

**Bondarenko Yu.,
Bilyk O.,
Bondar V.,
Lukyanenko K.**

RESEARCH ON INFLUENCE OF INULIN MADE FROM CHICORY ON THE QUALITY OF WHEAT BREAD

Об'єктом дослідження у роботі є пшеничний хліб. Одним з найбільших недоліків хімічного складу пшеничного хлібу є те, що при великому вмісті вуглеводів в ньому низький вміст харчових волокон. Вирішення проблеми збагачення пшеничного хліба розчинними харчовими волокнами можливе завдяки використанню інуліну. Найкращим джерелом інуліну є цикорій коренеплідний. Обмежувальним фактором використання розчинних продуктів переробки цикорію є надання виробам забарвлення та притаманної йому гірчинки. Тому доцільно використовувати в технології хлібобулочних виробів для надання їм оздоровчих та профілактичних властивостей безпосередньо інуліну, виділеного з цикорію.

Під час досліджень використовували інулін з цикорію «Cosucra» (Бельгія). Ця сировина має вигляд білого порошку, ледь солодкуватого на смак.

Встановлено, що включення інуліну з цикорію в рецептуру пшеничного тіста активізує бродильну активність мікрофлори тіста, сприяє скороченню тривалості вистоювання тістових заготовок. Внесення інуліну покращує органолептичні та фізико-хімічні показники готових виробів та подовжує збереження ними свіжості.

Отримані результати пов'язані з покращанням живлення дріжджової мікрофлори тіста за рахунок вмісту цукрів в порошку інуліну з цикорію. Інтенсивніше забарвлення скоринки виробів є наслідком того, що фруктоза активніше вступає в реакцію меланоїдиноутворення. Уповільнення черствіння виробів з інуліном, очевидно, пов'язано з покращанням пружно-еластичних властивостей м'якушки виробу та уповільненням в ній ретроградації крохмалю за рахунок вищих гідрофільних властивостей інуліну.

Завдяки дозуванню інуліну з цикорію в кількості 2 та 4 % до маси борошна в добовій нормі споживання хліба забезпечується вміст інуліну 27–54 % від його добової норми вживання. Це дозволяє надати пшеничному хлібові функціональних властивостей внаслідок збагачення розчинними харчовими волокнами. Впровадження у виробництво хліба з інуліном з цикорію сприятиме розширенню асортименту виробів з оздоровчими властивостями.

Ключові слова: хліб пшеничний, інулін з цикорію, активність мікрофлори тіста, свіжість хліба.

1. Introduction

In modern conditions, one of the most common diseases in the world is diabetes and obesity. According to the Ministry of Health in Ukraine, over 1 million people suffer from diabetes. Therefore, the important task of socio-economic development of Ukraine is provision of diabetics with special dietary supplements for food. The assortment of food products, in particular diabetic products produced in Ukraine, is very limited and requires expansion, improvement of organoleptic properties of products, enhancement of their food and biological value.

Today, the use of dietary fiber in such products is topical, since they have a wide range of effects on the human body.

Inulin is soluble dietary fiber, which are growth stimulants and energy substrates for bifidobacteria, which, in turn, suppresses the growth of a number of harmful strains of microorganisms. This improves the functioning of the lower intestine, as a result of which the level of toxic metabolites decreases, the uptake of minerals increases, the metabolism of carbohydrates and fats normalizes. Inulin improves glucose metabolism at the cell level, due to which it has a positive effect on its level in the blood, improves glucose tolerance and increases insulin sensi-

tivity. The best source of inulin is chicory root. In soluble products of processing of chicory, inulin is retained in a significant amount, but the limiting factor in their use is the provision of products with color and inherent bitterness. Therefore, it is important to use in the technology of bakery products to give them health and preventive properties directly inulin, isolated from chicory.

