Ministry of Education and Science of Ukraine
Black Sea Universities Network

ODESA NATIONAL UNIVERSITY OF TECHNOLOGY

International Competition of Student Scientific Works

BLACK SEA SCIENCE 2022

PROCEEDINGS

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Proceedings of International Competition of Student Scientific Works «Black Sea Science 2022» contain the works of winners of the competition.

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INTRODUCTION

International Competition of Student Scientific Works “Black Sea Science” has been held annually since 2018 at the initiative of Odesa National University of Technology (formerly Odesa National Academy of Food Technologies) with the support of the Ministry of Education and Science of Ukraine. It has been supported by Black Sea Universities Network (the Association of 110 higher education institutions from 12 countries of the Black Sea Region) since 2019, and by Iseki-FOOD Association (European Integrating Food Science and Engineering Knowledge into the Food Chain Association) since 2020.

The goal of the competition is to expand international relations and attract students to research activities. It is held in the following fields:

- Food science and technologies
- Economics and administration
- Information technologies, automation and robotics
- Power engineering and energy efficiency
- Ecology and environmental protection

The jury includes both Ukrainian and foreign scientists. In the 4 years that the competition has been held, the jury included scientists from universities of 24 countries: Angola, Azerbaijan, Benin, Bulgaria, China, Czech Republic, France, Georgia, Germany, Greece, Israel, Italy, Kazakhstan, Latvia, Lithuania, Moldova, Pakistan, Poland, Romania, Serbia, Slovakia, Switzerland, Turkey, USA.

At the same time, every year the geography has expanded and the number of foreign jury members has increased: from 46 jury members representing 25 universities from 12 countries in 2018, to 73 jury members of the 46 universities from 19 countries in 2022.

More than a thousand student research papers have been submitted to the competition from both Ukrainian and foreign institutions from 25 countries: China, Poland, Mexico, USA, France, Greece, Germany, Canada, Costa Rica, Brazil, India, Pakistan, Israel, Macedonia, Lithuania, Latvia, Slovakia, Romania, Kyrgyzstan, Kazakhstan, Bulgaria, Moldova, Georgia, Turkey, Serbia.

The interest of foreign students in the competition grew every year. In 2018, the students representing 15 institutions from 7 countries have submitted 33 works. In 2021 the number of submitted works increased to 73, authored by the students of 40 institutions from 18 countries.

The competition is held in two stages. In the first stage, student research papers are reviewed by members of the jury who are experts in the relevant fields. In the second stage of the competition, the winners of the first stage have the opportunity to present their work to a wide audience in person or online.

All participants of the competition and their scientific supervisors are awarded appropriate certificates, and the scientific works of the winners are included in the electronic proceedings of the competition. Every year the competition receives a large number of positive responses from Ukrainian and foreign colleagues with the desire to participate in the coming years.

1. FOOD SCIENCE AND TECHNOLOGIES

PSYLLIUM GEL AS A SUBSTITUTE FOR FAT IN THE COOKIES TECHNOLOGY

Author: Maryna Bozhko
Advisor: Kateryna Khvostenko
Odessa National Academy of Food Technologies (Ukraine)

Abstract. *The psyllium usage is of great interest for the value-added pastry production due to its functional and physiological characteristics. This raw-material is also characterized with some technological characteristics which will positively effect on their quality. The aim of the present study was to evaluate the effectiveness of psyllium usage for the reduced fat content cookies production. In the cookie`s recipe, 20 and 40 % of fat was replaced with psyllium gel using a combination of psyllium and water (P:W) in the ratio 1:8, 1:10 and 1:12. All samples were analyzed for moisture content, hardness, density, water absorption ability, spread ratio and sensory characteristics. It was found that the combine use of psyllium and water in ratio 1:12 leads to a negative effect on products quality, the denser structure formation compared with the control. The samples with 20 % fat replacement with psyllium (P: W -1:8) and 40 % (P: W -1:10) have showed the best results in all quality parameters – lower density and high overall acceptability. Density for these samples decreased by 14,8…9,0 %, spread ratio - by 2,07 … 32,78 %, compared with the control. Thus, the psyllium use provides the consumer characteristics improvement of enriched products and their energy value decrease.*

