Butter biscuit technology for specialized nutrition

N G Ivanova1,*, I A Nikitin1, S E Terentyev2 and S G Ushakova3 and M A Mitrokhin1

1 K G Razumovsky Moscow State University of technologies and management (the First Cossack University), 73 Zemlyanoy Val, Moscow, 109004 Russian Federation
2 Smolensk State Agricultural Academy, 10/2, Bolshaia Sovetskaia st., Smolensk, 214000, Russian Federation
3 Orel State University named after I.S. Turgenev, 95, Komsomolskaya st. Orel region, Orel, 302026, Russian Federation

*E-mail: a1c3@rambler.ru

Abstract. Flour confectionery products are considered one of the most popular food products, but the nutritional value does not allow them to be included in the diet of people leading a healthy lifestyle. The recent trend is the expansion of the flour confectionery products' range by imparting functional properties. Considering the worldwide growth in the level of alimentary-dependent diseases, it is urgent to develop butter biscuits of increased nutritional value characterized by a reduced sugar content. Improving the butter biscuits technology by introducing non-traditional types of flour and topinambour processing products into the recipe will make it possible to scientifically approach the problem's solution of the flour confectionery products' disadvantage of increased nutritional value and reduced calorie content, improve their assortment and ensure widespread consumption in everyday life. The study presents the research results on the technology development of butter biscuits enriched with dietary fiber, minerals and vitamins. The decrease in the recipe sugar content by replacing its part with topinambour syrup is substantiated, as well as the introduction of barley flour, chickpea flour and topinambour fiber into the recipe. The developed butter biscuits are distinguished by a reduced content of granulated sugar and an increased content of dietary fiber, magnesium, calcium, potassium, and phosphorus.

1. Introduction
Flour confectionery products have a low nutritional value characterized by a high caloric content, a high content of carbohydrates, fats and a very low content of essential amino acids, vitamins, dietary fiber and minerals necessary for humans. Due to their attractive appearance and various taste characteristics, these products are in steady demand both among children and adults.

Currently, studies are widely conducted aimed at researching the possibility of using new non-traditional types of raw materials in food technologies with increased nutritional value [1–7]. Along with products intended for everyday nutrition, the enterprises develop and produce confectionery products for specialized, dietary, therapeutic and protective diet purposes.

The layout and design of food products based on non-traditional types of plant materials will help expand the range of specialized products and have a beneficial effect on health [8–11]. Undoubtedly, an important stage is the methods' development for product quality control and monitoring of xenobiotics [12–14].
Based on the characteristics study of the diet and the needs for basic nutrients, it is possible to create a new type of butter biscuits recommended for the nutrition of women during pregnancy and lactation. The range of flour confectionery products for this population group is practically undeveloped.

The aim of the research was to create a technology of butter biscuits intended for nutrition of women during pregnancy and lactation with a reduced sugar content and increased nutritional value based on barley and chickpea flour, fiber and topinambour syrup.

2. Materials and methods
The objects of research were samples of butter biscuits based on barley and chickpea flour, topinambour fiber and syrup recommended for nutrition of women during pregnancy and lactation, as well as protective diet.

Samples of butter biscuits were prepared in the laboratory of the Department of Biotechnology of Food Products from Plant and Animal Raw Materials. The following raw materials were used in the composition of the sample formulations: barley flour, chickpea flour, topinambour fiber and syrup, sugar powder, butter, melange, baking soda, milk powder, drinking water. For all types of raw materials, the requirements for raw materials and the content of hazardous substances and impurities are regulated in accordance with the relevant regulatory documents.

When conducting research, the control was a sample of "Glagoliki" butter biscuits, which was prepared as follows. Sugar powder and softened butter are whipped for 3-4 minutes, then egg melange and topinambour syrup are added and whipped for another 2-4 minutes. Baking soda and vanilla powder are added and mixed for 7-9 minutes until a homogeneous structure is formed. Next, the dough is kneaded from the ready-made recipe mixture, milk powder and flour, the kneading time is 2-3 minutes. The dough pieces are formed by the deposition method, then baked for 11-16 minutes at a temperature of 180-190 °C. The quality of finished products was assessed according to standard methods for organoleptic and physicochemical indicators.