2. The object of research and its technological audit

The object of research in the work is wheat bread from first-class flour and inulin made from chicory. Wheat bread by chemical composition is not balanced enough for vital ingredients. With a high content of carbohydrates in it there are few dietary fibers, unsaturated fatty acids, a number of vitamins and minerals, the protein content is not optimal, which, moreover, are not balanced by amino acid composition. To increase the usefulness of bakery products, the enhancement of health-improving properties is advisable to introduce into their recipes raw materials containing physiologically functional ingredients.

Inulin made from in chicory «Cosucra» (Belgium) was used. Inulin made from chicory is a soluble dietary fiber, extracted from the roots of chicory. Inulin is a natural

polysaccharide consisting of D-fructose residues (up to 96 %), interconnected by a β -2-1-glycosidic linkage. Inulin is a low-calorie (1.3 kcal/g) prebiotic fiber, a bifid stimulator in the intestine. This raw material is a kind of white powder, a little sweet to the taste.

The chemical composition of inulin made from chicory is given in Table 1.

Table 1
Chemical composition of inulin made from chicory

Indicator	Content
Dry substances (SR), %	96.3
Ash, % to SR	0.06
Carbohydrates, % to SR	99.9
Content of free sugars, % to SR	7.6
Inulin, % to SR	92.3

Taking into account the chemical composition of inulin made from chicory, it can be argued that it is an effective source of soluble dietary fiber (inulin). However, perhaps a drawback of its use in bread technology is its partial loss during the manufacturing process. This must be taken into account in the calculation of the chemical composition of wheat bread enriched with inulin made from chicory.

3. The aim and objectives of research

The aim of research is determination of the influence of inulin made from chicory on the quality of wheat bread from the first grade flour in case of its application to enrich the products with soluble dietary fiber to provide them with health and preventive properties.

To achieve the aim it is necessary:

1. To determine the influence of inulin made from chicory on the parameters of the technological process and the quality of the finished products.
2. To investigate the effect of inulin made from chicory on the activity of fermentation microflora.
3. To investigate the influence of inulin made from chicory on the preservation of freshness products.

4. Research of existing solutions of the problem

In Ukraine, bread is one of the main food products, covers more than 30 % of the body's calorie needs. However, baked goods from wheat flour have a low content of dietary fiber.

To improve the quality, nutritional value and provide prebiotic and dietary properties to bakery products, the products of processing of chicory root crops – chicory powder, chicory paste-like, powdery and instant are used [1–3].

Chicory and its products are an effective source of inulin.

Inulin is a natural polysaccharide consisting of the residues of D-fructofuranose, connected by β -2-1 bonds and ending with the α -D-glucopyranose residue. Inulin molecules due to β -bonds do not cleave α -glucosidase of the intestine, and therefore they are not digested and reach the large intestine where they are utilized by microorganisms [4], contributing to an increase in the number of lactic acid bacteria and a decrease in the number of coliform microorganisms [5, 6]. Inulin affects the biologi-

cal assimilability of calcium and magnesium, to lower the level of cholesterol and lipids in the blood serum.

Products of chicory processing include in the formulation of bakery products to give them health and preventive properties. The authors of the paper [7] note that the chicory powder can be added to the bakery recipe to 5 % of the flour mass, since the greater the dosage will give a bitter taste to baked goods, due to the content of bitter substances – sesquiterpene lactones – in chicory.

In work [8] it is noted that the introduction of products made from chicory in the bakery products favorably affects the process of the grease, increases the stability and elasticity of the dough and regulates the absorption of water.

Studies [9, 10] have shown the promise of using flour from chicory, as a source of inulin, in the technology of gluten-free bread. It is noted that the addition of chicory flour allows not only to improve the functional properties of the product, but also to prolong its freshness.

The authors of [11] determine the optimal dosages and prove the possibility of using in the production of functional bakery products powder from chicory, chicory soluble and instant. Their positive effect on the activity of the fermentation dough microflora is established. However, both in this work and in previous ones it is noted that the restrictive factor of using such products from chicory is giving the products a bitter taste. Therefore, it is promising to use directly inulin preparation isolated from chicory to enrich bakery products with soluble dietary fiber.

