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# *Analysis of Contemporary Trends in Production of Sugar Products from Non-Traditional Raw Materials and Their Practical Use*

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*Abstract* — **All over the world, the requirement for sugary products is mainly satisfied by sugar products made from sugar beet, cane raw sugar or glucose syrup. Most of the current technologies of producing syrup, glucose, glucose-fructose syrups are based on the starch processing of different origins. For bakery industry, an urgent issue is to find out new types of sugar-containing raw materials, which requires the necessary technological properties and various chemical compositions. On the one hand, the technologies will allow one to improve the bread-making process; they will help to minimize the cost of raw materials, enrich the quality and nutritional value of the finished product. The article contains the analysis of literature data on the production of sugar-containing products from various unusual raw materials for this industry. A newly developed, enzymatic sugar-containing product of oats hydrolysis "Sakharok" influences positively the activation of pressed baking yeast. The product improves physiological state, the intensification of fermentation processes of leaven while making the leaved and not leaved dough. It should be noted that the amount of yeast recipe reduced by 60% under the straight dough procedure, and by 40% - under the sponge dough preparation. It also helps to minimize the duration of the technological cycle of bread production by 14.20%. Its output increased by 163% and the nutritional value grew at the same time.**

***Keywords — sugary products, cereals, processing technologies, product of enzymatic conversion of oats, activation of pressed bakery yeast.***

## I. INTRODUCTION

An inadequate situation in the food, ecological and socio-economic spheres in Russia requires the creation of new-generation food products, which will help to reduce the negative impact on the human body. The development of modern food production technologies is closely connected with the product-line expansion. It becomes possible because of processing of non-traditional raw materials, development of specialized, functional products, and transferring from artificial food additives to natural ones, which possess biological activity.

The modern strategy of creating healthy food products is in using food raw materials with known composition and properties. These products will guarantee full-scale supply of main and biologically active substances in the required combination, including from secondary products of processing of plant and animal raw materials. The attempts to find out new types of sources of ecologically harmless raw materials, which have high technological

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characteristics, and obtain preventive properties, are made in various directions [1]. One of them presupposes the use of natural, mainly vegetable sources of raw materials, containing, along with essential nutrients, other physiologically valuable minor and biologically active substances. Another way is the improvement of traditional and the development of new production technologies and food formulation of a given chemical composition. It means creating recipes, enriched with biologically active components, which allow one to improve nutritional status correctly.

Present technologies of getting sugar-containing products are connected with the separation of starch. Then goes its hydrolysis with the help of catalysts - acids, enzymes and acid-enzymatically. No matter of the type of catalyst, the process of conversion is conventionally divided into three stages: gelatinization, liquefaction and conversion of polysaccharides. Practically all the time, the stage of gelatinization is combined with liquefaction. It means that the starch grains disintegrate under the influence of the catalyst. As a result of gelatinization, long molecules chains forming starch, go into a high viscosity paste; break into shorter ones, which leads to a decrease in viscosity several thousand times. In a liquefied substratum with low viscosity, further processes of splitting high molecular polysaccharides, up to the formation of the simplest sugars goes easier.

The use of acid hydrolysis has a number of disadvantages - impurity of hydrolysates by products of reversion and thermal decomposition of carbohydrates, problems of complete conversion of polysaccharides what leads to a decrease in glucose yield, high costs and expensive equipment.

Until 1960, all kinds of sugar-containing products, including food glucose, were obtained by acid conversion [2]. In 1959, the enzymatic method of conversion was first used in Japan. By the end of 1960, the whole industry of this country, which based on producing sugar-containing goods, was transferred to enzymatic conversion [3].

Nowadays, glucose-fructose syrups are wide spread all over the world. They are produced by conversion with further isomerization of glucose into fructose with the help of the enzyme preparation with glucose isomerase [4].

Nowadays, the widespread use of glucose-fructose syrups, got from starch-bearing raw materials, has been practiced in the following countries: the US, Japan, Canada, South Korea, Argentina, Hungary, China, Indonesia [5].

High-conversion glucose syrup got by the enzymatic method has numerous of advantages over syrup, produced by acid hydrolysis. Molasses is not used very often with a glucose equivalent to 60% or higher. This happens because of the significant content of dextrins, the amount of such sugars as genobiosis, isomaltose, panose, which are not fermented by yeast, as well as high color and bitter taste. All of the above-mentioned makes its using in bakery difficult. More than that, during the keeping, molasses is tending to crystallization.

The first attempts of the research a method to get molasses with a high content of fermentable sugars and low crystallization ability were held in Japan and the United States. They presupposed starch liquefaction with the help of α-amylase or acid and conversion of polysaccharides with a complex of enzymes, providing the production of molasses with a given carbohydrate composition. For conversion of polysaccharides scientists used fungal amylase, bacterial β-amylase, glucoamylase in combination with malt enzymes. At that, they received sugar-containing products with a glucose equivalent by 58-71%, a content of maltose by 44-61%, and fermentable carbohydrates by 60-80% [6].

In the process of production glucose-fructose syrup, the suspension of purified corn starch is liquefied with an enzyme preparation of bacterial α-amylase. It is saccharified with glucoamylase to get a hydrolyzate with a content of reducing sugars by 97-98%. The obtained hydrolyzate is purified from the fat-proteinaceous suspension. Then, dye wares are removed by activated carbon with further cleaning and demineralize the syrups on the ion exchange resins. The syrup is boiled under vacuum to a concentration by 40-50%, after which it is sent to isomerization with the help of using preparations of immobilized glucose isomerase [7].