Keywords: *psyllium, biscuits, pastry, fat content, quality parameters.*

I. INTRODUCTION

Pastry products are known to be in demand among the consumers. According to the State Statistics Service, in 2020 more than half of confectionery products on the market were pastry products, which confirm their potential for manufacturers [1].

Pastry products belong to the multicomponent foods. They contain a large amount of vegetable and animal fats, as well as fast carbohydrates, but essential amino acids, dietary fiber and micronutrients are present in very small quantities. The main disadvantage of pastry products, in particular butter cookies, based on the requirements of healthy diet, is the high energy value due to the high content of fast carbohydrates and saturated fats and lack of essential macro- and micronutrients in their content. At the same time, current trends in the development of the food industry are focused on chemical composition, energy and biological value improvement.

It should be noted that hydrogenated vegetable fats, which may contain trans fats, are often used for the production of pastry products. Their presence does not meet product safety requirements and is negatively perceived by modern consumers. Trans fats are characterized with negative effect on human health – disrupting metabolic processes, which can lead to weight problems, impaired immune function, and risk of diabetes and cardiovascular disease [2]. In particular, the World Health Organization in 2018 presented the REPLACE project, aimed at phasing out trans-fatty acids of industrial production from food around the world [3]. Recently, in our country there

are also initiatives aimed at limiting the content of trans fatty acids in food, in particular, a draft law banning the use of hydrogenated fats in foods consumed by children is prepared [4].

As a result, manufacturers are faced with the issue of finding safe alternatives to fat, the use of which will reduce the energy value of products and will not lead to a deterioration of final product`s quality.

A perspective ingredient for fat substitution is psyllium - the husk of the seeds of plantain (Plantago ovata). Psyllium contains about 2% proteins and a small amount of fats, about 85-88% carbohydrates, a significant massfraction of which is presented by water-soluble dietary fiber (arabinoxylan) [5, 6, 7]. Due to the high content of dietary fiber, psyllium is a promising substitute for fat, because this raw-material is able to form a gel with water, which is characterized by a stable structure.

II. LITERATURE REVIEW

Psyllium is the common name for several plant species of the genus Plantago. The psyllium husk is the outer shell of its seeds, which is separated by crushing them [6].

Detailed studies of the active fraction of psyllium husk showed that it is presented by the neutral arabinoxylan (22,6% arabinose, 74,6% xylose and a molar base) with branched structure [7]. Psyllium husk gums have a high molecular weight, which enhance the viscosity [8].

The gel-forming fraction of psyllium husk is about 55-60% and has not only a laxative effect, but also reduces blood cholesterol levels [9]. Psyllium has shown to be effective in the treatment of chronic constipation in patients [10]. According to another study, psyllium has a less pronounced effect than dried plums (prunes), but is still recognized as effective in the treatment of constipation [11].

Psyllium has been used in the treatment of mild to moderate hypercholesterolemia. During eight weeks of treatment of patients, the level of total cholesterol in the blood serum decreased by 14,8% and low-density lipoprotein (LDL) cholesterol by 20,2% [12, 13]. Psyllium has also been found to be a safe addition to the diet of patients with hypercholesterolemia (10 mg of simvastatin) and was effective in lowering cholesterol levels as 20 mg of simvastatin alone [14]. In addition, psyllium reduces the level of glucose in blood serum by 11% for the patients with type II diabetes mellitus, improves glycemic and lipid control [15-18].

