

PSYCHOCHEMICAL CHARACTERISTICS OF FUNCTIONAL BISCUITS AND *IN VIVO* DETERMINATION OF GLUCOSE IN BLOOD AFTER CONSUMPTION OF FUNCTIONAL BISCUITS

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Abstract

Biscuits are confectionery products, which are mostly made from flour, fats and sugar. Various types of biscuits are commercially available, but today, people want to be healthy and functional biscuits have to be introduced.

In order to determine physicochemical properties of functional biscuits, three types of biscuits with fructose have been made: basic biscuits (control) and biscuits in which Acacia gum (Fibregum™) and inulin were added. Production of biscuits includes several steps of production: measuring raw materials, mixing powder raw materials, adding water and oil, mixing, resting dough to rise (refrigerator, 15 min.), rolling out, shaping, baking (150 °C, 7-10 min.), cooling and packing. Following parameters have been analyzed: mass of biscuits (Mettler Toledo AB204-S analytical balance), length and thickness of biscuits (Powerfix calliper), moisture (ISO 6540), ash (ISO 5984:2002), proteins (Method of Lowry), fats (AACC Method 30-25), reducing sugars (AACC Method 80-68), fructans (spectrophotometric) and dietary fiber (AACC Method 32-21.01). Also, we have *done in vivo* research to measure the influence of biscuits over the level of glucose in the blood in healthy people, people with type 1 diabetes and type 2 for a time of 30, 60, 90 and 120 min. after consumption of the biscuits. Glycaemia was measured with a strip glucometer.

As a result of the experiments we found that the addition of inulin and Fibregum to the recipe of the biscuits is increasing: moisture content, proteins, fats, reducing sugars, total sugars and fructans after inversion, as well as the total nutrition fibers. We have determined that after consumption of all three types of biscuits, the level of glucose in the blood increases, relative to the initial (on an empty stomach). The best results for all groups of people have been obtained through consumption of the biscuits with Fibregum.

From the results, it can be concluded that produced biscuits have characteristics of functional food. Adding Acacia gum and inulin in biscuits contributed to change in values of the analyzed parameters, whereupon increasing the content of dietary fiber should be pointed out.

Key words: Functional biscuits, Inulin, Fibregum™, Level of glucose, Blood.

1. Introduction

Functional foods are conventional foods containing substances that give them functional properties. They represent a new trend by eating foods with special nutritional qualities that can improve people's health

and reduce the risk of disease and could extend human life [1].

Production of biscuits is considered as a very important part of the food industry, because the crackers have a high nutritional value, especially when raw materials which are prepared from are rich in fats, carbohydrates and proteins [2]. According to Popov-Rajlić *et al.*, [3], in addition to affect nutritional values, biscuits act positively on the emotional status of users, improving their mood. Most often they are made from flour, butter, sugar [3] and other constituents which have a moisture content less than 4% and expiry date more than 6 months [4]. The main disadvantage of eating these cookies is that making so, it will violate the balanced diet of the consumers. To solve this problem, we add traditional local raw materials that enrich the biscuits with a biological nutritional value [5].

The biscuits are stable products, and have a number of advantages. The main ones are: long expiry date and good quality. The physical properties of the flour and the appearance of the biscuits depend on the nature and type of the received cookies and the method of forming the flour. In the biscuits production, it is important to follow the raw materials quality standards [6].

Nowadays, biscuits with functional properties can be found on the market. These properties are acquired after enrichment of biscuits with different raw materials (flour, buckwheat, oats, inulin, acacia gum, etc.) which have functional properties. The purpose of this article is to examine physicochemical properties of cookies, which are made from different types of flour and to which are added inulin and acacia gum (Fibregum). The last two supplements can replace sugars and fats; they contain high amounts of fibers, reducing the glucose content in the blood and have a proven prebiotic effect.

2. Materials and Methods

All samples are prepared according to the official method AACC Method 62-20A [7].

The biscuits are produced using recipe composition which is represented by the authors Nakov *et al.*, [8]. The length and thickness of the biscuits was measured using a caliper Powerfix, and the mass of the crackers was measured by means of an analytical balance Mettler Toledo AB204-S.

Determination of moisture content of the cookies was done according to the official method ISO 6540 [9], and determination of mineral content (ash) in biscuits was made according to official document ISO 5984:2002 [10].

