of gluten-free products – by a ratio of difference between test preparation mass and the baked semi-finished product to test preparation mass.
- Swelling capacity of crumb of baked gluten-free products – according to a method developed by Saint-Petersburg State Science and Research Institute of Baking Industry.
- Water activity of baked gluten-free products using a device Aqulab Pawkit.

A generalized organoleptic indicator was identified by (1):

$$\sum_{i=1}^{n} p_i k_i , \quad (1)$$

where p_i is a value of i organoleptic indicator;

k_i is a value of ponderability coefficient of i organoleptic indicator.

TABLE I. COEFFICIENTS OF PONDERABILITY OF ORGANOLEPTIC INDICATORS OF GLUTEN-FREE BISCUIT SEMI-FINISHED PRODUCTS

Organoleptic indicator	**Appearance**	**Color**	**Texture**	**Aroma**	**Taste**
Ponderability coefficient	5.0	2.0	4.0	4.0	5.0

TABLE II. ORGANOLEPTIC EVALUTION CRITERIA

Organoleptic indicator	**Verbal characteristic of points**				
	5	*4*	*3*	*2*	*1*
Appearance	Correct form, complies with form in which baked products were produced earlier, with somewhat salient upper crust without cracks and tears, smooth surface, thin and soft upper crust	Correct form, insignificant tears, insufficient extent of rise, smooth surface, thin upper crust	Correct form, with small defects of surface (tears, cracks, hollows), thicker upper crust	Incorrect form of the biscuit, flat upper crust with significant tears and cracks and hollows, thick crust	Incorrect form of the biscuit, absence of rise, thick and flat crust with significant tears and cracks
Color	Light-brown crusts, light green crumb that complies with the color of pumpkin seeds, even color	Light-brown crusts, light green or yellowish crumb, even color	Dark-brown crusts, yellowish crumb, even color	Dark-brown crusts and crumb, uneven color	Dark color of crusts and crumb, uneven color, burned parts
Texture	Well-developed porosity, even pore distribution, soft and elastic crumb	Uneven pore distribution, soft and elastic crumb	Weakly expressed porosity, unevenly distributed pores, friable crumb	Not expressed porosity, quite firm crumb	Nonporous biscuit, teared crumb
Aroma	Well expressed, complies with pumpkin seeds smell, without foreign hints	Well expressed, complies with pumpkin seeds smell, without foreign hints	Typical to the type of product with a small hint of pumpkin seeds smell	Not expressed, presence of foreign smells	Aroma untypical to the studied type of products, presence of foreign hints
Taste	Well expressed, complies with pumpkin seeds smell, without foreign tinges	Well expressed, complies with pumpkin seeds smell, without foreign tinges	Weakly expressed, presence of bitter tinge	Not expressed, presence of foreign tinges	Taste untypical to the studied type of products, presence of foreign tinges

III. RESULTS AND DISCUSSIONS

Results of investigation of physicochemical parameters are demonstrated in table III.

Coefficients of ponderability were established depending on significance of an organoleptic indicator (table I). The sum of all the coefficients was set as 20. This way, with a 5-point scale of organoleptic indicators evaluation, the maximum value of a generalized organoleptic indicator amounts to 100.

Organoleptic analysis of gluten-free biscuit products was conducted according to a 5-point scale. For a comparative organoleptic evaluation, a system of indicators was developed which includes appearance, color, texture, aroma, and taste (table II).

Pumpkin seeds flour is a loose powder of a light-green color, no crunch is felt during chewing, which implies the absence of mineral admixture, taste and aroma typical for pumpkin seeds.

TABLE III. PHYSICOCHEMICAL INDICATORS OF PUMPKIN SEEDS FLOUR QUALITY

Indicators	**Premium grade wheat flour**	**Pumpkin seeds flour**
Humidity, %	14.5±0.2	7.6±0.2
Autolytic activity, %	30.0±0.5	24.0±0.5
Amount of gluten, %	83.0±0.1	-
Acidity, ° T	4.0±0.2	22.6±0.2

The autolytic activity indicator of pumpkin seeds flour complies with the indicator of premium grade wheat flour. An increased acidity of pumpkin seeds flour (5 and a half time more than of wheat flour) is explained by the presence of a great amount of organic and polyunsaturated fat acids, which will contribute to intensification of a sucrose hydrolase process during biscuit dough formation.