3. Results and Discussion
Rational nutrition of women during pregnancy and lactation implies the intake of the necessary essential, easily assimilated substances with daily food into the body. In this case, the energy value of the daily diet and the content of simple sugars in it are of great importance.

At the same time, the amount of incoming calories without considering the ratio of all nutrients cannot be the final indicator of assessing the quality of the diet. Based on the analysis of the literature and reference data on the chemical composition of Russian food products, the following raw materials were selected when developing butter biscuits intended for the nutrition of women during pregnancy and lactation: barley flour, chickpea flour, topinambour syrup and fiber.

In order to increase the nutritional value of butter biscuits, the premium wheat flour was replaced in its recipe with a mixture of chickpea and barley flour, which is distinguished by a large amount of macro- and micronutrients in the composition (Table 1).

| Table 1. Average chemical composition of barley and chickpea flour in comparison with wheat. |
|---------------------|---------------------|---------------------|---------------------|
| indicators          | Nutrient content (%) in 100 g flour | wheat flour, premium | chickpea | barley |
|---------------------|---------------------|---------------------|---------------------|
| Protein, g          | 10.3                | 20.1                | 10.0                |
| Fat, g              | 1.1                 | 4.3                 | 1.6                 |
| incl. PUFA          | 0.51                | 1.82                | 0.26                |
| Carbohydrates       | 70.6                | 46.2                | 57.6                |
| assimilable, g,     | 68.5                | 43.2                | 55.1                |
| incl. starch         | 3.5                 | 12.4                | 15.4                |
| Dietary fiber, g    | 0.5                 | 3.0                 | 1.4                 |
Barley flour differs in the content of more complete protein compared to wheat flour, a large amount of dietary fiber, potassium, phosphorus, silicon. It includes Beta-glucan, which helps to lower cholesterol levels and slow down the rise in blood sugar [7, 8].

Chickpea flour contains highly digestible proteins with high biological value, magnesium, iron, potassium, zinc, copper, B and E vitamin groups, dietary fiber. Chickpea helps to improve digestion, normalize blood sugar levels, strengthen immunity and the cardiovascular system, and eliminate excess cholesterol [9, 10].

A decrease in the recipe amount of white sugar without a threat to health and not leading to a deterioration in biscuits' organoleptic qualities is possible by replacing it with various syrups - fruit, berry, glucose, etc.

Topinambour fiber is a source of inulin, a natural polysaccharide that is 95% fructose. Topinambour pectins are able to bind and remove radioactive substances, heavy metals and pesticides from the human body. Partially neutralizing toxins in the blood and intestines, inulin relieves the liver and restores the work of the gastrointestinal tract, helping the body to fight various potentially hazardous environmental factors and diseases. Topinambour syrup is a natural sugar substitute that is widely used in foods and diets for people with type 2 diabetes.

To determine the optimal dosage of unconventional raw materials when conducting research, laboratory test baking of butter biscuits was carried out using standard dough preparation and baking modes. The butter biscuits' quality of the control and experimental samples was determined by organoleptic (shape, surface, color, fractured appearance, taste) and physicochemical indicators (density, mass fraction of moisture, absorptivity and spreading during baking).

When studying the effect of barley flour on the butter biscuits' quality in the control sample recipe, the entire amount of wheat flour was replaced with barley flour. The results are shown in Table 2.

