Fruits and berries are an integral part of a healthy diet. The seasonality of production, short-term preservation in fresh form predetermines the need for their processing in order to provide the population with the necessary nutrients year-round.

Common sauces are tomato and mayonnaise sauces. The assortment of fruit sauces is limited, and the traditional technologies of their production do not make it possible to preserve the biologically active substances of vegetable raw materials in them as much as possible and do not always differ in high organoleptic indicators.

The established relationship between the quality of the fruit product, its color, nutritional value, and digestibility is directly dependent on polyphenols, which are chemically active and extremely unstable.

One of the adopted technological solutions aimed at preserving the polyphenols of cherries and black currants during the development of sauce technology is the use of aromatic plant raw materials widely distributed in Ukraine. Previous studies have suggested that the leaves of black currant, walnut, oregano, elderflower, and chamomile flowers are able to preserve polyphenols from oxidation.

Studies have confirmed the assumptions. It was established that the adopted concentrations of additives are optimal and make it possible to preserve cherry and blackcurrant bioflavonoids by 34…82 % more compared to traditional products. According to the organoleptic parameters, the products are advantageously distinguished by their intense color and pleasant aroma, characteristic of the raw materials.

The radioprotective properties of cherry and blackcurrant sauces were investigated. Their positive influence on the removal of radionuclides from the body has been proven. Sauces reliably have radioprotective, immunomodulating properties and can be used in therapeutic and preventive and baby nutrition

Keywords: technological solutions, unique ingredients, antioxidant activity, immunomodulating properties, stabilization of bioflavonoids

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FORMATION OF QUALITY INDICATORS OF PRODUCTS BASED ON FRUITS AND BERRIES

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1. Introduction

Complete nutrition of a modern person is one of the most important components that shape his/her health as a whole. Control of the state of nutrition, development and introduction of new products aimed at correcting and preventing existing nutritional deficiencies, optimizing the quantity and quality of products consumed by the population is a priority for the development of nutrition science.

Under current conditions of a polluted environment, low level of material and living conditions, the leading factor in food shortages is the deterioration of quality and violation of the optimal ratio between individual nutrients. This is explained by insufficient supply of vitamins, bioflavonoids, mineral compounds, and other biologically active substances to the human body. The absence or deficiency of biologically active substances in food rations leads to metabolic disorders, reduced work capacity and immunological reactivity, etc. Therefore, there is a need to develop new food products for everyday use, with the help of which it is possible to solve the identified problems.

Therefore, under current conditions, nutrition must meet not only the requirements of rational nutrition but also take into account a set of special medical and preventive measures that will reduce the impact of adverse environmental factors on the human body.

A valuable source of biologically active substances is fruit and berry raw material, which enriches the body with vitamins, bioflavonoids, mineral salts, organic acids, and other substances. Fruits and berries are widely used in dietary, medical, and preventive and children's nutrition due to their high nutritional value and a number of valuable characteristics inherent in them. The main properties of fruit and berry raw materials are a positive effect on all types of metabolism, the body's resistance to various diseases, adverse environmental factors [1].

The seasonal nature of production, the short-term preservation of fruits in fresh form necessitates their processing in order to provide the population with the necessary nutrients throughout the year.

During processing and long-term storage of fruits, oxidation processes occur in them, which lead to qualitative

changes and loss of nutritional value. Therefore, it is necessary to pay special attention to the study of the factors influencing fruit polyphenols in order to be able to manage them in order to devise a progressive technology for the production of sauces from vegetable raw materials.

Therefore, the research and application of technological methods and regimes during the development of technologies for food products with an increased content of biologically active substances, which will have radioprotective and antioxidant properties, are appropriate and relevant. Consumption of such products will increase the resistance of the human body and activate metabolic processes.

2. Literature review and problem statement

Sauces occupy an important place among the products of the food industry, restaurant industry, and are of great importance during the preparation of many meals. They have the ability to strengthen or weaken the taste inherent in the main product of the meal, give a special aroma, juiciness, enrich the composition of meals, and increase their caloric content, stimulate appetite, and contribute to better assimilation of the product. This is due to their content of extractive, aromatic, and flavoring substances that stimulate the secretion of digestive glands. The use of some sauces in the recipe when preparing meals not only enriches them with fats, proteins, carbohydrates, and minerals, but also intensifies the cooking process, which is one of the important functions of sauces in culinary production [2].