Thus, pumpkin seeds flour does not possess baking properties of wheat flour; however, it may be recommended to use in confectionery industry as the main and additional component of gluten-free mixture, during creation of functional products, for flour confectionery products that do not require a high content of gluten like biscuit.

Gluten-free mixture based on pumpkin seeds flour and the method of adding eggs were taken as factors that influence quality of biscuit semi-finished products and especially porosity of the finished products.

Gluten-free mixture used for production of biscuit semi-finished products consists of pumpkin seeds flour and starch.

Investigation of organoleptic indicators and humidity of biscuit semi-finished products was conducted based on gluten-free mixture samples varying ration of starch from 0 to 20% with a 2% step.

On the grounds of experimental data, regression equations were obtained characterizing dependency of generalized organoleptic indicator (Y1) (2) and humidity of biscuit semi-finished products (Y2) (3) on starch content (x, ratio) in a gluten-free mixture.

$$Y_1=\frac{1}{0{,}01+0{,}15x^2}; \quad (2)$$

$$Y_2=\frac{1}{0{,}03+0{,}14x}. \quad (3)$$

Correlation coefficients of obtained regression equations are 0.86 and 0.99 correspondingly, which allows one to speak about functional dependency of generalized organoleptic indicator and humidity of biscuit semi-finished product on starch content in a gluten-free mixture. Determination coefficients of obtained regression equations are 0.75 and 0.98 correspondingly, corrected determination coefficients are 0.72 and 0.97 correspondingly which proves significance of the chosen factors.

Graphic interpretation of equations (2) and (3) are illustrated in Fig. 1 and Fig. 2.

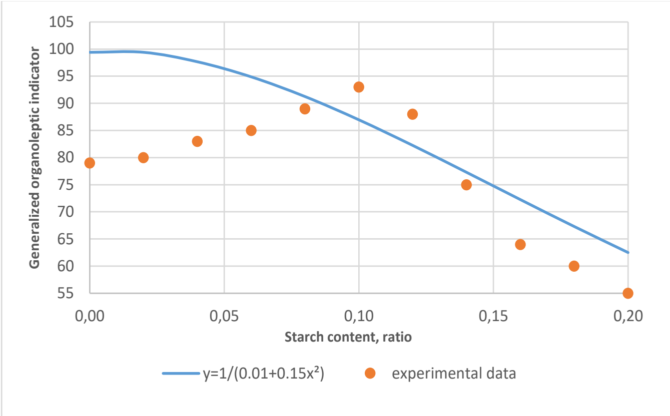


Fig. 1. Dependency graph of generalized organoleptic indicator of biscuit semi-finished products on starch content in gluten-free mixture

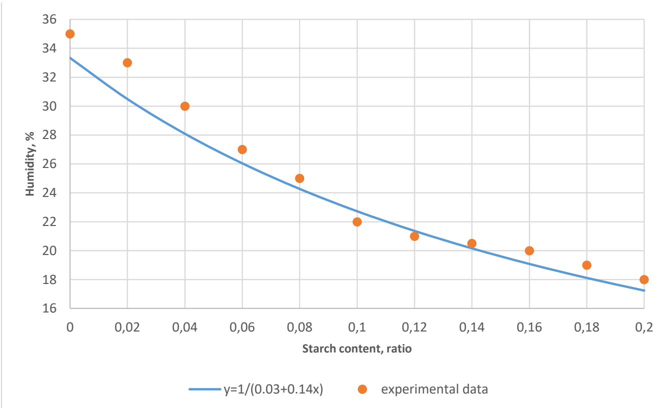


Fig. 2. Dependency graph of humidity of biscuit semi-finished products on starch content in gluten-free mixture

Analysis of revealed dependencies showed that the ratio of pumpkin seeds flour and starch 90.5±0.5% to 9.5±0.5 % is close to optimal and provides satisfactory quality of biscuit semi-finished products.