### Table 2. Influence of barley flour on organoleptic and physicochemical indicators of butter biscuits' quality.

| indicators          | Control                                      | Prototype                                   |
|---------------------|----------------------------------------------|---------------------------------------------|
| Surface             | Smooth with few rough edges                  | Slightly rough with cracks                  |
| Shape               | Not blurry, with smooth edges                | Light brown                                |
| Colour              | Amber straw                                  | Biscuits' characteristics with a pleasant nutty-milk taste and aroma |
| Taste and smell     | Biscuits' characteristics with a pleasant milky taste and aroma |                                   |
| Broken view         | Porous baked biscuits                        |                                             |
| Moisture content, % | 5.0                                          | 5.1                                         |
| Density, g / cm³    | 0.538                                        | 0.537                                       |
| Moisture,%          | 160.0                                        | 159.0                                       |
| Diffusion,%         | 114.3                                        | 130.6                                       |

Analysis of the obtained data (Table 2) revealed that barley flour imparted a more brownish tint to the surface of the finished biscuit. The test sample showed small cracks, which, however, did not deteriorate the appearance. The experimental sample acquired a clearly noticeable nutty flavor, imparted by the presence of barley flour in the recipe. Both samples had a non-diffused shape with smooth edges.

The view in the fracture of the studied biscuit samples showed that the barley flour in the recipe had practically no effect on the porous structure of the finished products' crumb. Both samples were characterized by a crumbly pulp characteristic of butter biscuits. Experimental cookie samples were characterized by a greater spreading of the dough piece during baking (by 16.3%), which is probably due to the minimum gluten content in barley flour compared to wheat flour.

The replacement of wheat flour with barley flour practically did not affect the physicochemical parameters of the finished product. The difference in results is within the measurement error. Thus, it
was established that it is possible to completely replace wheat flour with barley flour in the butter biscuits recipe.

When conducting studies to determine the effect of chickpea flour on the quality of developed butter biscuits, 10, 20 and 30% of the total amount of barley flour were replaced with chickpea flour (experimental samples 1-3). The control was a biscuit sample made entirely with barley flour obtained in a previous study. The results are shown in Table 3.

**Table 3. Influence of different chickpea flour dosages on the physicochemical indicators of the butter biscuits' quality**

| indicators          | Control | Experimental with the addition of chickpea flour |
|---------------------|---------|-----------------------------------------------|
|                     |         | Sample 1 | Sample 2 | Sample 3 |
| Moisture content, % | 5.1     | 5.1 | 5.1 | 5.1 |
| Density, g/cm³      | 0.537   | 0.536 | 0.538 | 0.543 |
| Moisture, %         | 159.0   | 162.0 | 160.0 | 141.0 |
| Diffusion, %        | 130.6   | 120.7 | 121.6 | 126.6 |

The results obtained showed (table 3) that small cracks appeared on the surface of test samples 1 and 2, the same as in the control, but those did not worsen the appearance. Sample 3 had strong cracks over the entire surface of the biscuit. All experimental samples acquired a specific bean flavor imparted by the presence of chickpea flour in the recipe. However, compared to test samples 1 and 2, this flavor in sample 3 was predominant and outweighed the pleasant nutty flavor imparted by the barley flour. All samples had a non-diffused shape with smooth edges.

The fracture view of the studied samples showed that chickpea flour in the formulation of experimental samples 1 and 2 had almost no effect on the porous structure of the finished products' crumb. Both samples were characterized by a crumbly pulp characteristic of butter biscuits. Due to the greater amount of chickpea flour, sample 3 was distinguished by a denser and jetted crumb not characteristic of butter biscuits.

Samples of cookies with chickpea flour differed in less spreading of the dough piece during baking compared to the control sample (by 10.1–4.0%). However, the spreading increased with an increase in the dosage of chickpea flour. This is possibly due to the greater water absorption capacity of the mixture of barley and chickpea flour due to the ratio of protein and dietary fiber content in sample 1.

Replacement of barley flour with chickpea flour in the amount of 10-20% practically did not affect the physicochemical parameters of the finished product. The difference in results is within the measurement error. A high dosage of chickpea flour reduced the biscuits' absorptivity and increased their density.