Sauces are made for use in the process of preparing meals and culinary products, when baking, when canning – as fillings, as well as for serving various sweet (puddings, casseroles, porridge, ice cream, mousse, sambuca, etc.) and meat meals. To intensify the cooking process, some sauces can be used as additives, for example, tomato sauce is used in the production of products from yeast dough, apple, carrot, pumpkin – to enrich baby food products, confectionery with biologically active substances.

Among the sauces produced at canning industry enterprises, tomato sauces predominate. The range of fruit sauces produced by the food industry is extremely limited and includes the following names: apricot, peach, plum, apple, blackcurrant, cherry [3].

Sauces are made from fresh mashed berries boiled with sugar. According to the existing technology, the berries are washed, inspected, blanched, wiped, finished, and boiled with sugar until the content of dry substances in the sauce is at least 21 %, in apricot – at least 23 %. The ready-made sauce is packed hot (70...85 °C) in a hermetic container and sterilized at 100 °C according to specified modes, depending on the type and volume of the container [4].

Condiments, which are a type of sauce, are made on the basis of mashed potatoes with the addition of various spices and herbs. Fruit puree is a pureed mass of fresh fruits or berries with a dry matter content of 8...13 %, packaged in a hermetically sealed glass or tin container and sterilized. For the preparation of fruit seasonings, puree is subjected to secondary finishing and boiled with sugar to a dry matter content of 30 %, and in plum – 35 %. After boiling, finely ground spices are added to the finished mass, mixed, packaged, and sterilized [4].

Analysis of existing technologies allows us to state that they have a number of certain disadvantages: high sugar content, duration of the technological process, strict thermal regimes of fruit processing, use of imported spices. To obtain the required consistency, the fruits are boiled, or starch is used as a thickener, which is characterized by delamination of the product during storage.

The above does not make it possible to achieve high nutritional value and organoleptic characteristics of the product and is a limiting factor in the production of high-quality sauces.

Therefore, the invention and application of such technological solutions with optimization of the recipe, which will make it possible to obtain a high-quality sauce, remain relevant.

It was established that the relationship between the quality of the fruit product, its color, nutritional value, and digestibility is directly dependent on polyphenols [5].

Polyphenols occupy a significant place in the chemical composition of fruits and berries. Being in plant raw materials in a relatively small amount, they have a significant impact on the quality of the finished product, its color, nutritional value, and digestibility. One of the important biological features of polyphenols is their P-vitamin activity and synergism in relation to vitamin C [6].

Polyphenols regulate the permeability and eliminate the fragility of capillary blood vessels, lower blood pressure, promote bile formation, improve the condition of the adrenal glands, have anti-inflammatory, diuretic, anti-ulcer effects, as well as an effect that regenerates liver function [7].

Flavonoids such as flavanols, dihydroflavonols, and catechins are effective antioxidants. The antioxidant activity of these compounds exceeds that of the artificial antioxidant propyl gallate, which is widely used in non-food products. This is explained by the fact that flavonoids not only prevent the accumulation of short-lived radicals but also interact with heavy metal ions, which are catalysts of oxidation processes [8].

Being chemically active, polyphenolic substances are extremely unstable. Their chemical transformation and possible destruction can be caused by the influence of various factors (interaction with water, air oxygen, metals, as well as high temperature and duration of its action, and many others) [9].

Their oxidation and subsequent transformation are accompanied by a change in the color and quality of fruits and berries during processing, and in the case of canned products – storage [10].

Despite the fairly wide range of additives used in the food industry during the processing of fruit and berry raw materials, the search and use of natural effective additives during the development of cherry and blackcurrant sauces, the study of their impact on nutritional value, biological activity, organoleptic quality indicators, remain a priority task. An important role belongs to the study of the influence of food additives on the bioflavonoids of cherries and black currants.