Fats content in the biscuits was determinate according to the official method ISO 6492:1999 [11], proteins

according to the Lowry method [12], while fructans were determined according to the method presented by Petkova *et al.*, [13].

Total, soluble and insoluble nutrition fibers were determined according to the official method AACC Method 32-21.01 [14].

The glycemic response was assessed in 9 volunteers of which: three healthy volunteers, three volunteers who have insulin type 1, and 3 volunteers who have insulin type 2. All participants gave their informed written prior content to the experiments and a standard protocol was used to assess their glycemic response. Briefly, they attended three morning sessions after fasting overnight. They were fed with a portion of 100 g biscuits (one type biscuits every day). Blood samples were taken before (time 0) and 30, 60, 90 and 120 min. after starting the meal. Glycaemia was measured with a strip glucometer based on glucose oxidation mediated by glucose dehydrogenase (One Touch Select®). The white bread was used as reference food.

3. Results and Discussion

In the last decade innovation in the production of biscuits are looking to produce biscuits with reduced sugar content, replacing sugar with other sweeteners, using fats with different characteristics and enrichment of crackers with different supplements which have functional properties.

3.1 Physical characteristics of the biscuit

The biscuits can differ in mass and size. By measuring the mass, length and thickness of selected samples (10 samples) of the three types of biscuits (Fructi, Fructi + Inulin, Fructi + Fibregum), the average value of each of the before mentioned parameters was calculated. The obtained results are shown in Table 1.

Table 1. Physical parameters of biscuits "Fructi", "Fructi + Inulin" and "Fructi + Fibregum"

Parameters	Fructi	Fructi + Inulin	Fructi + Fibregum
Thickness (mm)	9.58	8.56	9.93
Length (cm)	5.50	7.48	6.20
Mass (g)	14.80	15.00	15.10

From the obtained results it was found that Fructi biscuits are characterized by lower average weight (14.80 g) in relation with biscuits Fructi + Inulin (15.00 g) and Fructi + Fibregum (15.10 g). The last two biscuits have

approximately the same average weight. The longest average length was found in biscuits Fructi + Inulin (7.48 cm), while with the largest average thickness - where biscuits Fructi + Fibregum (9.93 cm).

3.2 Chemical properties of the biscuits

Term "chemical composition" means the content of all ingredients in the biscuits, including the water.

3.2.1 Moisture content and dry matter (%)

From a technological point of view, the chemical composition is most easily determined by determining the dry matter content. This concept covers amounts of all the ingredients that make up the crackers without water. Figure 1 shows the amount of moisture and solids in examined biscuits.

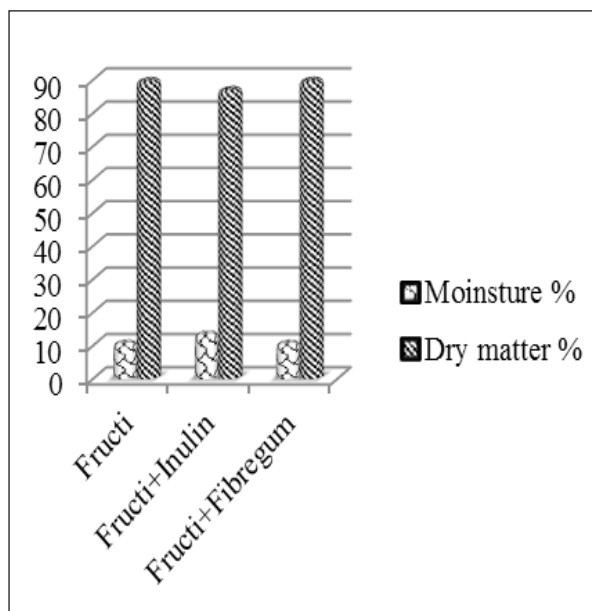


Figure 1. Moisture content and solids

From performed tests it was found that the biscuits are characterized by the following dry matter: "Fructi" - 89.51%; "Fructi + Inulin" - 86.78% and "Fructi + Fibregum" - 89.56%. The results presented in Figure 1 show that the percentage of moisture content in the biscuit Fructi + Inulin (13.22%) is largest. With the least moisture content were Fructi biscuits (10.49%). Therefore, after addition of inulin and Fibregum in the composition of the biscuits it increases their moisture content. This was confirmed also by other authors who have studied the moisture content of various food products to which was added inulin. They have also found that the increase of moisture content in products is due to the added inulin. According to Lourencetti *et al.*, [15], the moisture content of the biscuit, in which inulin was added as a partial replacement of fats varies in the range from 6.8% (standard - sample) to 7.1%.