There is a method of producing molasses with a high content of maltose (by 90%) by conversion with β-amylase and amylase obtained from Streptomyces [8].

The technology of transformation starch to sugar-containing products requires high purity of starch. With the evolution and purification of starch, we can't avoid losses of a significant amount of valuable, in the food aspect, components of plant raw material. At that, the huge amount of material and energy costs is inevitable. As the consequences of all above, the attention of researchers has recently been focused on the development of enzymatic methods of conversion by processing whole plant raw materials excluding the stages of preliminary starch isolation [9, 10].

We know a method of getting glucose syrup by crushing rice, soaking it in an aqueous solution of sulfur dioxide, and washing it with water in order to remove the dissolved components. Then, the α-amylase enzyme preparation is processed to dilute the starch, followed by the conversion of polysaccharides with glucoamylase at pH of 5.0-6.0 and the duration of hydrolysis necessary to obtain a certain amount of glucose content in the product [11].

It is necessary to pay special interest to the technology of processing flour from whole grain cereals. It presupposes several stages: production of a water-flour suspension with solids content by 30-50% and a pH of 5.0-7.0. Another aspect is carrying out of hydrolysis by enzyme preparations, which choice and conditions are determined by the properties and composition of the raw materials and the specified composition of the final product. The process of gelatinization and liquefaction of starch is carried out with the help of a heat resisting enzyme preparation of α-amylase from Termamyl-120. It happens after heating the suspension by direct injection of steam under intensive mixing. The hydrolyzate, received at the end of the process, contains a lot of maltose and maltotriose (Dp3). After inactivation, the enzyme can be used in bakery. It is possible to separate the insoluble fraction consisting mainly of protein and fiber [12].

There is another way of getting sugar-containing syrup directly from starch-bearing raw materials. Flour is suspended with water at a ratio of 1: 2. It is exposed to α-thermomil of bacterial origin to reduce viscosity for 1 hour at 50°C. After that the suspension is gelatinized and liquefied with α-amylase preparation at 95°C for 1 hour. Then the mixture is separated into a liquid and a solid phase in a centrifuge at 95°C. The solid phase is dried and processed into high protein flour. The glucoamylase preparation is injected into the liquid phase and hydrolysis is carried out with adding sulfuric acid at pH of 4.5, temperature of 60 °C for 40-47 hours. At the end of the conversion of polysaccharides, the glucose equivalent becomes 90%. The effect on the hydrolyzate made by the preparation of glucose isomerase leads to getting glucose-fructose syrup [13].

The technology that presupposes direct conversion of containing fresh and dried manioc was developed. Pre-ground manioc was mixed with water. Then the solid phase was separated by centrifugation, what allowed removing some of the soluble protein and reducing the color of the finished product. After that, gelatinization was carried out at a temperature of 90-96 °C, dilution with α-amylase preparation and conversion of polysaccharides with glucoamylase. At the final stage, the solid phase was separated, and the syrup was purified by activated carbon [14].

There are technologies of getting fructose syrups from inulin-containing raw materials - Jerusalem artichoke, dahlia, chicory [14, 15, 16, 17].

The method of getting syrup from sugar sorghum is to be noted. It inclines temperature coagulation of nonsugars, gelatinization of starch and its enzymatic cleavage with amylolytic enzymes. It also means processing with activated carbon and a two-stage thickening of the juice with intermediate filtration [11, 19].

There is a research of getting high-conversion glucose hydrolysates from wheat flour. The degree of conversion of polysaccharides of starch reaches 85.5% [20, 21].

There is a method of getting a sugar-containing product from a grain of rye, ground to a meal. This method presupposes mixing flour with water in a ratio of 1: 3 to form slurry. Then liquefaction of the suspension, with the help of amylolytic and cytolytic enzymes of the flour, takes place. The suspension is heated up to 80°C at a rate of 1°C / min with 30-minute pauses at 40° C, 60°C, 70°C. At the end of the process, the product is warmed at a temperature of 120-125 ° C for 2-3 minutes [21]. Fermentolysis is carried out by a composition of enzyme preparations. They include: - cellulase with high xylonase activity in the amount of 0.5-0.7 units of cytological activity per 1 gram of flour.
- fungal α-amylase in the amount of 2-2.5 units of amylolytic activity.
- glucoamylase in the amount of 0.5-1.5 units of glucose-amylase per 1 gram of starch.

The process is carried out at a temperature of 55-57°C, a pH of 5.3-5.5 for 16-20 hours. After that, the hydrolyzate is heated up to 80°C to inactivate the enzymes.

There is a method of getting a sugar-containing product from a grain of rye, ground to a meal. This method presupposes mixing flour with water at a ratio of 1: 3 to form slurry. The suspension is liquefied with amylolytic enzymes of flour at a temperature of 56-65°C and a pH of 4.5-5.0 for 10-30 minutes. After that, hydrolysis of the liquefied suspension is carried out with the help of the enzyme to a predetermined content of reducing substances and enzyme inactivation [22]. For the hydrolysis, the enzyme glucoamylase is used in the amount of 4.0-7.0 units of glucoamylase activity per 1 gram of flour starch. The process lasts during 5-22 hours at a temperature of 56-65ºC.

There is a technology of getting sugar-containing butter from potatoes and sugar beets. It is carried out by means of enzymatic conversion with the help of an enzyme preparation AMG. The temperature of hydrolysis is 45°C, the concentration is 20%, pH 6.4, the dosage of the enzyme preparation is 0.03-0.05% of the weight of the raw material, the duration of conversion of polysaccharides is 3-4 hours [24, 25].