Therefore, special attention should be paid to the study of the factors that affect the polyphenolic complex of fruits and berries in order to be able to manage them in order to devise a progressive technology for manufacturing products from plant raw materials. Evaluation of the changes occurring in the product is the most important theoretical prerequisite for the formation of ideas about the physiological effects of new sauces in the human body. This will make it possible to obtain a new technology of cherry and blackcurrant sauces, which will be characterized by high quality indicators. This, in turn, will make it possible to expand the range of products of the restaurant industry and canning industry, to provide the population with the necessary nutrients contained in vegetable raw materials throughout the year.

3. The aim and objectives of the study

The purpose of this study is to evaluate the changes that occur with the ingredients of the food system during the development of the technology of sauces from cherries and black currants of increased quality, which will have antioxidant, radioprotective, and other properties.

To achieve the goal, the following tasks were set:

– to determine the influence of aromatic plant raw materials on the trends of changes in biologically active substances (polyphenols), which are responsible for the formation of quality indicators of products based on fruits and berries;

– to study the radioprotective properties of the devised cherry and blackcurrant sauces.

4. The study materials and methods

The objects of our research are cherry fruits and blackcurrant berries in the stage of technical maturity, fruit and berry puree, semi-finished products, and finished products from fruits and berries.

The specificity of the studied objects – fruit and berry masses is the significant instability (lability) of valuable biologically active substances contained in them, which under the influence of various technological factors (wiping, heat treatment, etc.) are able to change their chemical composition, which can affect the quality of food products. Therefore, the ongoing research is aimed at identifying trends in changes in labile biologically active substances of cherries and black currants and establishing rational technological methods and regimes in order to maximize their preservation.

One of the technological solutions aimed at preserving cherry and blackcurrant bioflavonoids during the development of sauce technology is the use of aromatic plant raw materials widely distributed in Ukraine.

Modern accurate identification of polyphenols is based on the use of spectral, chemical, chromatographic, and other methods. The need for qualitative identification of raw material polyphenols is determined by the goal of having indicators of the quality of food products.

Determination of the qualitative composition of polyphenolic compounds of fruits and berries was carried out by the method of spectroscopy in the ultraviolet and visible regions of the spectrum on spectrophotometers "SPECORD UV VIS" and SF-46. The method is based on measuring the absorption of ethanol extracts and determining the volume of polyphenols. The process of qualitative determination involves the extraction of polyphenols from the tissue of fruits and berries with 70 % ethyl alcohol. The choice of this solvent is due to the fact that it provides a higher degree of extraction of polyphenolic compounds than 96 % alcohol. It is important to note that water removes the largest volume of polyphenols, and the polymeric forms of flavonoids are transferred to aqueous solutions, which is undesirable [11].

Organoleptic evaluation of semi-finished products and sauces from fruits and berries was carried out according to GOST 8756.1-79, microbiological studies – according to GOST 26669-85. The resulting data were treated by the methods of mathematical statistics using the "Regress" program in the MathCad-15 software on a personal computer.

The research was carried out on a spectrophotometer "SF-46" according to traditional procedures. The process of quantitative determination involved the extraction of polyphenols from the tissue of fruits and berries with 50 % ethyl alcohol heated to 60 °C, the processing of the extract in accordance with the research objectives, and the actual measurement of the substance concentration [12]. The content of anthocyanins, leucoanthocyanins, and catechins was determined in extracts having a red color. Uncolored and yellow-colored ones contain catechins, leucoanthocyanins, and flavanols.

The content of radio cesium in the body of animals was measured by gamma radiation of cesium-137 (biologically active substances iu-137) on the day of administration of the isotope and three to four days later. The research was carried out on a metrologically equipped gamma spectrometer "ADKAM" of the company "ORTEC" (USA) with a pulse analyzer for 4096 channels, with a scintillation detector NaI of the company "BICRON". Measurements were performed in the geometry of the plastic case in which the animal was fixed [13].

The results were treated using the methods of variational statistics [14, 15].

5. Results of investigating technological methods and regimes

5. 1. Determination of trends in changes in biologically active substances of plant raw materials

Evaluation of the changes occurring in the product is the most important theoretical prerequisite for the formation of ideas about the physiological effects of new sauces in the human body. This especially applies to those ingredients that are introduced into the product to increase its nutritional value, biological activity, add new qualitative characteristics, or other orientation.

Obtaining products from fruits and berries of increased quality is possible by reducing the intensity of oxidative transformations of polyphenols.

