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APPLICATION OF PERSIMMON SYRUP TO INCREASE THE BIOLOGICAL VALUE AND ORGANOLEPTIC INDICATORS OF BREAD

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One of the factors hindering the widespread use of persimmon syrup in baking is the lack of knowledge of its functional properties for the production of a wide range of bread products due to its chemical composition. Based on this, a study of the method of obtaining persimmon syrup, quantitative changes in the nutritional content of the first-grade "Azamatli-95" wheat flour, persimmon syrup of the "Hyakume" variety, mixtures of wheat flour and persimmon syrup, bread with the addition of persimmon syrup was conducted. It was found that during the hot pre-treatment of persimmon, the pulp yield decreases to 25 %, and the juice yield increases to 67.7 %. The regularity of changes in water consumption for diluting the syrup and for kneading the dough, depending on the amount of syrup added to wheat flour, was revealed. With a 1 % increase in persimmon syrup, the consumption of water for diluting the syrup increases on average by 1.193, and the consumption of water per dough decreases by 1.3 on average. The regularity of the quantitative change of food substances during baking is revealed, which allows correcting their content in mixtures of wheat flour and persimmon syrup, and in bread with additives. It was found that the content of phenolic compounds in bread with the additive increases: in the control sample of bread it was 0.13 g/100 g, and in the samples of bread prepared according to options I, II and III it was 0.4, 0.51 and 0.64 g/100 g, respectively, which is 2.7 times more than in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures from wheat flour and persimmon syrup. When adding up to 10 % persimmon syrup to the first-grade wheat flour, the organoleptic characteristics of the bread, except for the crumb color, improved. Increasing the amount of added persimmon syrup up to 15 % to wheat flour leads to the deterioration of all organoleptic indicators of bread with the additive. The obtained results give an opportunity to regulate the desired quality of bread and use persimmon syrup as a functional ingredient

Keywords: "Azamatli-95" wheat, flour, "Hyakume" persimmon, fiber, vitamins, minerals, dough, bread

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1. Introduction

Replenishment of the human body with the necessary nutrients can be ensured mainly through the product that is an integral part of food. The main product of the human diet is bread, which can be used as a good carrier of food substances.

In the food ration of the population, not everyone has fruits and vegetables. Therefore, it is possible to say with great probability that there is a lack of nutrients in their body, which eventually leads to illnesses. In addition, it should be noted that when buying bread, consumers pay attention mainly to the volume, correctness of the shape, condition and color of the surface of the crust, and softness of bread. However, they do not pay attention mainly to the nutritional value of bread. Therefore, one of the priority areas of social and economic development of any state is to provide the population with full-fledged, balanced mass consumption bread products, enriching them with physiologically functional ingredients that contribute to the normal development and vital activity of the body, increasing its resistance to adverse environmental factors and disease prevention [1, 2]. In this area, the most innovative is the development of baking technologies, increasing efficiency based on scientific and technical progress, development and implementation of technological processes in production, aimed at increasing food value [3].

In this regard, the enrichment of bread products by adding raw materials rich in food substances to the recipe will prevent the development of unwanted diseases of the human body and at the same time expand the range of bakery products. The most expedient and effective in this direction is persimmon, which is rich in mono- and disaccharides, vitamins, minerals, carotene, pectin substances, phenolic compounds, dietary fibers, etc. [4]. Persimmon fruit carotene has antioxidant properties, which can neutralize free radicals and prevent the development of malignant tumors. Pectin is a safe natural detoxifier that removes toxins, heavy and radioactive metals from the body [5].

Persimmon has a high immune defense system, it is not badly damaged by diseases and microorganisms, is more resistant to spoilage, the frost resistance of persimmon, especially the eastern one, is higher than that of most other subtropical crops [6].

It should be noted that many varieties of persimmon and products of its processing have not yet been studied in terms of using them for enriching bread with food substances.

The world of persimmon crops is very diverse. The most common types of persimmon (*Diospyros*): Caucasian (*D. lotus*), virgin (*D. virginiana*) and eastern (*D. kaki*). Cultivated varieties of oriental persimmon in Azerbaijan are mainly "Hyakume", "Xachia", "Goshe", "Zanji-maru" and others [7].

Environmental degradation in the world has increased the level of food contamination, and stress damages the mechanisms of self-regulation of the body, leading to an increase in negative trends in public health [8]. Improving the health, performance and livelihoods of all age groups through quality and safe food is the main goal of all governments.

Modern technologies should ensure the production of complete bread products. Therefore, it is necessary to develop and improve technologies based on scientific and technical progress. In this regard, the wide use of local raw materials and including them in technological processes remain insufficiently solved problems [9].

Thus, the improvement of bread production technology depends on the solution of the world's urgent problem. This allows increasing the usefulness, as well as expanding the range of bread products.

The deterioration of ecology and inclusion of inferior food products in the daily diet, especially bread made from high-grade wheat flour, which is poor in chemical composition, create conditions for the development of various diseases in the human body. The second reason is that enriching bread to ensure its quality by adding persimmon syrup to wheat flour has not been studied. Therefore, the study of the nutritional value of date syrup and wheat flour to increase the biological value of bread, taking into account their quantitative changes during baking and improving the organoleptic indicators of bread as a result of using date syrup, is very relevant.

2. Literature review and problem statement

In [10], it is cited that some authors consider it promising to use grain mixtures for the preparation of bakery products. Such mixtures allow not only intensifying the biochemical and microbiological fermentation processes, adjusting the rheological properties of the dough, improving the organoleptic and physico-chemical characteristics of bread, but also increasing its nutritional and biological value, making bread more beneficial to human health. An example is given that the use of non-hulled dispersed grain allows saving nutrients and biologically active substances in the finished product in full with improved performance, but at the same time increases the risk of developing potato bread and mold disease. In the same work, again, the study of the nutritional characteristics and safety of baking mixtures is continued in the context of the quality and nutritional value of finished bread products from high-grade wheat flour. And this does not critically solve the problem of increasing the usefulness of bread products, since high-grade wheat flour is always poor in useful substances and rich in easily digestible carbohydrates. Therefore, the recipe of bread products should include products that are rich in vitamins, fiber, minerals and substances that prevent the development of pathogens and ensure the safety of bread products, as well as replenish the human body. In this regard, the most suitable and economically beneficial is oriental persimmon, which is rich in carotene, pectin, phenolic compounds and a number of organic compounds such as potassium, calcium, iodine and cobalt.

In [11], in order to improve the properties of the most commonly used types of flour (type 550 equivalent to all-purpose flour and type 1,050 equivalent to flour with a high gluten content) without the addition of chemicals, non-thermal, so-called "cold plasma" treatment was proposed. It was found that plasma treatment of 550 grade wheat flour for less than 180 s enhanced intermolecular disulfide bonds in gluten proteins, which led to the formation of stronger protein-starch networks, an increase in flour hydration by 6–7 %. Longer processing time did not lead to a significant increase in the viscoelastic properties of the wheat dough. However, this method does not provide enrichment with the necessary nutrients and obtaining sufficiently high-grade bread products. In addition, the work does not consider the chemical composition of flour and the issue of bread fortification.

In [12], a study was conducted to assess the physiological and organoleptic properties of bread with different contents of persimmon peel. It was found that the moisture activation of the loaf of bread decreased as the shelf life increased, with a smaller range of decrease in the group with the addition of persimmon peel powder. The weight has increased and the volume has somewhat decreased. As a result of measurements using a texture analyzer, hardness, elasticity, cohesiveness, stickiness and chewing properties decreased. The results of the sensory test showed that bread with the addition of 4 % and 6 % persimmon peel was the best.

In [13], for the development of food products using dried persimmon, a hot-water infusion of dried persimmon was added to durum wheat flour in a ratio of 10, 20, 30 and 40 % and the qualitative characteristics of bakery products were studied. Approximate compositions of dried persimmon hot water extracts are: 70.37 % moisture, 1.72 % crude protein, 0.18 % crude lipids, 1.99 % crude ash, and 4.37 % crude fiber, respectively. With an increase in the addition of hot water extracts of dried persimmon, the moisture content of the added loaves increased from 41.12 % to 47.20 % without additives and the water activity from 0.495 to 0.576. The moisture-binding capacity of the added hot-water extracts of dried persimmon increased the mass of the bread, but decreased the specific volume.

In [14], the influence of varietal characteristics of oriental persimmon ("Hyakume", "Zolotistaya", "Yuzhnaya Krasavitsa", "Mechta", "Seedles"), grown in the soil and climatic conditions of the southern coast of Crimea, on the biochemical composition of fresh fruits was studied and changes occurring in the products of their processing during storage were determined. From ripe persimmon fruits, dried fruits and candied fruits were made with peeling according to the classical recipe.

Dry substances, ascorbic acid, titratable acidity, the amount of phenolic substances, dry soluble substances (for dried fruits and candied fruits) were determined in persimmon fruits and products of its processing. These indicators were higher in dried fruits and candied fruits than in persimmon fruits. Analysis of the data showed that the leadership in the content of dry matter among the samples of dried fruits belongs to the sample made from the fruits of the "Hyakume" variety – 89.60%, and among the samples of candied fruits, the maximum indicator for the "Mechta" variety is 95.60 %.

Comparison of the results of the biochemical analysis of the samples indicates that the sample of dried fruits of the "Ceedles" variety contains the maximum amount of ascorbic acid – 10.56 mg/100 g. The results of the biochemical analysis showed that the highest content of carbohydrates was recorded in dried fruits (77.94 %) and candied fruits (84.47 %) prepared from the fruits of the "Ceedles" variety, which is higher than that in the control samples ("Hyakume" variety) by 10.98 and 2.92 %, respectively. The authors focus on the importance of consuming dried fruits and candied fruits, the persimmon varieties under consideration, as a replenishment of the body with useful substances. However, such products are not included in the daily diet of the population as bread products. This is not a rational way to solve the problem of providing the population with a complete food product.

In [15], a study was conducted to facilitate the release of clarified juice from ripe persimmons. For this purpose, food additives E330, E509, Amylase XML and Pectinex 5XL were tested. Experiments were carried out with ripe persimmons of 4 varieties ("Zenji-maru", "Hyakume", "Giboshi" and "Gosho") grown in the experimental farm of the Research Institute of Fruit Growing and Tea Growing (Guba, Azerbaijan).

It was found that obtaining juice from ripe persimmons by diffusion with water, as a prerequisite, should include facilitating its release by introducing a pectolytic enzyme or amylase into the treated medium. The recommended dose of enzymes Pectinex 5XL and Amylase XML is 0.03 % by weight of persimmon. It was also proposed to extract ripe softened persimmon crushed in a propeller mixer with the addition of 0.3 parts of water per 1 part of crushed persimmon at a temperature of 50–55 °C when the mixer is running in a slow mode.

However, not every consumer will allow himself to use juice with various additives obtained by artificial synthesis (E330, E509 are no exceptions). In addition, the work did not investigate the chemical composition and did not reveal the effect of these additives on the usefulness of juices, as well as their significance in the daily diet. Daily consumption of products, for example, with the addition of E330, negatively affects the human body: it exacerbates existing chronic diseases of the gastrointestinal tract, affects tooth enamel, and can lead to cancer. It should also be noted that pectolytic enzymes have a destructive effect on pectins, cellulose and hemicellulose, causing destruction and decay [16].

The paper [17] reviewed the benefits of persimmon and its products with an emphasis on the digestibility of essential nutrients and biologically active compounds *in vitro* and *in vivo*. Much of the literature related to *in vitro* digestion of persimmon and persimmon products focuses on the digestibility of phenolic compounds and, to a lesser extent, on the digestibility of carotenoids. The review [17] also presents the results of research in the field of obtaining and using persimmon products: the effect of the particle size of persimmon flour (from two varieties, "Rojo Brillante" and "Triumph") on the content of primary (sugar and organic acids) and secondary (polyphenols, flavonoids and carotenoids) metabolites, as well as their antioxidant activity, to assess whether this flour could be used in the food industry as a potential functional ingredient; the effect of adding (3 % and 6 %) two different types of persimmon flour (from varieties "Rojo Brillante" and "Triumph") on the chemical composition, physico-chemical properties, lipid oxidation, emulsion stability, texture and organoleptic properties of pork pate was studied. It was found that persimmon flour improves the polyphenolic profile of spaghetti by adding gallic acid and coumaric acid o-hexoside, as well as increasing their content in spaghetti by 2 and about 3 times with 3 % and 6 % persimmon flour, respectively. It was also revealed that adding 24 % persimmon puree to the ice cream mix is the most preferred. When studying the organoleptic characteristics of six different persimmon milkshakes with improved functional properties, it was found that consumers perceived persimmon milkshakes as a drink with a high content of antioxidants. When studying the effect of different fermentation temperatures on the phenol content, aromatic profile and antioxidant activity of persimmon wine, it was found that a low concentration of ethanol and a high content of residual sugar were found in wine fermented at a low temperature (15 °C), which led to sluggish fermentation. For persimmon snacks, the hot air drying method was used and it was found that after drying, the dehydrated samples became harder, acquired a more orange hue and had a reduced content of soluble tannins. However, this review does not mention the use of persimmon and its products in bread baking, as well as in other industries that produce daily food products.