5. Methods of research

Laboratory tests were carried out to study the parameters of the technological process, biochemical, physical and chemical changes in the dough and the quality indicators of the bread. The dough was kneaded in a kneading machine Esher (Italy) for 4 minutes at the first speed and 7 minutes for the second. The dough was prepared in a free-form way with a mass fraction of the dough moisture – 41 %. During the fermentation period, dough kneaded was conducted 60 and 120 minutes after mixing. The dough was handled manually, the dough billets were tested in a cabinet at a temperature of 38 ± 2 °C and a relative humidity of 78 ± 2 % until ready. The products were baked in a cabinet oven at a temperature of 220...240 °C with humidification of the baking chamber.

The capacity of the semi-finished products was determined on the AG-1M instrument (Russia) [12]. The gas-holding ability of the dough was characterized by the specific volume of the dough after 4:00 of its fermentation: samples of a 100 g of dough were placed in a 500 cm³ cylinder, and the fermentals were compacted at a temperature of 30 °C.

The yeast fermentation activity was determined by the method of the yeast lift [13] after its dipping. The operation was repeated twice.

The quality of bread was assessed by the physicochemical (specific volume, shape stability, structural and mechanical properties of the crumb) and organoleptic characteristics (appearance, crustal surface condition, porosity structure, taste, odor). The duration of preservation of freshness products was investigated with a change in the structural and mechanical properties of the crumb. Its general deformation was determined after 48 hours of storage per penetrometer AP 4/1 (Germany) [12]. The degree of bread staling was also investigated for crumbling bread crumbs.

The results of the experimental studies were subjected to statistical processing, realized with the help of standard Microsoft Office software packages.

6. Research results

To establish the technological effectiveness of using inulin made from chicory in the production of bakery products, studies were conducted to determine its effect on the technological process and the quality of products.

During the research, they baked products with inulin in amounts of 2 and 4 % to the weight of flour. Products without inulin served as a control.

The analysis of the obtained data (Table 2) shows that the application of inulin slightly affects the titrated acidity of the dough. The dough with inulin to the touch was more elastic, more pleasant to the touch and less viscous in comparison with the samples of the dough with the appropriate dosage of chicory.

Table 2
Effect of inulin made from chicory on the quality of dough and finished products

Indicator	Control	Inulin is introduced from chicory (by dry matter)% to the mass of flour	
		2	4
Dough			
Humidity, %	41.0	41.3	41.1
Fermentation duration, min	170		
Acidity, degree			
primary	2.0	1.9	2.0
final	2.5	2.5	2.6
Proofing duration, min	52	40	46
Specific dough volume, cm ³ /g	2.1	2.4	2.4
Gas formation in the dough during fermentation and proofing, cm ³ /100 g of dough	980	1025	1038
Finished goods			
Specific volume, cm ³ /g	2.8	3.2	3.0
Formability, H/D	0.38	0.44	0.42
Porosity, %	72	74	74
Acidity, degree	1.8	2.1	2.1
Surface condition	Smooth without cracks and destructions		
Crust color	Light colored	Golden yellow	
Crumb color	Light colored		
Porosity structure	Uniform, medium, thin-walled		
Flavor and aroma	Natural wheat bread		

Duration of the dough proofing made with inulin was less by 6–12 minutes than the control sample. It can be assumed that this is due to the improvement in yeast nutrition due to the content of sugars in the powder of inulin made from chicory.

There was also a greater release of carbon dioxide during the fermentation of dough samples made with inulin as compared to the control, as a result of activation of the fermentation microflora of the dough.

To confirm this, the influence of inulin made from chicory on the vital activity of the yeast microflora of the dough was determined. The results of the studies are given in Table 3.

Table 3

The speed of dough lifting with inulin made from chicory, min

Indicator	Control	Inulin dosage, % by weight of flour	
		2	4
First lifting	95	79	79
Second lifting	37	41	42
Third lifting	30	28	25
Total	162	148	146

It is proved that the application of inulin reduces the dough duration as compared to the control by 9 %.

