УДК 664.14/.16

BIOCHEMICAL PROCESSES IN THE DOUGH FOR DIABETIC BAKERY PRODUCTS, ENRICHED WITH PROTEINS AND FOOD FIBERS

A. Shevchenko
National University of Food Technologies

Key words:
Biochemical processes
Casein
Jerusalem artichoke powder
Bran buckwheat fiber
Fructose

Article history:
Received 12.03.2018
Received in revised form 03.04.2018
Accepted 19.04.2018

Corresponding author:
A. Shevchenko
E-mail:
npnuht@ukr.net

ABSTRACT

Today the problem of manufacturing of products, in particular bakery products for people with diabetes mellitus, enriched with useful substances such as proteins and edible fibers is acute in the world. Biochemical processes in the dough system during their manufacturing when additional components are researched insufficiently. Therefore, such studies are relevant, because they determine the quality of finished products.

As objects of research there were chosen a dough system with fructose for manufacturing bakery products, casein as a source of protein, artichoke powder and buckwheat bran fiber as sources of food fibers.

The kinetics of sugars in the dough was determined by the number of formed and fermented sugars, the fractional composition of proteins, the intensity of acid accumulation and the amount of volatile acids were also determined. The content of sugar depends on the ratio between the intensity of accumulation of sugars in the dough and its digestion by microorganisms. Improvement of sugar forming ability in the dough with the use of researched additives is established.

Significant changes are expected in the composition of the protein substances of the dough, as casein was selected as a protein enrichment agent for diabetic products. During fermentation due to the action of proteolytic enzymes, disaggregation of protein molecules and hydrolysis of polypeptide chains occurs. And rheological properties of the dough depend on the composition of the protein fractions. Investigation of the fractional composition of proteins showed an increase of water-soluble and intermediate nitrogen fractions in the dough, which contributes to the improvement of nutrition of microorganisms of the dough.

During the fermentation of the dough acidifying substances accumulate. They increase the titrated and active acidity. The introduced ingredients have a significant amount of inorganic acids, which will affect the taste properties of baked goods. The increase of volatile acids in the dough and finished products compared to the control sample without additives was also established.

DOI: 10.24263/2225-2924-2018-24-2-22

БІОХІМІЧНІ ПРОЦЕСИ В ТІСТІ ДЛЯ ДІАБЕТИЧНИХ БУЛОЧНИХ ВИРОБІВ, ЗБАГАЧЕНИХ БІЛКАМИ ТА ХАРЧОВИМИ ВОЛОКНАМИ

А.О. Шевченко
Національний університет харчових технологій

Сьогодні в усьому світі особливої гостроти набуло питання виготовлення виробів, зокрема хлібобулочних, для людей, хворих на цукровий діабет, збагачених корисними речовинами, такими як білки та харчові волокна. Недостатньо досліджено біохімічні процеси, які відбуваються в тістовій системі за їх виготовлення при внесенні додаткових компонентів. Тому такі дослідження є актуальними, адже вони визначають якість готової продукції.

Об'єктами досліджень обрано тістову систему з фруктозою для виготовлення булочних виробів, казеїн як джерело білка, порошок топінамбуру та клітковину висівок гречки як джерела харчових волокон.

Визначено кінетику цукрів у тісті за кількістю утворених і зброджених цукрів, фракційний склад білків, інтенсивність кислотонакопичення та кількість летких кислот. З'ясовано, що вміст цукру залежить від співвідношення між інтенсивністю накопичення цукрів у тісті та зброджуванням їх мікроорганізмами. Встановлено покращення цукроутворювальної здатності у тісті при використанні досліджуваних добавок.

Передбачаються значні зміни у складі білкових речовин тіста, адже як білковий збагачувач діабетичних виробів було обрано казеїн. У процесі бродіння під дією протеолітичних ферментів відбувається дезагрегація молекул білка, гідроліз поліпептидних ланцюгів. А від складу фракцій білка залежать реологічні властивості тіста. Дослідження фракційного складу білків показали збільшення у тісті водорозчинної та проміжної фракцій азоту, що сприяє покращенню живлення мікроорганізмів тіста.

