Technology of biscuit semi-finished products using recycled pumpkin seeds

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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.

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

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. Regarding current consumer requirements flour confectionery needs to not only be a mere calorie 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].

Due to that the search for raw materials, which could allow creating gluten-free products of high quality possessing a balanced chemical content and high nutritional 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 purees, pastes and powders; grain and groats conversion products [3-12]. 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 purpose of this paper is to develop a technology for a biscuit semi-finished product with a complete substitution of wheat flour to pumpkin seeds flour.

In compliance with the mentioned purpose 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 [13-17] were chosen as the object of investigation.

2. Methods of investigation

Sampling and their preparation for analysis was conducted in compliance with a 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 indicator 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 a 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 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).

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

where \( p_i \) is a value of \( i \) organoleptic indicator;

\( k_i \) is a value of ponderability coefficient of \( i \) organoleptic indicator.

Coefficients of ponderability were established depending on significance of an organoleptic indicator (table 1). 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 indicator | Appearance | Color | Texture | Aroma | Taste |
|------------------------|------------|-------|---------|-------|-------|
| Ponderability coefficient | 5.0 | 2.0 | 4.0 | 4.0 | 5.0 |

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 2).

Pumpkin seeds flour is a loose powder of a light-green color, no crunch is felt during chewing, which speaks for the absence of mineral admixture, taste and aroma are typical for pumpkin seeds.
### Table 2. Organoleptic evaluation criteria.

| Organoleptic indicator | Verbal characteristic of points |
|------------------------|---------------------------------|
| **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 |

### 3. Results and screenings

Results of investigation of physicochemical parameters are demonstrated in a table 3.

### Table 3. 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 times 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 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 for 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 method of adding eggs were taken as factors that influence on quality of biscuit semi-finished products and especially on 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 ratio 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 (2) and humidity of biscuit semi-finished products (3) on starch content (x, ratio) in a gluten-free mixture.

\[ \Psi_1 = \frac{1}{0.01 + 0.15x^2} \]  

\[ \Psi_2 = \frac{1}{0.03 + 0.14x} \]  

Correlation coefficients of obtained regression equations are 0.86 and 0.99 correspondingly, which allows speaking 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 at Fig. 1 and Figure 2.

![Figure 1](image1.png)  
**Figure 1.** Dependency graph of generalized organoleptic indicator of biscuit semi-finished products on starch content in a gluten-free mixture

![Figure 2](image2.png)  
**Figure 2.** Dependency graph of humidity of biscuit semi-finished products on starch content in a gluten-free mixture

Analysis of revealed dependencies showed that ration 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.

Sectional view of pumpkin seeds flour based biscuit sample is demonstrated at Fig. 3. It is evident that the baked biscuit sample had a small rise and sank after baking, which speaks for a weak stability of biscuit dough.
Stored gluten-free biscuit semi-finished products were evaluated according to generalized organoleptic indicator, water activity and mass as well as organoleptic indicators grounding on which 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 finely-porous and elastic structure of the biscuit.

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

\[ \Psi_3 = \sqrt{0.56 + 0.61/x} \]  \hspace{1cm} (4)

\[ \Psi_4 = 26.18 + 3.2/x \]  \hspace{1cm} (5)

Correlation coefficients of obtained regression equations are 0.994 and 0.992 correspondingly, which allows speak about functional dependency of water activity indicator and mass of 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 at Figure 3, changes in mass of biscuit semi-finished products – at Figure 4.

![Figure 3. Water activity of biscuit semi-finished products](image1)

![Figure 4. Changes in mass of biscuit semi-finished products](image2)

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 a method of separate addition of eggs and boiling protein with hot syrup insubstantially decreases after baking. At the same time, the process of staking that is related to retrogradation of starch is almost not observed, the products stays soft and elastic.

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

Expediency of pumpkin seeds flour utilization in a biscuit semi-finished product technology was proved by investigation of its nutritional value (table 4) and mineral elements, vitamins and polyunsaturated fat acids composition.

| 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                           |
4. Conclusion
Technological characteristics of pumpkin seeds flour were investigated, on the basis of which the studies were conducted on 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 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%.

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.

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