# Use of chokeberry in the preparation of bakery products

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## Abstract

**Introduction.** The purpose of the study was to determine the quality indicators of chokeberry fruits and their by-products, to select the most promising ones for improving the sensory and physicochemical properties of bakery products and their stability during storage.

**Materials and methods.** Chokeberry fruit, puree, and juice were used for their inclusion to the recipe of bakery products. The titrated and active acidity, content of dry substances, pectin, L-ascorbic acid, colorants, phenolic substances, organic acids, sugars and biological activity were determined in phyto-raw materials.

**Results and discussion.** The valuable chemical compounds, g/100 g fresh weight (FW): phenolic substances (0.9), organic acids (2.3), sorbitol (7.19), glucose (3.67), fructose (3.22), fiber (2.3), ash (0.85), and, mg/100 g FW: ascorbic acid (37) and high biological activity were found in the chokeberry by-products. It was found the presence of citric acid – 0.04 g/100 g, malic acid – 1.20 g/100 g, succinic acid –1.05 g/100 g of fresh fruits. Malic acid dominated among organic acids – 52.0% of the total content, succinic acid – 45.9%. Colorants predominated among phenolic substances consisted 70.5%. The content of anthocyanins was 95.9% of total the flavonoids.

When preparing bread from wheat flour of the 1st grade, chokeberry puree was added in the amount of 3, 6, 9, and 12% to the weight of flour, intensification of dough fermentation was found. The addition of puree in the amount of 3 to 9% to the mass of flour had a positive effect on the specific volume, porosity and acidity of the products. The color of the crust and crumb of the bread changed, and an uncharacteristic color and taste of the finished product appeared. The volume of bread increased by 2.6%, porosity by 3.7%, and the structural and mechanical properties of the pulp improved. Loss of freshness of bread enriched with 9.0% chokeberry puree after 72 hours of storage was 22.7%, and the total deformation of the crumb decreased by 49.4% compared to the control. Chokeberry puree was effective in preventing the development of potato disease of bread within 120 hours of storage.

**Conclusions.** The studies of the quality characteristics of chokeberry by-products showed their valuable chemical composition and high biological activity. Addition of chokeberry puree to bread increased its specific volume, porosity, and sensory characteristics.

## Introduction

Considering the need to ensure food security, sustainable development in the world and improve the nutritional value of food products, herbal raw materials are widely used in the food industry (Ivanov et al., 2021; Stabnikova et al., 2021).

Chokeberry fruits are rich in valuable compounds in its composition. Ripe fruits contain 74.1–81.0% water, 6.5–10.6% sugars, 0.3–0.6% pectin substances, 0.1–0.2% nitrogen substances, 0.7–1.8% organic acids. The total amount of mineral substances varied from 1.85 to 2.97% dry matter (DM). The iodine content in it is 0.005–0.01 mg/100 g of ripe fruits, while only red currants and persimmons contain the same amount of iodine – 0.0021–0.0021 mg/100 g (Bakhshaliyeva et al., 2023), although feijoa fruits contain more of it – 0.008–0.009 mg/100 g (Ferrara and Montesano, 2001). However, the most valuable component in the composition of chokeberry is bioflavonoids – catechins, flavonols, and anthocyanins (Sidor and Gramza-Michałowska, 2019). Chokeberry and their by-products have antioxidant properties, which makes them a valuable additive to different food products (Aksoy, 2023).

Chokeberry fruits are characterized by a tart and bitter taste. That is why they are rarely consumed in fresh form. They are processed for the production of juices, jams, beverages, preserves, wines, liqueurs, and infusions, jellies, and for obtaining food extracts and colorants (Kitryte et al., 2017).

Nowadays, chokeberry fruits in form of dry powder or extracts are used in preparation of functional food products, such as yogurt (Cuşmenco and Bulgaru, 2020; Ryzhkova et al., 2023), kefir (Du and Myracle, 2018), confectionary (Ghendov-Mosanu et al., 2022; Sady and Sielicka-Różyńska, 2019), and bakery (Koshak and Pokrashinskaya, 2020).