In [18], the authors analyzed the content of extractable polyphenols (EP) and the antioxidant capacity of fruits, leaves, and fiber extracted from "Rojo Brillante" persimmon during its digestion in vitro. It was found that the antioxidant capacity during digestion led to total losses at the end of digestion in leaves, persimmon fruits and fibers. The bioavailability of EP in persimmon fiber was higher than in persimmon fruits and leaves. Moreover, the bioavailability of the total antioxidant capacity was lower than that of EP and did not exceed 40 %. The authors concluded that the EP and total antioxidant capacity of persimmon leaf aqueous extract were more sensitive to the gastrointestinal environment than extracts derived from persimmon fruit or fiber. Although the bioavailability of all antioxidant compounds in persimmon fruit and fiber is higher than in an aqueous extract of persimmon leaves, an infusion of persimmon leaves (1.5 g per 110 ml of water) and persimmon fruit (200 g) provides similar bioavailable antioxidants at the end of digestion. In [19], the authors analyzed the inhibitory effect of tannins extracted from "Niuxin" persimmon on pancreatic lipase. This critical enzyme is associated with hyperlipidemia and obesity. It was found that tannins extracted from persimmon have a high affinity for pancreatic lipase and inhibit the activity of this enzyme; the interaction was spontaneous through non-covalent bonds. Thus, the binding and inhibiting ability of persimmon tannins on lipid digestive enzymes can be effective for the treatment and prevention of obesity. In [20], the authors demonstrated the effect of tannins extracted from fresh persimmon "Gongcheng Yueshi". They concluded that tannins in persimmons can help reduce postprandial hyperglycemia by regulating glucose levels in the human body. The paper [21] presents the results of a study by some authors on the benefits of persimmon. In addition to nutritional value, persimmon was used against hypertension, hemorrhages, to maintain body temperature and slow down oxidative processes in general, due to their diuretic effect in diabetes and atherosclerosis. Persimmon is also used to improve the function of the lungs, stomach, spleen, and intestines, as well as to prevent and treat conditions such as sore throat, thrush, and insomnia. Persimmon has antitumor properties, prevents dyslipidemia, has anti-hypercholesterolemic, antioxidant and antidiabetic effects. These health benefits have been linked to its richness in antioxidants, including vitamins, phenolic compounds, and carotenoids. However, nothing is said about its use as a daily food product and application in the food industry. The results obtained by the authors [22] also confirmed the nutritional value of persimmon even under special dietary regimens such as hypertension and heart disease, as well as the authenticity of its cultivation in Central and Southern Italy. These works also do not provide recommendations on the use of persimmon and its products in making daily food products.

In [23], the authors carried out a technological and biochemical evaluation of the fruits of oriental persimmon varieties for use in the food industry. The specific gravity, comparative keeping quality, transportability, volume change during storage, natural loss of persimmon fruits ("Zanji-maru", "Jiro", "Hyakume" and "Khachia"), acidity, sugar content, vitamins and minerals were determined. However, the chemical composition and recommendations for the use of persimmon fruits and products of its processing as a fortifier of bread products are not shown.

The paper [24] carried out a study to investigate the chemical composition, antioxidant activity and phenolic compounds of persimmon puree and evaluate the impact of utilizing persimmon puree on some chemical, physical and organoleptic properties of cupcakes. Persimmon puree was added to the cupcake at a ratio of 33.3, 50, 66.6 and 83.3 %. Moreover, persimmon puree cupcake had higher scores for the organoleptic properties than the control sample. Based on the previous results, it can be concluded that the utilization of persimmon puree in cupcake manufacture at a ratio of 33.3 % can improve the chemical, physical and organoleptic characteristics, as well as the antioxidant activity of cupcakes.

It was shown in [25] that whole wheat grains are rich sources of phenolic compounds. They have antioxidant properties. However, the most abundant phenolic compounds found in wheat grain are phenolic acids and flavonoids. Due to strong antioxidant activity, they possess anti-inflammatory, anti-carcinogenic activity and diabetes alleviation properties and could be associated with cardiovascular disease prevention, obesity and aging control. However, specific changes in phenolic acids and flavonoids in the bread-making process have not been investigated.

In [26], rose hips, chokeberries, nettles, bananas, apples, and carrots were used to prepare mixtures with fruit and berry powders for the production of bakery products for therapeutic, prophylactic, and gerontological purposes. In this work, organoleptic, toxicological and microbiological indicators, as well as storage conditions for mixtures with fruit and berry powders, were investigated.

In [27], they demonstrated the effect of apple flour on the viscoelastic properties of the dough, increasing the modulus of elasticity and the viscosity modulus. Apple flour has shown good technological and organoleptic properties as a sustainable and healthy food ingredient for gluten-free bread. The effect of apple flour on the nutritional, technological and organoleptic characteristics of gluten-free sweet bread was studied, starch hydrolysis in vitro and the glycemic index were analyzed.

It was shown in [28] that natural sugars in apple flour can provide the functions of sucrose in bakery products.

In [29], studies on the addition of fruit and vegetable by-products (FVB) to wheat bread included the use of grape pomace, grape wine pomace, pear, apple and date pomace, banana pseudostem flour, green banana flour, pomegranate peel, pomegranate pomace, citrus peel. It was found that the replacement of wheat flour by these products never exceeded 10 %. In general, loss of bread acceptability has already been observed with small additions of FVB. This loss in bread quality consisted mainly in a decrease in bread volume and organoleptic acceptability, as well as an increase in crumb firmness. However, in the works listed above, the quantitative change in nutrients in mixtures with fruit and berry powders and bread products based on them has not been studied.

Thus, bread products are a necessary daily product in the human diet, and do not fully enrich the body with vitamins, macro- and microelements. An analysis of the literature data confirms that the nutritional value of persimmon and the products of its processing has been sufficiently studied. However, there is no data on the mechanical composition of the persimmon fruit, the yield of pulp and juice from persimmon. In addition, studies on the use of persimmon and its products, especially persimmon juice in baking have not been carried out.

Therefore, in order to further substantiate the development of technology for the production of new types of bread products that expand the range of products and satisfy various consumer preferences, a comprehensive analysis of the nutritional value of raw materials is necessary, i.e. flour, persimmon fruit, persimmon syrup, a mixture of flour and persimmon syrup, organoleptic indicators of finished products – bread with the addition of persimmon syrup.

3. The aim and objectives of the study

The aim of the study is to analyze the nutritional value of persimmon syrup and wheat flour to increase the biological value of bread taking into account their quantitative changes during baking and improving the organoleptic parameters of bread as a result of using persimmon syrup.

To achieve this aim, the following objectives are accomplished:

– to analyze the methods of pre-treatment of persimmon fruits to obtain syrup from them;

– to analyze the nutritional substances of persimmon syrup and wheat flour, their mixtures and bread with additives;

– to analyze the effect of persimmon syrup on the organoleptic characteristics of bread with additives.

4. Materials and methods

The object of the study was the first-grade flour of the Azamatli-95 wheat variety, obtained in the selection process carried out at the Azerbaijan Scientific Research Institute of Agriculture.

The methods of the research: theoretical studies – com-parative analysis of the literature resources, experimental studies – experiments based on the GOST standards. The research was carried out at the "Food Engineering and Expertise" department of the Azerbaijan Technological University, "Ganja-Deyirman", Ganja "NEON" enterprises, and at the laboratories of the Georgian Research Institute and the Azerbaijan Research Institute of Agriculture.

At the "Hyper Gold Amina" market in Ganja, dry yeast of the "Pakmaya" (Turkey) trademark with a moisture content of 8 % and iodized salt "Azeriduz" (Azerbaijan) with a moisture content of 3 % were purchased.

Total protein in the studied objects was determined using the Kjeldahl method. Protein indices for flour, bread and persimmon syrup were found to be 5.83, 5.7 and 6.25, respectively.

Vitamin contents were studied using a highly effective liquid chromatograph Shimadzu LC-20 Prominence (Germany). The ash amount was defined in the muffle furnace.

Phenolic compounds were determined on a high-performance liquid chromatograph ProStar-MS 500 (Varian, USA).

Pectin, cellulose, and carbohydrates were determined according to the manual [30].

The mineral substances were quantified using the atomic absorption spectrometer AAnalyst 400 (Perkin Elmer, USA).

The gluten amount in the first-grade flour of the Azamatli-95 wheat variety was defined according to the GOST standards, extensibility was measured on a ruler, gluten deformation index (GDI) in the "IDK-1M" device, moisture in the flour using the Pfeuffer HE-50 device (Germany), its color in the "R3-TBMS-M" device, the falling number was found using the "Hagberg-Perten" device (Switzerland). The following indices were determined for the wheat flour: fresh gluten amount – 31.6 %, extensibility – 9.5 cm, GDI – 77.8 units, moisture in the flour – 14 %, color – 52.5 units, ash content – 0.6 %, FN – 265 sec.

"Hyakume" persimmon variety was used as an enricher. Ripe orange color persimmon fruits were used. Because persimmon is widely cultivated in Azerbaijan and cost-effective. Persimmon was purchased from the "Ganja sabati" market. The quantities of dry matter of persimmon syrup were determined by the IFX-22 refractometer and were found to be 77.2 %.

We believe that it is more advisable to use persimmon juice than its puree and powder.

Preparing persimmon puree and powder requires much time and a considerable number of operations.

Persimmon juice is quickly processed, losses in the technological process are negligible, and the amounts of beneficial substances in its composition are relatively high. In addition, persimmon juice is quickly and evenly distributed in flour when kneading dough.

Persimmon juice is prepared by the classic and hot methods as follows. In contrast to the hot method, the resulting pulp is not heated in the classic method. The fruits are prewashed, sorted and cleaned of impurities, then rinsed with clean water. Then the stalk is removed, the skin is removed, cut along the diametrical plane into two halves, the bones are removed, rubbed through a metal sieve. To facilitate the extraction of juice, 10–15 % pure water is added to the resulting homogeneous mass (pulp) and heated for 10 minutes to a temperature of 80÷85 °C while stirring. Then, 1–2 % bentonite suspension is added to clarify the juice. The clarified juice is filtered, separated from the sediment, placed in clean containers, stored at a temperature of 0÷1 °C. Persimmon juice is evaporated in an MZS-320M vacuum apparatus to obtain 50 % dry matter. The resulting syrup, after cooling to room temperature, is stored at 0÷1 °C. The syrup had a slightly dark straw color.

When preparing juice, the mechanical composition of persimmon fruits was studied using both methods. We determined the average weight of the persimmon fruit, the number of seeds in the pulp, the weight of the peduncle with the calyx, the weight of the skin, the weight of 1 seed, the weight of the pulp with juice, the weight of the pulp of the persimmon fruit, as well as the percentage of the components of the average weight of the persimmon fruit (skin, seeds, peduncle, pulp yield, pulp yield with juice, opaque juice yield without pulp).

Before using the syrup, it was diluted with a certain part of the water used for kneading the dough. This is necessary for the quick and even distribution of the syrup in the flour when kneading the dough. By adding water, the moisture content of the syrup was adjusted to the moisture content of the juice, which, when measured on an IHF-22 refractometer, was 77.2 %.

The bread products were prepared using the following options (Table 1).

Table 1

Options for making bread products

Options	Products	Amount of additives, %	Abbreviations
Control	1-grade Azamatli-95 (A95) wheat flour (WF)	0	A95WF
I	Azamatli-95 wheat flour (A95WF) + persimmon syrup (PS)	5	A95WF-PS5
II		10	A95WF-PS10
III		15	A95WF-PS15

The dough was prepared in two stages on a tight sponge. Table 2 shows the consumption of raw materials for kneading dough.

As can be seen from Table 2, the water consumption for diluting the syrup was 30.56, 60.73 and 91.09 g, respectively.

The suitability of flour for baking was determined by a sample of bread made in the laboratory [31]. The moisture content of bread was determined according to the method [32].

The main food substances of the first-grade "Azamatli-95" wheat flour, persimmon juice, a mixture of persimmon juice and flour, organoleptic indicators of bread with the addition of persimmon juice were studied relatively.

Analyses of variance (ANOVA) to the correlations between the options were performed using Microsoft Excel 2016 at a significance level of $p<0.05$ [33].

Table 2

Consumption of raw materials for the preparation of wheat flour dough with a moisture content of 14 % with a content of 960 g of dry matter

Raw materials and semi-finished products	Consumption of raw materials by stages, g						Moisture content, %
	option I A95WF-PS5		option II A95WF-PS10		option III A95WF-PS15		
	Tight sponge	Dough	Tight sponge	Dough	Tight sponge	Dough	
1-grade wheat flour	502	614	502	614	502	614	14.0
Yeast suspension	6.7	–	6.7	–	6.7	–	93.75
Salt solution	–	6.44	–	6.44	–	6.44	74.78
Persimmon syrup	–	55.81	–	111.6	–	167.44	50.0
Water for syrup	–	30.56	–	60.73	–	91.09	100
Water for kneading	256.3	295.85	256.2	259.51	256.32	223.2	100
Tight sponge	–	765.3	–	765.3	–	765.3	43.5
Total:	765.3	1767.8	765.3	1817.6	765.3	1867.4	44.0

5. Results of a scientific and experimental study of the possibility of using persimmon syrup to increase the nutritional value of bread

5. 1. Analysis of methods of preliminary processing of persimmon fruit to obtain syrup from it

Table 3 presents the indicators of the mechanical composition of persimmon.