Many substances are known that stop the oxidation of polyphenolic compounds. Ascorbic acid, sulfuric anhydride, cysteine, phosphates, and their derivatives have become widespread in the food industry. However, it should be emphasized that the mentioned polyphenol stabilizers are not effective enough and are not always harmless. They have a destructive effect on certain polyphenolic compounds, which leads to a deterioration of their color, and the use of other substances is limited due to toxicity. Therefore, the task of identifying and studying harmless, effective, practically available substances as stabilizers of polyphenols is extremely urgent.

The modern trend in the field of improving the nutrition structure is aimed at devising new technologies by using herbal supplements. The use of aromatic plant raw materials, which are widely distributed in Ukraine, is promising in this regard.

The basis of the development of technology for the production of sauces from cherries and black currants is the experimental results of a multifactorial study of the technological and functional properties of plant raw materials. In addition, the influence of technological factors and food additives on the complex of labile biologically active substances and on the indicators of consistency of fruit masses was studied. Rational ratios of recipe components and technological parameters of thermal and mechanical processing of raw materials, which ensure the specified quality indicators of the developed sauces, were experimentally determined.

Cherries and black currants are chosen as the main raw materials for the production of sauces, which are the most valuable food products with extremely high nutritional, taste,

and dietary properties. Their chemical composition includes vitamin C (30...450 mg %), polyphenols with P-vitamin activity (700...7500 mg %), vitamins K, B_1, B_2, PP, carotene, sugars, organic acids (apple, lemon, salicylic, amber, wine), trace elements (iron, iodine, manganese), pectin substances, etc. [1, 16].

On the basis of literature data [17] on the organoleptic evaluation of products, aromatic plant raw materials were chosen for the study, namely: black currant leaves, walnuts, cherries, oregano, elderflower, chamomile flowers. The purpose of using aromatic plant raw materials is stabilization of polyphenolic compounds. In order to form the given consistency of the sauce, orchis was chosen for the study.

The fundamental factor in their selection is the ability to influence the formation of the color and aroma of the product and the presence of a high content of vitamin C, phenolic compounds, etc.

This choice is determined by the chemical composition and properties of the plant material used. In particular, aromatic additives are a rich source of vitamin C (100...400 mg %), vitamins of group B, PP, micro and macro elements, essential oils (1.0...3.0 %), polyphenols (1000...7000 mg %), carotenoids (30...50 mg %), organic acids /citric, malic, etc./(0.1...0.4 %), alkaloids, phytoncides, sugars (fructose, glucose, rhamnose), nitrogenous, colored and other substances [18, 19].

Orchis is the dried tubers of yarrow, contains mucilage (47...50 %), starch (27...31 %), dextrin (up to 13 %), sucrose (1 %), pentosans, methyl pentosans, and other substances [20].

The studied plant material has antimicrobial, antispasmodic, sedative, general strengthening, antioxidant, radioprotective, and many other properties. Also, selected herbal supplements regulate the salt metabolism of the human body, tone the nervous system, stimulate the secretion of the stomach and intestines, increase appetite, and improve metabolism. To all of the above, it is necessary to add that the researched plant raw materials are characterized by their natural origin, are organically combined with the main raw materials (cherry fruits and black currant berries), have a high degree of safety, extremely low toxicity. A complex set of substances dosed in plants by nature has a beneficial effect on the body as a whole. It increases its resistance, activates metabolism, and allows one to use them together with food for an unlimited period in preventive, dietary, and children's nutrition. A complex set of substances dosed in plants by nature has a beneficial effect on the body as a whole, increases its resistance, activates metabolism, and allows you to use them together with food for an unlimited period in preventive and dietary nutrition.

Selected herbal supplements have antimicrobial, antispasmodic, sedative, tonic, antioxidant, radioprotective, and many other properties. In addition, they regulate the salt metabolism of the human body, tone the nervous system, stimulate the secretion of the stomach and intestines, increase appetite, and improve metabolism. To all of the above, it is necessary to add that the researched plant raw materials are characterized by their natural origin, are organically combined with the main raw materials, have a high degree of safety, extremely low toxicity. A complex set of substances dosed in plants by nature has a beneficial effect on the body as a whole and increases its resistance. The selected plant raw material activates the metabolism and allows you to use it together with food for an unlimited period in prophylactic, dietary and children's nutrition [21].

