

*Теоретично обґрунтовано та експериментально підтверджено доцільність використання плодів чорноплідної горобини у технології виробів з пісочного тіста. Досліджено вплив добавки чорноплідної горобини на основний рецептурний компонент пісочного тіста – пшеничне борошно. Встановлено, що добавка чорноплідної горобини сприяє не лише підвищенню харчової цінності виробів з пісочного тіста, але й дозволяє поліпшити якість пісочного тіста*

*Ключові слова: чорноплідна горобина, пісочне тісто, пшеничне борошно, антоціани, амілолітична активність*

*Теоретически обоснована и экспериментально подтверждена целесообразность использования плодов черноплодной рябины в технологии изделий из песочного теста. Исследовано влияние добавки черноплодной рябины на основной рецептурный компонент песочного теста – пшеничную муку. Установлено, что добавка черноплодной рябины способствует не только повышению пищевой ценности изделий из песочного теста, но и позволяет улучшить качество песочного теста*

*Ключевые слова: черноплодная рябина, песочное тесто, пшеничная мука, антоцианы, амилолитическая активность*

# SUBSTANTIATION OF FEASIBILITY OF USING BLACK CHOKEBERRY IN THE TECHNOLOGY OF PRODUCTS FROM SHORTCAKE DOUGH

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## 1. Introduction

Flour confectionery is a group of food products of a wide range, which considerably differ in the formulation composition, production technology and consumer properties. Despite the fact that they are not included into the “food basket”, these products enjoy great demand among the population and play a significant role in the replenishment of energy balance of a human [1].

A common kind of flour confectionary is the products from shortcake dough, which include several hundred items. Consumption of products from shortcake dough is at a stable high level. Their popularity may be explained by the diversity of form and taste and relatively low cost.

Products from shortcake dough are distinguished by considerable content of fat and carbohydrates, so they are high in calories. Along with high caloricity, products made from shortcake dough are characterized by low nutritional value; they are not balanced by mineral and vitamin composition [2]. Therefore, the necessity of improving technology of products from shortcake dough, obtaining competitive products with balanced composition and reduced energy value and increased nutritional value is becoming especially relevant today.

An important source of essential nutrients is vegetable raw materials. Vegetable raw materials contain large quan-

ties of vitamins, macro- and micronutrients, antioxidants, dietary fiber, organic acids, etc. [3]. The use of non-traditional phytoenrichment in technology of products from shortcake dough may contribute to increasing their nutritive value and decreasing their energy value. This is possible due to a decrease in high-caloricity components in the formulation [4].

## 2. Literature review and problem statement

One of the promising types of alternative raw materials that may be used for enrichment of flour confectionery is black chokeberry. An analysis of the chemical composition of black chokeberry indicates that it contains biologically active substances:

- easily assimilated sugars (glucose and fructose);
- organic acids (malic, tartaric, citric, sorbic);
- sorbitol;
- carotene (provitamin A);
- minerals, pectin, nitrogenous and other valuable substances;
- phenolic compounds (anthocyanins, catechins, leucoanthocyanins, flavonols), etc. [5].

Studies in vitro and in vivo indicate that plant polyphenols, including anthocyanins, play an important role in maintaining human health. Anthocyanins are effective antioxidants

that accumulate free radicals and inhibit peroxide oxidation of lipids. Due to this fact, anthocyanins have a significant anti-inflammatory, and anti-cancer effects, and some of them have antimicrobial activity [6].

In paper [7], the content of anthocyanins in the black chokeberry, blueberry, raspberry and strawberry was examined. It was found that the largest amount of anthocyanins is contained in black chokeberry (4341 mg kg<sup>-1</sup>). Significant content of anthocyanins in black chokeberry fruit indicates their high antioxidant activity.

Due to the high content of anthocyanins, fruit of black chokeberry may contribute to prevention of occurrence and development of various complications of arterial hypertension [8]. Constant consumption of black chokeberry improves digestion, normalizes activity of cardiovascular system, digestive system, and provides a disinfectant and antisclerotic effect on the human body [9].