A sectional view of pumpkin seeds flour-based biscuit sample is demonstrated in Fig. 3. It is evident that the baked biscuit sample has a small rise and sank after baking, which implies weak stability of biscuit dough.

Fig. 3. Sectional view of gluten-free biscuit semi-finished product sample

In order to investigate the influence of methods of adding eggs on biscuit dough and quality of biscuit semi-finished products, they were added in the form of mélange (sample 1) and separately (sample 2). For separate addition, yolks were shaken up with ¼ of sugar, whereas whites where shaken up until the increase of the volume reached 6 times and then boiled with syrup under 120 ºC. Then all the ingredients were mixed with flour regardless of the method of adding eggs. Flour is added directly before baking the semi-finished product. This relates to the fact that when increasing time period between mixing and baking, the biscuit dough foamy structure is destroyed which in turn leads to deterioration of baked product's quality.

The baked biscuit products were analyzed according to the main organoleptic (appearance, color, texture, aroma, taste) and physicochemical (humidity, porosity, density, swelling capacity of crumb, dough rise extent, baking losses) indicators.

Experimental data are shown in Fig. 4-10 and in table 4.

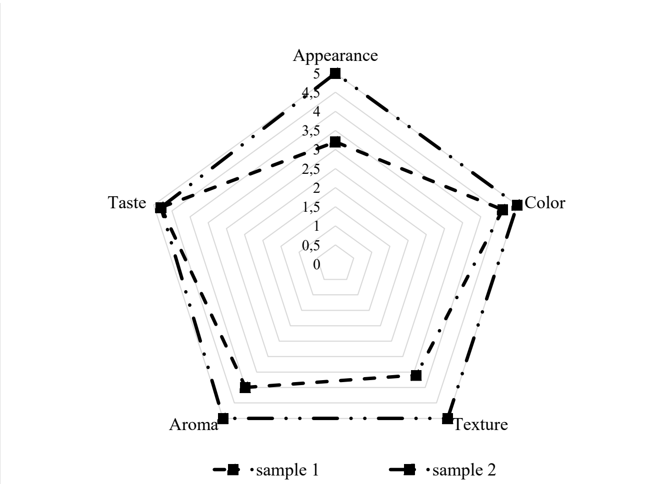


Fig. 4. Profilogram of dependency of point-based organoleptic evaluation on biscuit semi-finished product technology

Fig. 4 demonstrates that the biscuit made using a method of separate addition of eggs and boiling protein shows superiority over the sample made by traditional technology with the use of mélange by all the organoleptic indicators, which denotes its high quality.

Appearances of biscuit semi-finished products are illustrated in Fig. 5 a) and b).

(a)

(b)

Fig. 5. Appearances of biscuit semi-finished products with use of mélange (a) and separate eggs addition (b)

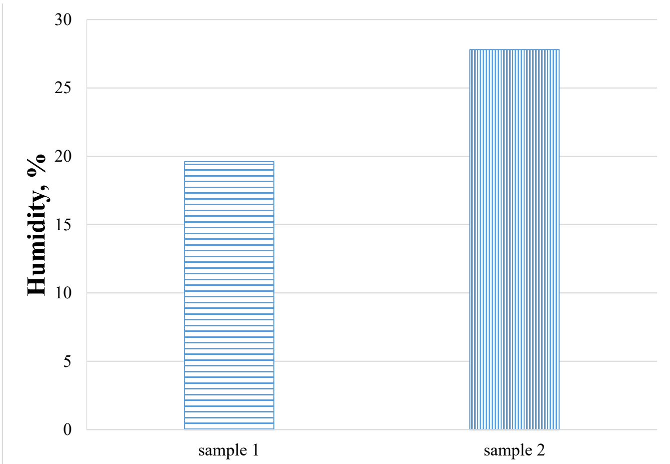


Fig. 6. Histogram of dependency of humidity on biscuit semi-finished product technology

The humidity indicator (Fig. 6) of biscuit semi-finished product, baked according to technology of separate addition of eggs and boiling protein with hot syrup, amounts to 27.8% and complies to standard humidity for biscuit from wheat flour stated in collection of flour confectionery and bun products which totals to 25.00±3.0 % [15]. A low indicator of humidity of the first sample indicates its dry consistency and crumbliness.