Based on a series of our experiments and organoleptic evaluation of products, rational concentrations of selected additives were determined: aromatic raw materials – 0.10...0.50 %, orchis – 1.0...2.0 %, granulated sugar – 16.0...19.0 %, as well as optimal modes of heat treatment: 8...10 minutes at 80...85 °C. It is this thermal regime that makes it possible to preserve biologically active substances of native raw materials as much as possible, to obtain a product of a given consistency, and to ensure the necessary microbiological indicators.

Studies have been conducted to examine the effect of aromatic plant raw materials on polyphenols of cherry fruits and blackcurrant berries. On the basis of organoleptic evaluation, the concentrations of additives within the range of 0.10...0.50 % of the raw material are defined as rational.

During the processing of vegetable raw materials, there is a need to determine the most acceptable method of their addition to ensure the preservation of fruit polyphenols. The introduction of aromatic plant raw materials is possible in various ways – in the form of decoctions, tinctures, extracts, etc. our studies showed the impracticality of introducing alcohol-based tinctures and extracts into the puree, as a result of which there is a noticeable deterioration of the organoleptic properties of the products.

Cherry and blackcurrant puree was tested, to which plant raw materials were added in dried, crushed form in different concentrations. The manufactured samples were heated at a temperature of 80–85 °C for 8...10 minutes and pureed. Cherry and blackcurrant puree, natural without additives, unheated, was used as a control. The content of polyphenols in puree without additives, heated, was also investigated.

The results of the experimental data are given in Tables 1, 2, and Fig. 1.

Table 1

The content of polyphenolic substances in fruit masses based on cherry puree

Sample	Polyphenol content, 10^{-3} %	
	Catechins	Anthocyanins
	λ=280 nm	λ=520 nm
Cherry puree warmed up/control/	476.0±19.0	870.0±34.0
Cherry puree. warmed with additives (%) cherry leaves: 0.15	548.0±21.0	975.0±39.0
0.20	602.0±24.0	1135.0±45.0
0.25	640.0±25.0	1155.0±46.0
0.30	652.0±26.0	1170.0±46.0
0.35	846.0±33.0	1220.0±48.0
0.40	976.0±39.0	1245.0±49.0
0.45	1030.0±40.0	1255.0±50.0
0.50	1108.0±44.0	1290.0±51.0
walnut leaves: 0.10	502.0±20.0	952.0±38.0
0.15	542.0±21.0	1048.0±41.0
0.20	604.0±24.0	1162.0 ±46.0
0.25	640.0±25.0	1196.0±47.0
0.30	672.0±26.0	1245.0±49.0
0.35	690.0±27.0	1252.0±50.0
0.40	716.0±28.0	1290.0±51.0
0.45	742.0±29.0	1312.0±52.0
black currant leaves: 0.15	602.0±24.0	890.0±35.0
0.20	650.0±25.0	910.0±36.0
0.25	700.0±27.0	960.0±38.0
0.30	720.0±28.0	1020.0±40.0
0.35	750.0±30.0	1110.0±44.0
0.40	812.0±32.0	1200.0±48.0
0.45	802.0±32.0	1290.0±51.0
0.50	840.0±33.0	1410.0±55.0

Table 2

The content of polyphenolic substances in berry masses based on blackcurrant puree

Sample	Polyphenol content, 10^{-3} %		
	Catechins	Anthocyanins	Flavanols
	λ=270...280 nm	λ=550...560 nm	λ=350...370 nm
Blackcurrant puree, unheated/control/	66.20	408.0	12.80
Blackcurrant puree, warmed up	23.80	303.50	7.0
Blackcurrant puree. warmed with additives (%): black currant leaves: 0.10	37.0	381.0	7.60
0.15	42.40	383.42	8.0
0.20	51.45	384.90	9.90
0.25	56.65	387.0	10.70
0.30	62.70	390.10	11.0
0.35	65.25	394.0	11.45
0.40	67.75	395.90	11.96
0.45	72.95	399.67	12.20
elder blossom: 0.10	41.60	368.60	8.80
0.15	43.15	377.0	9.46
0.20	48.86	383.40	10.20
0.25	52.28	389.75	10.90
0.30	56.60	411.0	11.30
0.35	60.97	415.78	11.78
0.40	63.23	422.30	12.0
0.45	67.20	427.80	12.38
oregano: 0.20	57.20	351.0	10.0
0.25	59.98	354.80	11.12
0.30	65.80	361.50	11.85
0.35	69.23	368.40	12.0
0.40	71.60	373.64	12.20
0.45	73.67	377.21	12.64
0.50	75.10	380.0	12.69
0.55	78.0	385.80	12.77
0.60	81.31	396.0	13.0
chamomile flowers: 0.10	61.20	350.0	12.80
0.15	66.10	361.36	13.23
0.20	77.40	378.0	13.78
0.25	82.90	384.50	14.0
0.30	83.24	388.75	14.61
0.35	86.0	392.0	14.80
0.40	87.99	396.10	15.0
0.45	89.34	401.0	15.60