In paper [10], it was proved that black chokeberry is worthwhile using in the form of a semi-finished product of multifunctional purpose – paste, which allows preserving quality indicators for a long time. It is established that the use of complex processing of black chokeberry (processing in the vortex layer of ferromagnetic particles of the electromagnetic field, pulping, homogenization, and pasteurization) leads to a more complete extraction of biologically active substances. Such semi-finished product may be used as filling or stuffing in manufacturing flour confectionery.

The use of black chokeberry in the powder form is also promising.

Anthocyanins of black chokeberry fruit were separated from dried raw materials by the extraction with solutions of HCL in water or ethanol alcohol  $\omega=1$  [11]. Their content in water and alcohol extract is almost the same – 1.98 and 2.12 %, respectively. In this case, the total content of bioflavonoids in fruit is known to make about 5 %.

Waste-free technology of deriving finely dispersed powdered vitamin dietary additives from black chokeberry was developed. The technology allows us to save color substances and other biologically active substances and obtain the product, “enriched” by 30...80 % compared with the original raw product. It is different from traditional technologies of obtaining powders by using the processes of mechanoactivation (fine grind), microwave UHF (instead of blanching), vacuum drying and sublimation drying [10].

It was proved [12] that when using ultrasound, not only a significant acceleration of the production process, but also an increase in the yield of the main product, in comparison with other methods of extraction, were observed. By using ultrasound, it is possible to obtain from vegetable raw materials almost all known compounds that are produced by plants.

Ultrasound generates sound wind, which is distributed in the sonicated space in the direction from the emitter. The sound wind creates the overall flow, laminar or turbulent. The force of this wind depends both on ultrasound intensity and on the environment parameters.

Ultrasonic effect is clearly pronounced in the pre-cavitation period of raw material extraction. Powerful ultrasonic waves significantly increase the rate of impregnation of different materials with capillary structure. This is explained by the fact that the lifting height of the liquid under the influence of ultrasound increases and depends directly on the diameter of a capillary and excess sound pressure. Sound-capillary pressure, regardless of the position of the

ultrasound source, is always directed along the normal to the cut of the capillaries.

Soaking time depends on the rate of air displacement from the cell, i.e. on the value of capillary conductivity of raw material. However, many capillaries end in bundles and fibrils without going out. Here, the air is retained until it is dissolved in an extragent. In addition, a part of the air in the form of air bubbles of different configuration remains within the cell.

Ultrasound, which creates a sound-capillary effect, not only accelerates displacement of such air bubbles, but also creates conditions for its dissolving in liquids. Vacuum is formed, that is, a so-called sponge effect occurs. As a result, the time of soaking raw material under the influence of ultrasound is significantly reduced.

The rate of processes of extraction of biologically active substances from vegetable raw materials with the use of ultrasound is influenced by the factors that depend on the physical and mechanical condition of raw material, the nature of the solvent and parameters of sonication.

As it was already noted, the efficiency of the extraction process in many respects depends on morphological-anatomical structure of raw materials, and in this regard, on its dispersion.

While soaking, fresh vegetable raw materials quickly swell in the sonicated media, cells are turgorized within a few tens of minutes. Thus, while the time of optimal swelling under normal conditions is about 2 h, in the case of using ultrasound it takes 30 min of soaking and 10 min of sonication for the raw materials to swell completely.

If the sonicated raw material is a group of strong lignified cells with dense structure, the number of damaged cells becomes the determining parameter for the extraction process. With an increase in the degree of dispersion of raw material particles, the factor of reflectance of sound energy at the bound of phase separation will be minimal, given fast impregnation of chopped raw material by the extracting agent. Dissolution and washout of the content from the destroyed cells occur more intensively.

Therefore, in any case, at sonication, the time of extraction of vegetable raw materials is reduced, while the concentration of the extract increases, so the use of ultrasound technologies for processing black chokeberry is a relevant task.