There is a method of getting hydrolyzate from the pulp of Jerusalem artichoke with a content of reducing substances by 42.75%. The bioconversion process is carried out using a composition of enzyme preparations: - Pectofoetidine P 10X at a dosage of 3.6 units per gram and - Cellobranin G 3X at a dosage of 2.9 units per gram at a temperature of 50°C for 6 hours. The use of this hydrolyzate in bakery promotes the intensification of gassing and acid accumulation in the dough, reducing the duration of its maturation up to 30-40 minutes, increasing the nutritional value and quality of the finished bread [26].

It is necessary to outline the method of producing a sugar-containing hydrolyzate from amaranth flour. They take water-flour suspension from amaranth flour and water in a ratio of 1: 2. Then it's added 0.25-0.35% of Amilosubtiline G 10 X from the weight of the starch in the flour. The suspension is heated rapidly to a temperature of 85-95 ° C and held for 15 minutes. After which the hydrolyzate is cooled to a temperature of 60 ° C and Glucoamamorin P 10 X is added at a rate of 180-220 units per gram of amaranth flour starch. The conversion of polysaccharides is held during 4 hours at 60 ° C. Also, it is possible to get the hydrolyzate from the amaranth seed meal, after deriving a protein-lipid complex from it [5].

There is a way of producing a sugar-containing paste from whole grain of oats. The whole grain of the oats is soaked in a 0.08 ml of citric acid solution (pH 3.0) at a temperature of 40°C during 60 minutes. Then, the grain is washed in drinking water at a temperature of 40°C for 10-15 minutes. Oats grain is stopped up with a solution of the enzyme preparation Celloviridin G 20 X. The irrigation module is up to 1:3 (the humidity of the suspension is 75%), the temperature is 50°C and the pH is 4.5-5.0. The mixture is aged for 60 minutes until the moisture content of the grain reaches 38-40%. At the end of enzymatic hydrolysis, the grain is washed in drinking water for 10-15 minutes.

Cereal hydrolyzate with humidity of 38-40% is crushed to a size of 280-420 μm at constant temperature of about 40-45°C. This temperature makes it possible to avoid physicochemical and biochemical processes, which lead to the decrease in nutritional value while grinding. The crushed hydrolyzate is poured with a solution of Ban 480 L. enzyme preparation. It is

important to keep the irrigation module up to 1:3 (humidity of the suspension is 75%), pH 5.0-6.0. Being stirred, the suspension is heated up to the temperature of 85-90°C during 60 minutes. At the end, the enzyme is inactivated by heating the liquefied mass to 110-115 °C during 10 minutes. After all, the mass is cooled up to 55-60ºC. A certain amount of the enzyme preparation "Sun Extra L" in the form of an aqueous solution is added to the liquefied mass. A certain amount of water is determined from the calculation of maintaining the humidity of the suspension of 75%. The suspension is kept at a temperature of 55-60°C during 180 minutes until the mass fraction of reducing sugars reaches 38.0% in terms of dry matter [8, 10].

Based on the analysis of literature reference, we can conclude that, in most of cases, the sugar-containing products are produced from isolated and purified starch of different cultures. To a lesser extent they are produced from whole grain and its flour. That's why, the existing technologies do not contribute to the production of high nutritional value products. More than that, they take a long period of time and some types of raw materials are inaccessible to the Russian manufacturer. Therefore, the actual task for today is to find new types of local starch-containing raw materials and develop technologies for the production of new sugar-containing products with high yield. From this point of view, grain of oats is of great interest.

One of the actual applications of sugar-containing products is the adaptive regulation of the biotechnological properties of bakery yeast. Bakery yeast is the main type of raw material for the production of bakery products.

For quick adaptation of yeast cells to flour prepack, it is reasonable to use liquid nutrient mixtures, carbon compounds, water, nitrogen, biogenic and oligobiogenic elements, vitamin and growth substances [26, 27, 28].

Biogenic elements, which are necessary for the life of yeast cells, include: potassium, sodium, magnesium, calcium, sulfur, phosphorus and iron. Potassium is involved in the formation of spores. It activates numerous yeast cell enzymes (kinase, dehydrogenase). It stimulates the fermentation of maltose and maltotriose. Potassium is closely connected with the growth of yeast and fermentation rate. Magnesium is involved in the construction of proteins, as well as sulfur and phosphorus. In addition, magnesium is necessary for the activation of phosphatases, enzymes involved in alcohol fermentation. Calcium stimulates the multiplication of cells; magnesium activates numerous enzymes (phosphokinase, decarboxylase) and stimulates fermentation of maltose [29].

Oligobiogenic elements, such as: zinc, copper, molybdenum, boron, manganese, nickel, silicon, aluminum, contribute to the growth of yeast cells. The intensity of alcoholic fermentation also depends on the presence of sulfates and phosphates. They are sources for the formation of phosphorus esters of glucose and the synthesis of ATP [29].

A special place in a chain of necessary elements belongs to carbon and nitrogen. These two elements should be present in each nutrient mixture in an easily digestible form.

The most easily carbon is absorbed from glucose. Some sugars, for example lactose, promote the growth of yeast cells. Good carbon-containing sources of nutrition are organic acids: acetic, citric and tartaric. They also include alcohols: ethanol, glycerin, manna sugar d, fats, proteins and their decay products: peptones and amino acids. Inorganic compounds can also be assimilated in the form of carbonates [30].

Nitrogen is an essential component of nutrition. It can be represented in a wide variety of forms of organic and inorganic compounds. Due to the fact that yeast practically does not induce peptidase and proteinase, the intake of nitrogen is necessary in an easily digestible form. Amino acids are sources of both nitrogen and carbon.

