Flaxseed bread for therapeutic nutrition

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Abstract. The study analyzes the effects of the diet and various classes of macronutrients on metabolism, as well as the use of low-carb nutrition in the treatment of cardiovascular diseases, diabetes, and metabolic syndrome. The authors have proposed an optimal set of ingredients for the production of bread, the use of which will allow to correct the course of these diseases, and also will allow consumption for groups of people suffering from intolerance to gluten, milk and sugar. Two recipes for yeast-free flaxseed bread with the addition of a vegetable drink made from oats and hazelnuts, as the least allergenic foods, are proposed. The analysis of the quality of the finished product is performed, as well as the comparison of samples in nutritional value with industrial varieties of bread, including products made for the dietary sector.

1. Introduction

The stages of human development are traditionally accompanied by changes in the nutrition system. Agriculture improvement has led to the emergence of various methods of processing products that allow to save crops for a long time. Grain processing products have become the basis of the baking sector, headed by bread.

The history of the creation of bread and the development of bakery began in the Oldest Dryas more than 14 thousand years ago. Primitive people first consumed raw grains, then learned to grind them and ate, mixing with water. Further experiments with grain mass that is slightly reminiscent of modern dough, allowed to obtain cakes cooked on fire. It is worth noting that this product was not much like modern bread, but it was with it that the era of the development of bakery began.

Since ancient times, bread has been revered as a valuable and nutritious product. A variety of recipes, the use of local types of raw materials, such as sesame and camphor in Egypt, made it possible to create a unique product for each nation and state. The profession of a baker made it possible to have great privileges. So, for example, in ancient Rome, a slave who knew how to bake bread was several times more expensive than the strongest bustuarius.

In ancient Russia, bread became not only a traditional product, but also part of the Slavic culture. “Bread is the head of everything”, “There will be bread - there will be a song!” and many other sayings are so closely included in the vocabulary of the inhabitants of our country that their interpretation served as an illustration of a particular event. For example, “Bread is good everywhere - both with us and overseas” explains the diversity of cultures, traditions and values.
This important role of bread explains its central place on almost every table. Black breads became more widespread due to their lower cost, while it saturated for a longer period than its younger brother made from wheat. In the modern food system, bread began to lose ground. Having a high glycemic index and a large amount of carbohydrates, it became a persona non grata in many menus.

The growing urbanization has led to the development of a fast-food system and physical inactivity, which has led to the development of many metabolic diseases. According to the World Health Organization, the global prevalence of diabetes among people over 18 years old increased from 4.7% in 1980 to 8.5% in 2014, and the total number of cases in the world is 422 million. The number of people suffering from metabolic changes including obesity is also growing rapidly. The statistics for Russia look frightening, where almost two million people were officially diagnosed with “obesity”, which makes up 1.3% of the country’s population. At the same time, the proportion of the child population with this pathology has significantly increased - 436.9 per 10 thousand children [1].

The treatment of diabetes mellitus, cardiovascular diseases, hepatic steatosis and other pathologies associated with metabolic changes is effective in combination with a change in diet, namely, a decrease in the proportions of proteins, carbohydrates and fats. 75% of the carbohydrates of the average daily diet, previously taken as the basis of a “rational nutrition”, negatively affect the metabolism. A high level of simple carbohydrates (mono- and disaccharides) received with food leads to a shift in the reaction of the intestinal environment to the acidic side, as a result of which both the activity of many enzymes and the disturbance of absorption of micro- and macronutrients are reduced. Glucose, as the main metabolite formed during the hydrolysis of carbohydrates, enters the blood of the portal vein and its concentration increases, leading to the synthesis of the hormone insulin in the pancreas. The action of insulin is aimed primarily at the utilization of glucose by cells. By activating the transport of glucose into the cell, insulin triggers the cascade mechanism of glucose transformations. This is both glycolysis, which gives the body energy in the form of ATP, and the synthesis of glycogen and lipids, as the main forms of energy storage. As soon as the glucose level drops, insulin synthesis stops. Fluctuations in glucose lead to the so-called “insulin swing”, leading the nervous system now to a state of excitement, then to a state of rest. It is generally accepted that glucose is necessary for the nervous system, as it is the only source of energy. This erroneous opinion makes it impossible to make adjustments to the diet for many population groups suffering from metabolic diseases. Studies conducted by Advancing Nutrition in Diabetes Management (March 2008) showed what the glycemic curve looks like in people after consuming high and low glycemic index foods (figure 1).