Thus, for enrichment of shortcake dough products, it is advisable to use fruit of black chokeberry, which is an important source of vitamins, macro- and microelements, pectins and other essential nutrients. It should be noted that there is virtually no research, aimed at enhancing nutritional and biological values of shortcake dough applying black chokeberry additives directly to wheat flour. This method of using this non-traditional raw material could open new ways to enhance the quality and nutritional value of products from shortcake dough. Thus, it is advisable to examine the influence of physiologically active compounds of black chokeberry additives (BCA) on the quality of shortcake dough products.

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### 3. The aim and tasks of the study

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The aim of present study is scientific substantiation and experimental proof of feasibility of using the black chokeberry fruit in processing the products from shortcake dough.

To achieve the set goal, the following tasks were solved:  
 – to explore the effect of BCA on the state of protein complex of wheat flour;  
 – to determine the impact of BCA on the amylolytic activity of wheat flour.

**4. Materials and methods of research**

Objects of research:  
 – higher grade wheat flour;  
 – fresh fruit of black chokeberry (Fig. 1, *a*);  
 – dry fruit of black chokeberry (Fig. 1, *b*);  
 – powder from dried fruit of black chokeberry (Fig. 1, *c*);  
 – gluten, freed from the samples of higher grade wheat flour;  
 – alcohol, aqueous extracts from black chokeberry fruit;  
 – extracts, obtained with the use of ultrasound technology.  
 Preparation of materials and methods of research are described in detail in paper [13].

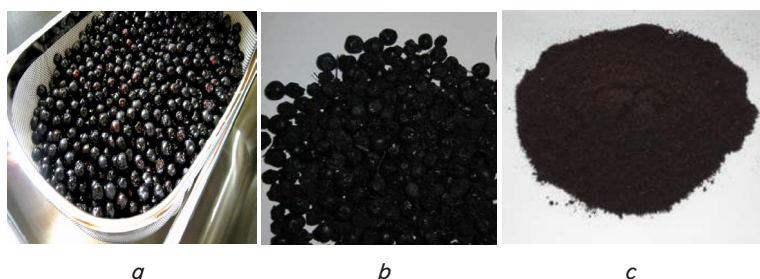


Fig. 1. Objects of research: *a* – fresh fruit of black chokeberry; *b* – dry fruit of black chokeberry; *c* – powder from dry fruit of black chokeberry

**5. Results of examining the influence of black chokeberry additives on the baking properties of wheat flour**

Development of quality shortcake-dough products is defined considerably by the bakery properties of flour, which are determined by the state of its protein-proteinase and carbohydrate-amylase complexes. In this regard, the impact of BCA on the protein-proteinase and carbohydrate-amylase complexes of wheat flour was determined.

The leading role in formation of shortcake dough belongs to enzymes of flour gluten, which at dough kneading absorb water and associate, forming three-dimensional sponge-reticular gluten frame in the dough. The quality of wheat flour gluten is, first of all, affected by thioldisulfate conversion in macromolecules and their ability to bind and retain large masses of water. Fruit of black chokeberry has a complex of physiologically active substances of high reactivity. In direct contact with the gluten proteins, they are sure to participate in the processes of formation of the three-dimensional structure of protein macromolecules.

To reveal this influence, qualitative characteristics of gluten were explored. One was washed out of the dough, made of higher grade wheat flour with the BCA in the amount of 5 % of the flour weight. The second was obtained from the dough, produced on the water extract of black chokeberry with mass fraction of 5 %.

The yield of raw and dry gluten, its ability to stretch and run were selected as characteristics of gluten quality. Results of research into the influence of CBA on the gluten quality of wheat flour are presented in Table 1.

Table 1

Influence of black chokeberry additives on the gluten quality of wheat flour

Examined sample of dough	The yield of crude gluten, %	The products of dry gluten, %	Capability of gluten to stretch, cm	Capability of gluten to run, mm
Without additive	34.2±2.4	14.0±0.8	3.5±0.2	41.0±3.3
With adding BCA	33.4±2.3	14.9±0.6	4.3±0.2	45.0±3.2
On water extract of BC	32.0±1.9	15.5±1.1	3.8±0.2	42.0±3.4

It should be noted that bioflavonoids of black chokeberry are mostly presented by antocyan – glycosides of antocyanidins. Along with its high physiological activity (capacity to strengthen the walls of blood vessels) antocyanidins are complex aromatic compounds that have a number of fairly active functional groups, in particular, hydroxyl groups. Mobility of a hydrogen atom of hydroxyl group is even exacerbated by its conjugation with all aromatic system of pyril cation of the antocyanidin that is a powerful acceptor of electrons of an oxygen atom in the studied group. For the quantitative estimation of

acid properties of the compounds, we carried out potentiometric titration of aqueous extract of black chokeberry fruit with 0.01 n sodium hydroxide solution, results of which are shown in Fig. 2.