The technology of cookies with chokeberry additives was developed. Addition of 5% chokeberry powder and 5% chokeberry extract to the mass of wheat flour showed that the protein content increased by 1.3±0.1% in cookies compared to the control sample without chokeberry, phenolic compounds – by 0.04–0.21%. The determination of the peroxide index of lipids in cookies showed its decrease by 38.75–42.5% because of the effect of chokeberry phenolic substances on reduction free fatty acids and volatile carbonyl compounds (aldehydes and ketones) formation, which will contribute to slowing down the oxidation of fats during storage (Sady and Sielicka-Różyńska, 2019).

The effect of chokeberry powder on the quality of pasta made from flour with different gluten content (2.5 – 25%) was investigated. It was established that when using flour of normal quality with 25% gluten content, the addition of chokeberry powder in the amount of 5% to the weight of flour had a positive effect on the mechanical strength of pasta products, increasing it by 20% compared to the control sample without chokeberry powder. When using flour with 18% gluten content, pasta was obtained with a strength of 0.66 N and the amount of dry substances that passed into the cooking water was less than 7.9%. It means that chokeberry can be used as a pasta improver (Koshak and Pokrashinskaya, 2020).

During the processing of chokeberry fruits, pomace is obtained which is waste. Pomace has greater antioxidant activity than juice or powder (Mayer-Miebach et al., 2012). Lyophilized chokeberry pomace was added to wheat bread in the amount 1, 2, 3, 4, 5, and 6% to the weight of flour. The addition of pomace increased the water absorption of the flour, but caused a decrease in stability and loosening of the dough, leading to an increase in softening. The volume of bread decreased, and the hardness of the crumb increased. Bread enriched with pomace had higher content of minerals, dietary fibers, phenolic compounds and a higher antioxidant activity compared to the control bread. Sensory evaluation showed that the rational dosage of lyophilized chokeberry pomace was no more than 3%. Then dietary fiber content increased by 80.9%, ash content – by 2.6%, fat content – by 26.5%, and total phenolic content – by 272%. Protein content reduced by 1.2% and the carbohydrate content – by 4% compared to the control sample (Cacak-Pietrzak et al., 2023).

Considering the valuable components of chokeberry and the mass consumption of baked goods, it is important to consider the possibility of using chokeberry to improve the quality and nutritional value of bakery products.

The aim of the present study was to determine the effect of chokeberry puree on sensory and physicochemical properties of bread from wheat flour, and its stability during storage.

## Materials and methods

### Materials

Chokeberry fruit (variety 'Vseslava', Ukraine), puree and juice were used for research. Dough samples were prepared according to the recipe, % by mass of flour: wheat flour – 100.0%, pressed baker's yeast – 3.0%, salt – 1.5%. Black chokeberry puree was added to the experimental samples in the amount of 3.0%, 6.0%, 9.0%, and 12.0% to the mass of flour. The dough with 44.0% moisture was kneaded in a steamless method. The fermentation period lasted for 60 – 90 minutes. The dough was kneaded in a two-speed Kenwood KVC 5100T kneading machine (China). The dough pieces were left in a thermostat at a temperature of 38±2°C and a relative humidity of 78±2% until ready. The products were baked in a Sveba-Dahlen cabinet oven (Italy) at a temperature of 200–220 °C with humidification of the baking chamber for 30 minutes.

### Methods

#### Phenolic compounds content in chokeberry by-products

The content of phenolic compounds was determined by the method of high-performance liquid chromatography on an Agilent Technologies chromatograph (model 1100). A chromatographic column 2.1 × 150 mm filled with an octadecylsilyl sorbent with granule size of 3.5 μm, "ZORBAX" SB-C18, was used for the analysis.

The detection parameters were set: wavelength – 313 nm (for phenolic acids and their derivatives), 350 nm (for glycosides of flavones), 371 nm (for flavones), 525 nm (for anthocyanins); for a fluorescent detector extinction was 280 nm, emission – 320 nm for catechin and epicatechin; measurement scale – 1.0; scan duration – 2 sec. Parameters of spectrum capture – each peak 190 – 600 nm.

