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CITRATES OF MINERAL SUBSTANCES IN THE TECHNOLOGICAL PROCESS OF MANUFACTURING BAKERY PRODUCTS

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ABSTRACT

Salts of inorganic acids were mainly used to enrich food products with minerals for a long time. However, minerals in this form have low bioavailability, so scientists are increasingly considering the use of organic mineral compounds. Substances in the form of citrates are of interest, because they function in the human body in this chemical form. The health-improving effect of minerals that are part of physiologically active compounds is explained by their effect on metabolic processes.

Various sugar substitutes are used in the manufacture of bakery products to replace sugar in the diet of patients with diabetes. The study of the complex effect of sugar substitute — fructose and citrates of calcium, magnesium, zinc, iron, both individually and in a mixture, on the manufacturing process of bakery products and the properties of semi-finished and finished products was provided. Dough with fructose without the addition of citrates has less springiness, better elasticity, it dilutes more due to the high hydrophilicity of fructose. Fructose has a lower molecular weight, so its solutions penetrate better into the protein structure. However, due to the decrease in the viscosity of the dough with fructose, the shape stability of the products decreases.

The course of the processes in the dough was characterized by the kinetics of sugars during the maturation of the dough, the properties of the water-flour suspension using amylograph, the springy-elastic properties of the dough were studied using farinograph.

It was found that the addition of citrates to the dough stimulated the activity of flour enzymes and fermentation activity of the microflora, which increased the accumulation of sugars in the dough during fermentation and their fermentation by the dough microflora, delayed the beginning of starch gelatinization. There was an increase in the specific volume of products by 7—9%, shape stability and porosity improved. The nutritional value of products increased significantly in terms of meeting the body's needs for minerals when eating the daily norm of bread.

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ЦИТРАТИ МІНЕРАЛЬНИХ РЕЧОВИН У ТЕХНОЛОГІЧНОМУ ПРОЦЕСІ ВИГОТОВЛЕННЯ ХЛІБОБУЛОЧНИХ ВИРОБІВ

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Протягом тривалого часу для збагачення харчових продуктів мінеральними речовинами використовували в основному солі неорганічних кислот. Проте мінерали в цій формі мають низьку біологічну доступність, тому науковці все частіше вважають перспективним використання органічних сполук мінеральних речовин. Зацікавленість викликають речовини у формі цитратів, оскільки саме в такій хімічній формі вони функціонують в організмі людини. Оздоровча дія мінеральних речовин, що входять до складу фізіологічно активних сполук, пояснюється їхнім впливом на метаболічні процеси.

У харчуванні хворих на цукровий діабет при виготовленні хлібобулочних виробів для заміни цукру використовують різні цукрозамінники. У статті проведено дослідження комплексного впливу цукрозамінника — фруктози та цитратів кальцію, магнію, цинку, заліза як окремо, так і в суміші, на технологічний процес виготовлення хлібобулочних виробів та властивості напівфабрикатів і готових продуктів. Тісто з фруктозою без додання цитратів має меншу пружність, кращу еластичність і більше розріджується, що пов'язано з високою гідрофільністю фруктози. Фруктоза має меншу молекулярну масу, тому її розчини краще проникають у структуру білка. Проте внаслідок зниження в'язкості тіста з фруктозою зменшується формостійкість виробів.

Перебіг процесів у тісті характеризувався кінетикою цукрів під час дозрівання тіста, властивостями водно-борошняної суспензії за допомогою амілографа, пружинно-еластичні властивості тіста вивчали за допомогою фаринографа.

Встановлено, що додання цитратів у тісто стимулює активність ферментів борошна та бродильну активність мікрофлори, що зумовлює збільшення накопичення цукрів у тісті під час його ферментації та їх зброджування мікрофлорою тіста, затримує початок клейстеризації крохмалю, підвищує стабільність тістової системи. Відмічено збільшення питомого об'єму виробів на 7—9%, покращення формостійкості та пористості. Значно підвищилась харчова цінність виробів з точки зору забезпечення потреб організму в мінеральних речовинах при вживанні добової норми хліба.