Vitamins are of great importance in the metabolism of yeast cells. Vitamin B1 (thiamine) is found in the form of a diphosphoric salt in the coenzyme of carboxylase. Vitamin B2 (riboflavin) is an integral part of the yellow enzyme. Vitamin B3 (pantothenic acid) is a part of coenzyme A. It is involved in carbohydrate metabolism. Vitamin B3 plays an important role in the release of energy from carbohydrates, proteins and fats, in the synthesis of fatty acids, acetylcholine. Vitamin B6 (pyridoxine) is one of the very important yeast cell biocatalysts. When it is in the enzymes, it catalyzes the conversion of amino acids. It behaves like phosphoric acid pyridoxal in the decarboxylation of amino acids. It was found that for the majority of yeast the presence of inositol, pantothenic acid and biotin is necessary. Less often, they require substances in combination with thiamine and pyridoxamine [30]. Stimulant for yeast is glutamic acid, especially in the presence of sugar in the medium. As a coenzyme, Biotin takes part in the carboxylation of pyruvate (pyruvic acid) and oxaloacetate (oxaloacetic), it also takes part in the deamination of some amino acids.

Yeast cells do not synthesize extracellular enzymes, which provide hydrolysis of organo-compounds. That is why nutrient mixtures should contain hydrolyzed high-molecular compounds. Preliminary aging of yeast cells in such environment creates favorable physicochemical conditions. In addition, it increases the activity of enzymes, accelerates and provides intracellular biochemical transformations.

A.G. Ginzburg developed a method of activating compressed yeast. It is based on the fact that the period of rearrangement of yeast cells from the respiratory to the fermentation type is carried out before they are added to the dough in a specially prepared nutrient medium. This, in turn, consists of welding a small amount of processed flour and soy flour. The processed flour is enriched with white barley malt. What concerns soy flour, it contains enzymes and nutrients necessary for yeast - amino acids, vitamins, etc. [31, 32]. The yeast's stoving in this mixture lasts from 1 up to 3 hours. It depends on the method of preparation of the dough. However, at the same time, dough fermentation property of yeast decreases from 14 minutes to 8. This method is effective, but it provides a significant consumption of flour for activation and use of scarce unfermented malt.

On the basis of this method, native researchers developed various modifications of the yeast activation methods. The most common method is the activation of yeast in tea brewing or batter [31, 32].

The composition of the nutrient mixture is significantly enriched with the use of high-sugared enzymatic hydrolysates [33, 34, 35, 36, 37]. For their production, wheat and corn flour or starch is used. It is separated during washing of gluten in the process of producing dietary varieties of bread - protein-wheat and protein-bran. It is considered, that the effectiveness of the use of such hydrolysates depends on the depth of hydrolysis of the substrate.

In the process of getting such hydrolysates, the enzymatic conversion of starch-containing raw materials is currently considered as one of the most promising directions, because it excludes the stage of starch isolation. As a substrate, starch-containing raw materials are significantly different from free starch. The amount of protein substances, fat and insoluble substances in the flour complicates the hydrolysis process. However, both corn and wheat flour contain organic phosphorus in the form of lecithin, phytin, vitamins of group B, biotin, vitamin E and other biologically active substances. They can be transferred to the final product and significantly increase its nutritional value.

There is a method of activation of yeast, which involves the preparation of a nutritional mixture of flour, water and enzymatic hydrolyzate.

To activate the pressed yeast, yeast cells and yeast cream, they use nutrient mixture consisting of powdered apple pomace and water. Pressed yeast is kept in a mixture containing 0.350-0.375% of powdered apple pomace and 8-10% of water to flour mass in the dough during 30-40 min. When it comes to yeast milk, it is kept in a mixture containing 0.300-0.325% of powdered apple pomace and 6.5 - 7.0% of water to flour weight in the dough during 20-30 min [38].

There is a method for activating yeast using a nutrient mixture in an amount of 0.009-0.01% of the weight of flour in the dough. It includes: kvass wort concentrate, soy flour, milky whey, water, mineral salts in the form of ammonium persulphate or ammonium sulfate with potassium bromate or ammonium phosphate with potassium bromate, KH2PO4, (0.015-0.030%), NH4Cl (0.025-0 , 04% to the mass of flour in the dough)). However, the control of kvass wort concentrate leads to a darkening of the crumb of white bread [39].

In Kuban State Technological University, a method of preliminary activation of compressed yeast was developed. The nutrient medium is prepared by mixing wheat flour, water and powder from lentil seeds. Lentils are ground in two stages. When it comes to the first stage, the lentil seeds are crushed, and to the second – they are subjected to fine grinding in a spirally rotating film 0.1-1.5 mm thick at a temperature of 30-35 ° C. In a similar way, yeast activation is performed using a powder of triticale grain instead of lentil flour [40].

One can't but pay attention to the method of increasing ferment ability of yeast. It is based on their pre-treatment in a nutritional mixture in which one of the biologically active ingredients is acorn flour. Its composition is represented by substances of (% mass): nitrogenous - 6.5 - and tannic - 11.4; lipids - 5,5; starch - 54.7; assimilable sugars - 10,4; cellulose - 2.5. One of the effective ways to activate yeast lies in keeping it in nutritional mixture during 30-40 minutes. The mixture should consist of: flour from acorns, amaranth flour, crushed wheat germ and milky whey. As a result, the maltase and zymase activity of the yeast increases. And it has absolutely a positive effect on yeast baking strength - before activation, it is 14-12 minutes, and after aging it becomes 7-6 minutes. The use of activated yeast increases the quality of finished products from bakery wheat flour of the first and higher grades by specific volume by 19%, porosity - by 8% [41].