While carrying out the chemical analysis of the biscuits prepared from gluten-free and enriched with inulin flour were found different moisture contents, which depends on the amount of added inulin. Biscuits with the least amount of added inulin (3%) have the least moisture content (2.50%), whereas the biscuits with the highest inulin content of (4%) contained the greatest amount of moisture (2.94%) [16]. Sharoba *et al.*, [17], observed biscuits made from gluten-free flour with inulin from Jerusalem artichoke and found that the moisture content is in the range of 3.21% to 3.91% (controlled sample).

When compared biscuits made from 100% white flour and a mixture of 70% white wheat, 20% soybean and 10% rice flour was found that the biscuits obtained from the flour mixture, have greater moisture content [18].

Pasha *et al.*, [19], have investigated the influence of various sweeteners on the quality of the biscuits. The highest moisture content has been found in cookies, whereas the sweetener was used mixture of 70% fructose, 15% sorbitol and 15% manitol. At least moisture content was determined in the controlled samples biscuits in which as a sweetener were used sucrose (100%).

3.2.2 Ash content (%)

Ash content determines the amount of minerals contains in food. The mineral substances promote the metabolism of carbohydrates and other organic compounds [20].

According to the data shown in Table 2 the biscuits "Fructi" are distinguished by the highest ash content (2.27%). With at least ash content are crackers "Fructi + Inulin" (1.73%). In biscuits so called "Fructi + Fibregum" we found 2.11% ash content.

Table 2. Ash content of biscuits

Type of biscuits	Fructi	Fructi + Inulin	Fructi + Fibregum
Ash (%)	2.27	1.73	2.11

When comparing the ash content of the produced by us cookies with biscuits which were examined by Yenkar *et al.*, [20], we noticed that there are no significant differences between both products. Lourencetti *et al.*, [15], have researched the biscuits with added certain quantity of inulin and found that when increasing the amount of inulin in the biscuit it results in increasing of the ash content. Biscuits with added 1.1% inulin have 2.88% ash content, crackers with added 2.2% inulin - 4.10% ash content and biscuits with added inulin 3.3% - 4.18% ash content.

After producing functional biscuits made from gluten free flour to which was added a certain amount of inulin (substitute of fats) it was found that the ash content is in the range of 1.81% to 2.75%. In biscuits produced from the same flour but inulin added as a substitute for sugars we found ash content of 2.10% to 4.20%. It has been proven that the difference in ash content is due to the different amounts of added inulin [17].

According to Maghaydah *et al.*, [16], in the biscuits made from gluten-free flour, to which was added in various amounts inulin, the ash content ranges from 13.91% to 13.97%.

Upon ash content determination in biscuits, in which are used various sweeteners, Pasha *et al.*, [19], found that the most ash content have biscuits with 50% sucrose and 50% fructose (0.54%). At least ash content was found in the biscuits containing 80% fructose and 20% sorbitol (0.37%).

3.2.3 Proteins (mg)

Proteins are complex macromolecular compounds that in aqueous solutions are in colloidal state. They are made up of amino acids which are linked together by peptide bonds. Chemical composition of the proteins includes components with strictly defined quantity (C, H, N, O, S, P). They are divided into simple and complex proteins. The importance of proteins in nutrition results in their ability to provide the human body nitrogen in amino form [21]. The protein content is an important indicator, we judge by it for the quality of the biscuits [22].

From conducted studies we found that crackers "Fructi" contain 18.48 mg protein, biscuits "Fructi + Inulin" - 22.32 mg, and biscuits "Fructi + Fibregum" - 19.92 mg protein (Figure 2). The obtained results show that when inulin and Fibregum that were added led to increasing the biscuits protein content. The higher values of the proteins are due to the use of our raw materials which are rich sources of proteins (sesame, olive oil, seed, etc.).