![Glycemic index curves depending on the amount of carbohydrates in the diet.](image)

In addition to changing the curve of sugar load due to a decrease in the amount of carbohydrates in the diet, metabolism is rearranged. A slight shift in glucose levels after a meal allows you to use not only glucose as a source, but also ketone bodies that easily pass the blood-brain barrier and nourish nerve tissue. Ketogenesis, using both lipids and proteins as substrates, allows you to adjust the hormonal background. Research results show a positive effect of low-carb diets on the course of the disease, with a noticeable correction in body weight [2–6].
But no matter how good the effect of a balanced diet is, it is not always acceptable due to the presence of bad eating habits. It is the eating behavior that forms the very frame on which health rests. Love for bread and dishes from it leads to daily fluctuations in both glucose concentration and the body’s metabolism. Therefore, the development of a product that will be possible to integrate into the diet and which will meet modern ideas about the balance of nutrients is relevant.

In this regard, we have set the following tasks:

1. To develop optimal diet bread recipes suitable for a wide target audience that adheres to a low-carb diet for the treatment and prevention of the above diseases;
2. To analyze the products obtained by organoleptic and physicochemical properties;
3. Compare bread samples with existing on the market analogues.

2. The experimental part
To conduct research in the field of developing the optimal formulation of bread with a low glycemic index, an analysis of possible raw materials was carried out. It is worth noting that often metabolic changes are accompanied by intolerance to certain substances. For this reason, we have chosen a strategy for eliminating gluten [7], milk [8], sugar [6, 9], yeast and selecting raw materials so that the combination of ingredients meets the principles of nutrient balance with a minimum content of reactive compounds.

Modern studies note the positive effect of fats on the correction of cardiovascular diseases and the risk of carbohydrates, including sugar, as well as trans fats on the course of metabolic diseases [10].

One option for gluten-free flour is a flaxseed product. It is worth noting the positive impact of the use of flaxseeds in the correction of body weight and lipid profile of the body [11, 12].

In the course of the work, two bread formulations were developed and tested, which included linseed flour, eggs, vegetable oil, soda, salt and natural apple cider vinegar. The liquid part was represented in the first sample by oat milk (a drink based on oat grains - Sample No. 1, Figure 2) and hazelnut drink in the second sample (Sample No. 2). Also, industrial production options were selected for comparison of nutritional value: rye bread from peeled flour (Sample No. 3), since it is similar in organoleptic and physicochemical properties to the developed samples; rice with cereals (Sample No. 4) and rice-corn with flax and sunflower seeds (Sample No. 5), since these two types of bread are presented on the market as dietetic foods.

![Figure 2. Sample No. 1.](image)

To determine the quality of bread standard methods for determining the quality of bakery products were used.

Moisture content determination of bread was carried out according to the method by drying the crushed bread crumb. Samples crushed into crumbs weighing 5 g were weighed to the nearest 0.01 g and placed in pre-prepared dried and weighed paper bags with a layer of no more than 1.5-2 mm.
Drying was carried out at 160 °C for 5 minutes, after which the bags were cooled in a desiccator for 1–2 minutes and weighed. The amount of evaporated water is expressed as a percentage of the mass of dried bread.

Determination of porosity of bread. Porosity is understood as the volume of pores contained in a specific volume of crumb, expressed as a percentage. The porosity of bread, taking into account its structure (pore size, uniformity, wall thickness), characterizes an important property of bread - its digestibility. Bread with low porosity is usually obtained from fermented and poorly baked dough or from flour of low baking qualities. The bread cuts were weighed to an accuracy of 0.01 g and the porosity was calculated by the formula:

\[ X = 1 - \left( \frac{C}{pV} \right) \times 100\% \]

where \( V \) is the total volume of all cuttings, \( cm^3 \);
\( G \) – weight of cuts, g;
\( p \) – the density of the pore-free crumb mass.

The acidity of the bread was determined by the titrimetric method with visual indication. Acidity was expressed in degrees. By degrees of acidity, we understand the number of milliliters of a normal NaOH solution necessary to neutralize the acids contained in 100 g of bread crumb.

A portion of a crumb of bread weighing 25 g was dissolved in 250 ml of distilled water, heated to 60 °C. It was dissolved gradually: in the flask, distillate (62.5 ml) was first added to the sample, the crumb was quickly ground with a spatula to obtain a homogeneous mass, then the remainder of the distillate was added. The resulting mixture was shaken for 3 minutes, then left to precipitate for 8 minutes. The mixture was filtered twice: through cheesecloth and through filter paper. An aliquot of 10 ml was then taken and titrated with 0.1 N NaOH. 1-2 drops of phenolphthalein were added to an aliquot until a faint pink color was obtained that did not disappear when the flask was still standing for 1 min.