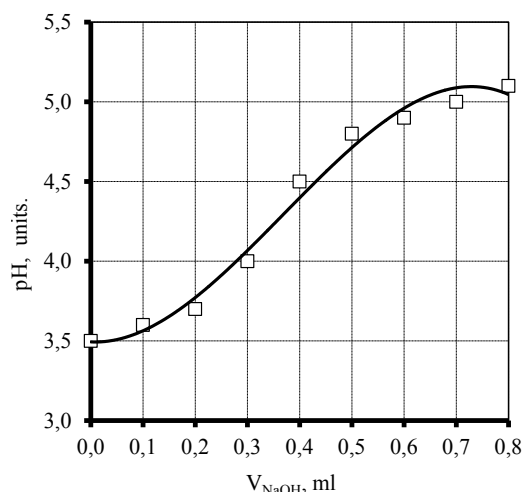


Fig. 2. Potentiometric titration of the aqueous extract of black chokeberry fruit 0.01 n with the solution of NaOH

When evaluating the acid properties of antocyanins, the pH value at the point of half-neutralization was accepted as the pH value. Data in Fig. 1 show that pH value is equal to 3.7. This figure characterizes anthocyanins of black chokeberry as rather strong acids.

Chemical structure and properties of anthocyanidins of black chokeberry implies their easy interaction with functional groups of complex gluten proteins, which may lead to formation of complex donor-acceptor complexes. More polar acidic hydroxyl group of anthocyanidins win the “competition” with water and take its place in the protein complex of gluten. Hydrate shell of macromolecules decreases, which results into the decreased capacity of macromolecules to retain water.

There is more (by 6...11 %) dry gluten, that is, proteins themselves, in the dough that is made with BCA than in the dough that is made by usual way. This fact indicates that gluten proteins almost were not subjected to the action of proteolytic enzymes of both flour and the additive. A complex set of various chemicals of the additive probably blocks the action of proteolytic flour enzymes, acting as their inhibitors, yet unknown in what way.

It is known that a change in the concentration of hydrogen ions in the medium of fermentative reaction is accompanied by a significant change in its rate. Each enzyme in full degree reveals its action at a certain pH value, which is called pH-optimum. The optimum of action of enzymes-protease of wheat flour is 5.5 [14, 15]. Acid polyphenol compounds of BCA, especially when using water extract, decrease the pH value of the dough semi-finished product and inhibit the enzymatic hydrolysis of gluten proteins. Inhibition of hydrolysis may be caused by the destabilization of the active center of proteolytic enzyme and generally throughout the tertiary structure of the enzyme-substrate complex by polyphenol chemicals of the additive.

Such behavior of the additive shows that black chokeberry does not have (or has a very small amount) active enzymes-protease in its composition and their action is weak.

We studied relative viscosity of aqueous solutions of gelatin that were preliminary kept with addition of aqueous extract of black chokeberry fruit with the mass fraction of 5 %. The obtained data indicate that viscosity of gelatin solutions did not decrease after the influence of the extract of raw materials, but, in contrast, quite noticeably increased.

While the gelatin solution ( $\omega=1$  %) had relative viscosity of 1.41, its solution with  $\omega=2$  %, diluted by half, that is, to the concentration of 1 %, with water extract from dry fruit of black chokeberry with  $\omega=5$  % had viscosity of 2.45. This increase in viscosity may be explained by the contribution of its natural viscosity to the fruit solution with  $\omega=5$  %. However, the natural viscosity of this fruit extract was equal to 1.2. We consider that it cannot affect the final viscosity of the solution as a result of simple addition of magnitudes.