Ключові слова: *хлібобулочний виріб, фруктоза, цитрати, кальцій, магній, цинк, залізо.*

Formulation of the problem. Salts of inorganic acids were mainly used to enrich food products with minerals for a long time: carbonates, sulfates, phosphates. However, minerals in this form have low bioavailability, so scientists are increasingly considering the use of organic mineral compounds. Substances in the form of citrates are of interest,

because they function in the human body in this chemical form. The problem of enrichment is acute for products for people with special nutritional needs, in particular patients with diabetes, because such patients need food products with high nutritional value and high degree of absorption of essential nutrients. One of the main food products is bread. To obtain bakery products, the influence of enriching ingredients on the technological process of their manufacture is important, so it is important to study the use of citrates to ensure consumer properties of products.

Analysis of recent research and publications. Sugar substitutes of natural and artificial origin are used in the manufacture of bakery products to replace sugar and reduce the glycemic index of the finished product in the diet of patients with diabetes mellitus [1—2]. Scientists established the feasibility of replacing sugar with fructose in the production of bread for diabetics, because the fructose monosaccharide is sweeter than sacchacrose, for assimilation requires almost no insulin [3].

The influence of fructose on the technological process of bread production was established. It contributed to the intensification of the color of the products due to the high reactivity of fructose to the reaction of melanoidin formation, helped to extend the shelf life of products. Compared to sugar dough, fructose dough had less springiness, better elasticity and it diluted more due to the high hydrophilicity of fructose. Fructose has a lower molecular weight, so its solutions penetrate better into the protein structure. Thus, fructose, when it replaces sugar, improves the elasticity of gluten and dough, which at lower gas formation in the dough has a positive effect on the formation of the volume of the finished product, provides proper porosity structure and elasticity of the crumb of the product. However, due to some decrease in the viscosity of the dough with sugar substitutes, its stability is reduced [4].

The functioning of all body systems is stimulated by minerals. The health-improving effect of minerals that are part of physiologically active compounds is explained by their effect on metabolic processes. Modern technologies allow to obtain ecologically pure microelement complexes, at the same time the biological value of foodstuffs increases, their digestibility improves, biologically active components become more active. For patients with diabetes, it is important to get calcium, magnesium, zinc and iron, for which wheat flour bread is poor [5].

The main function of calcium is the formation and maintenance of complete bones and teeth. Iron is a component of hemoglobin, complex iron-protein complexes and a number of enzymes that enhance respiratory processes in cells. Magnesium is involved in processes such as protein synthesis, nutrient transport and glucose metabolism. Zinc is a component of insulin, prolongs its hypoglycemic effect [6—9].

Due to the above mentioned, **the purpose of the research** was research of complex influence of fructose and citrates of calcium, magnesium, zinc, iron both separately, and in a mixture, on technological process of manufacturing bakery products and properties of semi-finished and finished products.

Materials and methods. Samples with high quality wheat flour, yeast, salt, and fructose were prepared for research. Fructose was dosed in an amount of 5% by weight of flour. As added ingredients there were citrates of calcium, magnesium, zinc and iron and their mixture. A product without citrates was used as a control sample.

The course of processes in the dough was determined by the kinetics of sugars during maturation of the dough, the gelatinization of starch in suspension was determined in the amylograph, springy-elastic properties of the dough were studied using farinograph.

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 [10].

The viscosity of the aqueous-flour suspension was determined on the amylograph ('Brabender', Sweden). The principle of the method is to mix the suspension and fix the torque of the working body of the device using a measuring system [10].

Springy-elastic characteristics of the dough were studied on the farinograph ('Brabender', Sweden). The principle of the method is as follows: in the mixer a mechanical force acts on the semi-finished product. The resistance of the dough is transmitted to the stock of the motor. Torque is recorded and expressed as a function of time [10].

Results and discussion. The accumulation and fermentation of sugars in the dough is due to the activity of flour and yeast enzymes (Table 1).