Identification of phenolic compounds was carried out by retention time of standards and spectral characteristics (compared to literature data of high-performance liquid chromatography of berries and juices) (de Araújo et al., 2014).

#### Amount of sugars and organic acids in chokeberry by-products

To analyze the content of sugars and organic acids in chokeberry processed products, 5 g of pulp was placed in a 10 ml measuring tube and brought up to the mark with water. After 30 min of exposure in an ultrasonic bath, the solution was filtered through a Teflon membrane filter with a pore size of 0.45 μm into a vial for analysis.

A carbohydrate chromatographic column 7.8×300 mm "Supelcogel-C610H" was used to analyze the content of organic acids and sugars by the method of high-performance liquid chromatography.

To carry out the analysis, the following chromatography mode was set: mobile phase supply rate 0.5 ml/min, eluent aqueous 0.1% $H_3PO_4$ solution, the working pressure of the eluent was 33-36 kPa, the temperature of the column thermostat was 30 °C, sample volume – 5 µl.

Spectrophotometric detection parameters were set as follows: wavelength 210 nm, gap width 8 nm, scanning time 0.5 – 1.0 s.

Identification of organic acids and sugars was carried out according to the retention time of the corresponding standards (Rodrigues et al., 2021).

**Biological activity in chokeberry by-products**

For determination of biological activity in chokeberry fruit (Patent of Ukraine G01N33/00/ The method of determining the biological activity of objects of natural origin), fruits were ground in the presence of quartz sand and a phosphate buffer solution at pH 6.8-7.4. Then, it was transferred with a buffer solution into a volumetric flask at a dilution of 1:(50-200), infused with a buffer solution for 8-12 minutes and filtered. The prepared extract was diluted in distilled water in a ratio of 1:(10-100) and added to a mixture of buffer and potassium ferrocyanide, a solution of $NAD \times H_2$ was introduced, and the biological activity was calculated by the ratio of the change in the oxidation rate $NAD \times H_2/NAD$ in the control and test samples, taking into account the dilution. The oxidation rate was determined by measuring the optical density of the solutions of the test and control samples at a wavelength of 325 nm and a thickness of the absorbing layer of 10 mm (at t=120 s) according to the formula (1):

$$BA = \frac{(A_0^s - A_{120}^s) \cdot V \cdot K}{(A_0^c - A_{120}^c) \cdot m} \quad (1)$$

where BA – biological activity, units of activity; $A_0^s$ – initial optical density of the test sample; $A_{120}^s$ – initial optical density of the test sample after 120 s; $A_0^c$ – initial optical density of the control sample; $A_{120}^c$ – initial optical density of the control sample after 120 s; V – capacity of the measuring flask, ml; K – the degree of dilution of the extract in distilled water, m – weight of raw material, g.

The indicator of biological activity in chokeberry juice was determined by the method of controlling the electron transport activity of juice in the system of reduced nicotinamide adenine dinucleotide ($NAD \cdot H_2$) – potassium ferrocyanide in a phosphate buffer (pH=7.5) (Ivanisová et al., 2015). During the interaction of reduced nicotinamide adenine dinucleotide with potassium ferrocyanide in a phosphate buffer, the transfer of electrons was catalyzed by the phenolic compounds of juice, that possess electron transport properties, in particular, the transfer rate depends on their nature and concentration. The value of biological activity was calculated from the ratio of the oxidation rate of $NAD \cdot H_2/NAD$ in the control sample and the test sample, taking into account the dilution, and the oxidation rate was determined by measuring the relative density of the analyzed solutions at a wavelength of 325 nm and a thickness of the absorbing layer of the cuvette of 10 mm according to the formula (2):

$$BA = \frac{\Delta A_s}{\Delta A_c} K \quad (2)$$

where BA – biological activity, units of activity, $\Delta A_s$ – value of the optical density of the test sample, $\Delta A_c$ – value of the optical density of the control, K – the dilution factor.