Thus, based on the studies carried out, the possibility of replacing barley flour with chickpea flour in the amount of 20% in the recipe of the developed butter biscuits was established.

To establish the best dosage of topinambour syrup in the recipe for butter biscuits, 25, 50 and 75% sugar was replaced with topinambour syrup by weight (samples 4-6). To increase the content of dietary fiber in the product, as well as to improve the structure of the dough, the formulation of all experimental samples included topinambour fiber in the amount of 5% instead of part of the barley flour. The control was a sample without replacing sugar on a mixture of barley and chickpea flour in a ratio of 80:20 obtained in the previous study. The results are shown in Table 4.

**Table 4. The effect of replacing a part of sugar with topinambour syrup on the physicochemical indicators of butter biscuits' quality**

| indicators          | Control | Experimental |
|---------------------|---------|--------------|
|                     | Sample 4 | Sample 5 | Sample 6 |

4
Moisture content, % | 5.1 | 5.9 | 6.5 | 7.0  
Density, g / cm³ | 0.538 | 0.539 | 0.541 | 0.543  
Moisture, % | 160.0 | 168.0 | 172.0 | 164.0  
Diffusion, % | 121.6 | 103.4 | 114.3 | 119.9

The obtained results’ analysis revealed that with an increase in the topinambour syrup dosage, the color intensity of the finished product increased together with the fruity aroma. Samples 1 and 2 were distinguished by a pronounced straw-brown color compared to the control. Sample 3 had a brown color; the shape was not diffused with darker colored edges and a pronounced fruity taste in comparison with samples 1 and 2.

The fracture view of the test samples showed that an increase in the topinambour syrup dosage influenced the porous structure and the presence of a straw-brown tint on the surface of finished products. Sample 1 had a more crumbly structure inherent to the biscuit in comparison with the control. Sample 2 had a slightly flatter shape with a crumbly and porous structure and a uniformly colored pulp. The texture of test sample 3 with the replacement of 75% sugar with topinambour syrup was very viscous and more difficult to mold. Biscuits made from this dough were brown, less loosened and poorly baked. Samples of biscuits with topinambour syrup were characterized by less spreading of the dough piece during baking in comparison with the control sample (by 18.2 - 1.7%).

The research results showed that with an increase in topinambour syrup dosage, the mass fraction of the product’s moisture increased, and its absorptivity decreased. This seems to be due to the addition of moisture along with the syrup. Sample 2 with the replacement of 50% of sugar amount in the formulation with topinambour syrup was characterized by the best physicochemical quality indicators, which is associated with an improvement in the porous structure by improving the dough texture.

The nutritional value and the degree of the daily need satisfaction for some essential substances of women during pregnancy and lactation were determined when consuming 100 g of butter biscuits according to the control and developed formulations (Figures 1 and 2).

![Figure 1. The degree of daily need satisfaction of women during pregnancy and lactation in macronutrients when consuming the developed biscuits compared to control, %](image-url)
The results obtained by calculation showed that when consuming 100 g of Isida cookies, the degree of daily need satisfaction for vegetable protein increases by 2.7-3.0%, fat - by 2.5-2.6%, magnesium - by 6.0%, phosphorus - by 5.1%, potassium - by 0.7%, calcium - by 0.4%. The degree of daily need satisfaction for vitamins also increases - B1 - by 1.7%, B2 - by 1.4-1.5% compared to the control biscuit sample.

Due to the introduction of non-traditional types of plant raw materials, it was possible to reduce the sugar content of biscuits - the amount of mono- and disaccharides decreased by 19.2%, and the amount of added sugar - by 50%. The energy value of 100 g of "Isida" biscuits is 49 kcal lower than the energy value of the control biscuit sample.

4. Conclusion

From the presented results, it can be concluded that butter biscuits based on barley and chickpea flour and topinambour processing products are characterized by an increased content of dietary fiber, protein, minerals and vitamins, including calcium, potassium, magnesium and phosphorus, and a reduced content of added sugar.