Acidity was determined by the formula:

\[ X = \frac{V \cdot V_1 \cdot a \cdot K}{10m \cdot V_2} \]

where \( V \) is the volume of a solution of a molar concentration of 0.1 mol / dm3 NaOH consumed in the titration of the test solution, \( cm^3 \);
\( V_1 \) – the volume of distilled water taken to extract acids from the test product, \( cm^3 \) (250 cm3);
\( a \) – conversion factor per 100 g of sample;
\( K \) – correction factor for reducing the NaOH solution used to the exact molar concentration of 0.1 mol / dm3;
\( 1/10 \) – coefficient of reduction of NaOH solution to a molar concentration of 0.1 mol / dm3;
\( m \) – weight of sample, g;
\( V_2 \) – volume of test solution taken for titration, \( cm^3 \).

Calorie and nutritional values were determined in the laboratory of Rospotrebnadzor.

3. Results and discussion
The analysis of the quality of experimental bread samples (table 1) showed that the samples slightly differ from each other in porosity, crust characteristics and crumb color (sample No. 2 is darker and finer-porous, 56.0% in sample No. 1 versus 50.9% in the second sample). According to the organoleptic properties and visual assessment, flax bread can be attributed to the group of rye breads, so normal indicators of this kind of bread were taken as a basis. The moisture content of rye bread should not exceed 51%, acidity not more than 12, and porosity not less than 45%.

It is worth noting that both bread samples have good organoleptic properties, they lack crunching and lumpiness, there is a characteristic smell of baking. Positive taste and aromatic properties of bread will allow to quickly integrate the developed options into the diet.
Table 1. Quality comparison of bread prototypes.

| Indicators                      | Comparison of developed samples results |          |
|--------------------------------|----------------------------------------|----------|
|                                | Sample No. 1                          | Sample No. 2 |
| Shape                          | Round                                  | Oval         |
| Characteristic of crust        | Colour: light-brown                    | Colour: dark-brown |
|                                | Surface: smooth                        | Surface: rough |
| Crumb resilience               | Resilient                              | Resilient   |
| Porosity structure             | Medium porous                          | Finely porous |
| Crumb color                    | Taupe                                  | Dark brown  |
| Taste                          | Normal                                 | Normal      |
| Smell                          | Odour-free                             | Odour-free  |

Moisture determination of bread showed the following results - 28.0% for sample No. 1 versus 31.6% in the second sample, acidity was 1.0 and 0.9 in the first and second samples, respectively. Low acidity results from the lack of yeast. The taste in comparison with traditional rye bread seems a bit dull.

The analysis of nutritional value showed that the developed bread samples have a lower calorie content, while the protein content in them is 2.5–5 times higher, the fat content is 5.5–13 times higher, and the amount of carbohydrates is 10–14 times lower. Such proportions of macronutrients will make it possible to successfully use the product in the diet of people with diabetes mellitus, cardiovascular diseases and many other pathologies in need of dietary correction [6, 11, 12].

Table 2. Comparison of the nutritional value of bread samples per 100 g.

| Parameter                   | Research results |          |          |          |          |
|                            | Sample No. 1     | Sample No. 2 | Sample No. 3 | Sample No. 4 | Sample No. 5 |
| Calorie content            | 208 kcal         | 212 kcal     | 212 kcal   | 226 kcal  | 246 kcal  |
| Protein content, g         | 19.1              | 19.3          | 6.0        | 3.8        | 7.4        |
| Fat content, g             | 12.4              | 13.3          | 1.0        | 2.4        | 2.2        |
| Carbohydrate content, g    | 5.1               | 3.7           | 42.0       | 44.0       | 53.0       |
| Number of bread units (XE) | 0.42              | 0.31          | 3.50       | 3.67       | 4.42       |

4. Conclusion

As part of the scientific and practical work, two formulations of dietary bread based on flax flour, differing from each other only in the liquid part, were developed. The quality analysis showed compliance with the quality standards for bakery products. Adjusted nutritional value will allow to integrate this product into a low-carb diet, which is especially important for people suffering from diabetes and metabolic syndrome. The number of bread units (XE) in the developed samples is also optimal and lower than that of the corresponding analogues. These numerical parameters will reduce insulin intake in people with diabetes.

It is worth noting that the developed bread samples are suitable for nutrition of people who adhere to various low-carb nutritional protocols, and the absence of gluten, milk and sugar will significantly increase the target audience.

Also note that the bread recipes will be finalized. It is desirable to make this product available to those categories of citizens who adhere to vegetarianism. In addition, it is planned to develop and
introduce leaven in the bread production technology to improve the organoleptic and therapeutic properties of the product.

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