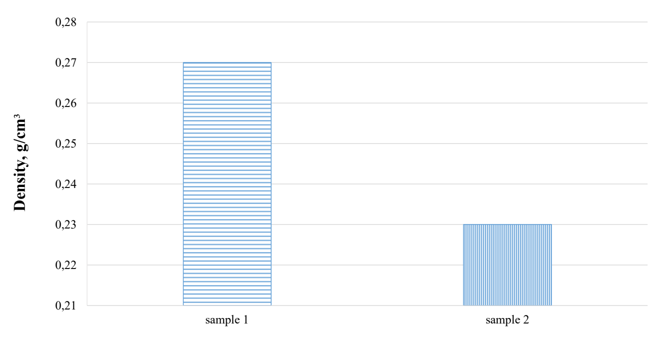


Fig. 7. Histogram of dependency of density on biscuit semi-finished product technology

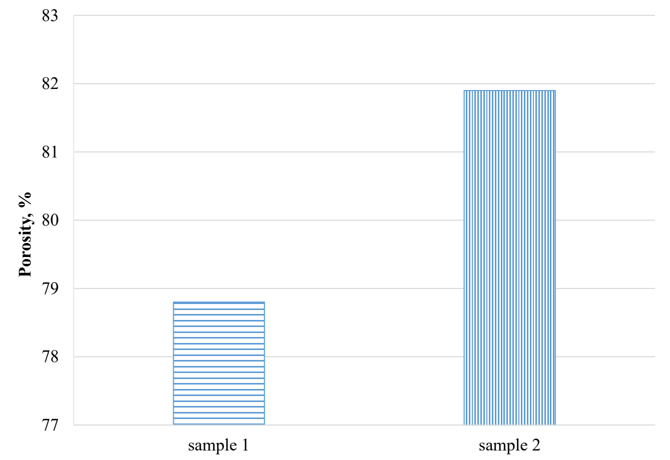
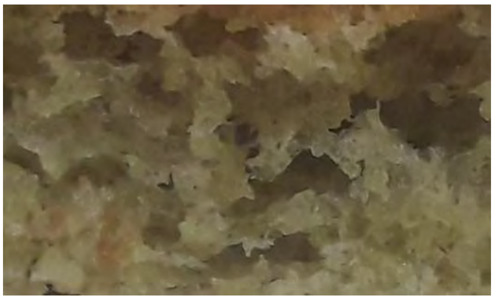


Fig. 8. Histogram of dependency of porosity on biscuit semi-finished product technology



(a)

(b)

Fig. 9. Cross-section view of a biscuit semi-finished product from mélange (a) and with a separate addition of eggs (b)

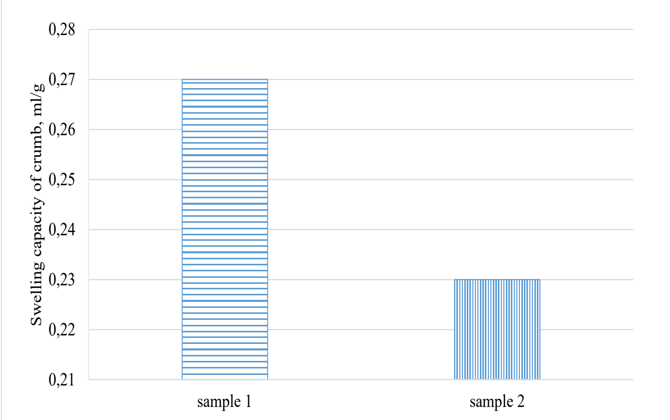


Fig. 10. Histogram of dependency of swelling capacity of crumb on biscuit semi-finished product technology

The second sample of the biscuit semi-finished product baked by a new technology possesses lower density and has an advantage over the first sample in porosity indicators as the method of separate addition of eggs and boiling protein with hot syrup under 120 ºC stabilizes the foam and contributes to the even distribution of small pores, which can be seen in a cross-section view of two samples of biscuit semi-finished products in Fig. 9 a) and b).