Thus, the developed butter biscuits "Isida" will provide vital nutrients for the nutrition of women during pregnancy and lactation and reduce the amount of added sugar in the recipe for butter biscuits. These biscuits can be recommended for inclusion in the diet for people leading a healthy lifestyle and for protective diet.

References

[1] Gonchar V et al. 2016 Development of technology for custard gingerbread products using syrup obtained from Jerusalem artichoke tubers Bulletin of higher educational institutions Food technology 1(349) 37-9 (in Russian)

[2] Ivanova N, Makarova E and Nikitin I 2019 Development of low-sugar biscuit technology for feeding breastfeeding women Bread baking of Russia 3 16-20 (in Russian)

[3] Kulushtayeva B et al. 2019 Gluten-free diet: Positive and negative effect on human health, Indian Journal of Public Health Research and Development 10(7) 889-92

[4] Smolnikova F, Okuskhanova E, Khayrullin M, Pasko O, Zhukovskaya S, Zubtsova Y and Yakunina E 2019 Main Problems of School Nutrition Indian Journal of Forensic Medicine & Toxicology 13(4) 1633–8
[5] Zinina O, Merenkova S, Tazeddinova D, Rebezov M, Stuart M, Okuskhanova E, Yessimbekov Zh and Baryshnikova N 2019 Enrichment of meat products with dietary fibers: a review Agronomy Research 17(4) 1808–22 DOI: 10.15159/AR.19.163

[6] Abu-Izneid T et al. 2020 Sesquiterpenes and their derivatives-natural anticancer compounds: An update Pharmacological Research 161 105165 DOI 10.1016/j.phrs.2020.105165

[7] Rebezov M et al. 2020 Role of beetroot as a dietary supplement in food products Plant Cell Biotechnology and Molecular Biology 21(57-58) 8-16

[8] Smolnikova F, Khayrullin M, Pasko O, Zhukovskaya S, Zubtsova Y and Yakunina E 2020 Main Problems Of School Nutrition International Journal Of Scientific & Technology Research 9(02) 1105–8

[9] Suychinov A, Rebezov M, Maksimyuk N, Khairullin M, Kulikov D, Konovalov S, Konovalova O, Penkova I and Moldabaeva Zh 2019 Vitamins and their role in human body International Journal of Pharmaceutical Research 11(3) 1246–8

[10] Torshina O, Panova L, Moskyna E, Smirnova L, Somova Y, Limarev A, Zotov S, Makhacheva E and Khayrullin M 2019 Simulation methods as an effective tool for solving healthy applied and theoretical problems International Journal of Pharmaceutical Research 11(4) 286-90

[11] Kulushtayeva B, Nurymkhan G, Smolnikova F, Okuskhanova E, Kozubayeva L, Abilova M, Khayrullin, M and Kisimov B 2019 Technology of production, nutritional value and food safety of gluten free bread International Journal of Recent Technology and Engineering 7(6) 1338-44

[12] Vaskovsky A, Chvanova M and Rebezov M 2020 Creation of digital twins of neural network technology of personalization of food products for diabetics Conference Proceedings - 4th Scientific School on Dynamics of Complex Networks and their Application in Intellectual Robotics, DCNAIR 2020 251-253 DOI 10.1109/DCNAIR50402.2020.9216776

[13] Rebezov M, Shariati A M, Ryskina E, Bogonosova I and Sepiashvili E 2020 Monitoring the research results on the toxic elements content (lead, cadmium and arsenic) in food Paper presented at the IOP Conference Series: Earth and Environmental Science 613(1) doi:10.1088/1755-1315/613/1/012123

[14] Aboua A, Rebezov M, Mukhamedyarova L, Shakirova S, Khaimuldinova A and Yermakhanova F 2021 Results of studies of wheat bread for lead content using the additive method Paper presented at the IOP Conference Series: Earth and Environmental Science 677(5) doi:10.1088/1755-1315/677/5/052050