### Gas-forming capacity of flour

The gas-forming capacity of flour was determined using the AG-1 device by the amount of released carbon dioxide (ml) at a temperature of 30 °C during 5 hours of fermentation of the dough from 100 g of the studied flour, 60 ml of water and 10 g of pressed yeast (Shevchenko et al., 2023a).

### Amount and quality of gluten in flour

The amount of wet gluten in flour was measured as the ratio of the mass of washed raw gluten to the mass of flour, expressed as a percentage.

Gluten deformation indexwas measured using the principle of the residual deformation of the gluten sample after the effects of the tare load during the 30 sec (Shevchenko et al., 2023b).

### Sensory evaluation of bread

Bread quality was assessed by sensory parameters – appearance, surface condition, crust color, porosity structure, taste, smell (Galenko et al., 2024). The scoring of bread was carried out with the involvement of 20 tasters by the 5-point scale of individual indicators (Sammalisto et al., 2021).

### Moisture of bread crumb

Moisture of bread crumb was determined by drying the weight in a SESH-3M drying cabinet (Ukraine) at a temperature of 130°C for 40 min (Hetman et al., 2021).

### Acidity of bread crumb

Acidity of bread crumb was determined by titrating the extract prepared from bread crumb with sodium hydroxide solution or potassium in the presence of a phenolphthalein indicator (Hetman et al., 2021).

### Porosity of bread crumb

The porosity of bread crumb was determined as the volume of pores in a certain volume of crumb, expressed as a percentage of the total volume.

### Specific volume of bread

The volume of bread was determined on special device - a volume meter (capacity with small grain), which works on the principle of squeezing out grain with bread. The volume of extruded grain (ml), measured using a cylinder, corresponds to the volume of bread (Shevchenko et al., 2022). The specific volume of bread was determined by dividing the volume of bread by its mass and was expressed to the nearest 1 ml/100 g (Zhu et al., 2016).

### Dimensional stability of bread

The dimensional stability of bread was determined by measuring the height and diameter of bread (mm) and was evaluated by their ratio (Shevchenko et al., 2022).

### Deformation of bread crumb

Deformation of bread crumb is measured as the amount of immersion (penetration) of an equipment of a certain shape and size under the influence of a certain load for a certain time. To characterize the structural and mechanical properties of pulp, its relative plasticity and elasticity were determined (Bilyk et al., 2022; Wongsagonsup et al., 2015).

### Mold and Potato disease of bread

Bread crumb is put to the plate containing a growth medium (agar) and then analyzing the plate under a microscope for colonies of mold (viable or cultured sample analysis) (Garcia and Copetti, 2019). Potato disease of bread was determined after baking and storage during 2 days by observation the process of growth of molds (Uazhanova, 2014).

### Statistical analysis

The data represents the mean of a minimum three replicates ± standard deviation (S.D.).

## Results and discussions

Chokeberry fruits were analyzed at the stage of consumer ripeness. According to the sensory evaluation, chokeberry fruits had intensive black color, a pleasant astringent taste and a weak aroma.

Physico-chemical indicators of raw materials are important for determining their potential influence on the quality characteristics of products, to the recipe of which they will be added. It was determined that the chemical composition of chokeberry fruits contain up to 80.0% water, they have a sufficiently high titrated acidity (Table 1).