Based on the analysis of literature, we can conclude that the by-products, unconventional raw materials and secondary products of the food industry are the main sources for improving the composition of nutrient mixtures for yeast activation. In this regard, we consider it to be relevant to conduct research on the use of oats, which takes place at activating baking yeast. It is available and contains all the nutrients that are needed to stimulate the biotechnological properties of yeast.

The aims of the study are: to identify the possibility and feasibility of using the enzymatic sugar-containing hydrolyzate of oats "Sakharok" to stimulate the biotechnological properties of bakery yeast.

According to the aims, the following **tasks** were solved:

- Studying the chemical composition of the enzymatic sugar-containing hydrolyzate of oats "Sakharok";
- Studying the effect of the enzymatic sugar-containing hydrolyzate "Sakharok" on the physiological state of yeast;
- Studying the effect of activated yeast on the intensity of fermentation processes in bakery semi-products.

## II. OBJECTS AND METHODS OF RESEARCH

Objects of the research are:

- Enzymatic sugar-containing hydrolyzate of oats "Sakharok".
- Laboratory samples of activated yeast with the use of hydrolyzate oats "Sakharok".
- Laboratory samples of the dough prepared with a different amount of activated yeast, products baked from it.
- Gluten of wheat dough.

Determination of the kinematic viscosity was carried out with the help of a capillary viscometer. The determination of the products of conversion and amine nitrogen in the hydrolyzate was carried out according to generally accepted procedures.

Yeast activation was carried out according to the GOSNIIHP procedure. The determination of the yeast and maltase activity of yeast was done with the help of a micro analyzer of gas volume IK. Yeletsky. Microscopy of the yeast was carried out with the MICMED-1 microscope (v. 2-20). The cells were counted by means of a counting chamber of Goriaev-Tom.

Counting and control of the intensity of gas formation, acidity of semi-finished products and the amount of gluten was carried out according to generally accepted methods. The time of kneading of the dough was fixed using a farinograph according to GOST R 51404-99. Structural and mechanical properties of the dough were analyzed on the instruments "Reotest-2" and "Structurometer ST-1M". The content of reduced glutathione was defined by the iodimetric determination.

Determination of bread quality indicators was set according to generally accepted methods. The duration of the baking was controlled by means of a thermocouple Digital Thermometer and Hygrometer BC-TW4. The estimation of aromatic substances in bread was given by the number of bisulfite-binding carbonyl compounds.

The amino acid and carbohydrate composition was analyzed by HPLC on an HPLC LC-2010A chromatograph. Analysis of the fatty acid composition was carried out by the gas chromatography method in accordance with GOST 30418-96, GOST R 51483-99 on the HP-6890 Series GC System. The determination of starch was carried out according to GOST 10845-98. The determination of fiber was carried out in accordance with GOST 13496.2-91. The determination of pectin substances was carried out according to GOST 29059-91. The determination of the total amount of hemicelluloses and β-glucan was done according to generally accepted procedures. The determination of ash content was studied in accordance with GOST 27494-87. The determination of the mass fraction of macro- and microelements was carried out according to GOST 51637-2000 by means of the atomic absorption spectrophotometry method using a spectrometer with flame atomization "Kvant-2A". The content of vitamins was determined according to GOST 50929-96, GOST 50928-96, GOST 29138-91, GOST 29139-91, GOST 29140-91 using spectrophotometry methods on a spectrometer with flame atomization "Quantum-2A" and high-performance liquid chromatography on an HPLC LC chromatograph -2010A.

The reliability of the experimental data was assessed using mathematical statistics methods, using the tools of MathCAD 13 and Excel 2007. Calculations and plotting were performed using the applications Microsoft Word and Excel for Windows 2007.

## III. Results and discussion

In order to create the scientific basis for using of a new product in bakery industry, we need comprehensive research to study its chemical composition, properties and influence on the course of the technological process, as well as the quality of the finished products. For this purpose, we carried out comparative analysis of the chemical composition of the enzymatic sugar-containing hydrolyzate of oats "Sakharok" and wheat flour of the first grade, as the main raw material of bakery production.

This product was obtained by enzymatic conversion of whole grain of oats in several stages. The key point of the technology is in the following – an oats grain was dispersed to a particle size of 280-420 μm after pretreatment using the enzyme preparation Celoviridin G 20 X. The ground hydrolyzate was treated with a complex of amylolytic enzyme preparations of diluting and conversion of polysaccharides action, such as Ban 480 L and San Extra L. In order to increase the activity and the stability of the enzymes, we added Ca salts as a stabilizer of the tertiary structure of the enzyme molecule. It has a positive effect on α-amylases, and Zn salts. Enzymatic hydrolysis was carried out under optimal conditions, which make it possible to obtain the product with the maximum amount of easily digestible carbohydrates and free amino acids.

As follows from the obtained experimental data, the sugar-containing hydrolyzate "Sakharok" repeatedly exceeds the wheat flour of the first grade by the content of the components. For example, amine nitrogen and easily digestible sugars, lipids exceed 3.8 times, in particular unsaturated fatty acids - 5.8 times, hemicellulose - 2.3 times, fiber - 46.0 times. It contains pectin and β-glucan absent in wheat flour of the first grade. Sugar-containing hydrolyzate "Sakharok" has rich mineral and vitamin composition. In comparison with wheat flour of the first grade, it has a high content of substances: potassium - 1.9 times, calcium - 3.2 times, magnesium - 2.7 times, phosphorus - 2.8 times, manganese - 4.6 times, biotin - 50 times, pantothenic acid - 2 times, choline - 1.4 times. And because of its rich chemical structure, it has a high nutritional value [6, 7].