Під час бродіння тіста накопичуються кислореагуючі речовини, які спричиняють збільшення титрованої та активної кислотності. Внесені інгредієнти у своєму складі мають значну кількість неорганічних кислот, які впливатимуть на смакові властивості випечених виробів. Встановлено зростання кількості летких кислот у тісті та готових виробах (порівняно з контролем без добавок).

***Ключові слова**: біохімічні процеси, казеїн, порошок топінамбуру, клітковина висівок гречки, фруктоза.*

Formulation of the problem. Recently diabetes mellitus has become widespread in the world. But the range of products with a low glycemic index and a high nutritional value, enriched with useful substances, such as complete proteins and edible fibers [1—4], presented on the market is small. To reduce the glycemicity of products, sugar substitutes are used and fructose as a product that does not increase blood sugar level [5]. There is actual to use milk proteins, as components of high-grade chemical composition, and cereals for the enrichment of bakery products with fiber [6; 7]. For diabetic nutrition inulin-containing raw materials are especially useful, they do not increase sugar level in the blood and at the same time provides body with fiber [8; 9]. It should be noted that at this time the influence of non-traditional raw materials and additives on the technological process of making bakery products is not sufficiently researched. The decisive role in bread technology belongs to biochemical processes [10]. During the maturation of the dough, the biotransformation of its polymers takes place. Significant changes are observed in the protein-proteinase and carbohydrate-amylase complex. The biochemical processes occurring in the dough are the splitting of the components of the flour, mainly proteins and starch, under the action of own flour enzymes, as well as enzymes of yeast and other microorganisms. Sugars and nitrogenous substances accumulate in the dough. In this case, a certain degree of decomposition of proteins is desirable, as it allows to obtain sufficiently elastic dough with optimal properties for obtaining good quality bread [11]. In addition, the products of the decomposition of proteins during the baking stage are involved in the formation of the color, taste and flavor of bread [12]. When intensive decomposition of proteins, especially with the use of weak flour, the dough spreads and the quality of bread is unsatisfactory. Therefore, the intensity of proteolysis is regulated taking into account the strength of the flour.

As a result of the digestion of starch by enzymes, maltose (5—6% by weight of the flour) is formed, which is spent on the fermentation of dough and involved in the process of baking, determining the taste and color of the crust of bread.

As biochemical processes are among the determining factors, **the purpose of our research** was to determine the effect of a mixture of proteins and food fibers on the course of biochemical processes in the dough with fructose for diabetic nutrition.

Materials and methods. For research, samples with high quality wheat flour, yeast, salt, and fructose were prepared. Fructose was dosed in an amount of 5% by weight of flour. As added ingredients there was a mixture of casein with Jerusalem artichoke powder (9% and 4% by weight of flour) and a mixture of casein with fiber of bran buckwheat (8% and 8% by weight of flour). As a control there was a product with fructose without additives.

The course of biochemical processes was determined by the kinetics of sugars during maturation of the dough, the rate of acid accumulation and the degree of disaggregation of proteins. The content of volatile acids in the dough and finished products was also characterized.

The kinetics of sugar accumulation was determined by the accelerated iodometric method without hydrolysis in terms of maltose. Its content was established in yeast and non-yeast dough after mixing and after 1.5 and 3 hours of fermentation. The principle of the method is based on the fact that during boiling of the exact amount of Feling liquid with the investigated solution containing reducing sugars, the latter restore the bivalent copper to monovalent copper oxide. Next, remaining divalent copper is acted by potassium iodide. Marked molecular iodine is titrated with sodium thiosulfate solution. In parallel, a control experiment is conducted, in which distilled water is taken instead of the investigated solution. By the difference in volumes of sodium thiosulfate solution spent on titration of the control experiment and the investigated one, the amount of bacillus copper recovered by sugar is determined [13].