Table 3

Indicators of the mechanical composition of the "Hyakume" persimmon variety fruit

Indices	Methods of processing	
	Classical	Hot
Average mass of the persimmon fruit, g	164.5	164.5
Number of seeds in the persimmon pulp, pcs	5–6	5–6
Mass of the stalk with a cup of the persimmon fruit, g	4.1	4.1
Mass of the skin of the persimmon fruit, g	3.3	3.3
Mass of 1 seed of the persimmon fruit, g	4.9	4.9
Mass of persimmon fruit pulp with juice, g	152.2	152.2
Mass of persimmon fruit pulp, g	50.3	41.2
Percentage of the average mass of the persimmon fruit, %		
– skin	2.0	2.0
– seeds	2.8	2.8
– stalk	2.5	2.5
– output of pulp	30.6	25.0
– output of pulp with juice	92.7	92.7
– output of opaque juice without pulp	62.1	67.7

Table 3 shows that with the classical method of processing, the average weight of the persimmon fruit is 164.5 g, the number of seeds is 5–6 pieces, the weight of the stalk with the cup is 4.1 g, the skin is 3.3 g, the weight of 1 seed is 4.9 g, the weight of persimmon fruit pulp with juice is 152.2 g, the mass of persimmon fruit pulp is 50.3 g.

The percentage of the average weight of the persimmon fruit in the classical and hot processing methods: peel, seeds, peduncle was 2.0, 2.8, 2.5 %, respectively.

With the classical and hot methods of processing the persimmon fruit, only the yield of pulp, the yield of pulp with juice and the yield of opaque juice without pulp differed. With the classical method, the yield of pulp, the yield of pulp with juice, and the yield of opaque juice without pulp were 30.6, 92.7, and 62.1 %, respectively, of the average weight of the persimmon fruit. And with the hot processing method, the yield of pulp, the yield of pulp with juice and the yield of opaque juice without pulp were, respectively, 25.0, 92.7 and 67.7 % of the average weight of the persimmon fruit.

As a result of the research, it was found that in the course of processing in the classical way (i.e. without heat treatment), obtaining natural juice with pulp and without pulp is very difficult and requires a lot of labor time. The main reason for this is the strong connection of the tissue structure of the persimmon fruit. This makes it difficult to extract juice from the persimmon fruit. Hot pre-treatment, as a result of complete destruction of the tissue structure of the persimmon fruit, provides not only an increase in the yield of juice, but also an increase in the amount of extractives compared to the classical method.

Table 3 shows that when processing persimmons by the classical method, the yield of opaque juice without pulp and the yield of pulp were 62.1 and 30.6 %, and with hot pretreatment, 25 and 67.7 %, respectively. Thus, the use of the hot method for persimmon pre-treatment in the juice production technology provides an increase in the yield of juice and a decrease in the yield of pulp compared to the classical method. Compared to the classical method, during hot pre-treatment of persimmon, the pulp yield decreases to 25 %, and the juice yield increases to 67.7 %.

Fig. 1 clearly shows the outputs of juice and pulp from the persimmon fruit according to various processing methods.

From Fig. 1 it is clearly seen that during the pre-treatment of persimmon fruits by the hot method, the juice yield is higher, and the pulp yield is lower compared to the classical method. This is due to the complete destruction of the tissue structure of the persimmon fruit. Therefore, the pre-treatment of persimmon fruits by the hot method is appropriate.

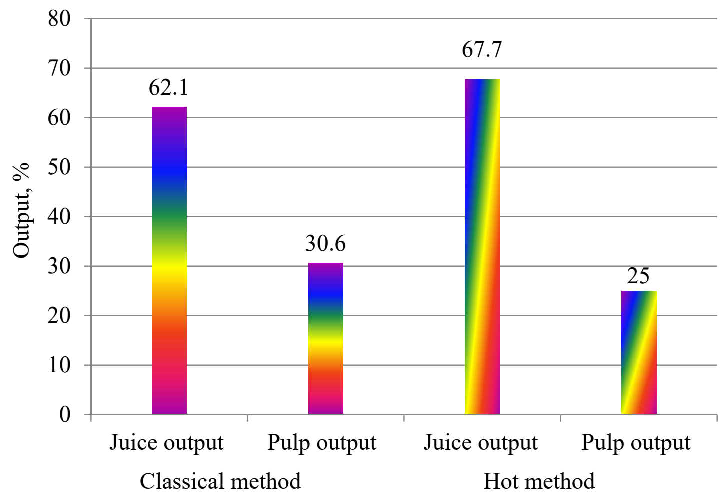

Fig. 1. Juice and pulp outputs from the persimmon fruit according to various processing methods

5. 2. Analysis of food substances of persimmon syrup and wheat flour, their mixtures and bread with additives

Table 4 presents a comparative analysis of the nutritional value of grade I Azamatli-95 wheat flour, persimmon syrup, mixtures of flour and syrup, and samples of bread with additives.

As can be seen from Table 4, the moisture content of wheat flour is 14 %. For quick and uniform distribution of persimmon syrup in flour during kneading, it was diluted with a certain part of water before use. To do this, we took such an amount of water from its total amount for kneading the dough, which ensures the achievement of juice moisture. By adding water in this way, the moisture content of the syrup was adjusted to the moisture content of the juice, which was 77.2 % (Table 5).

Table 4

Comparative analysis of the nutritional value indicators of the 1st-grade Azamatli-95 wheat flour, persimmon syrup, mixtures of flour and syrup, and samples of bread with an additive, per 100 g of product

Indices	Abbreviated	I grade Azamatli-95 wheat flour	Persimmon syrup	Mixture of wheat flour and persimmon syrup by options			Samples of bread by options			
				I	II	III	Control	I	II	III
Humidity, %	Hum	14.0	77.2	17.86	21.72	25.58	43.80	43.7	43.9	43.8
Nutrients, g										
Starch	Sta	57.4	0.1	57.41	57.41	57.42	40.64	40.65	40.65	40.66
Proteins	Pro	11.6	0.7	11.64	11.67	11.71	8.56	8.59	8.61	8.64
Glucose	Glu	0.08	8.2	0.49	0.90	1.31	0.04	0.21	0.39	0.57
Fructose	Fru	0.04	9.3	0.51	0.97	1.44	0.02	0.22	0.42	0.63
Sucrose	Suc	0.18	0.8	0.22	0.26	0.30	0.08	0.10	0.11	0.13
Raffinose	Raf	0.55	0.26	0.56	0.58	0.59	0.24	0.25	0.25	0.26
Cellulose	Cel	0.4	0.32	0.42	0.43	0.45	0.30	0.31	0.32	0.33
Pectin substances	Pec	0.1	0.21	0.11	0.12	0.13	0.10	0.11	0.12	0.13
Phenolic compounds	Phen	0.1	0.92	0.15	0.19	0.24	0.13	0.4	0.51	0.64
Vitamins, mg										
Thiamin	B1	0.38	0.05	0.383	0.385	0.388	0.246	0.247	0.249	0.251
Riboflavin	B2	0.3	0.06	0.303	0.306	0.309	0.225	0.227	0.230	0.232
Niacin	PP	1.54	0.3	1.56	1.57	1.59	1.155	1.166	1.178	1.189
β-carotene	Car	0.01	2.2	0.12	0.23	0.34	0.009	0.108	0.207	0.306
Ascorbic acid	C	0	9.6	0.48	0.96	1.44	0.00	0.24	0.480	0.720
Macroelements, mg										
Potassium	K	280	570	308.5	337.0	365.5	213.36	235.08	256.8	278.5
Calcium	Ca	38	54	40.7	43.4	46.1	42.22	45.22	48.2	51.2
Magnesium	Mg	95	440	117.0	139.0	161.0	83.13	102.38	121.6	140.9
Sodium	Na	5	8	5.40	5.80	6.20	582.41	582.81	583.21	583.61
Sulfur	S	75	110	80.50	86.0	91.50	56.75	60.91	65.1	69.2
Phosphorus	P	310	380	329.0	348.0	367.0	234.30	248.66	263.0	277.4
Microelements, **mcg**										
Iron	Fe	1,600	1,500	1675.0	1750.0	1825.0	1466.72	1535.47	1604.2	1673.0
Zinc	Zn	784	1,100	839.0	894.0	949.0	589.10	630.42	671.8	713.1
Iodine	I	4.2	6.4	4.52	4.84	5.16	3.12	3.36	3.6	3.8
Cobalt	Co	3.4	9.6	3.88	4.36	4.84	2.69	3.07	3.5	3.8

Table 5

Water consumption for diluting syrup, kneading sponge and dough

Consumables	Pouring diagram	option I		option II		option III	
		Tight sponge	Dough	Tight sponge	Dough	Tight sponge	Dough
Persimmon syrup	(blue)	–	55.81	–	111.6	–	167.44
Water for syrup	(red)	–	30.56	–	60.73	–	91.09
Water for dough	(green)	–	295.85	–	259.51	–	223.2
Water for sponge	(yellow)	256.3	–	256.3	–	256.32	–

Table 5 shows that in order to achieve juice moisture, as the amount of syrup added to wheat flour increases, the amount of water to dilute the syrup increases. At the same time, the moisture content of the resulting juice must always be constant (i.e. 77.2 %). In this regard, the water consumption for kneading the dough decreases as the amount of added syrup increases. The water consumption for kneading the tight sponge also remains constant.

The pattern of changes in water consumption for diluting the syrup, for kneading tight sponge and dough, depending on the amount of syrup added to wheat flour, according to the options, is shown in Fig. 2.

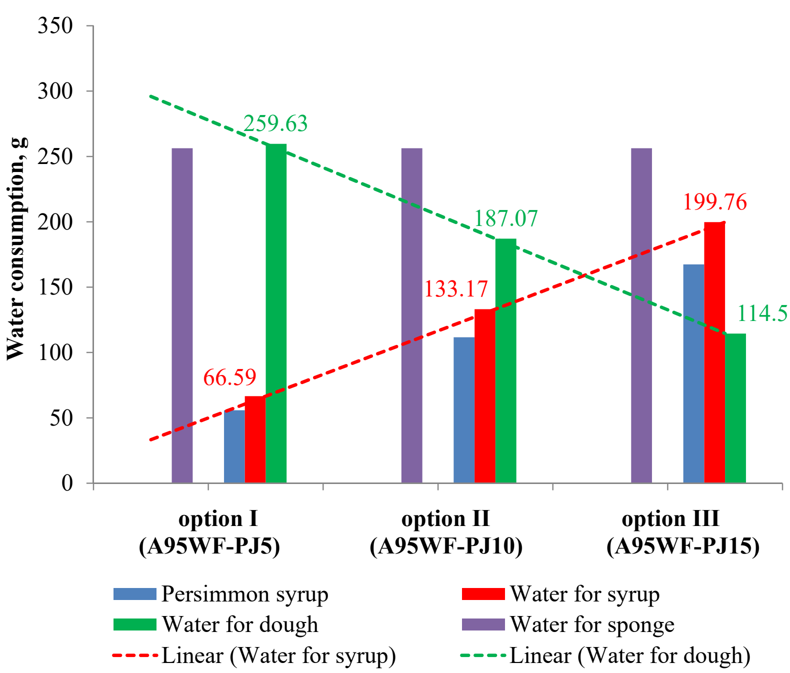

Fig. 2. Pattern of changes in water consumption for diluting the syrup, for kneading sponge and dough, depending on the amount of syrup added to wheat flour

When persimmon juice is added to wheat flour according to options I, II, and III, the moisture content of A95WF-PS5, A95WF-PS10, and A95WF-PS15 mixtures is 17.86, 21.72 and 25.6 %, respectively.

When adding persimmon syrup diluted with water to the moisture content of the juice in wheat flour according to options I, II and III, the moisture content of A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures is 17.86, 21.72 and 25.6 %, respectively.

Table 4 shows that among the nutrients in "Azamatli-95" wheat flour, the starch content is the highest and is 57.4 g/100 g. This is an easily digestible carbohydrate that creates conditions for the development of diseases (for example, diabetes, obesity, etc.). However, persimmon syrup contains only 0.1 g/100 g of starch. When adding persimmon syrup to wheat flour according to options I, II and III, the starch content in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures does not change and is in the range of 57.4–57.42 g/100 g. After making bread, the starch content decreases in all bread samples and is 40.64 g/100 g in the control sample, and in the bread samples prepared according to options I, II and III – within 40.65–40.66 g/100 g.

It was found that the protein substances in "Azamatli-95" wheat flour is 11.6 g/100 g. When persimmon syrup is added to wheat flour according to options I, II and III, the content of protein substances in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures is 11.64, 11.67 and 11.71 g/100 g, respectively, and after baking bread is 8.56 in the control sample, in samples of bread prepared according to options I, II and III – 8.59, 8.61 and 8.64 g/100 g, respectively.