The sum of essential amino acids and score in sugar-containing hydrolyzate "Sakharok" are 3.30% higher than in wheat flour of the first grade. However, the limiting amino acid in both the sugar-containing hydrolyzate "Sakharok" and in the wheat flour of the first grade is lysine. Since the amino acid score has minimal value, however, for the sugar-containing hydrolyzate "Sakharok", this amino acid is faster than wheat flour by 20.70%. This indicates that the quality of the protein and the balance of the amino acid composition of the sugar-containing hydrolyzate "Sakharok" are better than that of wheat of the first grade [14].

Sugar-containing hydrolyzate "Sakharok" has a higher content of nutrients. It is characterized by high biological value in comparison with wheat flour of the first grade. In connection with this, this product can be recommended in the baking industry as a nutrient mixture for activation of yeast, and also as an additive for functional purposes.

### *A. Research of the influence of sugar-containing hydrolyzate "Sakharok" on the activation of pressed baking yeast*

So, we determined the effect of the sugar-containing hydrolyzate "Sakharok" used for the activation of baking yeast. Physiological restructuring of the energy metabolism of pressed bakery yeast from the respiratory to the fermentation type is closely related to the morphological changes of the yeast cells. This relationship was used to determine the physiological state of yeast during the activation period. We made an analysis to determine the effect of sugar-containing hydrolyzate "Sakharok" on the change in indicators. For example: changing in enzymatic activity (zymase and maltase), changing in the yeast baking strength, changing in the appearance of the yeast cell, the number of budding, dead yeast cells and cells with glycogen.

As control, we used the method of activation of baked pressed yeast according to the GOSNIICH method proposed in the 50-60's of the 20th century by AG. Ginzburg [42]. In an

experimental sample, the yeast was activated in a nutrient mixture from the sugar-containing “Sakharok” hydrolyzate. It took 100 kg of flour and 5-7 kg of sugar-containing hydrolyzate "Sakharok" and mixed it with 12 liters of water. After that, the mixture was of 30-32°C. The activation lasts during 60 minutes.

TABLE 1. THE RESULTS OF THE STUDY.

| Indicator name | Control | Experimental sample |
|---|---|---|
| Zymaze activity, min | 44 | 31 |
| Maltase activity, min | 75 | 50 |
| dough fermentation property, min | 10 | 6 |
| Cells content in yeast, mln / g | 1450±5 | 1870±5 |
| including | | |
| dead | 58±5 | 47±5 |
| budding | 246±5 | 318±5 |
| cells with glycogen | 1193±5 | 1659±5 |

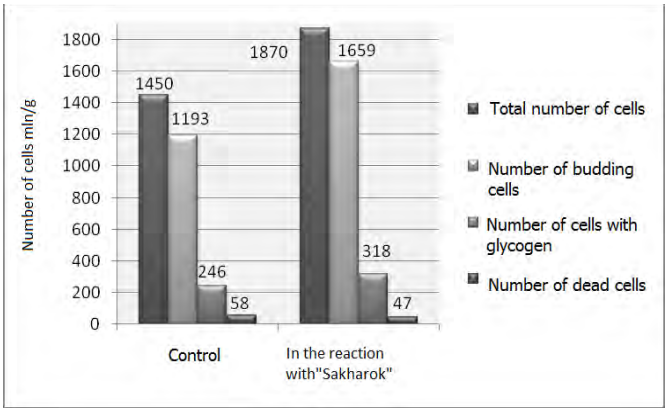


Fig. 1. Counting the total, dead, budding and yeast cells with glycogen

As a result of the activation of baking yeasts with the use of the sugar-containing hydrolyzate "Sakharok", the zymase and maltase activity of the yeast became higher by 29.50% and 33.30%. Accordingly, it influenced positively their dough fermentation property. For yeasts activated with "Sakharok", the property improved by 40.00% compared to the control.

Such changes in yeast cell activity in the experimental sample are provided by a nutritional mixture. The mixture is rich in assimilable nitrogenous substances and sugars, all necessary vitamins and minerals contained in the hydrolyzate "Sakharok". In addition, an improvement in the physiological state, presumably, may be due to an increase in the permeability of the cytoplasmic membrane. This is facilitated by the presence of surface-active substances (complex pectin-protein β-glucan [31]). They are adsorbed on the border of the cell and the environment; facilitate the transport of nutrients into the cell and the release of metabolic products from it [43].

While studying, the samples of activated yeast under a microscope, it was established that the cell surface is increased, and the shape is more rounded. The ratio of the cell surface to its volume affects the rate of diffusion of nutrients into the cell, and the release of metabolic products. Thus, yeast, activated with the use of the hydrolyzate "Sakharok", is capable of active life [8].

Comparison analysis of the morphological features of the yeast activated using sugar-containing hydrolyzate "Sakharok". We can conclude that in the experimental sample with a total cell count of 1870 ppm, the dead content does not exceed 2.5%, in the control variant, the total number of cells was 1450 ml/g, and 4.0% of them are dead.

The content of budding cells in yeast, activated using the sugar-containing hydrolyzate "Sakharok", does not exceed 20%. This indicates the ability of such yeasts to provide intensive fermentation in the dough and while making test patterns.

To assess the state of yeast cells after activation, an intracellular supply of substances was determined. They include glycogen as an energy source in the absence of external sources. When yeast is activated using the sugar-containing hydrolyzate "Sakharok", 88.7% of yeast cells contain glycogen, which is 6.4% more than a control pattern. As a result, yeast, activated with the use of Sakharok hydrolyzate, is more viable.