The intensity of acid accumulation was determined by the titrated and active acidity of the dough. The method for determining the titrated acidity is based on titration of a milled dough or crumb by 0.1 mol / dm^3 sodium hydroxide with the presence of a phenolphthalein indicator. Active acidity is determined using a pH meter in yeast and non-yeast dough after mixing and after 1.5 and 3 hours of fermentation [13].

The content of volatile acids was determined by the semi-micromethod of ASDIFT. The extract of dough or bread crumb is prepared, the indicator paper kongo red is put and after acidification by 1 mol / dm^3 sulfuric acid is distilled. The resulting distillate is heated to reflux and titrated with 0.05 mol / dm^3 sodium hydroxide solution with the phenolphthalein indicator [13].

The fractionation of the nitrogen-containing substances of the dough is carried out according to the scheme of Chyzhova K.N. and Shkvarkina T.I. Determination of the total nitrogen content in dough and gluten nitrogen is carried out by combustion of the sample due to the modified Kjeldahl method. Modification of the method consists in determining the content directly in the solution of the zeolite sample (without distillation) using indirect hypochlorite-iodometric titration. The principle of the method is the oxidation of ammonium in a light-alkaline medium with excessive amount of hypochlorite, the remainder of which is then determined by indirect iodometric titration. The content of the water-soluble fraction and non-protein nitrogen is determined after extraction and burning of the extract. Amount of nitrogen of free amino acids is determined by the method of formolith titration. The nitrogen content of the intermediate fraction is calculated as the difference between the content of total nitrogen and its total amount in gluten and water-soluble fractions [13].

Results and discussion. The process of gas formation in the dough is stipulated by the sugar-forming ability, which is provided by the activity of amylase and the tolerance of starch to the amylolysis. The content of sugar depends on the ratio between the intensity of accumulation of sugars in the dough and their digestion by microorganisms. In the presence of a mixture of casein and powder of artichoke and casein and buckwheat cellulose, the process of amylolysis passes more intensively than in the control sample, as evidenced by the accumulation more quantity of sugars during fermentation. After 3 hours after mixing the dough with additives, there were fermented sugars by 13.8% and 3.0% respectively more, than in the control sample (Table 1), indicating a positive effect of additives on the sugar-forming ability.

Table 1. **Acidification and fermentation of sugars in the process of fermentation of dough, % on dry matter**

Indexes	Sample with fructose (Control)	Sample with casein and Jerusalem artichoke powder	Sample with casein and cellulose of buckwheat bran
1	2	3	4
Dough without yeast			
After mixing	7,3	8,3	8,8
After 3 hours of fermentation	9,4	11,8	10,9

Continuation of Table. 1

1	2	3	4
Formed sugar s	2,1	3,5	2,3
Yeast dough			
After mixing	7,6	8,4	8,9
After 3 hours of fermentation	6,3	8,0	7,7
Fermented sugars	3,4	3,9	3,5

During the fermentation of the dough acidifying substances are accumulated. They increase the titrated and active acidity. It was established (Fig. 1) that adding a mixture of casein with powder of Jerusalem artichoke and casein with cellulose of buckwheat bran leads to the increase of titrated acidity by 0.1 and 0.3 degrees, respectively, due to the higher acidity of the added ingredients. Intensification of acid accumulation can be explained by the improvement of nutrition of lactic acid bacteria due to the constituents of additives.

During fermentation, the pH of the dough decreased (Fig. 2), which correlates with the value of titrated acidity at 2.2—6.2% obviously due to the intensification of microbiological processes.