The obtained result cannot characterize the activity of enzymes-proteinase of black chokeberry fruit. Along with the possible process of fermentative gelatine hydrolysis, there goes a much more powerful process of formation of a strong complex. This is a complex between phenolic substances of black chokeberry fruit and lateral functional groups of high-molecular protein.

As a result of this, molecular weight of protein associate, the main indicator of which is viscosity, increases. These data are completely consistent with the previously obtained indicators of the yield of raw and dry gluten at washing it out from the dough with BCA. Polyphenols of black chokeberry form strong complexes with lateral functional groups of gluten proteins and squeeze water from associates. As a result, output of raw gluten decreases, and due to the lack of proteolytic activity of black chokeberry fruit, the yield of dry gluten increases.

Such low proteolytic activity of raw materials may be explained by the inhibition of enzymes-proteinase by polyphenolic substances of the objects and screening of the effect of hydrolysis of substrate proteins by complexing process between them and substances of raw materials.

Data on the yield of dry gluten testify against the last method – pure protein was obtained as a result of the experiment. Under such conditions, preserving the structure of the complex between protein and polyphenols in black chokeberry fruit seems unlikely, because the energy of hydrogen bonds is very small and is comparable with the energy of thermal motion.

However, to obtain some more reliable evidence of the process of inhibiting proteolytic enzymes of wheat flour, it is necessary to explore the process of hydrolysis of proteins of flour gluten under the influence of both its own proteolytic enzymes and in the presence of BCA.

It is known that proteolytic activity of enzymes may also be determined by the nature of breakdown of protein substances and by the amount of the formed hydrolysis products, that is free amino acids [16]. The number of the formed amino acids is determined by the content of nitrogen amino-groups that is analysed by formolic or potentiometric titration. The authors carried out the study of autolytic activity of wheat flour both without additives and in the presence of CBA (its aqueous extract from  $\omega=5$  % and dry powder at concentrations of 5 % relative to flour weight). The number of amino acids, formed as a result of fermentative hydrolysis, was determined by formolic titration. The results of research into the influence of CBA on the content of free amino acids in products of wheat flour autolysis are shown in Table 2.

Table 2

Influence of black chokeberry additives on the content of free amino acids in the products of autolysis of wheat flour

Substrate	Content of amino acids in hydrolysate, mg/100 g
Aqueous suspension of wheat flour	352.3±28.2
Suspension of wheat flour in water extract of black chokeberry	212.6±14.9
Water suspension of wheat flour with BCA	155.1±13.9

Data of the experiment are completely consistent with the previous ones. Extract and powder of fruit not only does not demonstrate any proteolytic activity, but also quite actively inhibit the process of breakdown of protein molecules under the influence of proteolytic enzymes of wheat flour. This is proved by a sharp decrease in the content of amino acids in hydrolysate in cases of using the BCA.

In this case, as well as previously, dry powder of fruit inhibits processes of proteolysis more actively, which is again due to greater content of active substances-inhibitors in the reaction mixture.

Such active processes of inhibition of proteolytic enzymes of wheat flour, which belong to the class of hydrolases, suggest that other hydrolytic flour enzymes might be paralyzed by the influence of the BCA. Therefore, we studied the influence of black chokeberry additives on saccharification activity of wheat flour, that is, activity of its enzymes-amylases. The process was controlled by defining the amount



of maltose in the reaction mixture, which is characterized by the so-called maltose number. The results of studying the influence of BCA in the form of powder and its aqueous extract in terms of amylolytic activity of wheat flour are presented in Table 3.

Table 3

Influence of black chokeberry additives on the amylolytic activity of wheat flour

Substrate	Maltose number, % of maltose
Aqueous suspension of wheat flour	4.10±0.37
Suspension of wheat flour in aqueous extract of black chokeberry	0.72±0.04
Aqueous suspension of wheat flour with the CBA	2.91±0.17
Suspension of wheat flour in fresh juice of black chokeberry	–

The mechanism of inhibition of enzymes-amylases by preparations of black chokeberry may be interpreted in different ways. Optimum pH of action of enzymes-amylases is 5.6 [14], acid extracts of black chokeberry fruit decrease pH of the media and thus decrease the activity of enzymes. To test this mechanism, amylolytic activity of wheat flour was defined in the presence of preparations of black chokeberry. The pH of the reaction media was maintained within 5.5...6.0. The mixture was neutralized with the solution of sodium hydrocarbonate.