Due to its chemical composition, psyllium is also recognized as an effective additive in food production. So, psyllium is used not only for therapeutic purposes, but also as a substitute for gluten in the production of flour products. Thus, the adding of the 3.0% psyllium in the starch mixture for the gluten-free bread production, provides to obtain a product with high sensory characteristics and a lower content of fat and calories [19]. Adding hydrated psyllium to bread recipes leads to increase the moisture content and thus the softness of the finished bread [20]. At the same time, when replacing wheat flour with psyllium, the volume of finished bread decreased with an increase in its content in the recipe. However, the samples with psyllium were close to the control in terms of weight, volume and rheological properties [21-23]. In addition, psyllium incorporation provides positive effect on the gluten-free pasta preparation,

which eliminates the stage of gelatinization of rice flour and increases the digestibility of finished products [24].

The use of psyllium makes it possible to increase the content of dietary fiber in the composition of the product, while not affecting the taste characteristics of finished products [25]. The addition of 7,5% psyllium to the recipe of a diet cake did not significantly affect the organoleptic and physicochemical properties of the product and is recommended for the overall quality improvement of the product [26]. By partial replacement of the flour with psyllium, a biscuit with a high content of dietary fiber was developed, consumption of which can effects on the glucose levels regulation in blood [5]. Psyllium is also used as a fat substitute in food technology. For example, cake samples with 75% vegetable oil substitution for psyllium gel were found acceptable [27].

Due to this, there is a need for further research on the use of psyllium in the production of pastry products. For nowadays there is not much research on replacing fat in the recipe of butter cookies with psyllium gel, which makes this topic promising for study.

III. OBJECT, SUBJECT, AND METHODS OF RESEARCH

Objects of research. The following raw materials were used for the production of buttery cookies: wheat flour (GSTU 46.004-99), margarine (spread) (DSTU 4465: 2005), white sugar (DSTU 4623: 2006), cocoa powder (DSTU 4391: 2017), egg products (DSTU 8719: 2017), table salt (DSTU 3583: 2015), vanillin (GOST 16599-71). Psyllium – husk of plantain seeds (NPE Shebanova L.O.) was also used in the research.

The subjects of research were dough, butter cookies.

The aim of the project is to study the possibility of reducing the fat content in the recipe of butter cookies by the use of psyllium. For this aim, rational conditions for its preparation for the production of butter cookies were also elaborated.

As a control sample buttery cookies "Vanilla Pretzel" with a significant proportion of fat in the recipe was chosen. During the study, psyllium gel (PG) was used to replace 20… 40% of fat, which was prepared with a ratio of psyllium and water 1:8, 1:10 and 1:12.

Research methods. In all samples, moisture and density for the dough were determined, as well as moisture, hardness, density, wetting, distribution coefficient and organoleptic characteristics for finished products.

Moisture content for the raw materials, semi-finished products and cookies was determined by drying method [27, 29].

The density of the dough was determined by volumetric method using the mass and volume measured, density of sample was calculated as mass to volume ratio, according to the generally accepted method [28, 29].

All statistical analysis was carried out in triplicate and average values were calculated. All data was statistically analyzed through analysis of variance (ANOVA) and Fischer test. Significance was accepted at $p<0.05$.

The cookie dough was prepared in two stages according to the functional diagram shown in Fig. 1.