According to Oyeyinka *et al.*, [23], the increased amount of proteins in the biscuits are due to mixing different types of flour, which contained varying amounts of proteins. Maghaydah *et al.*, [16], have received cookies from gluten-free flour and studied the effects of different amounts of added inulin (3%, 3.5%, 4% and 4.5%). They found that the amount of inulin does not affect the percentage of proteins in the biscuits (13.95%, 13.93%, 13.92%, and 13.91% respectively). In the manufacture of biscuits Sharoba *et al.*, [17] inulin was used as a substitute for fats and sugars. In biscuits, in which inulin acts as a substitute for fats, the content of proteins ranges from 8.31% to 9.14%. In biscuits, wherein inulin is used as a sugar substitute, the amount of proteins is in the range from 8.50% to 10.35%.

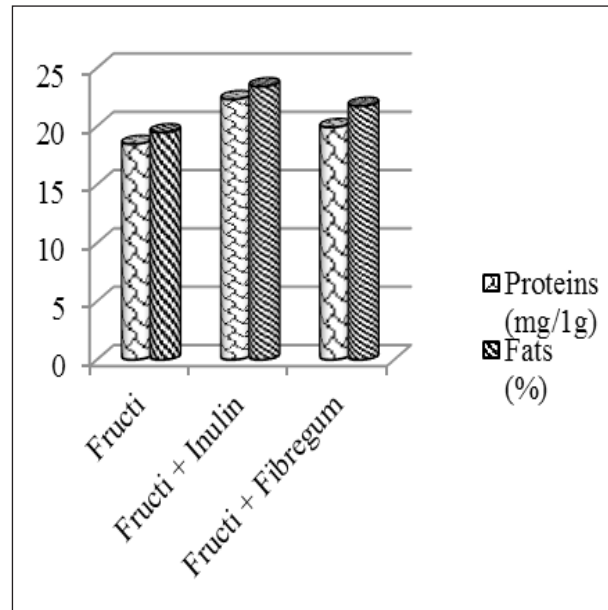


Figure. 2 Quantity of proteins and fats in biscuits

In the production of crackers the fats are very important as they give biscuits plasticity. Furthermore, during the formation of the biscuits, they help for introduction of air inside them [4]. Fats have important role on the food products durability. Relatively high fat content could cause changes that lead to strange smell and taste [20].

In our study (Figure 2) we observed that the fats content in cookies "Fructi" is 19.48%, in biscuits "Fructi + Inulin" is 23.42%, and in the biscuits "Fructi + Fibregum" - 21.75%. Bunde *et al.*, [18], have determined higher fat content (12.13%) in biscuits made from a mixture of different types of flour (70% white wheat flour, 20% soybean flour and 10% of rice flour) in comparison with biscuits made only with white flour (10.50%).

When analyzing biscuits made from gluten-free flour, to which was added inulin in various amounts, Maghaydah *et al.*, [16], found that the controlled biscuits (without added inulin) contained the least amount of fats (12.42%). In the biscuits, in which has been added a certain quantity of inulin, the fat content is in the range from 12.61 to 12.87%.

In the literature sources Sharoba *et al.*, [17], have received and studied biscuits, to which was added inulin from Jerusalem artichokes used as a fats substitute. They found that the amount of fats in the biscuits is decreasing proportionally with increasing the amount of inulin in them. In biscuits, in which 25% of the fats were replaced by inulin, the fats content was 8.12%. If we substitute 50% of fats with inulin the amount of fats decreases to 6.32% and if we substitute 75% of fats with inulin the amount of fats becomes 4.14%. If we substitute 100% of the fats with inulin, the fats content of the biscuits will be only 2.13%.

3.2.4 Reducing sugars, fructans, total sugars after inversion

The content of reducing sugars, fructans and total sugars after inversion in all produced from us biscuits is presented in Table 3. From the results can be seen that the biscuits "Fructi" have at least amount of reducing sugars, fructans and total sugars after inversion as compared to cookies "Fructi + Inulin" and "Fructi + Fibregum". This is probably due to the added amount of inulin and Fibregum. Biscuits "Fructi + Inulin" contained 8.37% reducing sugars, 16.05 g fructans/100 g, and 9.61% total sugars after inversion. In biscuit "Fructi + Fibregum" were found: 7.68% reducing sugars, 15.40 g fructans/100 g and 8.86% total sugars. For biscuits "Fructi" were found smaller values of these indices: 3.37% reducing sugars, 11.00 g fructans/100g and 6.68% total sugars after inversion.