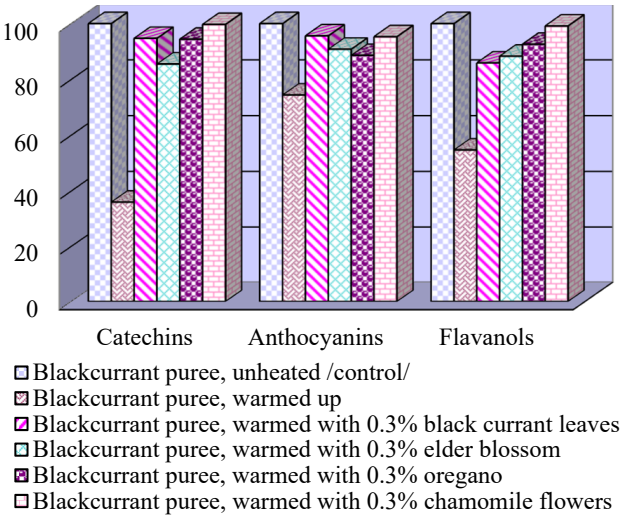

Fig. 1. The content of polyphenolic substances in berry masses based on blackcurrant puree (in %)

The analysis of the resulting data allows us to draw the following conclusion: all applied food additives have a significant stabilizing effect on the polyphenolic complex of cherries and black currants.

Blackcurrant leaves have the greatest stabilizing effect on cherry fruit polyphenols (Table 1). Adding 0.3 % of blackcurrant leaves to puree makes it possible to increase the preservation of catechins by 77 % compared to the control, and anthocyanins by 62 %. When walnut and cherry leaves are added to cherry puree, there is also a significant preservation of cherry fruit flavonoids from oxidative destruction. Thus, when 0.3 % of walnut leaves are added to the raw material, the increase in the amount of catechins compared to the control is 42 %, anthocyanins – 43 %. In samples with the same volume of cherry leaves, 38 % more catechins are stored than in the control, 34 % more anthocyanins.

Chamomile flowers have the greatest stabilizing effect on the polyphenols of blackcurrant berries, the addition of which in the amount of 0.3 % to the puree increases the preservation of catechins by 26 % and flavanols by 14 % compared to the control.

The best stabilizing effect on anthocyanins of blackcurrant berries is observed when elderflower is added. Thus, adding 0.3 % elderflower to blackcurrant puree makes it possible to preserve the maximum volume of anthocyanins and increase it by 1 % compared to the control.

When blackcurrant leaves and oregano are added to blackcurrant puree, a significant preservation of blackcurrant berries bioflavonoids from oxidative destruction is also observed. The introduction of 0.3 % of the specified food additives makes it possible to preserve up to 86...99 % of catechins, anthocyanins, and flavanols compared to the control.

It should be noted that flavanols are the least labile among flavonoids when aromatic raw materials are added. An increase in their content compared to the control by 71...82 % occurs when all the additives used are added in the amount of 0.3...0.4 % to the raw materials.

The process of heating blackcurrant puree leads to a loss of berry polyphenolic substances by 26...64 % compared to unheated puree. All the aromatic additives used make it possible to obtain a product with an increased content of bioflavonoids, keeping them by 35...150 % more compared to puree heated without additives.