As can be seen from Table 4, the glucose and fructose contents in wheat flour are very low (0.08 and 0.04 g/100 g, respectively), and higher in persimmon syrup (8.2 and 9.3 g/100 g, respectively). It is known that the fermentation of the dough begins as an end product with hexose, especially with glucose under the action of yeast. When persimmon syrup is added to wheat flour according to options I, II and III, A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures are enriched with glucose, respectively, 0.49, 0.9 and 1.31 g/100 g, and fructose, respectively, 0.51, 0.97 and 1.43 g/100 g. After baking bread, the content of glucose and fructose in the control sample was 0.04 and 0.02 g/100 g, respectively. In the bread samples prepared from the mixtures according to options I, II and III, the glucose content was 0.21, 0.39, and 0.57 g/100 g, and fructose, 0.22, 0.42 and 0.63 g/100 g, respectively. The enrichment of flour with glucose and fructose creates conditions for a quick and organized fermentation process.

As can be seen from Table 4, persimmon syrup is more enriched with sucrose compared to wheat flour and is 0.8 g/100 g. This is 0.62 g/100 g more than the amount of sucrose in wheat flour (0.18 g/100 g). Sucrose acts more intensively on the fermentation of the dough. When adding persimmon syrup to wheat flour according to options I, II and III, the content of sucrose in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures is 0.22, 0.26 and 0.30 g/100 g, respectively. In the bread samples prepared from the mixtures according to options I, II and III, the sucrose content was in the range of 0.1–0.13 g/100 g, and in the control sample of bread it was 0.08 g/100 g.

Compared to persimmon syrup, the content of raffinose in wheat flour is higher. The content of raffinose in wheat flour is 0.55 g/100 g, and in persimmon syrup – 0.26 g/100 g. When adding persimmon syrup to wheat flour according to options I, II and III, the content of raffinose in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures is 0.56, 0.58 and 0.59 g/100 g, respectively. In the control sample of bread, the content of raffinose was 0.24 g/100 g. At the same time, in bread samples prepared from the mixtures according to options I, II and III, the content of raffinose changed from 0.25 to 0.26 g/100 g.

Compared to persimmon syrup, the cellulose content of wheat flour is higher. The cellulose content in wheat flour is 0.4 g/100 g, and in persimmon syrup – 0.32 g/100 g. When adding persimmon syrup to wheat flour according to options I, II and III, the cellulose content in the A95WF-PS5, A95WF-PS10 and A95WF-S15 mixtures is 0.42, 0.43 and 0.45 g/100 g, respectively. In the control sample of bread, the cellulose content was 0.30 g/100 g, respectively. At the same time, in the bread samples prepared from the mixtures according to options I, II, and III, the cellulose content changed from 0.31 to 0.33 g/100 g.

Cellulose has a positive effect on the metabolism of carbohydrates in the gastrointestinal tract, prevents the development of cancer, stimulates the cardiovascular and digestive systems, and plays an important role in the functioning of the human body. Cellulose reduces the energy value, but increases the nutritional value of flour and bread. Because it accelerates intestinal peristalsis, normalizes lipid and carbohydrate metabolism in the body, and removes heavy metals from the body.

The pectin substances, which create conditions for the formation of aromatic substances during the fermentation of the dough, make 0.1 g/100 g in wheat flour, and 0.21 g/100 g in persimmon syrup. During the hydrolysis of pectin substances, as representatives of heteropolysaccharides, along with galacturonic acid, other simple monosaccharides are formed: galactose, arabinose, rhamnose, etc. The formation of a pleasant burnt aroma of bread is associated with the conversion of hexose into hydroxymethylfurfural or methylfurfural under the action of heat during bread baking. Under the action of heat, furfural is also formed from pentoses. When persimmon syrup was added to wheat flour, the amount of pectin compounds in the mixtures and bread samples prepared according to options I, II and III was 0.11, 0.12, and 0.13 g/100 g, respectively. At the same time, in the control sample of bread, the amount of pectin compounds was 0.1 g/100 g.

Compared to persimmon syrup, wheat flour contains very few phenolic compounds, which have antioxidant and antimicrobial, even antiviral properties. In wheat flour, the content of phenolic compounds is only 0.1 g/100 g, while in persimmon syrup it is 0.92 g/100 g. The addition of persimmon syrup to wheat flour was the main purpose of increasing the content of phenolic compounds in the dough. By adding persimmon syrup to wheat flour, it is possible to increase the content of polyphenols in the dough for enriching bread products with phenolic compounds. When adding persimmon syrup to wheat flour according to options I, II and III, the content of phenolic compounds in the A95WF-PS5, A95WF-PS10, and A95WF-PS15 mixtures is 0.15, 0.19, and 0.24 g/100 g, respectively. It was found that during the baking process, the total content of phenolic compounds in bread samples increases: in the control sample of bread it was 0.13 g/100 g, and in the samples of bread prepared according to options I, II and III it was 0.4, 0.51 and 0.64 g/100 g, respectively. This is 2.7 times more than in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 wheat flour and syrup mixtures. The trend towards an increase in phenolic compounds is also confirmed in [34]. When persimmon syrup is added to the dough, mold fungi are not observed in bread products for a long time.

Fig. 3 clearly shows the changes in nutrients in bread samples prepared according to the options.

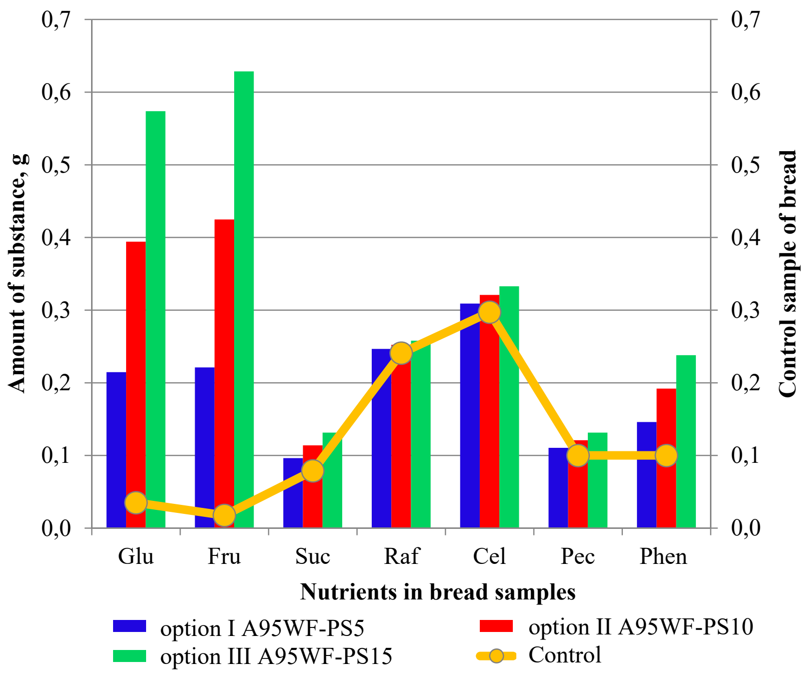

Fig. 3. Changes in nutrients in bread samples prepared according to the options

This pattern is also observed in the A95WF-PS5, A95WF-PS10, and A95WF-PS15 mixtures prepared according to options I, II, and III.

Compared to persimmon syrup, wheat flour is rich in thiamine (i.e. vitamin B1). The content of thiamine in wheat flour is 0.38 mg/100 g, and persimmon syrup – 0.05 mg/100 g (Table 4). When persimmon syrup is added to wheat flour according to options I, II and III, the content of thiamine in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures increases from 0.383 mg/100 g to 0.388 mg/100 g. However, in the process of making bread, the content of thiamine decreases: in the control sample of bread it was 0.246 mg/100 g, and in the samples of bread prepared according to options I, II and III it was 0.247, 0.249 and 0.251 mg/100 g, respectively. The lack of thiamine causes the beriberi, violation in the nervous system, heart and muscle functions, digestion (especially digestion of carbohydrates), as well as mental and physical fatigue.

Compared to persimmon syrup, wheat flour is rich in riboflavin (i. e. vitamin B2). The content of riboflavin in wheat flour is 0.3 mg/100 g, and persimmon syrup – 0.06 mg/100 g. When persimmon syrup is added to wheat flour according to options I, II and III, the content of thiamine in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures increases from 0.303 mg/100 g to 0.309 mg/100 g. In bread samples prepared according to options I, II and

III, it increased from 0.227 mg/100 g to 0.232 mg/100 g. However, in the control sample of bread, the content of thiamine was 0.225 mg/100 g. The lack of riboflavin leads to appetite deterioration, weakness, decreased body weight and impaired vision. Riboflavin protects hair, nails and skin, participates in the metabolism of proteins, fats and carbohydrates, is used in the treatment of ulcers in the tongue, mouth and lips. Therefore, bread can be enriched with natural vitamin B2 by adding persimmon syrup.

Compared to persimmon syrup, wheat flour is rich in niacin (i. e. vitamin B3). The content of niacin in wheat flour is 1.54 mg/100 g, and persimmon syrup – 0.3 mg/100 g. When persimmon syrup is added to wheat flour according to options I, II and III, the content of thiamine in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures increases from 1.56 mg/100 g to 1.59 mg/100 g. In bread samples, the content of niacin was lower compared to A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures: in the control bread it was 1.155 mg/100 g, and in bread samples I, II and III it was 1.166, 1.178 and 1.189 mg/100 g, respectively. With the insufficient intake of niacin, the skin, digestive organs and nervous system are affected. Vitamin PP deficiency causes pellagra.

Persimmon syrup contains more beta-carotene (provitamin A) than wheat flour.

In persimmon syrup, the content of beta-carotene was 2.2 mg/100 g, and in wheat flour – 0.01 mg/100 g. By adding persimmon syrup to wheat flour, the dough and mixtures prepared from it and bread products can be enriched with beta-carotene.

The A95WF-PS5, A95WF-PS10 and A95WF-PS15 blends had higher beta-carotene contents compared to wheat flour. When adding persimmon syrup to wheat flour according to options I, II and III, the content of beta-carotene in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures is 0.12, 0.23 and 0.34 mg/100 g, respectively.

In the bread samples, the content of beta-carotene was higher compared to wheat flour: in the control bread it was 0.009 mg/100 g, and in the bread samples I, II and III it was 0.108, 0.207 and 0.306 mg/100 g, respectively.

The presence of beta-carotene in the composition of bread is very important because beta-carotene is converted into vitamin A by the effect of the carotinase enzyme in the human body. Vitamin A deficiency causes vision deterioration and a number of diseases resulting in blindness.

Compared to wheat flour, persimmon syrup is richer in vitamin C. In wheat flour and in the control bread, vitamin C is absent, and persimmon syrup – 9.6 mg/100 g. When adding persimmon syrup to wheat flour according to options I, II and III, the content of vitamin C in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures is 0.48, 0.96 and 1.44 mg/100 g, respectively. In bread samples prepared according to options I, II and III, the content of vitamin C was higher compared to wheat flour and amounted to 0.24, 0.48 and 0.72 mg/100 g, respectively.

Vitamin C strengthens the human immune system, and also protects it from viruses and bacteria, accelerates the process of wound healing, affects the synthesis of a number of hormones, regulates hematopoiesis and normalizes capillary permeability, participates in the synthesis of collagen protein, which is necessary for the growth of tissue cells, participates in the synthesis of collagen – the main structural protein of connective tissue, which provides functionality and stability to blood vessels, bones, tendons. It is a powerful antioxidant. The main danger of vitamin C deficiency is the development of scurvy.

The change in the content of vitamins in bread samples prepared according to the options is clearly shown in Fig. 4.

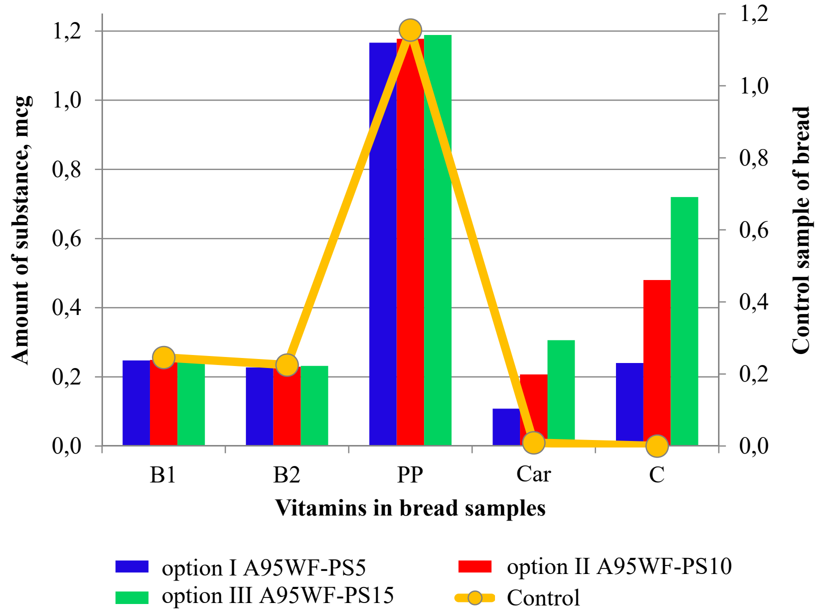

Fig. 4. Change in the content of vitamins in bread samples prepared according to the options

This pattern is also observed in the A95WF-PS5, A95WF-PS10, and A95WF-PS15 mixtures prepared according to options I, II, and III.