**Table 1**

**Physico-chemical characteristics of chokeberry fruit**

| Indicators | Content | Indicators | Content |
|---|---|---|---|
| Dry matter, g/100 g FW | 20.5±0.1 | Citric acid, g/100 g FW | 0.04 |
| Titrated acidity, grades | 1.38±0.12 | Malic acid, g/100gFW | 1.20 |
| Pectin, g/100 g FW | 0.3±0.1 | Succinic acid, g/100 g FW | 1.05 |
| Protopectin, g/100 g FW | 0.6±0.1 | L-ascorbic acid, mg/100 g FW | 37.50±0.75 |
| Fiber, g/100 g FW | 2.3±0.2 | Colorants*, mg/100 g FW | 718.86±5.14 |
| Ash, g/100 g FW | 0.85±0.03 | Phenolic compounds, mg/100 g FW | 1020±15.81 |

Note: * – conversion to cyanidin

Among the organic compounds carbohydrates predominated. Polysaccharides consisted mainly of pectin substances and fiber. The content of pectin substances was 0.9%. Determination of the composition of organic acids of chokeberry fruits indicated the presence of citric acid – 0.04 g/100 g of raw material, malic acid – 1.20 g/100 g, succinic acid –1.05 g/100 g. Malic acid dominated among organic acids and consisted 52.0% of the total content, followed by succinic acid, 45.9%. The presence of these acids is valuable in view of their properties. It is known that malic acid has anti-inflammatory, anti-edematous, and laxative effects (Chen et al., 2024), and succinic acid has the ability of a reducing and radical-accepting agent responsible for antioxidant protection (Chien et al., 2008).

The largest amount of soluble solids in chokeberry fruits were sugars. It was found that they are represented by hexoses – glucose – 3.67 g/100 g of raw material and fructose – 3.22 g/100 g of raw material. Chokeberry fruits contains sorbitol – 7.19 g/100 g of raw material, which consisted 51% of the total sugar content. The presence of sorbitol indicates the therapeutic and preventive properties of chokeberry fruits (Banjari et al., 2017). The high content of phenolic substances was determined in chokeberry fruits (Table 1), and colorants predominated among phenolic substances, their content was 70.5% of their total content.

Flavonoids were also present in chokeberry fruits (Zheng and Wang, 2003). Fractional composition of phenolic compounds in chokeberry fruits is shown in Table 2.

**Table 2**

**Composition of phenolic compounds in chokeberry fruits**

| **Compounds** | Oxycinnamic acids and their derivatives | Flavones and their derivatives | Anthocyanins | Total amount of flavonoids |
|---|---|---|---|---|
| Content, mg/100 g | 180.97 | 29.32 | 689.55 | 718.87 |

It was determined that anthocyanins predominated among the flavonoids of chokeberry fruits. In chokeberry fruits anthocyanins were represented by glycosidamicianidin with carbohydrates – glucose, galactose, arabinose and xylose. The amount of anthocyanins among the flavonoids was 95.9%. The composition of anthocyanins was dominated by cyanidin-3-O-galactoside – 442.43 mg/100 g (64.2% of the total content of anthocyanins), cyanidin-3-O-arabinoside – 185.36 mg/100 g (26.9%) and almost equal proportions of cyanidin-3-O-glucoside (31.72 mg/100 g) and cyanidin-3-O-xyloside (30.03 mg/100 g). Among the flavonoids there were representatives of flavones, their amount was 4.1% of the total content of flavonoids, and they were represented by quercetin-3-O-glucoside (20.95 mg/100 g) and quercetin-3-O-galactoside (8.37 mg/100 g).

The highest content of phenolic substances and, in particular, colorants was found in the peel of the fruit, their content was 2050 mg/100 g and 1500 mg/100 g, respectively.

The food industry often uses by-products of chokeberry processing – juice and puree, so the quality indicators were determined specifically in them (Table 3).

The obtained results show that the content of pectin, colorants and pectin substances in puree was higher than in juice obtained by pressing from crushed chokeberry fruits. During such preliminary processing of raw materials, the yield of juice was only 50% of the mass of raw materials, and the yield of puree was 76%. The extracts obtained after extracting juice contained 810 mg/100 g of colorants and 1050 mg/100 g of phenolic substances in their composition, which also confirms the fact that a significant part of them removes as waste, which can also be used for further processing with obtaining low-grade puree, extracts or powders.