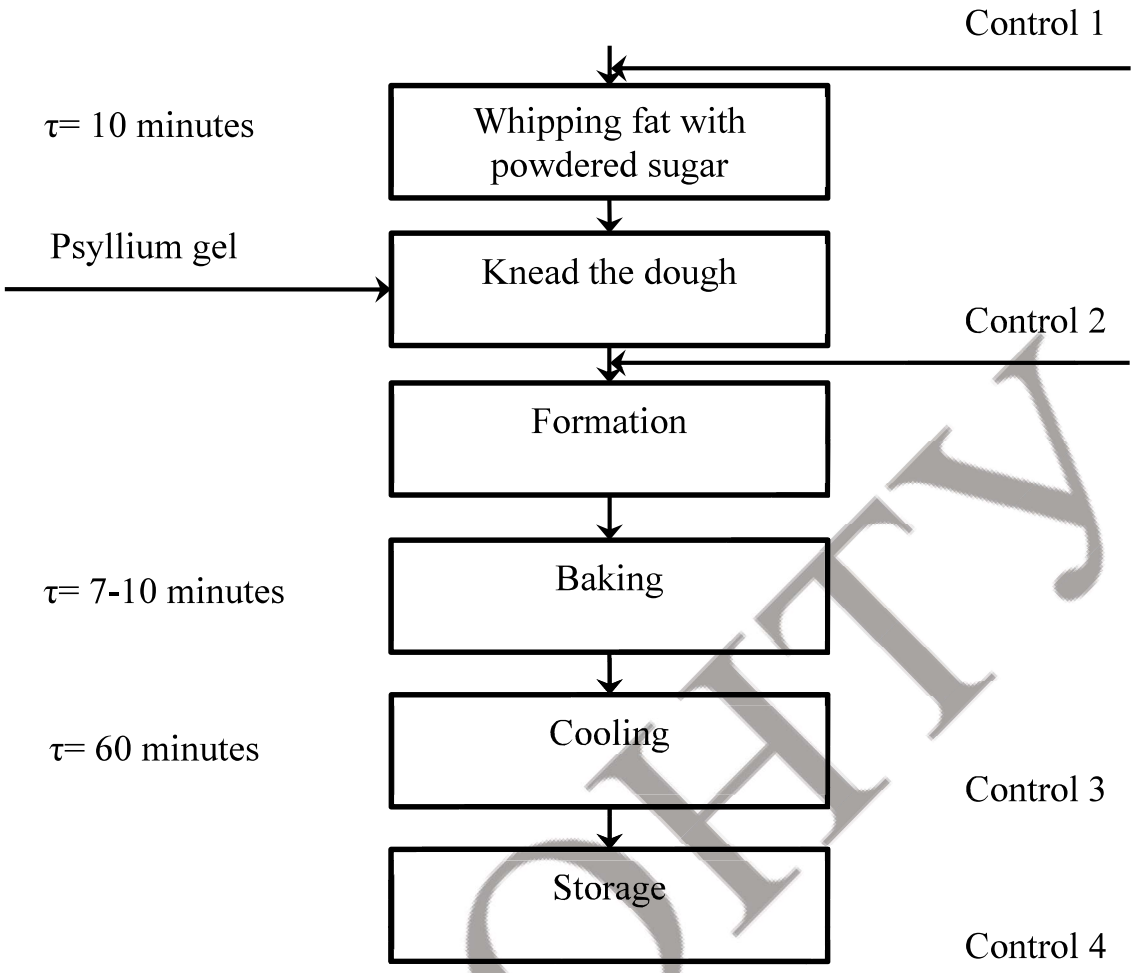

Fig. 1. Scheme of butter cookies production

The quality of cookies was determined after 24 hours after baking. Physico-chemical (hardness, density of cookies, water absorption ability, alkalinity and spread ratio) and sensory characteristics of cookies were determined according to the methods according to the standards. The hardness of cookies was determined by pressing the stamp to break the cookies [29]. The density of cookies was calculated as the ratio of pre-measured mass and volume of cookies [28, 29]. The spread ratio was determined by the ratio of the average diameter of the cookies to the average height [30].

Sensory evaluation of the product was carried out based on appearance, color, aroma, structure, and taste. A panel of 15 members was selected to evaluate the sensory properties of the cookies. Sensory evaluation was done using the preference ranking test method, in which the pre-coded samples were given scores on a five-point scale (1 – strongly dislike, 5 – strongly like).

Nutrition and energy values were calculated using a specific Excel spreadsheet according Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers.

All statistical analysis was carried out in triplicate and average values were calculated. All data was statistically analyzed through analysis of variance (ANOVA) and Fischer test. Significance was accepted at $p<0.05$.