The swelling capacity of crumb of thebiscuit semi-finished product with a separate addition of eggs (Fig. 10) is higher than that of the first sample. Therefore, the second biscuit sample will be easier to impregnate with syrup and will maintain its form better.

The biscuit dough rise extent and sinking indicators of biscuit semi-finished products are shown in table IV.

TABLE IV. DOUGH RISE EXTENT AND SINKING INDICATORS OF BISCUIT SEMI-FINISHED PRODUCTS

Biscuit semi-finished product type depending on a technology	**Biscuit dough rise extent, %**	**Sinking of biscuit semi-finished products, %**
Sample #1	17.2±0.2	19.9±0.3
Sample #2	46.4±0.4	12.9±0.2

The main reason for sinking is moisture evaporation and formation of the crust. Increase of sinking indicators leads to crust thickening and decrease of product output. Sinking indicator is lower than that of the second sample. The dough rise extent of sample #2 is higher, as the separate addition of eggs and boiling shaken protein, 6 times bigger the volume with hot syrup, stabilizes the foam and the products become more finely-porous.

Stored gluten-free biscuit semi-finished products were evaluated according to the generalized organoleptic indicator, water activity and mass as well as organoleptic indicators grounding on which the shelf-life period of baked products can be revealed.

Organoleptic indicators of the second sample during storing were substantially superior over those of the first sample due to the finely porous and elastic structure of the biscuit.

On the basis of experimental data, regression equations were obtained characterizing dependency of water activity indicator (Y3) (4) and mass (Y4) (5) on storing duration (days).

$$Y_3=\sqrt{0{,}56+0{,}61/x} \quad ; \qquad (4)$$

$$Y_4=26{,}18+3{,}2/x\,. \qquad (5)$$

Correlation coefficients of obtained regression equations are 0.994 and 0.992 correspondingly, which allows speaking about functional dependency of the water activity indicator and mass of the biscuit semi-finished product on storing duration. Determination coefficients of obtained regression equations are 0.985 and 0.983.

Investigation results of water activity of baked biscuit semi-finished products during storing are demonstrated in Fig. 11; changes in mass of biscuit semi-finished products – in Fig. 12.

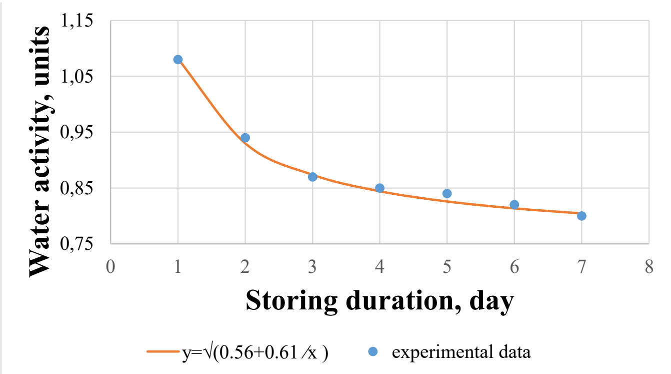


Fig. 11. Water activity of biscuit semi-finished products

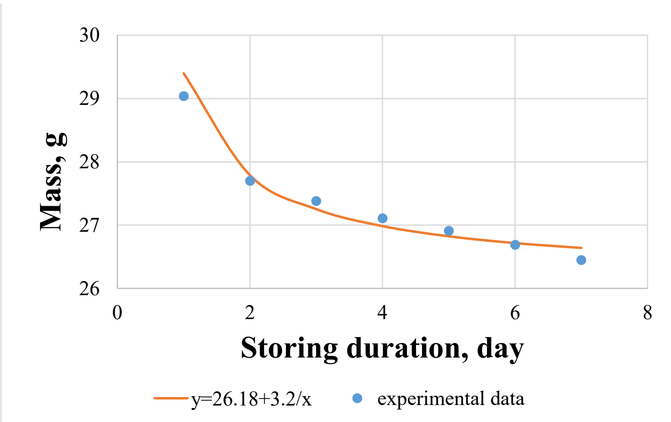


Fig. 12. Changes in mass of biscuit semi-finished products

Water activity of biscuit semi-finished products during storing decreases hyperbolically down to the value of 0.8; the mass of biscuit semi-finished product made with the method of separate addition of eggs and boiling protein with hot syrup insubstantially decreases after baking. At the same time, the process of staking related to retrogradation of starch is almost not observed; the products stays soft and elastic.