One of the main indicators of the nutritional value of wheat flour are minerals. As can be seen from Table 4, compared to wheat flour, persimmon syrup is richer in minerals. Of the macroelements, the content of potassium, calcium, magnesium, sodium, sulfur and phosphorus was determined.

As can be seen from Table 4, when persimmon syrup is added to wheat flour according to options I, II and III, the content of macroelements does not decrease, but rather increases. In wheat flour, potassium is 280 mg/100 g, in persimmon syrup – 570 mg/100 g, and in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures prepared according to options I, II and III, it is 308.5, 337.0 and 365.5 mg/100 g, respectively. In bread samples prepared according to options I, II and III, the potassium content was significantly higher compared to wheat flour and amounted to 235.08, 256.8 and 278.5 mg/100 g, respectively. However, in the control sample of bread, the potassium content was 213.36 mg/100 g.

Thus, adding persimmon syrup can increase the amount of potassium in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures. Potassium has a positive effect on the cardiovascular system, it increases the permeability of membranes to salts. Potassium is also essential for normal brain functioning, cleansing organism from slags and treatment of allergies.

Compared to wheat flour, persimmon syrup contains more calcium. In the first-grade wheat flour, the amount of calcium salts was 38 mg/100 g, in persimmon syrup – 54 mg/100 g. When persimmon syrup is added to wheat flour, the amount of calcium in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures is 40.7, 43.4 and 46.1 mg/100g, respectively. In the control sample of bread, the calcium content was 42.22 mg/100 g. However, in the bread samples prepared according to options I, II and III, the calcium content was higher compared to wheat flour and amounted to 45.22, 48.22 and 51.2 mg/100 g, respectively.

Thus, adding persimmon syrup can increase the amount of calcium in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures. Calcium is involved in all vital processes of the human body. Calcium plays an important role in the nervous-muscular irritability of tissues. Normal coagulation of blood occurs only with the participation of calcium salts.

Compared to wheat flour, persimmon syrup contains more magnesium. In the first-grade wheat flour, the amount of magnesium salts was 95 mg/100 g, in persimmon syrup – 440 mg/100 g. When persimmon syrup is added to wheat flour, the amount of calcium in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures is 117.0, 139.0 and 161.0 mg/100g, respectively. In the control sample of bread, the magnesium content was 83.13 mg/100 g. However, in bread samples prepared according to options I, II, and III, the magnesium content was higher compared to wheat flour and amounted to 102.38, 121.6, and 140.9 mg/100 g, respectively.

Thus, adding persimmon syrup can increase the amount of magnesium in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures. Magnesium is mainly found in bones and muscles, it is an important constituent of all cells and tissues; with ions of other elements, maintains the ionic balance of the body's liquid media; is included in the composition of the enzymes related to the metabolism of phosphorus and carbohydrates; activates plasma and bone phosphatase and participates in nervous-muscular irritation.

Compared to wheat flour, persimmon syrup contains slightly more sodium. In the first-grade wheat flour, the amount of sodium salts was 5.0 mg/100 g, in persimmon syrup – 8.0 mg/100 g. When persimmon syrup is added to wheat flour, the amount of sodium in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures is 5.4, 5.8 and 6.2 mg/100g, respectively. In the control bread sample, the sodium content was 505.42 mg/100 g. However, in the bread samples prepared according to options I, II and III, the sodium content was significantly higher compared to wheat flour and amounted to 506.6, 507.0 and 507.4 mg/100 g, respectively.

Thus, adding persimmon syrup can increase the amount of sodium in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures. Sodium salts have a positive effect on the cardiovascular system. The normal growth and state of the organism are important for the normal functioning of the neuromuscular system.

Compared to wheat flour, persimmon syrup contains more sulfur. In the first-grade wheat flour, the amount of sulfur was 75.0 mg/100 g, in persimmon syrup – 110.0 mg/100 g. When persimmon syrup is added to wheat flour, the amount of sulfur in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures is 80.5, 86.0 and 91.5 mg/100g, respectively. In the control sample of bread, the sulfur content was 56.75 mg/100 g. However, in the bread samples prepared according to options I, II and III, the sulfur content was higher compared to wheat flour and amounted to 60.91, 65.1 and 69.2 mg/100 g, respectively.

Thus, adding persimmon syrup can increase the amount of sulfur in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures. Sulfur is an "anti-inflammatory" mineral, an integral component of the proteins of most tissues of the body: blood vessels, hair and nails, skin and other organs, forms flexible disulfide bonds within proteins that provide flexibility and mobility of tissues. It contributes to the destruction of microbes and parasites, improves immunity, helps maintain the oxygen balance necessary for the normal functioning of the brain, ensures normal regeneration of body cells, which is able to resist tissue destruction by free radicals and, therefore, promotes rejuvenation processes.

Compared to wheat flour, persimmon syrup contains more phosphorus. In the first-grade wheat flour, the amount of phosphorus was 310 mg/100 g, in persimmon syrup – 380 mg/100 g. When persimmon syrup is added to wheat flour, the amount of phosphorus in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures is 329.0, 348.0 and 367.0 mg/100g, respectively. In the control sample of bread, the phosphorus content was 234.3 mg/100 g. However, in the bread samples prepared according to options I, II and III, the phosphorus content was higher compared to wheat flour and amounted to 248.66, 263.0 and 277.4 mg/100 g, respectively.

Thus, adding persimmon syrup can increase the amount of phosphorus in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures. Phosphorus compounds play an important role in all processes occurring in the human organism: phosphoric acid is involved in the construction of numerous enzymes (phosphatases) that perform chemical reactions in tissues. The human skeletal tissue is formed from salts of phosphoric acid.

Fig. 5 clearly shows the changes in macroelements in bread samples prepared according to the options.

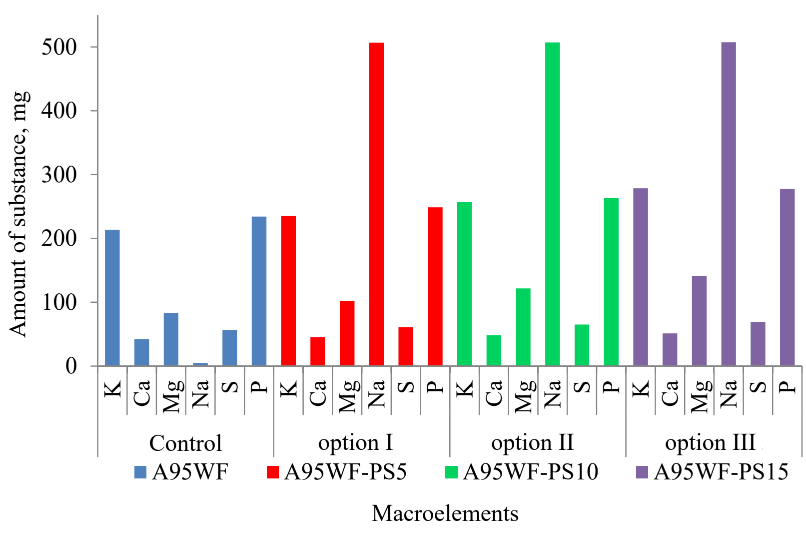

Fig. 5. Changes in macroelements in bread samples prepared according to the options

This pattern is also observed in the A95WF-PS5, A95WF-PS10, and A95WF-PS15 mixtures prepared according to options I, II, and III.

As can be seen from Table 4, by adding persimmon syrup to wheat flour according to options I, II and III, it is possible to enrich the dough and bread products made from it with microelements, especially iron, zinc, iodine and cobalt.

Compared to wheat flour, persimmon syrup contains slightly less iron. In the first-grade wheat flour, the amount of iron was 1,600 mcg/100 g, in persimmon syrup – 1,500 mcg/100 g. When persimmon syrup is added to wheat flour, the amount of iron in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures is 1675.0, 1750.0 and 1825.0 mcg/100 g, respectively. In the control bread sample, the iron content was 1466.72 mcg/100 g. However, in the bread samples prepared according to options I, II and III, the iron content was higher compared to the control bread and amounted to 1535.47, 1604.2 and 1673.0 mcg/100 g, respectively. Iron is involved in redox and immunobiological reactions.

Compared to wheat flour, persimmon syrup contains more zinc. In the first-grade wheat flour, the amount of zinc was 784 mcg/100 g, in persimmon syrup – 1100 mcg/100 g. When persimmon syrup is added to wheat flour, the amount of zinc in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures is 839.0, 894.0 and 949.0 mcg/100 g, respectively. In the control bread sample, the zinc content was 589.1 mcg/100 g. However, in the bread samples prepared according to options I, II, and III, the zinc content was higher compared to the control bread and amounted to 630.42, 671.8 and 713.1 mcg/100 g, respectively. Zinc has a significant effect on hematopoiesis, reproduction, growth and development, carbohydrate, protein, fat and energy metabolism. Iron and zinc present in persimmon fruits are able to form complexes with the corresponding groups of substances (ligands) and act as specific catalysts for the most important metabolic processes.

Compared to wheat flour, persimmon syrup contains slightly more iodine. In the first-grade wheat flour, the amount of iodine was 4.2 mcg/100 g, in persimmon syrup – 6.4 mcg/100 g. When persimmon syrup is added to wheat flour, the amount of iodine in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures is 4.52, 4.84 and 5.16 mcg/100 g, respectively. In the control sample of bread, the iodine content was 3.12 mcg/100 g. However, in the bread samples prepared according to options I, II and III, the iodine content was higher compared to the control bread and amounted to 3.36, 3.6 and 3.8 mcg/100 g, respectively.

Thus, by adding persimmon syrup, it is possible to increase the amount of iodine in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures. Iodine is a component of thyroid hormones and is essential for their synthesis. They determine the level of metabolism, affect the conversion of food into energy and the way it is used.

Iodine is involved in the regulation of energy metabolism, body temperature, the rate of biochemical reactions, the metabolism of proteins, fats, water and electrolyte metabolism, the metabolism of a number of vitamins, the processes of growth and development of the body, including neuropsychic development, increases oxygen consumption by tissues.

Compared to wheat flour, persimmon syrup contains more cobalt. In the first-grade wheat flour, the amount of cobalt was 3.4 mcg/100 g, in persimmon syrup – 9.6 mcg/100 g. When persimmon syrup is added to wheat flour, the amount of cobalt in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures is 3.88, 4.36 and 4.84 mcg/100 g, respectively. In the control bread sample, the cobalt content was 2.69 mcg/100 g. However, in the bread samples prepared according to options I, II, and III, the cobalt content was higher compared to the control bread and amounted to 3.07, 3.5, and 3.8 mcg/100 g, respectively.

Thus, by adding persimmon syrup, it is possible to increase the amount of cobalt in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures. Cobalt is essential for the human body. It is of great importance in the course of internal processes; it is one of the structural units of vitamin B12 involved in enzymatic reactions, hematopoiesis, regulation of the nervous system and liver.

Fig. 6 clearly shows the changes in microelements in bread samples prepared according to the options.

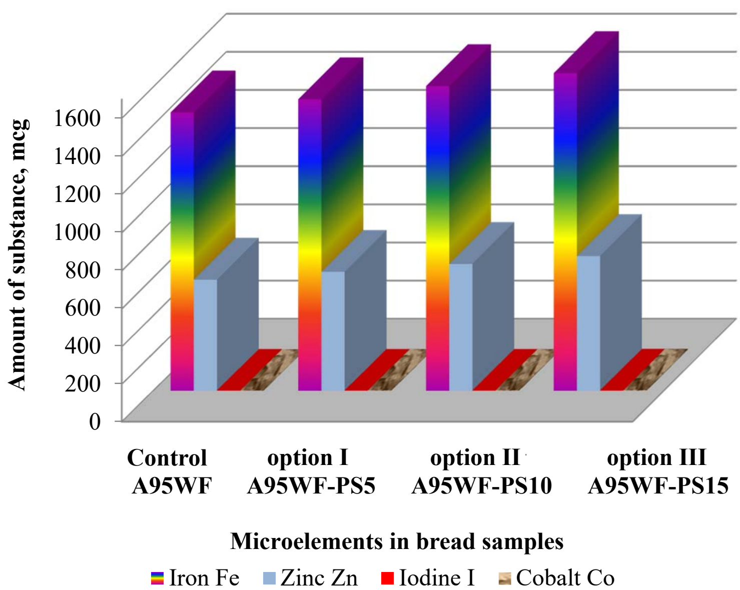

Fig. 6. Changes in microelements in bread samples prepared according to the options

This pattern is also observed in the A95WF-PS5, A95WF-PS10, and A95WF-PS15 mixtures prepared according to options I, II and III.

Thus, the health of all living beings, including the human body, their vital activity to a greater extent depend on the content of nutrients, vitamins and minerals. With a lack or absence of them in the body, the metabolic process is disrupted, especially the synthesis of certain enzymes, proteins, hormones and biologically active substances necessary for life. This creates conditions for unwanted diseases in the human body. Therefore, nutrients, vitamins and minerals are necessary in the daily diet of a person.