The obtained indicators of maltose content in the reaction mixture are listed in Table 4.

Table 4

Influence of black chokeberry additives on the amylolytic activity of wheat flour (pH of media – 5.5...6.0)

Substrate	Maltose number, % of maltose
Aqueous suspension of wheat flour	4.10±0.37
Suspension of wheat flour in aqueous extract of black chokeberry	0.93±0.07
Aqueous suspension of wheat flour with BCA	3.21±0.13
Suspension of wheat flour in fresh juice of black chokeberry	–

Polyphenols of black chokeberry are aromatic structures, so their molecule is located in one plane. Inter-molecular bonding of the metal cation by two phenolic hydroxyls of a single molecule is almost impossible because of the existence of steric hindrances.

Therefore, perhaps, there is an interaction of the metal cation with two different molecules of antocyanidins with formation of compounds with twice as large molecular weight. As a result of this process, cations of metals-activators are removed from the reaction mixture and become unavailable for activation of enzyme-substrate complex. This in turn leads to inhibition of hydrolytic processes in wheat flour (action of enzymes-amylases of wheat flour is inhibited by 29...82 %).

To test this assumption, we determined amylolytic activity of wheat flour in presence of a recognized activator of amylases – cation  $Ca^{2+}$ . The results of studying the influence of BCA in the presence of cation  $Ca^{2+}$  on the amylolytic activity of wheat flour are presented in Table 5.

Table 5

Influence of black chokeberry additives in the presence of cation  $Ca^{2+}$  ( $C_{Ca^{2+}} = 0,1\%$ ) on the amylolytic activity of wheat flour

Substrate	Maltose number, % of maltose
Aqueous suspension of wheat flour + $Ca^{2+}$	8.56±0.34
Suspension of wheat flour in aqueous extract of black chokeberry + $Ca^{2+}$	1.53±0.09
Aqueous suspension of wheat flour with BCA + $Ca^{2+}$	3.94±0.28

BCA was found to paralyse almost completely the action of wheat flour enzymes in the presence of calcium ions, binding all ions in the reaction mixture in strong complex compounds.

## 6. Discussion of results of examining the influence of black chokeberry additives on the baking properties of wheat flour

It was found (Table 1) that BCA weakens flour gluten (ability of stretching increases by 9.23 %). This is a positive factor for the formation of shortcake dough.

The dough becomes more elastic and does not require addition of starch, often added to formulas with the aim of enhancing plasticity of the formulation mixture. It is known that such an effect is accompanied by an increase of free sulfhydrylic groups in protein molecules of gluten. Probably, a powerful influence of polyphenolic substances of black chokeberry may be considered the reason for this significant shift of thioldisulfide equilibrium in the direction of thiolic groups.

Due to the existence of hydroxyl groups in the molecule of phenolic compounds and peculiarities of the electronic structure of the benzene ring, they have unique properties. The main is the ability of reverse oxidation, that is, transition of phenolic forms to quinoid ones.

Due to this, virtually all phenolic substances have clearly pronounced antioxidant activity [17–19]. In the reaction mixture, hydroxyls of phenolic fragment come into redox reaction. The consequence of this reaction is formation of two free sulfhydrylic groups of one disulfide bridge.

As a result of this process, a number of sulfhydrylic groups in gluten proteins increases greatly and gluten becomes weaker.

The black chokeberry powder more actively affects this process compared to the extract, which may be explained by greater concentration of polyphenols in dough semi-finished product in case of using the dry preparation. The yield of raw gluten when using the BCA decreases by 3...6 %. This indicates the decrease of hydrogen bonds in protein macromolecules and their partial loss of binding and water retaining properties. This process is explained by competition between

molecules of water and of hydroxylic groups of bioflavonoids for functional groups of protein molecules.