An increase in the gas-holding capacity of semi-finished products with an increase in inulin dosage was also noted (Fig. 1). This is probably due to the increase in the viscosity of the dough and the strengthening of gluten.

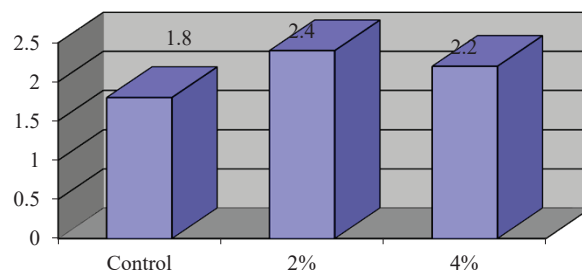


Fig. 1. Specific volume of the dough

Research results establish that the use of inulin makes it possible to obtain finished products of appropriate quality. Thus, according to the organoleptic characteristics of the product, with inulin, the color of the crust was somewhat more intense. It is obviously, this is a consequence of the fact that fructose is more active in reacting with melanoidin. It was also found that the products of inulin had a pleasant, more pronounced taste and aroma than control.

The specific volume of products with inulin was greater than that of the control sample by 14 %. This can be explained by the fact that the introduction of inulin into the dough improves its elasticity and allows obtaining a larger volume of finished products.

Thus, the results of the conducted studies prove the effectiveness of using inulin for the enrichment of bakery products with dietary fibers.

In bread baking technology, inulin, as raw materials, not only affects the organoleptic properties of products, but affects the preservation of freshness.

Inulin slows the retrogradation of crumb starch and increases its hydrophilic properties, which allows to keep the freshness of the products within 16–24 hours.

The analysis of the products was carried out 4, 24, 48 hours after baking, as it is during this storage period that the main changes in the structure of biopolymers of bread take place.

It is established (Table 4) that the total deformation of the crumb of products made from inulin is higher than in the control.

Table 4
Changes in the structural and mechanical properties
of the bread crumb with inulin

Indicators	Control (with- out additives)	Inulin dosage, % by weight of flour	
		2	4
Deformation of crumb, units device 4 hours:			
total	70	75	73
24 hours:			
total	48	45	51
Degree of freshness preservation, %	67	69	74
48 hours:			
total	25	23	28
Degree of freshness preservation, %	49	53	55

During storage, the structural and mechanical properties of the crumb with inulin decreased more slowly than in the control. Thus, after 24 and 48 hours of storage, the total deformation in the control sample decreased by 30 and 48 %, respectively, whereas the samples with inulin – by 26–28 and 43–45 %, respectively.

The slowdown of staling of products from inulin is evidently due to the improvement of the elastic-elastic properties of the crumb of the product and the retardation of starch retardation in it to a greater extent than to the crumb of the control sample, due to the higher hydrophilic properties of inulin. The higher hydrophilic properties of inulin are due to the presence in its composition of fructose, which is hygroscopic than glucose, although they have the same number of hydroxyl groups.

During staling, the pore walls of the crumb of the product lose their strength, which is accompanied by an increase in the crumbling of the crumb. Therefore, the effect of addition of inulin on the crumbling of the crumb was investigated.

Research results (Fig. 2) show that the value of crumbling of crumb is less in bread with inulin than in the control sample.

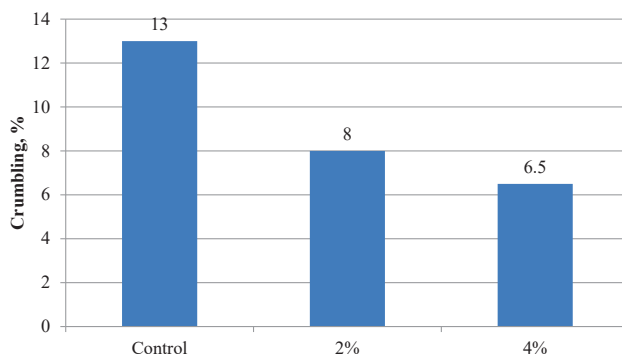


Fig. 2. Crumbling of crumb of products with inulin

Thus, the use of inulin made from chicory contributes to the improvement of the volume of finished products and the lengthening of their implementation.