Table 1. **Kinetics of sugars during the dough fermentation**

Indicators	Control sample	Added citrates			
		zink	magnesium	calcium	iron
Yeast-free dough					
After mixing	7.30±0.1	7.20±0.1	7.30±0.1	7.30±0.1	7.30±0.1
After 3 hours of fermentation	9.40±0.1	9.40±0.1	9.57±0.1	9.43±0.1	9.31±0.1
Accumulated sugars	2.10±0.1	2.20±0.1	2.27±0.1	2.13±0.1	2.11±0.1
Yeast dough					
After mixing	7.60±0.1	7.60±0.1	7.70±0.1	7.60±0.1	7.60±0.1
After 3 hours of fermentation	6.30±0.1	6.14±0.1	6.27±0.1	6.23±0.1	6.25±0.1
Fermented sugars	3.40±0.1	3.66±0.1	3.70±0.1	3.50±0.1	3.46±0.1

In samples with citrates during fermentation more sugars were accumulated than in the dough only with fructose, namely: with zinc citrate — by 4.7%, magnesium — by 8%, calcium and iron — by 2%. That is, adding them to the dough stimulates the activity of flour enzymes.

The studied salts increase the fermentation of sugars: zinc citrate — by 7.6%, magnesium — by 8.8%, calcium and iron — by 3%, ie intensify the fermentation of dough with fructose. Thus, the introduction of citrates activates the amylolysis of starch and the fermentation process of the dough. This can be explained by the positive effect of citrates on the enzymatic complex of yeast and flour enzymes.

The baking properties of flour depend on the gelatinization of starch and the enzymatic activity of amylase. With a slow rise in temperature (1.5°C/min.) in the amylograph, the gelatinization of starch in suspension occurs as in the normal mode of baking bread.

Sample with the addition of a mixture of citrates of metals was investigated. The amount of each mineral substance in the mixture was used at the rate of providing the

body with 50% in each substance when eating the daily norm of bread — 277 g (Table 2).

Table 2. **Viscosity of aqueous flour suspension with citrates of metals using amylograph**

Water-flour suspension	Time to the beginning of gelatinization of starch, min	The temperature of the beginning of starch gelatinization, °C	Maximum viscosity of the system, unit of the device
Control sample	4.0±0.5	47.5±0.5	575±5
Sample with the addition of the mixture of citrates	6.0±0.5	52.8±0.5	590±5

The addition of citrates delays the beginning of gelatinization of starch for 2 min compared to the control sample. Maximum viscosity of the system with citrates is 2.6% higher than the control sample. This is due to the fact that in case of the action of citrates on starch due to redox processes the conditions for its swelling and hydration are created. This is accompanied by an increase in viscosity due to its gelatinization. At the same time there are conformational disturbances which are an obstacle to spiral formation of amylose and causes opening of branched chains of amylopectin. Due to the formation of cross-links of different strength in the amylose molecule, even with a moderate addition of these salts, the viscosity of the paste and resistance to heat increase.

Studying dough using farinograph (Table 3) showed that the addition of citrates to the dough does not change its water absorption capacity.

Table 3. **Springy-elastic properties of the dough**

Sample	Consistency, unit of the device	Water absorption capacity, $cm^3/100g$	Duration of formation, min	Elasticity, unit of the device	Stability, min	Dilution during mixing, unit of the device
control	500	49.0±0.1	2.5±0.5	200±2	6.0±0.5	55±5
with a mixture of citrates	500	49.0±0.1	2.6±0.5	210±2	5.0±0.5	40±5

The duration of dough formation has slightly increased, the stability of the dough has increased by 1 minute, the dough does not dilute, which is explained by the fact that citrates act on redox processes in the dough.

Studies of the effect of citrates on the indicators of finished products showed an increase in the specific volume of products by 7—9%, improving the shape stability and porosity of products. The nutritional value of products increased significantly in terms of meeting the body's needs for minerals when eating the daily norm of bread.

Conclusions

It was established that the addition of citrates to the dough stimulated the activity of flour enzymes and fermentation activity of the microflora, which caused an increase in

the accumulation of sugars in the dough during its fermentation by 2—8% and their fermentation by the dough microflora by 3—8.8%.

Citrates delayed the beginning of starch gelatinization, increased the stability of the dough.

The nutritional value of finished products increased significantly, in particular, up to 49% of ensuring the daily requirement for added minerals.

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