The functional dependence of the content of polyphenolic compounds Y and concentration X (%) of aromatic raw materials (blackcurrant leaves, walnuts, cherries, oregano, elderflower, chamomile flowers) in cherry and blackcurrant fruits was modeled using statistical analysis methods. The results of the research are given in Table 3.

Table 3

Theoretical dependence of the content of polyphenolic compounds Y on the concentration of aromatic additives X

Base	Food additive	Bond form	Bond closeness R^2
Cherry puree	Cherry leaves	Catechins Y=1729.05X+238.1	0.97
		Anthocyanins Y=744.05X+938.81	0.92
	Blackcurrant leaves	Catechins Y=664.76X+518.45	0.98
		Anthocyanins Y=1511.91X+607.38	0.98
	Walnut leaves	Catechins Y=676.19X+452.55	0.98
		Anthocyanins Y=964.05X+917.01	0.95
Blackcurrant puree	Oregano	Catechins Y=818.09X+427.40	0.96
		Leucoanthocyanins Y=1914.27X–111.79	0.99
		Flavanols Y=1.84X+19.58	0.99
	Blackcurrant leaves	Catechins Y=701.90X+704.48	0.98
		Leucoanthocyanins Y=1088.81X+335.95	0.99
		Flavanols Y=16.48X+13.38	0.99
	Chamomile flowers	Catechins Y=471.67X+788.56	0.98
		Leucoanthocyanins Y=1947.67X+36.93	0.85
		Flavanols Y=4.82X+18.10	0.99
	Elderflower	Catechins Y=662.14X+850.61	0.94
		Leucoanthocyanins Y=632.14X+489.39	0.81
		Flavanols Y=13.64X+13.69	0.98

It should be noted that the correlation coefficient fluctuates somewhat within 0.81...0.99. This indicates that during the addition of various plant additives to the main raw materials, a chemical transformation of polyphenolic compounds occurs, which confirms their lability under the influence of various technological factors.

Mathematical treatment of empirical data on the effect of aromatic plant raw materials on cherry and blackcurrant polyphenols in the range of studied concentrations indicates the reliability of the obtained results. Empirical data on the dependence of the content of polyphenols on the concentration of added aromatic additives practically coincides with the theoretical regression line.

Our studies within the framework of pair correlation showed that the relationship between the concentration of aromatic additives and the content of polyphenols in fruit and berry masses is quite close and the correlation coefficient is $R \geq 0.94$. The obtained regression and correlation parameters according to the Fisher and Student tests are significant. We estimated confidence intervals with reliability of at least 95 % (significance level $\alpha=0.05$) for theoretical values of polyphenol content, regression coefficients. The dependence of the content of polyphenolic compounds on different concentrations of aromatic additives in fruit and berry systems is linear and takes the following form:

$$y=A+B\cdot x,$$

where y is the content of polyphenols in fruit and berry masses;

x – concentration of aromatic raw materials in fruit and berry masses;

A and B are coefficients.

It should be noted that the process of preservation of bioflavonoids is inseparable from the process of preservation of vitamin C and occurs due to their synergism.

Thus, it has been experimentally proven and theoretically substantiated that the addition of selected aromatic additives to cherry and blackcurrant puree has a significant stabilizing effect on the polyphenolic complex of plant raw materials. The resulting stabilizing effect is explained by inhibition of the accumulation of oxidized forms of flavonoids in the product.

5. 2. Investigating the radioprotective properties of the devised cherry and blackcurrant sauces

The nature of transformations of the nutritional complex of plant products based on fruit and berry raw materials was judged by the dynamics of radio cesium removal from the body of rats, which makes it possible to evaluate the effectiveness of sauces as radioprotectors.

Experimental studies were carried out in a radioisotope vivarium on outbred adult female white rats weighing 170.0±12.0 g, aged 4 months. The experiment used 30 rats, which were divided, depending on the conditions of the experiment, into three groups of 10 animals each:

– 1st group – control on vivarium diet;
– 2nd group – cherry sauce, 10.0 g/rat;
– 3rd group – blackcurrant sauce, 10.0 g/rat.

In the animals of the research groups, during the entire experiment, part of the vivarium diet was replaced with

sauces. The caloric content of the diets of rats in all groups was the same.