IV. RESULTS

The experimental data has shown that the adding of PG has a negative effect on the color of the products. As the mass fraction of psyllium gel increased, the number of dark spots on the surface of the cookies increased, which leads to a deterioration in the consumer characteristics of the developed cookie. To avoid the mentioned negative effect we have proposed to add additionally of 5% cocoa powder by weight of dry matter of flour.

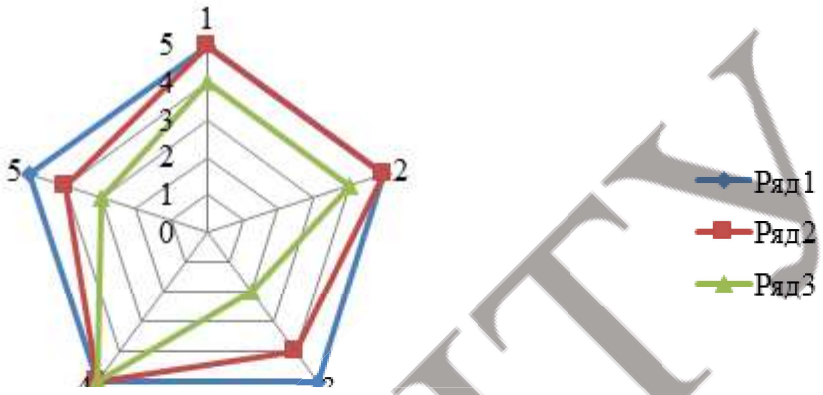

Fig. 2. Sensory characteristics of cookies

According to research results, the use of 20… 40% PG (a ratio of psyllium and water 1:12) to replace the fat has a negative effect on the quality of cookies. These samples with reduced fat content were characterized by an increase in hardness by 44-100% and reduced consumer properties compared to the control (Fig. 2). Cookies with PG were characterized with uneven and dense structure, with increasing the PG mass fraction (1:12) the color of the cookies became much darker. These samples were not evaluated in further studies.

Replacement of fat (20-40%) with PG (the ratio 1:8 and 1:10) had almost no effect on physicochemical parameters of dough (Table 1).

Table 1 – Physico-chemical quality indicators of dough for butter cookies

Quality indicators / Samples	Control	PG (1:8)		PG (1:10)	
		20%	40%	20%	40%
Moisture content,%	21,9	22,3	25,8	20,2	22,9
Density, kg/ m^3	636,88	701,55	741,42	692,05	737,2

The dough moisture content for samples with 20% PG remains almost at the level of control, which minimizes changes in the technological process. Density of dough for samples with replacement of 20… 40% fat increased by 10-16% for PG with the ratio 1: 8 and by 8-15% with 1:10 P:W ratio, compared with the control. This tendency is probably due to the increase in the content of dietary fiber contained in psyllium.

It was found that the reduction of 20… 40% of fat mass fraction with PG in the ratio of 1:8 and 1:10 provides to the formation of butter cookies with high quality and overall acceptability (Table 2).

Table 2 – Physico-chemical quality indicators of cookies

Quality indicators / Samples	Control	PG (1:8)		PG (1:10)	
		20%	40%	20%	40%
Cookies moisture content,%	2,8	2,5	3,2	3,5	3,4
Hardness, kg/mm^2	4,5	4,0	7,5	3,6	7,5
Water absorption ability, %	134,0	149,42	119,56	148,06	120,5
Alkalinity, deg	0,7	0,4	0,5	0,4	0,6
Spread ratio	4,82	4,72	3,13	3,93	3,24

The spread ratio of cookies decreased when replacing fat with psyllium by 2,07… 32,78% in the selected samples compared to the control. The obtained results have shown that cookies enriched with psyllium are characterized with less melting process during baking and are able to hold their shape better. The density of cookies is no less important characteristic, as it allows you to characterize the structure of products.