**Table 3**

**Physico-chemical characteristics of chokeberry by-products**

| Indicators | Chokeberry juice | Chokeberry puree |
|---|---|---|
| Dry matter, g/100 g FW | 15.20±0.62 | 16.80±0.73 |
| Titrated acidity, degrees | 1.34±0.17 | 1.31±0.07 |
| Pectin, g/100 g FW | 0.45±0.05 | 0.88±0.08 |
| L-ascorbic acid, mg/100 g FW | 18.21±1.12 | 14.20±0.98 |
| Colorants, mg/100 g FW | 224.80±9.80 | 340.80±9.93 |
| Phenolic compounds, mg/100 g FW | 368.20±15.50 | 530.50±15.80 |
| pH, units | 3.46±0.05 | 3.50±0.05 |

The presence of phenolic substances in chokeberry fruits and by-products, in particular, anthocyanins cause their high biological activity and antioxidant properties (Figure 1).

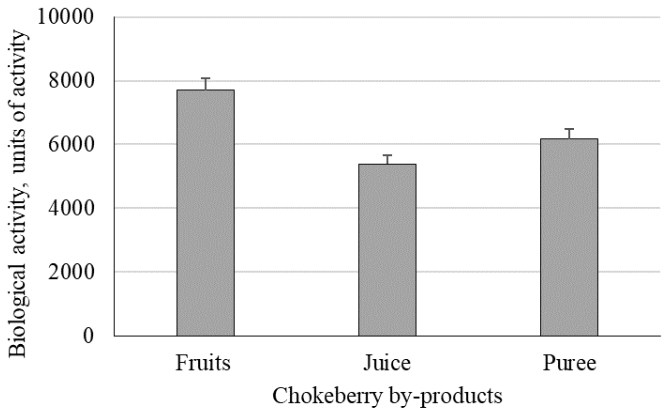


**Figure 1. Biological activity of chokeberry fruits and by-products**

The results of studies of biological activity during the production of juices and purees showed their decrease compared to fruits. However, in puree samples, the indicator of biological activity was higher by 14% in comparison with juice.

Thirty-five volatile compounds were determined in chokeberry juice, 34 of which were identified. Aromatic compounds included alcohols, acids, aldehydes, ketones, lactones, ethers, and heterocyclic compounds. The dominant group of acids was benzoic acid (15 mg/l), which indicated the presence of a natural antioxidant in chokeberry.

Thus, a more rational was using chokeberry puree to enrich food products. When producing bread of high quality when adding chokeberry by-products the properties of flour as the main raw material are extremely important.

The flour was characterized by average baking properties: flour moisture – 14%, wet gluten content – 29.2%, gluten deformation index – 85 device units, extensibility – 17.5 cm, gas generating capacity – 1500 ml/100 g. Fermentation was more intensive in all experimental samples. The best effect was in the dough with the content of puree in the amount of 9.0% by mass of flour (Figure 2).


**Figure 2. Dough (a) and bread (b) with different amount of chokeberry puree:**
1 – control; 2 – 3%; 3 – 6.0%; 4 – 9.0%; 5 – 12.0%

The addition of chokeberry puree caused a change in color, giving a pleasant purple color, intensity of which increased with increasing dosage (Figure 3).

The addition of puree in the amount of 3 to 9% to the mass of flour had a positive effect on the specific volume, porosity and acidity of the products, a tendency to strengthen the structure of the dough and increased the dimensional stability of bread (Table 4).

Addition of 12% chokeberry puree decreased specific volume by 1.02%.

In the case of adding puree to the dough, the general, plastic and elastic deformation of the pulp improved in all samples. However, the best result was obtained with a puree content of 9% by weight of flour. Thus, the loss of freshness of bread enriched with 9.0% puree after 72 hours amounted to 22.7% compared to the control bread, the total deformation of the crumb during this period decreased by 49.4%.

Evaluation of the microbiological stability of samples of bread wrapped in polyethylene film during 120 hours of storage showed that the addition of chokeberry puree was effective in preventing the development of potato disease and mold.