Results of calculations of amino acid score for biscuit semi-finished products with pumpkin seeds flour are shown in table V.

Biscuit semi-finished products based on pumpkin seeds flour satisfy the human need for tryptophan amino acid, the score of which equals 100%. Limiting acids in the studied semi-finished product are lysine and threonine.

TABLE V. AMINO ACID COMPOSITION AND SCORE FOR BISCUIT SEMI-FINISHED PRODUCTS

Amino acid	Amino acid content in the ideal protein, mg	Amino acid content in the studied protein, mg	Amino acid score, %
Isoleucine	40	28	70
Lleucine	70	47	67
Lysine	55	31	56
Methionine+cysteine	35	23	66
Phenylalanine+tyrosine	60	53	88
Threonine	40	23	58
Tryptophan	10	10	100
Valine	50	33	66

TABLE VI. NUTRITIONAL VALUE OF BISCUIT SEMI-FINISHED PRODUCTS

Indicator	Biscuit semi-finished product
Protein content, g/100 g of product	11
Lipid content, g/100 g of product	8
Carbohydrate content, g/100 g of product	13
Energy value, kcal	150

TABLE VII. MINIRAL ELEMENTS, VITAMINS AND POLYUNSATURATED FAT ACIDS COMPOSITION OF BISCUIT SEMI-FINISHED PRODUCTS

Name	Standard daily rate, mg	Content in 100 g of product, mg	Realization of a standard daily rate, %
Mineral elements			
Magnesium	400.00	177.92	**44.48**
Iron	18.00	3.95	21.95
Zinc	12.00	2.26	18.87
Selenium	0.06	0.03	**49.56**
Copper	10.00	0.39	**38.95**
Phosphorus	800.00	386.35	**48.29**
Manganese	2.00	0.93	**46.40**
Calcium	1000.00	44.07	4.41
Potassium	2500.00	308.17	12.33
Sodium	1300.00	72.20	5.55
Vitamins			
Vitamin A	0.90	0.12	12.80
Vitamin B1, thiamine	1.50	0.10	6.55
Vitamin B2, riboflavin	1.80	0.23	12.90
Vitamin B4, choline	500.00	15.53	3.11
Vitamin B5, pantothenic acid	5.00	0.18	3.70
Vitamin B6, pyridoxine	2.00	0.04	1.76
Vitamin B9, folata	0.04	0.01	**35.74**
Vitamin C, ascorbic acid	90.00	0.47	0.52
Vitamin E, alpha tocopherol	15.00	0.80	5.35
Vitamin K, phyloquinone	0.12	0.00	1.50
Vitamin PP	20.00	2.82	14.10
Polyunsaturated fat acids			
Linolenic	1600.00	20.88	1.31
Linoleic	10000.00	3603.54	**36.04**

Expediency of pumpkin seeds flour utilization in a biscuit semi-finished product technology was proved by investigation of its nutritional value (table VI) and mineral elements, vitamins and polyunsaturated fat acids composition (table VII).

IV. Conclusion

Technological characteristics of pumpkin seeds flour were investigated, on the basis of which the studies were conducted by the main organoleptic and physicochemical indicators of biscuit semi-finished products with a complete substitution of wheat flour to pumpkin seeds flour with variation of the starch ratio.

It was established that the optimal ratio of pumpkin seeds flour and starch is 90.5±0.5% to 9.5±0.5%.

Samples of biscuit semi-finished products baked with a separate addition of eggs surpassed the sample prepared with a traditional technology (with the use of mélange) by all quality indicators.