As a result of the experiment, it was established that the use of sugar-containing hydrolyzate "Sakharok" for the activation of pressed bakery yeast is expedient. This is explained by significant improvement in their physiological state, which presumably will allow intensification of the technological process of production bakery products and improve their quality [6, 9].

### *B. Research of the effect of activated yeast on the intensity of fermentation processes in semi-finished bakery products*

The economy and adaptability of the straight dough procedure and the sponge dough preparation method can be improved by pre-activating yeast, reducing their consumption without deteriorating the quality of semi-finished products and finished products [44]. It is obvious that under condition of preliminary activation of pressed baking yeasts, it is recommended to reduce their prescription quantity by 20-30% [8].

The research of the activated yeast’s effect on the process of maturation of the leaven was made. With minimizing of the prescription amount of yeast, the kinetics and dynamics of gassing during the fermentation of gums and the accumulation of acidity were controlled. Traditional leaven activated by yeast was prepared using a common method. At the same time, the amount of water and sugar-containing hydrolyzate "Sakharok", which were used to activate yeast instead of wheat flour, were taken into account. The samples of the straight dough procedure and the sponge dough preparation method were prepared in several variants. Variant 1 was prepared by using yeast, activated with sugar-containing hydrolyzate "Sakharok". Variant 2 was prepared with a prescription amount of yeast reduced by 20%, activated with "Sakharok". Variant 3 was done with the prescription amount of yeast reduced by 40%, activated with "Sakharok". Variant 4 was prepared with the prescription amount of yeast, reduced by 60%, activated with "Sakharok". Variant 5 was made with the prescription amount of yeast, reduced by 80% and activated with sugar-containing hydrolyzate "Sakharok". The control was based on yeast,

activated by the GOSNIICH method. Experimental data showed that the use of sugar-containing hydrolyzate "Sakharok" for the activation of bakery yeast instead of wheat flour of the first grade improves the formation of gasses in the spore by 28.90% compared to the control. At the same time, when the prescription amount of yeast was reduced by 60%, the amount of carbon dioxide emitted during the ripening process increased by 19.20% compared to the control.

Yeast activity was estimated by the maximum rate of gassing in the leaved dough. The curve of the dynamics of the gassing's rate for the leaven, indicates that the control sample reaches a maximum gasification rate of 2.8 $cm^3$ / min after 210 minutes of fermentation. For variants 1, 2, 3 and 4, the rate of gas generation is maximized by 17.90%, 14.30%, and 7.10% and is reached in 90 minutes, 120 minutes and 150 minutes, compared with the control. For Variant 4, the magnitude of the maximum speed does not differ from the control sample, but the come-up time reduces to 180 minutes. For Variant 5, the maximum speed is reduced by 14.30% compared to the control for the same time. The gassing process proceeds with the greatest speed in the leaven, prepared with the use of yeast, activated by the sugar-containing hydrolyzate "Sakharok". The change of titratable acidity in the leaven during fermentation indicates the intensification of the acid formation process in the experimental samples. This provides a reduction in the period of its maturation by 57.10%, 42.90%, 28.60% and 14.30% for variants 1, 2, 3 and 4. In comparison with the control, the duration increases by 14.30% for variant 5. At the same time, the final acidity of the gum is 3.2 degrees. Such value of acidity reflects the degree of ripening of the leaven, promotes the optimal course of swelling and peptizing of protein substances, the action of enzymes and the accumulation of flavor and aromatic substances [45].

The intensification of the maturation process of experimental samples of the sponge dough can be explained by the rich chemical composition of the sugar-containing hydrolyzate "Sakharok" in comparison with wheat flour. Easily assimilated sugars and free amine nitrogen serve as an ideal source of nutrition for yeast cells. The presence of potassium, magnesium, phosphorus, manganese, biotin and pantothenic acid stimulates their fermentation, which ensures an active metabolism of yeast under the anaerobic conditions of the dough.

As a result of the research, it was pointed out that, the activation of pressed baking yeast by the sugar-containing hydrolyzate "Sakharok", intensifies the process of leaven maturation and allows decreasing the prescription amount of yeast by 60%. Further reduction of the prescription amount of yeast is inadvisable, since it leads to deterioration in the studied parameters.

Analysis of the experimental data showed, that the use of the sugar-containing hydrolyzate "Sakharok" improves the gas formation in leaven, prepared by the straight dough procedure in the first variant by 30.50% compared to the control. At the same time, when the prescription amount of yeast was reduced by 40%, the amount of released carbon dioxide increased by 26.10%. With further decrease of yeast, the volume of carbon dioxide decreases by 17.80% compared to the control.

In the process of sponge dough preparation method, the first variant of the sample outgoes the control, by the amount of released carbon dioxide, by 5.50%. With the decrease in the prescription amount of yeast by 60%, the amount of carbon dioxide increases by 4.60%. With further decrease - the volume of carbon dioxide decreases by 4.40% in comparison with the control.

The activity of the yeast in leaven was evaluated by the maximum rate of gassing on the graph. When it comes to straight dough preparation method, after 180 minutes of fermentation, the maximum rate of gassing of the control sample achieves - 2.9 cm3 / min. For variants 1, 2 and 3, the value of the maximum rate of gas generation increases by 20.70%, 13.80% and 10.30% compared to the control. The time of its achievement is 120 minutes, 120 minutes and 150 minutes. For variants 4 and 5, the maximum rate of gas generation decreases by 17.20% and 24.10%,, and reaches 150 minutes in both variants.