Table 3. Reducing sugars, fructans, total sugars after inversion

Parameters/ Type of biscuits	Fructi	Fructi + Inulin	Fructi + Fibregum
Reducing sugars (%)	3.37	8.37	7.68
Fructans (g/100)	11.00	16.05	15.40
Total sugar after inversion (%)	6.68	9.61	8.86

Sharoba *et al.*, [17], have been investigated biscuits made from gluten-free flour and when preparing the recipe inulin from Jerusalem artichokes was incorporated. The content of total sugars in the cookie is variable depending on whether inulin is added as a substitute for fats, or as a substitute for sugars. In biscuits, wherein the inulin is added as a substitute for fats the content of total carbohydrates was in the range of 81.76% to 85.57%. In the biscuits, in which inulin is used as a substitute for the sugars the content of total carbohydrates was less and ranged from 77.29% to 78.90%. For biscuits prepared from gluten-free flour, and then added various amounts of inulin (3%, 3.5%, 4% and 4.5%) was found that the content of total carbohydrates will be increased by increasing the amount of inulin [16].

The obtained data for the content of reducing sugars, fructans and total sugars after inversion in all tested by us biscuits differ from those reported in the literature. These differences are probably due to the different types of raw materials with different characteristics, which are used in preparing the biscuits.

Sulieman *et al.*, [2], have studied the reducing and total sugars in biscuit made from wheat flour and found that their values were 1.95% and 20.45% respectively. Upon addition of soy flour in the recipe of the biscuits, the content of reducing and total sugars has increased.

Biesiekierski *et al.*, [24], have determined the content of fructans, galactooligo saccharides and other carbohydrates with short chains in processed cereal products and products derived from them. Various types of biscuits were studied and have found that the greatest amount of fructans they have in biscuits, in which the rye (4.60 g/100 g) was added to the recipe.

3.2.5 Total dietary fibre (TDF)

The most popular and consumed foods whose composition is enriched with dietary fibers are cereal and bakery products: wholemeal bread, biscuits, and products similar to them [25]. The enrichment of products with nutrition fibers resulted in that to be included in the group of products with functional characteristics.

The addition of inulin and Fibregum in the composition of the biscuits "Fructi" leads to an increase in the content of soluble and insoluble fibers in the biscuits "Fructi + Inulin" and "Fructi + Fibregum" (Figure 3). In biscuits "Fructi" content of soluble and insoluble fibers and general fibers is less (3.10%, 7.06% 10.16% respectively). Biscuits "Fructi + Inulin" contained 13.04% total nutrition fibers, of which 3.37% is soluble, and 9.67% - insoluble. In biscuits "Fructi + Fibregum" the contents of the common fibers is 11.07%, with 3.53% of them soluble, and 7.54% are insoluble.

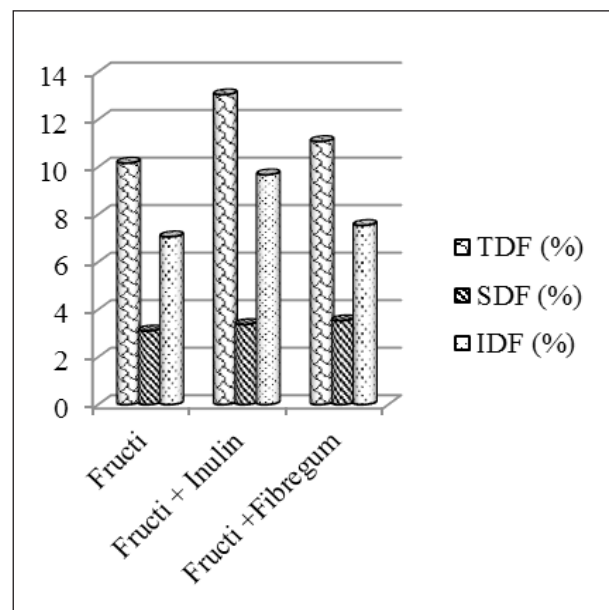


Figure 3. Total dietary fiber (TDF), Soluble dietary fiber (SDF) and Insoluble dietary fiber (IDF) in functional biscuits