This process plays a positive role in formation of shortcake dough. Shortcake dough kneading should be carried out within a short period of time, otherwise gluten proteins will start swelling and dough “tightens” and quickly loses its plasticity. The use of BCA containing polyphenolic substances prevents gluten proteins of wheat flour from swelling due to a decrease in water retaining capacity. This allows us to increase the duration of making a semi-finished product from shortcake dough and provides the possibility of its storing for a long time before baking.

The obtained experimental data (Table 3) outline a clear picture: preparations of black chokeberry are powerful inhibitors of enzymes-amylases of wheat flour. In this case, the inhibition pattern is slightly different from the case with enzymes-proteinases of flour. The aqueous extract of fruit inhibits amylases in a more powerful way than the powder from dry fruit, while the case of proteolytic enzymes is quite opposite.

The obtained data (Table 4) practically coincide with those previously obtained (Table 3) when using preparations of black chokeberry without neutralizing their acidic properties. We established almost imperceptible but steady increase in the maltose number, which may be explained by acidic inhibition of enzymes, but the contribution of such way of inhibition is insignificant. It was proved that a change in pH of the medium has practically no impact on those elements of the structure of black chokeberry compounds, responsible for the enzyme-inhibiting action.

The possibility of existence of quinoid form as two resonance structures contributes to overall stabilization of the system. In addition, this does not affect reactive characteristics of major functional groups of molecule, in particular hydroxyl. This explains the inhibiting action of compounds of black chokeberry at any pH values of the reaction media.

The results of exploring the influence of BCA in the presence of cation  $\text{Ca}^{2+}$  on the amylolytic activity of wheat flour (Table 5) indicates a higher degree of amylases inhibition by the extract or juice of black chokeberry compared with the powder of dry fruits.

This may be explained by the fact that water-soluble phenolic compounds of black chokeberry in the reaction mixture immediately interact with metal cations that exist there and bind them in strong complexes. When using dry powder from black chokeberry fruit, it takes some time for polyphenolic compounds to be extracted by water and to become available for reactions with cations. During this time,

the amylases of flour have already partly managed to fulfill its hydrolytic function.

The obtained experimental data make it possible to control hydrolytic processes in the dough semi-finished product. This provides the possibility of its storing for a long time before baking. In addition, it also expands the possibility of using wheat flour of lower grades after neutralizing harmful action of enzymes, especially  $\alpha$ -amylases.

Thus, the use of BCA in the processing of products from shortcake dough not only contributes to increasing their nutritional value, but also enables us to improve the quality of shortcake dough. Based on the performed research into the influence of BCA on the main formulation component of shortcake dough, wheat flour, it was found:

- BCA weakens gluten of wheat flour;
- BCA prevents swelling of gluten proteins.

All this has a positive effect on the process of shortcake dough formation and provides the possibility of its storing for a long time before baking.

The prospects for further research involve research into the influence of BCA on the state of a fat component of shortcake dough.

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## 7. Conclusions

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1. The influence of physiologically active compounds of BCA on the quality of wheat flour gluten was explored. BCA in the form of powder and its water extract was found to weaken flour gluten, which is a positive factor for the shortcake dough formation. The gluten capability of stretching increases by 9...23%. The dough becomes more plastic. It does not need any addition of starch, which is often added to formulations with the aim of enhancing plasticity of a formulation mixture.

Polyphenolic substances were found to prevent swelling of gluten proteins of wheat flour due to a decrease in water retaining capacity, which provides the possibility of its storing for a long time before baking.

2. We established a higher degree of inhibition of amylases in wheat flour by the extract of black chokeberry fruit or its juice compared to the powder from dry fruit. Water-soluble phenolic compounds of black chokeberry in reaction mixture interact with metal cations, existing there, and bind them in strong complexes. The obtained experimental data allow us not only to control hydrolytic processes in the dough semi-finished product, but also to extend the possibility of using wheat flour of lower grades after neutralizing the harmful action of enzymes in it.

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