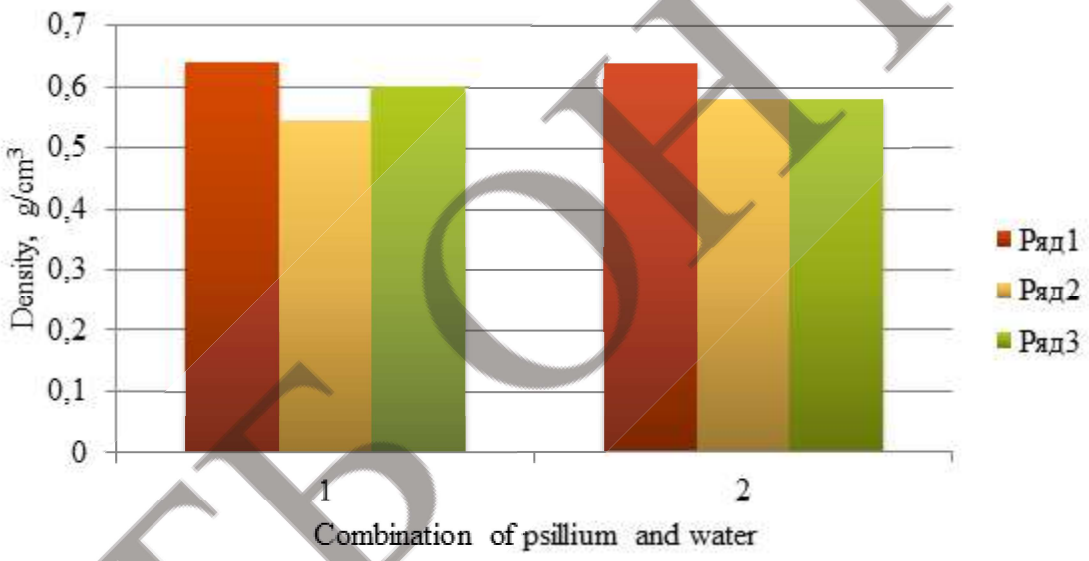

Fig. 3. Density of butter cookies

Thus, the density (Fig. 3) for samples with replacement of 20% fat by PG (1:8) and 40% fat by PG (1:10) decreased compared to the control by 14,8 and 9,0%, respectively. The obtained results have indicated the formation of a more porous structure of the final products.

According to the results of the sensory parameters evaluation (Fig. 4), the samples with 20 and 40% PG did not differ significantly from the control – the shape of the cookies was correct with a clear pattern on the surface with porous structure, pleasant taste and aroma.

Control 20% PG (1:8) 40% PG (1:10)

Fig. 4. Samples of butter cookies

In general, the quality of elaborated samples is in accordance with national standard requirements. According to the results of organoleptic evaluation, the samples with fat replacement by 20% PG (1:8) and 40% PG (1:10) were recognized as the best.

The nutritional value of these samples was investigated, too. The introduction of psyllium in the butter cookies recipe provides additionally the improvement of the nutritional value of the final product (Table 3).

Table 3 – Nutritional value of the cookies

Parameters	**per 100 g of final product**		
	Control	**20% PG (1:8)**	**40% PG (1:10)**
Protein, g	5,79	5,78	5,76
Fat, g	36,94	29,82	22,70
Carbohydrates, g:			
total	54,88	55,47	55,81
dietary fiber	0,83	1,45	1,85
Ash, g	1,28	1,26	1,24
Vitamins, mg:			
A	0,02	0,02	0,02
B_1	0,09	0,09	0,09
B_2	0,04	0,04	0,03
PP	0,87	0,85	0,83
Minerals, mg:			
Na	328,58	313,74	298,90
K	98,62	97,75	96,89
Ca	21,16	20,21	19,25
Mg	17,86	17,78	17,69
P	66,95	66,34	65,73
Fe	1,25	1,39	1,49
Energy value, kcal	563,17	501,59	438,99

The nutritional value of cookies with 40% fat replacement with PG in the ratio of 1:10 is significantly improved. There is an increase in the content of dietary fiber by almost 2,5 times, as well as a decrease in fat content by 38,5% compared with the control. As a result of replacing the proportion of fat with psyllium, there is a reduction in calories by 22%, which gives the product more dietary properties.