The fact that the addition of inulin in the flour for the biscuits leads to increase in the content of the nutrition fibers in the final product was found by Maghaydah *et al.*, [16]. In the cookies prepared from gluten-free flour, to which inulin was added it was found that with increasing the amount of inulin the amount of nutrition fibers is increasing also. The “controlled biscuits” in which inulin wasn’t added, are with 3.86% nutrition fibers. In biscuits with 3% added inulin content of the dietary fiber is 11.77%. Upon addition of 3.5% inulin amount of dietary fiber in the biscuits increased to 12.89%. Upon addition of 4% inulin, dietary fibers in the biscuits are 13.11% and upon addition of 4.5% inulin the content of the dietary fiber in cookies reaches 14.96%.

The content of nutrition fibers in the biscuits depends on the raw materials added in the recipe composition. This is confirmed by several of other literary sources. According to Jothi *et al.*, [26], the amount of nutrition fibers is increased by reducing the amount of gluten in the flour. Passos *et al.*, [27], have been studied the content of nutrition fibers (soluble and insoluble) in different types of biscuits. They found that the content of total nutrition fibers is in the range of 0.99 g/100 g up to 4.00 g/100 g. The amount of soluble nutrition fibers ranged from 0.09 g/100 g up to 1.32 g/100 g, and the amount of insoluble fibers is in the range of 0.58 g/100 g up to 1.54g/100 g. Bunde *et al.*, [18], prepared 2 types of biscuits - one with white wheat flour and the other with mixture of 70% white wheat flour, 20% soy bean flour and 10% of rice flour. When researching the content of nutrition fibers in the biscuits, they have found that in the first type of biscuits, it was 0.18%, whereas in the second type of biscuits it was 1.90%.

3.3 *In vivo* determination of glucose in blood

The insulin is the basic hormone which regulates the entry of glucose from the blood in a large number of body cells (except in the central nervous system). Normal levels of sugars in the blood are 3.6 - 6.1 mmol/L. This concentration is increased up to 6.6 - 7.7 mmol/L, after one hour from the ingestion of carbohydrates. From the feedback system we know that the concentration of glucose very quickly restores control levels. This occurs after about two hours from the final absorption of the carbohydrates. Without insulin glucose can’t enter the cells, and this leads to an increase in the concentration of glucose in the blood, i.e. the organism reaches the state of hyperglycemia. According to the definition, diabetes is a condition where the amount of sugars in the blood is greater than 7.0 mmol/L (126 mg/dL) [28].

On Figures 4, 5 and 6 are shown the average values of the level of blood glucose after consuming 100 g biscuits from healthy people, people with type 1 diabetes,

and people with type 2 diabetes. The obtained results are compared with the control sample which is 100 g wheat bread.

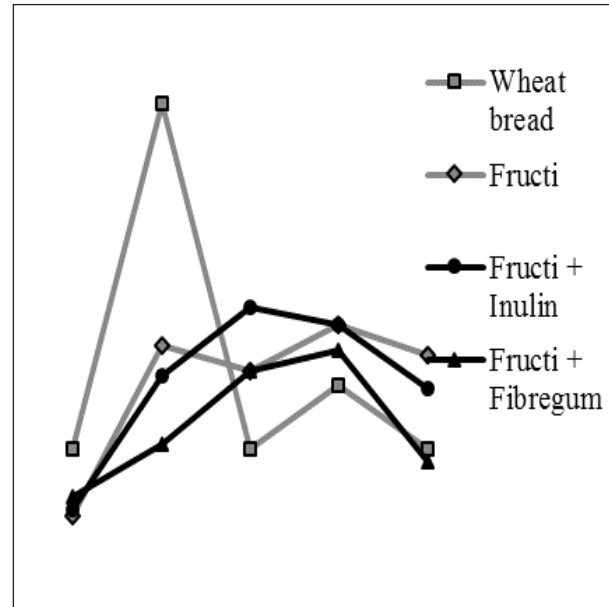


Figure 4. Level of glucose in the blood of healthy people after the consumption of 100 g biscuits

From the results presented in Figures 4, 5 and 6 it can be seen that after the consumption of the biscuits from healthy people the amount of glucose is increased, but not as much as after the consumption of the controlled sample. After 120 min. from the consumption of biscuits from healthy people, the lowest level of glucose in blood was reported for the biscuits “Fricti + Fibregum”.