When it comes to the sponge dough preparation method, the maximum gassing's rate of the control sample is 3.4 $cm^3$/min. It is reached in 120 minutes after fermentation. For variants 1, 2 and 3, the maximum rate of gassing increases by 14.70%, 11.80% and 3.00 %. They are reached in 60 minutes, 90 minutes. For option 4, the maximum speed and time of achievement do not change compared to the control. For option 5, the maximum speed is reduced by 5.90% compared to the control for the same time.

This research confirms that the rate of gassing in leaven depends on the method of yeast activation, the method of dough preparation and the amount of bakery yeast. In the dough with activated yeast, the rate of gas generation increases without changes, what indicates a reorganization of the yeast enzyme complex and is an objective criterion for their adaptation [8].

The change in acidity, during fermentation of experimental dough samples, indicates the intensification of the process of acid formation. With the straight dough procedure of dough preparation, the acidity of the control reaches the required value of 3.5 degrees in 140 minutes. For options 1, 2 and 3, this time minimizes up to 80, 50 and 35 minutes, in comparison with the control. For options 4 and 5, the time increases up to 160 and 175 minutes.

With the sponge dough preparation method, the acidity of the control reaches the required value of 3.5 deg. in 90 minutes. For options 1, 2, 3 and 4, this time minimizes up to 60, 50 and 40 minutes compared to the control. For option 5 the time increases up to 10 minutes. Consequently, the accumulation of acids in the experimental dough samples occurs more intensively during fermentation. This is typical of all the samples, except variants 4 and 5 for the straight dough procedure and variant 5 for the sponge dough preparation method.

The results of the study showed that during the fermentation process in the experimental dough samples, the amount of recovered glutathione increases by 20.00% for the straight dough procedure and 26.50% and for the sponge dough preparation method compared to the control. Intensification of glutathione release is due to a more active life of yeast in

conditions of a rich nutrient medium with the use of sugar-containing hydrolyzate "Sakharok". At the same time, while the amount of yeast recipe minimizes, the content of the released reduced glutathione naturally decreases by 37.10% and 27.70%.

The amount of raw gluten in the experimental dough samples decreases by 4.1% and 3.9%. The results are compared to the control for the straight dough procedure and sponge dough preparation method. At the same time, when the amount of yeast is reduced, the amount of raw gluten increases by 3.70% and 3.80% compared to the first variant for the straight dough procedure and sponge dough preparation method.

The hydration capacity of gluten in the experimental dough samples increases by 11.30% and 11.50% compared to the control for the straight dough procedure and the sponge dough preparation method. The result can be explained by the addition of polysaccharides and lipids with sugar-containing hydrolyzate "Sakharok", capable of interacting with proteins of flour, forming complexes - glycoproteins and lipoproteins. They have a higher water-absorbing capacity compared to the gluten-free proteins of flour [6, 46, 47]. When the amount of yeast is minimized, the increase in the hydration ability of gluten is explained by the decrease in the amount of yeast reclaimed glutathione. It has a less disaggregating effect on gluten proteins, as it is confirmed by previous studies.

While the fermentation of the dough mixed with yeast, the quality of gluten minimizes by 11,90% and 11,40% for the IDK. It increases due to extensibility by 9.30% and 14.80%, compared to the control for the straight dough procedure and the sponge dough preparation method. This can be explained by the disaggregating effect of the reconstituted yeast glutathione on gluten proteins. At the same time, when the amount of yeast is reduced, the quality of gluten according to the IDK index increases by 10.50% and 11.00%. It decreases in the index of extensibility by 11.10% and 7.90% in comparison with the first variant for the leaved and not leaved dough preparation methods. It can be explained by the decrease in the amount of reduced glutathione in the dough.

The amount of the dough, mixed with yeast and activated according to the proposed variant, practically does not change in comparison with the control of the straight dough procedure and the sponge dough preparation method. The expansion of the dough is due to gassing of yeast fermentation activity. But in addition, the dough should have certain structural and mechanical properties to retain the carbon dioxide formed. We will point out that the intensification of gassing in the dough, using activated yeast, was established according to the proposed variant. However, in this case, the amount of the dough did not change significantly. We can conclude that the gas holding capacity of the dough is lower than in the control. The results can be explained by the relaxation of the elastic properties of gluten (according to the IDK index) due to the intensification of the disaggregating effect of the reduced yeast glutathione. As a result, the dough cannot firmly retain the released carbon dioxide. In this regard, it is advisable to conduct further studies, aimed at reducing the amount of reduced glutathione in the dough. Presumably, it can lead to the strengthening of the elastic properties of gluten.

## IV. Conclusion

On the base of the research, we can make the conclusion that, the use of activated yeast with enzymatic sugar-containing hydrolyzate of oats "Sakharok" intensifies the process of dough maturation prepared by the straight dough procedure by 57.10%. The effectiveness of its use was confirmed for leaven and dough preparation. When it comes to straight dough procedure, the prescription amount of yeast minimizes by 40%. For the sponge dough preparation method this criterion is reached by 60% without deterioration of the studied parameters, and lowering the consumption.

With the help of the studied information, the practicability and efficiency of using enzymatic sugar-containing hydrolyzate of oats "Sakharok" was proved. It stimulates the biotechnological properties of bakery yeast and increases the nutritional value of bakery products. But for its further use in the bakery industry, it is necessary to carry out a series of studies that allow leveling the shortcomings of the accumulation of reconstituted yeast glutathione, which is possible by oxidative influence on it and the protein components of the flour.

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