5. 3. Analysis of the influence of persimmon syrup on the organoleptic indicators of bread with additives

The results of the analysis of the organoleptic indicators of bread with the addition of persimmon syrup are shown in Table 6.

Table 6

Results of the analysis of organoleptic indicators of bread with the addition of persimmon syrup

Indices	Row	Bread making options			
		Control	I	II	III
Bread output, cm^3/100 g		495	532	545	505
Volume point		4.2	4.2	5.0	4.4
State of the bread upper crust		4.2	4.7	4.8	3.8
Shape correctness H:B		4.2	4.6	5.0	3.7
Color of the bread crust		4.2	4.6	4.9	3.3
Crumb SMP		4.1	4.3	5.0	3.1
Pore structure		4.3	4.5	4.9	3.2
Crumb color		4.8	3.9	3.7	1.2
Total point		4.3	4.5	4.8	3.2

As seen in Table 6, the volume of bread samples made from the A95WF-PS10 mixture (option II) was 545 cm^3/100 g, which is more by 50, 13 and 40 cm^3/100 g compared to the control, options I and III, respectively. The increase in the persimmon syrup amount to 10 % resulted in an increase in the bread volume, but the further increase to 15 % led to a decrease in the bread volume. Nevertheless, the volume of bread made from the A95WF-PS15 mixture was greater by 10 cm^3/100 g than that of the control bread and equaled 505 cm^3/100 g. Therefore, the bread samples made from the A95WF-PS5, A95WF-PS10, and A95WF-PS15 mixtures scored 4.2, 5.0, and 4.4 points, respectively. Thus, the volume of bread made from the A95WF-PS10 mixture was greater compared with the other options. This can be seen clearly in Fig. 2.

When analyzing the condition of the bread surface, the control bread scored 4.2 points: the surface of the crust was quite smooth, bright with scarce bubbles, noticeable small cracks, and fissures. The crust surface of bread made from the A95WF-PS5 mixture was quite smooth and glossy, and there were also single small bubbles, small cracks and undermining. Therefore, this bread scored 4.7 points. The crust surface of bread made from the A95WF-PS10 mixture was quite smooth and glossy, and there were also invisible single small cracks. Therefore, this bread scored 4.8 points. Option III bread made from the A95WF-PS15 mixture is slightly wrinkled, like the control bread, bright with scarce bubbles, noticeable small cracks, and fissures. This option scored 3.8 points. This is 0.4 points less than for the control bread. The tasting score of the bread made from the A95WF-PS10 mixture was 0.6, 0.1 and 1.0 points higher than that of the bread samples made from the A95WF, A95WF-PS5 and A95WF-PS15 mixtures, respectively.

When evaluating the correctness of the shape of the bread samples, the control option scored 4.2 points, since the correctness of the bread shape was H:B=0.41. When evaluating the correctness of the shape of the bread made from the A95WF-PS5 mixture, the top crust was domed at H:B=0.54. Therefore, this bread scored 4.6 points. The top crust of bread made with the A95WF-PS10 mixture was domed at H:B=0.57 and received a score of 5.0. The correctness of the shape of bread from the A95WF-PS15 mixture according to option III was H:B=0.39, so it received a score of 3.7 points.

The control option, which has a golden crust, scored 4.2 points. The color of the crust of bread made from the A95WF-PS10 mixture (option II) scored 4.9 points due to the brown crust. The crust of bread made from the A95WF-PS5 mixture according to option I was dark in color compared to option II and therefore scored 4.6 points. The A95WF-PS15 bread crust scored 3.3 for dark brown.

It was found that when 10 % to 15 % persimmon syrup was added to wheat flour, the evaluation score decreased due to the accuracy of the bread shape, condition, and color of the crust. Thus, the analysis shows that bread made from the A95WF-PS10 mixture is superior to the bread samples made from the A95WF-PS5 and A95WF-PS15 mixtures, as well as the control bread A95WF in terms of shape accuracy, condition, and color of the crust.

Based on the SMP values, bread made from the A95WF-PS5 mixture (option I) scored 4.3 points, due to soft and elastic crumb. Whereas, bread made from the A95WF-PS10 (option II) mixture scored 5.0 points. However, in option III, i.e. when the bread was made from the A95WF-PS15 mixture, it scored 3.1 points because the crumb was satisfactorily soft, slightly dense, and elastic. This is 1.0 point less than the evaluation score of the control bread, is 1.2 and 1.9 points less than the evaluation score of options I and II, respectively.

Based on the pore structure of bread samples, bread made from the A95WF mixture (control bread) scored 4.3 points, because the pores of the bread were quite medium, thin-walled, and fairly evenly distributed. The pore structure of bread made from the A95WF-PS5 mixture (option I) scored 4.5 points, because the pores of the bread were medium, thin-walled, and fairly evenly distributed. Bread made from the A95WF-PS10 mixture (option II) scored 4.9 points as the pores were fine, thin-walled, and evenly distributed. Bread made from the A95WF-PS15 mixture (option III) scored 3.2 points as the crumb was satisfactorily soft, slightly dense, and elastic. Thus, the tasting score of bread from the A95WF-PS10 mixture (option II) is 0.6, 0.4, and 1.7 points higher than that of the bread samples prepared according to the control, options I and III, respectively.

Moreover, it was found that increasing the amount of persimmon syrup from 10 % to 15 % had a sharp effect on the color of the bread crumb. The control bread scored 4.8 points as its crumb had a very light color. The bread made from the A95WF-PS5 mixture (option I) scored 3.9 points, as its crumb had a slightly dark color. The bread made from the A95WF-PS10 mixture (option II) scored 3.7 points, as its crumb had a noticeably dark color. Whereas, the bread made from the A95WF-PS15 mixture (option III) scored 1.2 point because of the dark gray color of its crumb. This is 3.6, 2.7 and 2.5 points lower compared to the control, options I and II, respectively.

An analysis of the effect of persimmon syrup on organoleptic quality indicators shows that the maximum total tasting score was given to bread prepared according to option II (bread with the addition of 10 % persimmon syrup), and amounted to 4.8 points. In terms of total tasting points, the second place is occupied by bread prepared according to option I (bread with the addition of 5 % persimmon syrup), and amounted to 4.5 points. The third place is taken by the control bread (bread without additives), which received a total tasting score of 4.3 points, and the fourth place is occupied by bread prepared according to option III (bread with the addition of 15 % persimmon syrup), which received a total tasting score of 3.2 points.

Thus, the analysis shows that the condition of the bread crumb made with the A95WF-PS10 mixture is much better than that of bread samples made with the A95WF, A95WF-PS5 and A95WF-PS15 options.

Fig. 7 clearly shows the tasting scores of organoleptic indicators of bread samples from the A95WF, A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures, prepared according to the control, options I, II and III, respectively.

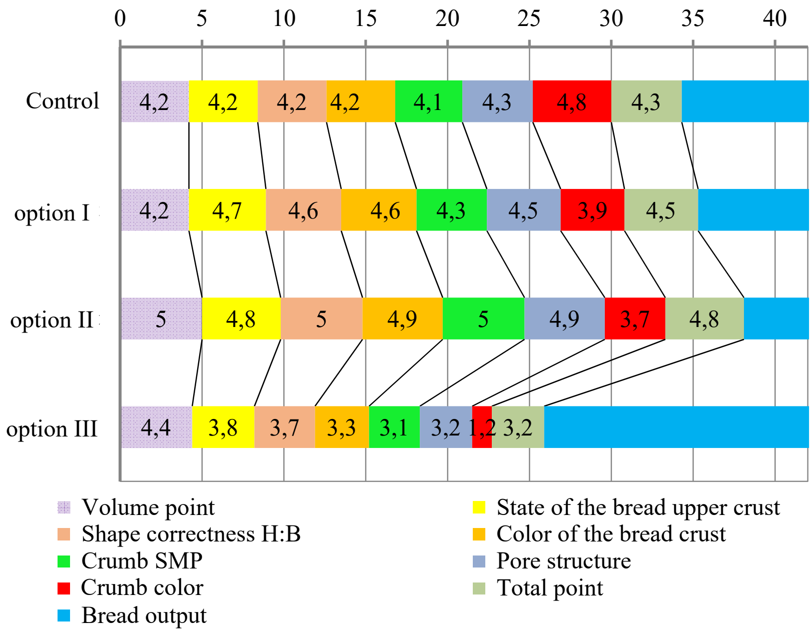

Fig. 7. Tasting scores of organoleptic indicators of bread samples from the A95WF, A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures, prepared according to the control, options I, II and III, respectively

Visualization of organoleptic indicators and numerical data allows us to conclude that the best option for making bread is option II. The total tasting score of option II bread is 4.8, and of the control bread – 4.3 points. This comparison is clearly shown in Fig. 8, 9.

Fig. 8. Samples of bread prepared according to the control and II options

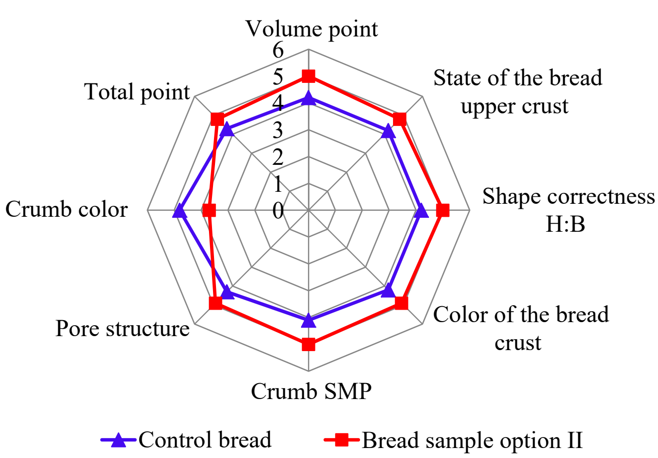

Fig. 9. Diagram of comparison of organoleptic indicators of bread samples of the control and II options

From Fig. 8, 9, it can be seen that the bread sample of option II, made from the A95WF-PS10 mixture, is more preferable than the control bread without additives.

6. Discussion of the experimental results of the study of the possibility of using persimmon juice to improve the food value of bread

Improving the textural and organoleptic properties of the product requires the reasonable use of persimmon syrup. This is possible only if the mechanical and chemical composition of the raw materials used for the production of bread of increased biological value and the best organoleptic characteristics are known.

As a result of the research, it was found that the method of processing the persimmon fruit affects the yields of pulp and opaque juice without pulp. From the results of the studies presented in Table 3, it can be seen that mechanical grinding alone is not enough for the persimmon fruit, which is explained by the structural features and physiological properties of the fruit tissue. The yield of juice from the persimmon fruit depends on the permeability of the cell protoplasm, its ability to withstand external influences during pre-treatment, i.e. the higher the cell permeability and the more damaged the cell membrane during the pre-treatment of the fruit, the higher the juice yield during subsequent pressing.

To increase the permeability of fruit cells, it is necessary to create a sufficiently strong external effect, after which the restoration of the original properties is impossible. At the same time, the cell structure is destroyed, the membrane of such cells loses the ability to retain juice, which easily comes out through the large pores formed. Therefore, along with grinding, it is necessary to carry out additional processing of fruits.

As can be seen from Table 3, the classical method of processing persimmon fruits does not provide a full yield of juice, and when they are crushed, intensive oxidation of both the pulp and the resulting juice occurs, which worsens its quality. In addition, with the classical method, the pulp yield was 30.6 %. With the classic method, the yield of opaque juice without pulp was 62.1 %, and with the hot method – 67.7 %. Compared with the classical method, the hot method of processing the persimmon fruit increases the yield of opaque juice without pulp by 5.6 %. Along with this, the yield of pulp also changes at the same time. With the hot method of processing persimmon fruits, the pulp yield decreased from 30.6 to 25.0 %. However, with both methods of processing the persimmon fruit, the yield of pulp with juice remained constant.

The use of a hot method of processing persimmons allows you to increase the yield of syrup and reduce the yield of pulp, to get bread with developed porosity and good volume.

From the data in Table 5 and Fig. 1, it can be seen that for a quick and uniform distribution of water, the pattern of increasing water consumption for diluting the syrup g_{wi} is approximated by the linear equation g_{wi}=1.193·g_{si}+0.00333, where g_{si} is the amount of persimmon syrup according to options I, II and III. At the same time, the regularity of the decrease in water consumption for diluting the dough g_{di} is approximated by the linear equation g_{di}=–1.3001·g_{si}+332.1967.

From the results of the studies presented in Table 4, it can be seen that the nutrient content in wheat flour bread with persimmon syrup is higher than in the control sample of bread and in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures prepared according to options I, II and III. It was found that when mixing wheat flour and persimmon syrup according to options I, II and III in the A95WF-PS5, A95WF-PS10 and A95WF-PS15 mixtures, the content of nutrients increases. However, the technological process leads to a decrease in the content of nutrients. At the same time, adding persimmon syrup to wheat flour allows you to increase their content in bread. Knowing the quantitative change of nutrients in the technological process, it is possible to determine the proportion of their content reduction (in %). This allows you to regulate the quantitative change in nutrients before and after the technological process of processing raw materials and making bread with additives [9].