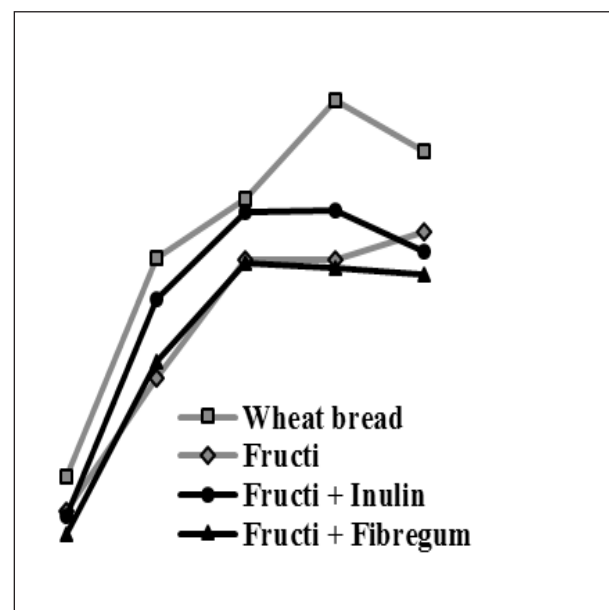


Figure 5. Level of glucose in blood of people with type 1 diabetes after the consumption of 100 g biscuits

Upon consumption of the biscuits from people with type 1 diabetes (Figure 5) the amount of glucose in the blood increases. The smallest rate of increase was measured after eating biscuits "Fructi + Fibregum".

With people with type 2 diabetes (Figure 6), after consumption of the biscuits "Fructi + Fibregum", the amount of glucose in the blood, both before and after 120 min of acceptance remains unchanged. The other two types of biscuits increased level of glucose in the blood.

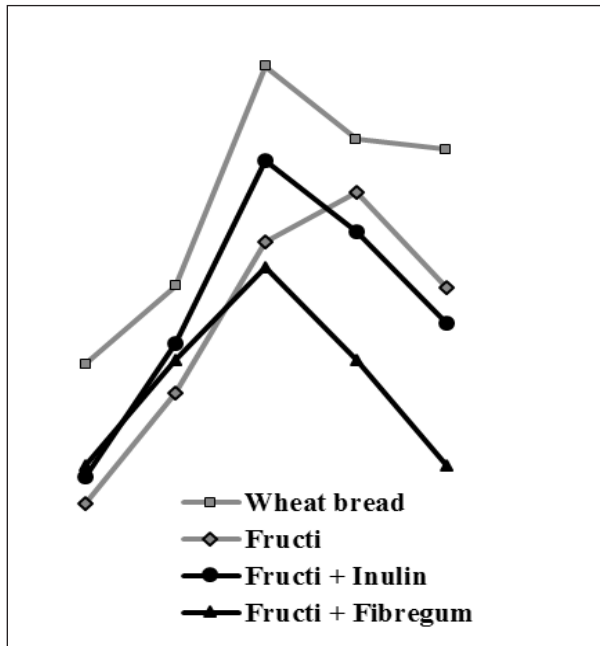


Figure. 6 Level of glucose in blood of people with type 2 diabetes after the consumption of 100g biscuits

4. Conclusions

- As a result of the experiments we found that the addition of inulin and Fibregum to the recipe of the biscuits is increasing: moisture content, proteins, fats, reducing sugars, total sugars and fructans after inversion, as well as the total nutrition fibers. As a result of the added inulin and Fibregum in the biscuits the ash content reduces.

- We have determined that after consumption of all three types of biscuits, the level of glucose in the blood increases, relative to the initial (on an empty stomach). The best results for all groups of people (healthy, with type 1 diabetes and type 2 diabetes) have been obtained through consumption of the biscuits "Fructi + Fibregum".

- The best results for people with type 2 diabetes show cookies "Fructi + Fibregum". The reason for this is probably due to the function of the islets of Langerhans, which synthesize the hormone insulin. They regulate the level of glucose in the blood, but in people with

type 1 diabetes are completely destroyed, while in people with type 2 diabetes Langerhans islets have diminished ability to synthesize insulin.

5. References

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