In the case of inulin dosing from chicory 2 and 4 % to the weight of flour, the daily norm of consumption of such bread (277 g) contains 2.7–5.4 g of inulin, which is

27–54 % of the daily norm of inulin consumption (10 g), that is, the product also acquires functional properties.

7. SWOT analysis of research results

Strengths. It is found that the addition of inulin made from chicory promotes an increase in the volume of wheat bread, its organoleptic characteristics and the prolongation of freshness of products.

Inclusion of inulin made from chicory in the formula of wheat bread from flour of the first grade in an amount of 2 and 4 % to the mass of products gives the products functional properties. This is due to the enrichment of finished products with soluble dietary fiber, contributes to the formation of health and preventive properties of products, taking into account the influence of inulin, which will come with bread, to improve the organism's tolerance to glucose and lower cholesterol levels in the blood.

Weaknesses. Inclusion of inulin made from chicory in the formula of wheat bread from the first grade flour will cause an increase in the cost of products.

Opportunities. Analysis of the research results indicates the effectiveness of using inulin made from chicory in the formula of wheat bread and the expediency of further studies on:

- development of new bakery products with functional properties and increased food value;
- in-depth study of the influence of inulin made from chicory on the formation of structural and mechanical properties of semi-finished products;
- influence of inulin made from chicory on the digestibility of products in in vitro conditions;
- mold development of products during storage.

In the case of the introduction of new bread with inulin made from chicory in bakery enterprises, it will help to expand the range of products with health-improving properties, both for patients with diabetes and obesity, and for a wide range of consumers.

Threats. Taking into account that Belgium is the largest producer and supplier of quality inulin made from chicory, the main factors affecting the stability of inulin products manufacturing can be fluctuations in the price of raw materials and the timeliness of inulin supply.

8. Conclusions

1. As a result of the conducted studies it is found that the dosage of inulin made from chicory in an amount of 2 and 4 % to the weight of flour provides in daily bread consumption the inulin content of 27–54 % of its daily consumption rate. This gives the product health and preventive properties, due to the enrichment of soluble dietary fiber. It is also established that the addition of inulin made from chicory contributes to a reduction in the duration of the proofing of dough billets and the improvement of the organoleptic and physicochemical parameters of the finished bread.

2. It is noted that the addition of inulin improves the fermenting activity of the microflora of the dough, as indicated by a 4.5–6.0 % increase in the amount of carbon dioxide released and less by 19 minutes the lift strength of the dough.

3. It is proved that, as a result of the introduction of inulin made from chicory, the freshness of the products is

prolonged, as evidenced by a decrease in the crumbling of the crumb and a slowing of the changes in the structural and mechanical properties of the crumb during storage.

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Bondarenko Yulia, PhD, Associate Professor, Department of Bakery and Confectionary Goods Technology, National University of Food Technologies, Kyiv, Ukraine, e-mail: bjuly@ukr.net, ORCID: <http://orcid.org/0000-0002-3781-5604>

Bilyk Olena, PhD, Associate Professor, Department of Bakery and Confectionary Goods Technology, National University of Food Technologies, Kyiv, Ukraine, e-mail: bilyklena@gmail.com, ORCID: <http://orcid.org/0000-0003-3606-1254>

Bondar Volodymyr, PhD, Associate Professor, Department of Thermal Power and Refrigeration Engineering, National University of Food Technologies, Kyiv, Ukraine, e-mail: ivanovish976@gmail.com, ORCID: <http://orcid.org/0000-0002-8106-4174>

Lukyanenko Kateryna, Department of Bakery and Confectionary Goods Technology, National University of Food Technologies, Kyiv, Ukraine, e-mail: katya240219@icloud.com, ORCID: <https://orcid.org/0000-0002-8522-2846>