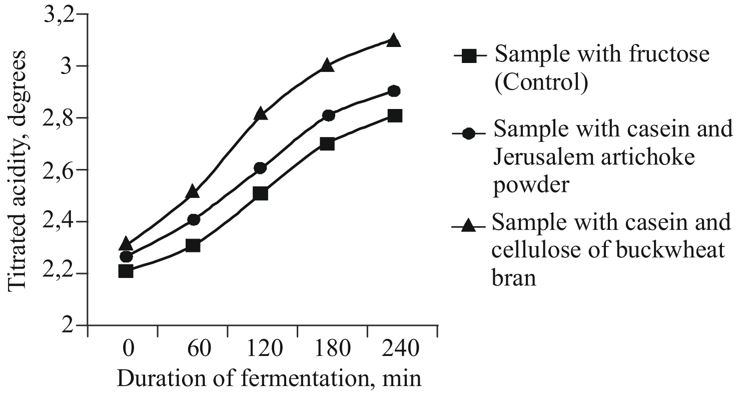

Fig. 1. Titrated acidity

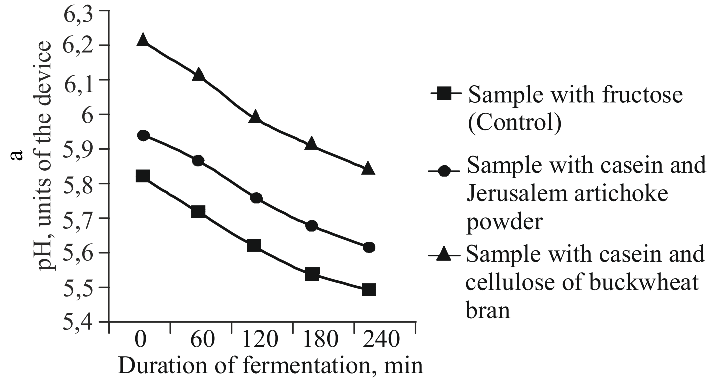

Fig. 2. Active acidity

The introduced ingredients in their composition have a significant amount of inorganic acids, which will influence on the taste properties of baked goods. Therefore, it was advisable to examine their content in the vinified dough and finished products.

It was established (Table 2) that the additives influence on the increase of the production of volatile acids by bacterial microflora of the dough: a sample with a mixture of casein and artichoke powder — by 15%, with a mixture of casein and cellulose of buckwheat bran — by 23.3%. In finished products the amount of volatile acids decreased, compared to their content in the dough, which is due to their weathering under the influence of temperature during the baking process.

Table 2. **The content of volatile acids in dough and bread**

Indexes	Sample with fructose (Control)	Sample with casein and Jerusalem artichoke powder	Sample with casein and cellulose of buckwheat bran
Dough			
Titrated acidity of the vintage dough, deg	2,8	2,9	3,1
Content of volatile acids,%	18,5	21,2	22,8
Bread			
Titrated acidity of bread, deg	1,8	2,0	2,2
Content of volatile acids,%	15,8	18,1	19,7

Significant changes occurred in the protein substances of the dough, because casein was chosen as a protein enrichment agent for diabetic products. In addition, the Jerusalem artichoke powder and the buckwheat seed fiber contain also a small amount of protein. During fermentation under the action of proteolytic enzymes, disaggregation of protein molecules occurs as well as the hydrolysis of polypeptide chains. And rheological properties of the dough depend on the composition of the protein fractions. It has been established (Table 3.) that the content of total nitrogen in samples with additives is greater by 11.5% and 38% than in the control due to the added with the additional ingredients protein. The amount of gluten nitrogen in the fermentation process is reduced due to the transfer of its part to the water-soluble and intermediate fraction. Water-soluble nitrogen is an additional nutrition for the dough microflora. An increase in its amount was observed in the process of fermentation of the dough in all samples, and to a greater extent in samples with additives. This is a consequence of proteolysis in the dough. The content of the intermediate fraction also increases as a result of lowering the pH of the dough in the case of using additives. In this case, non-protein nitrogen (amides, nitrogen of free amino acids, etc.) is formed. Increasing the content of water-soluble and intermediate fractions leads to the improving of microorganisms' nutrition and rheological properties of the dough.