After consuming 100 g of the biscuit with a complete substitution of wheat flour to the gluten-free mixture 44.48% of daily need in magnesium, 49.56% - in selenium, 38.95% - in copper, 48.29% - in phosphorus, 46.40% - in manganese, 35.74% - in vitamin B9, and 36.04% - in linoleic acid is satisfied.

References

[1] A.S. Locmanov, G.I. Nazimova, A.S. Romanov “Beekeeping products utilization for enhancing the nutritional value of cakes” Techniques and technologies of food industries vol 3, pp.71-77, 2011

[2] M.O. Revnova “Allergic diseases and Gee’s disease: mechanisms of contiguity and differences” Life without gluten vol 3, pp.4-63, 2006

[3] V.F. Docenko ‘Studies on possibility of fruit powder utilization in biscuit semi-finished products technology” East-European Magazine of Advanced technologies V. 3, vol 10 (69), pp. 64-69, 2014

[4] A.A. Lukin, S.P. Merenkova, T.U. Fomina “Development of technology and recipe for biscuit semi-finished products from bird cherry flour” Ypung scientist. vol 10, pp. 2663-266, 2016.

[5] T.V. Matveeva, S.Y. Koryachkina Flour confectionery of functional use. Scientific basis, technologies, recipes – Spb.: GIORD, 2016. – 360 p

[6] T.V. Matveeva “Pumpkin, carrot, and orange purees utilization in cupcakes technologies” Commodity researcher of Food Products. vol 7, pp. 17-21, 2009

[7] E.V. Moskvicheva, E.E. Safonova, I.A. Timoshenkova “Thistle seeds flour utilization in production of gluten-free products” International science and research magazine, vol 8-3(62), pp.46-50, 2017

[8] E.V. Moskvicheva, I.A. Timoshenkova, D.A. Chernikova “Development of technology and recipe of flour confectionery with the use of pumpkin conversion products” Week of science in SpbPU: material of scientific conference with international participation. Higher School of Biotechnology and Food Technologies. – Spb.: Edition of Polytechnic University, 2017 – pp.95-98

[9] O.V. Perfilova “Fruit anf vegetable powders from extracts in confectionery industry” Storing and recycling of agricultural materials. vol 9, pp.52-54, 2009

[10] Yu.G. Bazarnova, O.B. Ivanchenko Investigation of the composition of biologically active substances in extracts of wild plants, Voprosy Pitaniia, vol. 5, pp. 100-107, 2016

[11] Ji Y. “Staling of cake prepared from rice flour and sticky rice flour” Food Chemistry vol 100. pp. 53-58, 2007

[12] A. Sae–Eaw “Acceptance and purchase intent of US consumers for non wheat rice butter cakes” Journal of Food Science vol 72, pp. 92-97, 2007

[13] V.S. Popov, S.S. Sergeyeva, N.V. Barsukova “Functional and technological proper-ties of oat grain and a line of promising food products on its basis.” Bulletin of the University of technology, Vol. 19, no. 16, pp. 147-151, 2016.

[14] I.A. Pankina, A.V. Barsukov “Investigation of the technological properties of the narrow-leaved lupine in order to create functional food products” A collection of articles III international scientific and practical Conference. Ekaterinburg, 2015, pp. 127-131.

[15] Collection of recipes of flour confectionery and bun products for public food enterprises. – M.: Economics, 1986. – 295 p.

[16] Natalia Barsukova, Elena Moskvicheva, Irina Timoshenkova, “Evgeny Tsopa Informational technologies and the prospects of personalization of food rations” SHS Web of Conferences. Vol. 44, p.8, 2018

[17] J.E.R. Batista, L.P. Braga, R.C. de Oliveira, E.P. Silva, C. Damiani “Partial replacement of wheat flour by pumpkin seed flour in the production of cupcakes filled with carob” Food Science and Technology vol. 38(2), pp. 250-254, 2018

[18] L.L. Costa, P.H.F. Tomé, F.B.B. Jardim, K.A. Damasceno, P.C.B. Campagnol “Physicochemical and rheological characterization of pan bread made with pumpkin seed flour” International Food Research Journal vol. 25(4), pp. 1489-1496, 2018