In addition, the replacement of 20… 40% fat with PG leads to the energy value reduction the of finished products by 11… 22% and increase the content of dietary fiber in cookies (Fig. 5), compared with the control.

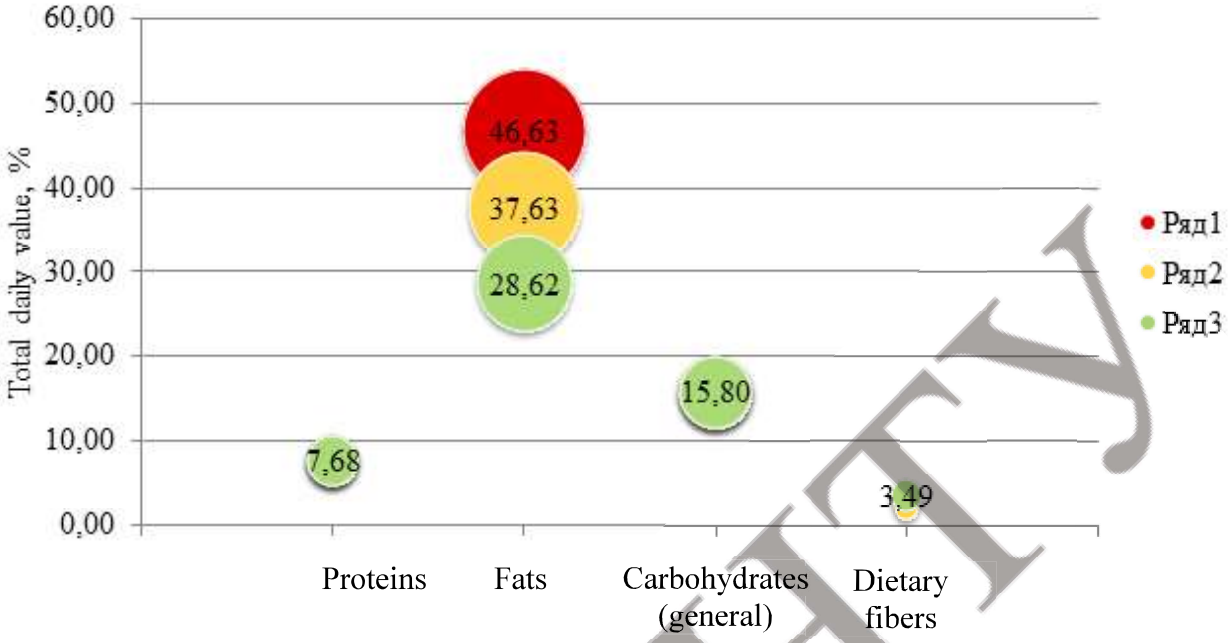

Fig. 5. The daily value of product

Based on these data, it can be seen that the consumption of 100 g of cookies with the replacement of 40% of fat with PG in the ratio of 1:10 leads to an increase in proteins and dietary fibers content to satisfy total daily value recommendations compared with the control sample.

V. CONCLUSIONS

Based on the experimental data, we can conclude that the use of psyllium gel in the technology of butter cookies has a positive effect and provides to:

- replace 20% fat on PG (1: 8) or 40% fat on PG (1:10) in cookies recipe;
- to obtain products with high consumer characteristics and consistently high quality;
- reduce the energy value of products by 11… 22%, respectively;
- to expand the range of pastry products with low energy value and high content of dietary fiber.

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TABLE OF CONTENTS