The quantitative change in nutrients when mixing wheat flour with persimmon syrup and making bread from the mixtures according to options I, II and III can be represented as follows (Table 4, Fig. 3): in the A95WF-PS5, A95WF-PS10 and A95WF- PS15 mixtures, the starch content almost does not change and is in the range of 57.41–57.42 g/100 g, since its content in persimmon syrup is very low (0.1 g/100 g). However, in the technological process, the starch content in bread samples prepared from these mixtures decreased by 29.19 % and was in the range of 40.65–40.66 g/100 g (0.03–0.05 %); the content of protein substances in the mixtures did not change and was in the range of 11.64–11.71 g/100 g, since their content in persimmon syrup was not high (0.7 g/100 g). However, in the technological process, the content of protein substances in bread samples prepared from these mixtures decreased by 26.2 % and was in the range of 8.59–8.64 g/100 g. But this is more in the range of 0.35–0.93 % than that of the control bread (8.56 g/100 g); the glucose content in the mixtures was higher and was in the range of 0.49–1.31 g/100 g, since the glucose content in persimmon syrup was much higher (8.2 g/100 g) than in wheat flour (0.08 g/100 g). However, in the technological process, the glucose content in bread samples prepared from these mixtures according to options I, II and III decreased by 56.2 %. But despite such losses, the glucose content in the bread samples prepared from these mixtures according to options I, II and III was higher by 0.17 g/100 g (80.95 %), 0.35 g/100 g (89.74 %) and 0.53 g/100 g (92.98 %), respectively than in the control bread (0.04 g/100 g); the content of fructose in the mixtures was higher and was in the range of 0.51–1.44 g/100 g, since the content of fructose in persimmon syrup was even higher (9.3 g/100 g) than in wheat flour (0.04 g/100 g). However, in the technological process, the content of fructose in bread samples prepared from these mixtures according to options I, II and III decreased by 56.2 %. But despite such losses, the fructose content in bread samples prepared from the mixtures according to options I, II and III was higher by 0.20 g/100 g (90.91 %), 0.40 g/100 g (95.24 %) and 0.61 g/100 g (96.83 %), respectively than in the control bread (0.02 g/100 g); the content of sucrose in mixtures was higher and was in the range of 0.22–0.30 g/100 g, since the content of sucrose in persimmon syrup was slightly higher (0.8 g/100 g) than in wheat flour (0.18 g/100 g). However, in the technological process, the content of sucrose in bread samples prepared from the mixtures according to options I, II and III also decreased by 56.2 %. But despite such losses, the content of sucrose in the bread samples prepared from the mixtures according to options I, II and III was higher by 0.02 g/100 g (20 %), 0.03 g/100 g (27.27 %) and 0.05 g/100 g (38.46 %), respectively than in the control bread (0.08 g/100 g); the content of raffinose in the mixtures was somewhat higher and was in the range of 0.56–0.59 g/100 g, since the content of raffinose in persimmon syrup was slightly lower (0.26 g/100 g) than in wheat flour (0.55 g/100 g). However, in the technological process, the content of raffinose in bread samples prepared from these mixtures according to options I, II and III also decreased by 56.2 %. But despite such losses, the content of raffinose in bread samples was higher by 0.01 g/100 g (4 %) for options I and II, and by 0.02 g/100 g (8 %) more for option III than in the control bread (0.24 g/100 g); the cellulose content in the mixtures was somewhat higher and was in the range of 0.42–0.45 g/100 g, since the cellulose content in persimmon syrup was slightly lower (0.32 g/100 g) than in wheat flour (0.4 g/100 g). However, in the technological process, the cellulose content in bread samples prepared from these mixtures according to options I, II and III decreased by 25.7 %. But despite such losses, the cellulose content in the bread samples prepared from the mixtures according to options I, II and III was higher by 0.01 g/100 g (3.23 %), 0.02 g/100g (6.25 %) and 0.03 g/100 g (9.1 %), respectively than in the control bread (0.3 g/100 g); the content of pectin substances in the mixtures was somewhat higher and was in the range of 0.11–0.13 g/100 g, since the content of pectin substances in persimmon syrup was slightly higher (0.21 g/100 g) than in wheat flour (0.1 g/100 g). However, in the technological process, the content of pectin substances in bread samples prepared from these mixtures according to options I, II and III did not change. The content of pectin in bread samples prepared from the mixtures according to options I, II and III was higher by 0.01 g/100 g (9.1 %), 0.02 g/100 g (16.67 %) and 0.03 g/100 g (23.08 %), respectively, than in the control bread (0.1 g/100 g); the content of phenolic compounds in the mixtures was somewhat higher and was in the range of 0.15–0.24 g/100 g, since the content of phenolic compounds in persimmon syrup was higher (0.92 g/100 g) than in wheat flour (0.1 g/100 g). However, in the technological process, the content of phenolic compounds in bread samples prepared from these mixtures according to options I, II and III did not change. The content of phenolic compounds in bread samples prepared from the mixtures according to options I, II and III was higher by 0.3 g/100 g (75 %), 0.41 g/100 g (80.39 %) and 0.54 g/100 g (84.37 %), respectively, than in the control bread (0.1 g/100 g).

A comparative analysis of vitamins revealed the absence of vitamin C in the first-grade wheat flour and the control sample of bread. Along with this, there was very little beta-carotene in the first-grade wheat flour and the control sample of bread. Compared to wheat flour, beta-carotene and ascorbic acid were higher in persimmon syrup, while thiamine, riboflavin, and niacin were lower.

The quantitative change in vitamins when mixing wheat flour with persimmon syrup and making bread from the mixtures according to options I, II and III can be represented as follows (Table 4, Fig. 4): the content of thiamine in the mixtures is higher and is in the range of 0.383–0.388 mg/100 g, since the content of thiamine in persimmon syrup is less (0.05 mg/100 g) than in wheat flour (0.38 mg/100 g). However, in the technological process, the content of thiamine in bread samples prepared from these mixtures according to options I, II and III decreased by 35.3 %. The content of thiamine in bread samples prepared from the mixtures according to options I, II and III was higher by 0.001 mg/100 g (0.41 %), 0.003 mg/100 g (1.22 %) and 0.005 mg/100 g (2.03 %), respectively, than in the control bread (0.246 mg/100 g); the content of riboflavin in the mixtures is higher and is in the range of 0.303–0.309 mg/100 g, since the content of riboflavin in persimmon syrup is lower (0.06 mg/100 g) than in wheat flour (0.3 mg/100 g). However, in the technological process, the content of riboflavin in bread samples prepared from these mixtures according to options I, II and III decreased by 25 %. The content of riboflavin in bread samples prepared from the mixtures according to options I, II and III was higher by 0.002 mg/100 g (0.89 %), 0.005 mg/100 g (2.22 %) and 0.007 mg/100 g (3.11 %), respectively, than in the control bread (0.225 mg/100 g); the content of niacin in the mixtures is higher and is in the range of 1.56–1.59 mg/100 g. In persimmon syrup, the content of niacin is lower (0.3 mg/100 g) than in wheat flour (1.54 mg/100 g). However, in the technological process, the content of niacin in bread samples prepared from these mixtures according to options I, II and III decreased by 25 %. The content of niacin in bread samples prepared from the mixtures according to options I, II and III was higher by 0.011 mg/100 g (0.95 %), 0.023 mg/100 g (1.99 %) and 0.034 mg/100 g (2.94 %), respectively, than in the control bread (1.155 mg/100 g); the content of beta-carotene in the mixtures is higher and is in the range of 0.12–0.34 mg/100 g, since the content of beta-carotene in persimmon syrup is higher (2.2 mg/100 g) than in wheat flour (0.01 mg/100 g). However, in the technological process, the content of beta-carotene in bread samples prepared from these mixtures according to options I, II and III decreased by 10 %. The content of beta-carotene in bread samples prepared from the mixtures according to options I, II and III was higher by 0.099 mg/100 g (91.67 %), 0.198 mg/100 g (95.65 %) and 0.297 mg/100 g (97.06 %), respectively, than in the control bread (0.009 mg/100 g); the content of ascorbic acid in the mixtures is higher and is in the range of 0.48–1.44 mg/100 g. In wheat flour, ascorbic acid was absent, and in persimmon syrup, the content of ascorbic acid was 9.6 mg/100 g. However, in the technological process, the content of ascorbic acid in bread samples prepared from the mixtures according to options I, II and III decreased by 50 %. Despite such losses, the content of ascorbic acid in bread samples prepared from the mixtures according to options I, II and III was 0.24, 0.48 and 0.72 mg/100 g, respectively.

From the results of the studies presented in Table 4, it can be seen that the content of minerals in bread made from the first-grade "Azamatli-95" wheat flour with persimmon syrup is higher than in the control sample of bread. It was found that in the technological process there is a quantitative change in mineral substances. But adding persimmon syrup to wheat flour can increase the mineral content of bread. The study of quantitative changes in mineral substances makes it possible to determine the proportion of changes in their content. Based on this, it is possible to regulate the content of mineral substances before and after the technological process of processing raw materials and making bread with additives.

In a comparative analysis of macronutrients, the amount of potassium, calcium, magnesium, sodium, sulfur and phosphorus in persimmon syrup was greater than in the first-grade wheat flour. Compared to the control bread, persimmon syrup had more potassium, calcium, magnesium, sodium, sulfur and phosphorus.

The quantitative change in macroelements in the technological process of bread production can be represented as follows (Table 4, Fig. 5): the potassium content in the mixtures is higher and is in the range of 308.5–365.5 mg/100 g, since the potassium content in persimmon syrup is higher (570 mg/100 g) than in wheat flour (280 mg/100 g). However, in the technological process, the potassium content in bread samples prepared from these mixtures according to options I, II and III decreased by 23.8 %. The content of potassium in bread samples prepared from the mixtures according to options I, II and III was higher by 21.72 mg/100 g (10.18 %), 43.44 mg/100 g (20.36 %) and 65.14 mg/100 g (30.53 %), respectively, than in the control bread (213.36 mg/100 g); the calcium content in the mixtures is higher and is in the range of 40.7–46.1 mg/100 g, since the calcium content in persimmon syrup is higher (54 mg/100 g) than in wheat flour (38 mg/100 g). However, in the technological process, the calcium content in the bread samples prepared from these mixtures according to options I, II and III was 11.11 % higher. The calcium content in bread samples prepared from the mixtures according to options I, II and III increased by 3.0 mg/100 g (7.11 %), 5.98 mg/100 g (14.16 %) and 8.98 mg/100 g (21.27 %), respectively, than in the control bread (42.22 mg/100 g); the content of magnesium in the mixtures is higher and is in the range of 117–161 mg/100 g, since the content of magnesium in persimmon syrup is higher (440 mg/100 g) than in wheat flour (95 mg/100 g). However, in the technological process, the content of magnesium in bread samples prepared from these mixtures according to options I, II and III decreased by 12.5 %. The content of magnesium in bread samples prepared from the mixtures according to options I, II and III increased by 19.25 mg/100 g (23.16 %), 38.47 mg/100 g (46.28 %) and 57.77 mg/100 g (69.5 %), respectively, than in the control bread (83.13 mg/100 g); the sodium content in mixtures is slightly higher and is in the range of 5.4–6.2 mg/100 g, since the sodium content in persimmon syrup is higher (8 mg/100 g) than in wheat flour (5 mg/100 g). However, in the technological process, the sodium content in bread samples prepared from these mixtures according to options I, II and III increased several times. The reason for the increase in the amount of sodium in bread is that according to the recipe of bread, 1.5 kg of common salt (NaCl) is consumed per 100 kg of the first-grade wheat flour. The mass fraction of sodium chloride in terms of dry matter for edible salt of the first grade is at least 97.7 %. 1 g of salt contains 0.394 g (394) mg of sodium. Since 100 g of bread contains 1.5 g of salt, then the mass fraction of sodium will be 1.5*97.7*394/100=577.41 mg of sodium [35]. In the first-grade "Azamatli-95" wheat flour, the amount of sodium is 5 mg, and persimmon syrup – 8 mg. In addition, 100 g of bread contains 1.5 g of dry yeast, in which the amount of sodium is 0.77 mg. When persimmon syrup was added to wheat flour according to options I, II and III, dry yeast and salt, the sodium content in the bread samples was 582.81, 583.21 and 583.61 mg, respectively. A person consumes about 2.4 of sodium per day with bread; the sulfur content in the mixtures is higher and is in the range of 80.5–91.5 mg/100 g, since the sulfur content in persimmon syrup is higher (110 mg/100 g) than in wheat flour (75 mg/100 g). However, in the technological process, the sulfur content in bread samples prepared from these mixtures according to options I, II and III decreased by 24.33 %. But the sulfur content in bread samples prepared from the mixtures according to options I, II and III was higher by 4.16 mg/100 g (7.33 %), 8.35 mg/100 g (14.71 %) and 12.45 mg/100 g (21.94 %), respectively, than in the control bread (56.75 mg/100 g); the content of phosphorus in the mixtures is higher and is in the range of 329–367 mg/100 g, since the content of phosphorus in persimmon syrup is higher (380 mg/100 g) than in wheat flour (310 mg/100 g). However, in the technological process, the phosphorus content in bread samples prepared from these mixtures according to options I, II and III decreased by 24.42 %. But the content of phosphorus in bread samples prepared from the mixtures according to options I, II and III was higher by 14.36 mg/100 g (6.13 %), 28.7 mg/100 g (12.25 %) and 43.1 mg/100 g (18.39 %), respectively, than in the control bread (234.3 mg/100 g).