Table 3. **Fractional composition of protein substances of the dough, mg/100 g of dry matter**

Sample	Nitrogen content by fractions,% to dry matter of the dough					
	total	gluten nitrogen	water-soluble fraction	intermediate fraction	non-protein nitrogen	nitrogen of free amino acids
Sample with fructose (Control)						
After mixing	3,73	3,06	0,41	0,26	0,07	0,01
After fermentation		2,92	0,44	0,37	0,08	0,014
Sample with casein and Jerusalem artichoke powder						
After mixing	4,16	3,1	0,43	0,63	0,1	0,05
After fermentation		2,88	0,46	0,82	0,13	0,059
Sample with casein and cellulose of buckwheat bran						
After mixing	5,15	3,95	0,56	0,74	0,18	0,05
After fermentation		3,87	0,48	0,80	0,22	0,62

Conclusions

It was established that the addition of protein and food fibers sources influences positively on the course of biochemical processes during the manufacture of bakery products. Sugar-forming ability improves, the amount of volatile acids increases, which contributes to the formation of a more pleasant flavor of finished products. The addition of additives leads to the increase of the density of water-soluble and intermediate fractions of nitrogen, which contributes to the improvement of nutrition of microorganisms of the dough and improves its rheological properties. Therefore, the enrichment of products with the investigated sources of protein and dietary fiber is appropriate in view not only of increasing the nutritional value of finished products, but also of intensifying biochemical processes during their production.

References

1. *Полумбрик М.О.* Углеводы в пищевых продуктах : монография. / М.О. Полумбрик, В.В. Литвяк, З.В. Ловкис, В.Н. Ковбаса // Нац. ун-т пищ. технол., Украина; Науч.-практ. центр Нац. акад. наук Беларуси по продовольствию, Республика Беларусь. — Минск : Минфина, 2016. — 592 с.

2. *Haripriya, S., Premakumari, S.,* (2010). Effect of wheat bran on diabetic subjects, Indian Journal of Science and Technology, 3(3): 284—286.

3. *Mohamed, S.,* (2014) Functional food against metabolic syndrome (obesity, diabetes, hypertension and dislipidemia) and cardiovascular diseases, Trends in Food Science and Technology, 35, 114—128.

4. *Nathan D.M.,* (2010) Navigating the choices for the diabetes prevention, N. Engl. J. Med., 1—3.

5. *Місечко Н.О.* Використання фруктози і лактулози в технології хлібобулочних виробів: автореф. дис. канд. техн. наук: 05.18.01 / Н.О. Місечко. — НУХТ, 2014. — 20 с.

6. *Sivam, A.S., Sun-Waterhouse, D., Quek, S.Y., Perera, C.O.,* (2010). Properties of Bread Dough with Added Fiber Polysaccharides and Phenolic Antioxidants: A Review. J Food Sci, 75(8): 163—174.

7. *Davidenko,* O. (2013). Control of protein and energy intake — brain mechanisms. European Journal of Clinical Nutrition. № 67, 455—461.

8. *Rubel, I.A., Perez, E.E., Manrique, G.D., Genovese, D.B., (*2015). Fibre enrichment of wheat bread with Jerusalem artichoke inulin: Effect on dough rheology and bread quality. Food Structure, 3: 21—29.

9. *Коркач Г.В.* Вплив порошку топінамбура на якість хлібобулочних виробів / Г.В. Коркач, Т.Є. Лебеденко, Н.Ю. Соколова // Наукові праці Одеської національної академії харчових технологій. — 2009. — 36, том 1. — С. 137—140.

10. *Claire, J.,* (2014). The Chemistry of Baking. Senior Theses, 23. 92.

11. Процеси, що відбуваються підчас утворення тіста / Київ. Baker-Group. Режим доступу : https://baker-group.net/bread-and-bakery-products/technology-of-bread-and-bakery-products/-976-2015-09-29-20-08-53.html.

12. *Everts, S.* (2012). “The Maillard Reaction Turns 100”. Chemical & Engineering News, 90 (40): 58—60

13. *Дробот В.І.* Технохімічний контроль сировини та хлібобулочних і макаронних виробів / В.І. Дробот // Київ, НУХТ, 2015. — 902 с.