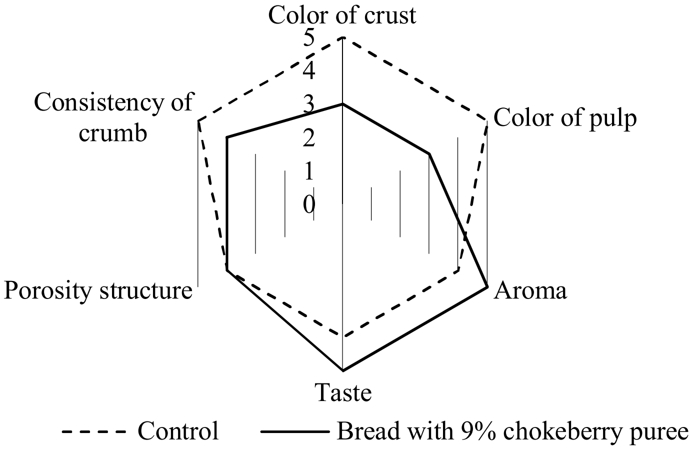


**Figure 3. Evaluation of sensory indicators of wheat bread with 9% of chokeberry puree**

**Table 4**
**Physico-chemical and microbiological indicators of the quality of wheat bread with chokeberry puree**

| Indicators | Control | Additive dosage, % by mass of flour | | | |
|---|---|---|---|---|---|
| | | 3 | 6 | 9 | 12 |
| Moisture content, % | 42.8 | 43.2 | 43.0 | 42.8 | 43.6 |
| Specific volume, ml/g | 2.93 | 2.92 | 3.13 | 3.19 | 2.90 |
| Form stability, H/D | 0.59 | 0.65 | 0.63 | 0.61 | 0.57 |
| Porosity, % | 69.8 | 70.1 | 71.6 | 72.4 | 69.7 |
| Acidity, degrees | 2.2 | 2.6 | 2.9 | 3.2 | 3.5 |
| Deformation of the crumb, units of penetrometer | | | | | |
| after 4 hours | 79 | 82 | 84 | 88 | 800 |
| after 72 hours | 40 | 58 | 65 | 68 | 65 |
| Mold | after 96 hours | not detected | | | |
| Potato disease of bread | after 48 hours | not detected | | | |

Therefore, the conducted studies of the quality indicators of chokeberry by-products and the quality indicators of bread with this raw material testified to the improvement of the specific volume, porosity of bread and the possibility of increasing its the antioxidant activity. However, some aspects require further research. There are substantiation of the methods of storage of chokeberry by-products, preparation for production, quality standardization, which will ensure the formation of the necessary functional and technological properties while preserving the valuable biologically active substances, physiological and preventive effects.

## Conclusions

1. The valuable chemical composition and high biological activity of chokeberry fruits were found, which was ensured by the high content of pectin, phenolic substances, organic acids, sorbitol, ascorbic acid.
2. The obtained results show that the content of pectin and colorants in puree was higher than in juice obtained by pressing from crushed chokeberry fruits. During such preliminary processing of raw materials, the yield of juice was only 50% of the mass of raw materials, and the yield of puree was 76%. The extracts contained 810 mg/100 g of colorants and 1050 mg/100 g of phenolic substances in their composition, which also confirms the fact that a significant part of them removes as waste, which can also be used for further processing with obtaining low-grade puree, extracts or powders.
3. For use in the preparation of bread from wheat flour of the first grade, the use of chokeberry in the form of puree was proposed.
4. The influence of chokeberry puree in dosages of 3, 6, and 9% to the weight of flour had a positive effect on the specific volume, porosity and acidity of the products, a tendency to strengthen the structure of the dough and increased the dimensional stability of bread. Addition of 12% chokeberry puree decreased specific volume by 1.02%.
5. In the case of adding puree to the dough, the general, plastic and elastic deformation of the pulp improved in all samples. However, the best result was obtained with a puree content of 9% by weight of flour. Thus, the loss of freshness of bread enriched with 9.0% puree after 72 hours amounted to 22.7%, compared to the control bread, the total deformation of the crumb during this period decreased by 49.4%.

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