In a comparative analysis of trace elements, the amount of zinc, iodine and cobalt in persimmon syrup was greater, and iron was somewhat less than in the first-grade wheat flour. Compared to the control bread sample, persimmon syrup, flour and syrup mixtures, and bread samples had more iron, zinc, iodine, and cobalt.

The quantitative change in microelements in the technological process of bread production can be represented as follows (Table 4, Fig. 6): the iron content in the mixtures is higher and is in the range of 1,675–1,825 mcg/100 g. In persimmon syrup, the iron content is slightly lower (1,500 mcg/100 g) than in wheat flour (1,600 mcg/100 g). However, in the technological process, the iron content in bread samples prepared from these mixtures according to options I, II and III decreased by 8.33 %. But the iron content in bread samples prepared from the mixtures according to options I, II and III was higher by 68.8 mcg/100 g (4.69 %), 137.5 mcg/100 g (9.38 %) and 206.2 mcg/100 g (14.06 %), respectively, than in the control bread (1466.7 mcg/100 g); the zinc content in the mixtures is higher and is in the range of 839–949 mcg/100 g, since the content of zinc in persimmon syrup is higher (1,100 mcg/100 g) than in wheat flour (784 mcg/100 g). However, in the technological process, the zinc content in bread samples prepared from these mixtures according to options I, II and III decreased by 24.86 %. Despite such losses, the zinc content in bread samples prepared from the mixtures according to options I, II and III was higher by 41.32 mcg/100 g (7.02 %), 82.7 mcg/100 g (14.04 %) and 124 mcg/100 g (21.05 %), respectively, than in the control bread (589.1 mcg/100 g); the iodine content in the mixtures is higher and is in the range of 4.52–5.16 μg/100 g, since the iodine content in persimmon syrup is higher (6.4 mcg/100 g) than in wheat flour (4.2 mcg/100 g). However, in the technological process, the iodine content in the bread samples prepared from these mixtures according to options I, II and III decreased by 20.88 %. Despite such losses, the iodine content in bread samples prepared from the mixtures according to options I, II, and III was higher by 0.24 mcg/100 g (7.69 %), 0.48 mcg/100 g (15.38 %) and 0.68 mcg/100 g (21.8 %), respectively, than in the control bread (3.12 mcg/100 g); the content of cobalt in the mixtures is higher and is in the range of 3.88–4.84 mcg/100 g, since the content of cobalt in persimmon syrup is higher (9.6 mcg/100 g) than in wheat flour (3.4 mcg/100 g). However, in the technological process, the content of cobalt in bread samples prepared from these mixtures according to options I, II and III decreased by 20.88 %. Despite such losses, the content of cobalt in bread samples prepared from the mixtures according to options I, II and III was higher by 0.38 mcg/100 g (14.13 %), 0.81 mcg/100 g (30.11%) and 1.11 mcg/100 g (41.26 %), respectively, than in the control bread (2.69 mcg/100 g).

Table 7 shows the values of the body's daily requirement for nutrients, vitamins, minerals and their content in bread samples prepared according to the control and II options.

Table 7

The daily need of the body for nutrients, vitamins and minerals due to bread prepared according to the control and II options (per 100 g of the product)

Nutrients	Daily rate	Samples of bread by options		% of the norm in 100 g according to option II
		Control	II	
Digestible carbohydrates, g	365	41.02	41.82	11.46
Proteins, g	75	8.56	8.61	11.48
Cellulose, g	15	0.30	0.32	2.13
Pectin substances, g	15	0.10	0.12	0.80
Thiamine, mg	1.5	0.246	0.249	16.6
Riboflavin, mg	1.8	0.225	0.230	12.8
Niacin, mg	20	1.155	1.178	5.89
β-carotene, mg	5	0.009	0.207	4.14
Ascorbic acid, mg	70	0	0.480	0.69
Potassium, mg	3,500	213.36	256.8	7.34
Calcium, mg	1,000	42.22	48.2	4.82
Magnesium, mg	400	83.13	121.6	30.4
Sodium, mg	2,400	582.41	583.21	24.3
Sulfur, mg	1,000	56.75	65.1	6.51
Phosphorus, mg	1,000	234.30	263.0	26.3
Iron, mcg	14	1.4667	1.6042	11.5
Zinc, mcg	12	0.5891	0.6718	5.6
Iodine, mcg	150	3.12	3.6	2.4
Cobalt, mcg	15	2.69	3.5	23.33

Table 7 clearly shows how much the body's need for nutrients, vitamins and minerals is satisfied by bread prepared according to option II.

From the results of the tasting evaluation of the organoleptic characteristics of the bread samples presented in Table 6, it can be seen that the bread prepared according to option II from the A95WF-PS10 mixture was the best compared to the control bread samples, options I and III. This can be represented as follows: when adding persimmon syrup up to 10 % (option II) to the first-grade wheat flour, the volumetric yield of bread was 545 cm^3/100 g, which is 50 cm^3/100 g more than that of the control bread and scored 5.0 points, and a further increase in the dosage of syrup to 15 % (option III) led to a decrease in the volume of bread; the surface of the bread crust was quite smooth and glossy, and there were also imperceptible single small cracks and scored 4.8 points, which is more than that of the bread samples of other options, and a further increase in the syrup dosage to 15 % led to a deterioration in the condition of the bread surface, since the upper bread crust was slightly wrinkled, bright, with a small amount of bubbles, noticeable small cracks and breaks, which led to a decrease in the tasting score to 3.8 points; the correctness of the bread shape was H:B=0.57, the upper crust was domed and therefore the bread scored 5.0 points, which is more than that of the bread samples of other options, and a further increase in the syrup dosage to 15 % (option III) led to a deterioration in the correctness of the bread shape and a decrease in tasting score up to 3.7 points; the color of the bread crust was brown and therefore scored 4.9 points, which is more than that of the bread samples of other options, and a further increase in the dosage of syrup to 15 % bread crust was dark brown, which led to a decrease in the tasting score to 3.3 points; the bread crumb was very soft, tender, elastic and therefore scored 5.0 points, which is more than that of the bread samples of other options, and a further increase in the syrup dosage to 15 % bread crumb was satisfactorily soft, slightly dense and elastic, which led to a decrease in the tasting score to 3.1 points; the crumb pores were small, thin-walled and evenly distributed, and therefore scored 4.9 points, which is more than that of other bread samples, and a further increase in the dosage of syrup to 15 % crumb was satisfactorily soft, slightly dense and elastic, which led to a decrease in the tasting score to 3.2 points; the crumb had a noticeably dark color and therefore scored 3.7 points, which is 1.1 and 0.2 points less than that of the control and I options, respectively, and with a further increase in the syrup dosage to 15 %, the crumb had a dark gray color, which led to a decrease in the tasting score up to 1.2 points.

An analysis of the effect of persimmon syrup on the organoleptic characteristics of bread shows that the maximum total tasting score was scored by bread with the addition of 10 % persimmon syrup and took first place (4.8 points), the second place was taken by bread with the addition of 5 % persimmon syrup (4.5 points), the third place was taken by the control bread (4.3 points), and the fourth place is occupied by bread with the addition of 15 % persimmon syrup (3.2 points).

To visualize the changes in the organoleptic characteristics of bread, a series of tasting scores was built as the content of persimmon syrup in bread increased (Fig. 4). From this series, it can be seen that adding persimmon syrup to wheat flour up to 10 % improves all the organoleptic characteristics of bread, except for the crumb color. With an increase in the content of persimmon syrup, the color of the crumb becomes even darker. The addition of persimmon syrup to wheat flour up to 15 % worsens the organoleptic characteristics of bread, except for the volumetric yield of bread (Table 6).

It is known that when buying bread, almost all consumers (customers) first of all pay attention to the volume of bread. According to consumers, the larger the volume of bread, the better. Therefore, this issue is also considered in this paper.

The results of the study of the effect of persimmon syrup on the organoleptic characteristics of bread made it possible to find the relationship between the volumetric yield of bread and the content of persimmon syrup added to wheat flour, which is approximated by the equation $y=-0.76\cdot x_i^2+12.557\cdot x_i+491.571$, where x_i is the dosage of persimmon syrup, %.

Thus, the use of persimmon syrup in bakery products from wheat flour will increase the biological value and organoleptic characteristics of bread, expand the range, raw material base and the use of non-traditional raw materials.

The study identified limitations related to the amount of persimmon syrup added to wheat flour. An increase in the dosage of persimmon syrup by more than 10 % leads to a darkening of the bread crumb color. This is especially observed at a dosage of pumpkin puree from 10 to 15 % by weight of flour. In addition, the condition of the upper crust, the correctness of the shape, the color of the crust, the structural and mechanical properties of the crumb, the structure of the pores and the color of the bread crumb also deteriorate. In the process of fermentation, the dough is liquefied, as a result, the adhesion of the dough increases, and thus the modes and conditions of mechanical processing are violated (for example, when kneading dough, when dividing fermented dough into pieces, when laying pieces of dough on the under proofing cabinet and oven, etc.). Therefore, in further studies it is necessary to determine the nature of the change in the adhesive properties of the dough depending on the dosage of persimmon syrup, as well as to identify the behavior of the dough in contact with the surfaces of the working bodies of the machines. This will make it possible to develop and introduce new anti-adhesive materials and thereby determine the optimal modes of the technological process of bread production.

It should be noted that the technological process of baking bread to a greater extent affects the chemical composition, which leads to a decrease in nutritional value. The successful practical application of persimmon syrup lies in the further improvement of the relevant technological parameters of bread production in order to achieve greater preservation of nutrients at lower energy costs.

The best indicator is a great product. The process parameters must be improved considering the use of different feedstocks to limit biologically active components. This diversity will further expand the range of bakery products.

Development of new technological methods for the use of products rich in nutrients, especially beta-carotene, vitamin C, phenolic compounds, etc. will allow modernizing existing technologies to provide the population with rational nutrition, as well as ensure long-term storage of finished products.

7. Conclusions

1. It was found that the use of the hot method for persimmon pre-treatment in the technology of obtaining juice provides an increase in the yield of juice and a decrease in the yield of pulp compared to the classical method. Compared to the classical method, during hot pre-treatment of persimmon, the pulp yield decreases to 25 %, and the juice yield increases to 67.7 %.

2. A pattern was revealed for changing the water consumption for diluting the syrup and for kneading the dough, depending on the amount of syrup added to wheat flour. With an increase of persimmon syrup by 1 %, the water consumption for diluting the syrup increases by an average of 1.193, and the water consumption for the dough decreases by an average of 1.3. In bread with the addition of persimmon syrup 10 % by weight of flour, the content of nutrients, vitamins and minerals was higher than in the control sample: nutrients (g/100 g): starch by 0.01, proteins – 0.05, glucose – 0.35 (89.74 %), fructose – 0.40 (95.24 %), sucrose –

0.03 (27.27 %), raffinose – 0.01 (4 %), cellulose – 0.02 (6.25 %), pectin substances – 0.02 (16.67 %), phenolic compounds – 0.41 (80.39 %); vitamins (mg/100 g): thiamine by 0.003 (1.22 %), riboflavin – 0.005 (2.22 %), niacin – 0.023 (1.99 %), beta-carotene – 0.198 (95.65 %), ascorbic acid – 0.48; macroelements (mg/100 g): potassium by 43.44 (20.36 %), calcium – 5.98 (14.16 %), magnesium – 38.47 (46.28 %), sodium – 0.8 (0.14 %), sulfur – 8.35 (14.71 %), phosphorus – 28.7 (12.25 %); microelements (mcg/100 g): iron by 137.5 (9.38 %), zinc – 82.7 (14.04 %), iodine – 0.48 (15.38 %), cobalt – 0.81 (30.11 %). It was found that the content of phenolic compounds in bread with the addition increases by almost 3 times. The study of changes in the content of nutrients, vitamins, macro- and microelements during baking allows you to adjust their content before and after processing raw materials and making bread with additives.

3. When adding persimmon syrup up to 10 % to the first-grade wheat flour, the organoleptic indicators of bread, except for the crumb color, improved: volumetric yield, crust surface, correctness of shape, crust color, crumb CMC, crumb pore structure scored 5.0, 4.8, 5.0, 4.9, 5.0 and 4.9 points, respectively, which is more by 0.8, 0.6, 0.8, 0.7, 0.9 and 0.6 points, respectively, and the color of the crumb scored 3.7 points, which is 1.1 points less than that of the control bread sample. The maximum overall tasting score was scored by bread with the addition of 10 % persimmon syrup and took first place (4.8 points), the second place was taken by bread with the addition of 5 % persimmon syrup (4.5 points), the third place was taken by the control bread without additives (4.3 points), and the fourth the place was taken by bread with the addition of 15 % persimmon syrup (3.2 points).

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Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

The manuscript has associated data in a data repository.

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