The animals of the control and experimental groups were administered a single dose of 917.0±46.3 Bq/animal of cesium chloride solution using an intragastric probe per os. Then, for 31 days, the influence of sauces on the removal of radio cesium from the body of rats was observed.

The results of experimental data on the influence of sauces on the dynamics of radio cesium removal from the body of rats are shown in Fig. 2.

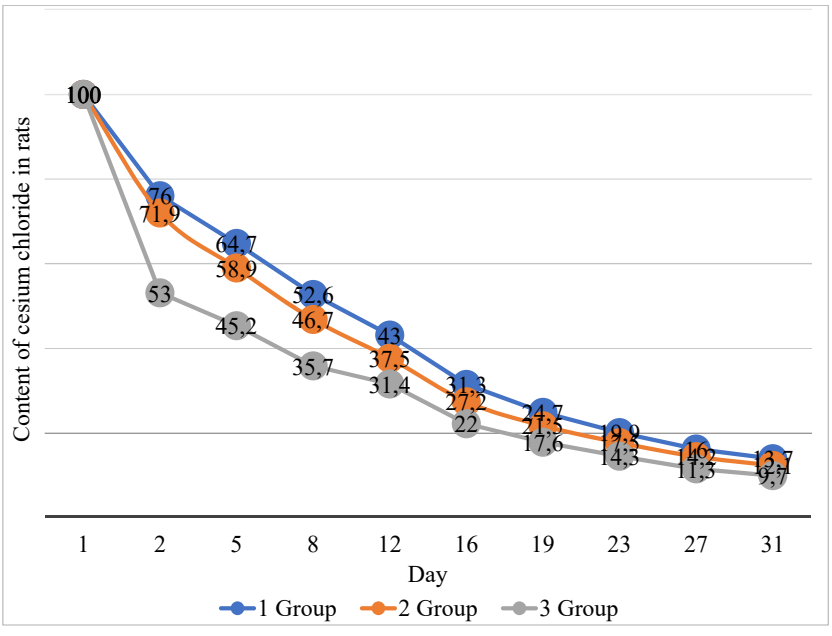

Fig. 2. Effect of devised cherry and blackcurrant sauces on the removal of cesium-137 in rats

In the control animals (group 1), which during the experiment received a normal vivarium diet, 31 days after the introduction of the isotope, the content of radio cesium in the body amounted to 13.7±0.31 % of the injected amount. The half-life of cesium-137 ($T_{1/2}$) was 9.90±0.21 days.

In the animals of the second group, which received cherry sauce during the experiment, 31 days after the introduction of the isotope, the content of cesium-137 in the body was 12.1±0.47 % of the injected amount. The elimination half-life was 7.80±0.19 days. That is, the rats of the second group had 11 % more radioisotope compared to the control animals of the first group.

6. Discussion of results of investigating the quality of the developed sauces

Usually, during the production of fruit and berry sauces, producers use flavor, consistency, and color stabilizers of chemical origin. During the development of new cherry and blackcurrant sauces, only natural plant additives are used. This made it possible to obtain finished products of increased quality, which have increased nutritional value, and also have the taste and color characteristic of the original raw materials.

During the development of cherry and blackcurrant sauces with a given consistency, great attention was paid to the stabilization of bioflavonoids of fruits and berries. The main goal is to obtain products with an increased content of biologically active substances and high organoleptic indicators.

The achievement of the set goal became possible thanks to the use of plant raw materials, which are a rich source of biologically active substances that have antioxidant and radioprotective properties.

The results of our research (Tables 1–3, Fig. 1) proved that the addition of all the selected additives in the accepted concentrations to cherry and blackcurrant puree has a significant stabilizing effect on bioflavonoids. Adopted technological solutions made it possible to save 14...99 % more bioflavonoids compared to traditional products. The resulting high stabilizing effect of aromatic raw materials on cherry and blackcurrant bioflavonoids is explained by the antioxidant activity characteristic of the selected additives.

The volume of plant additives (0.10...0.60 %) contains 1.0...40.0·10^{-3} % of polyphenolic compounds, which is 1...4 %, which are per 100 g of leaves. Therefore, the increase in the content of biologically active substances in samples with the addition of aromatic raw materials occurs not so much due to the introduction of polyphenols but due to the properties they have. Biologically active substances contained in the selected raw materials cause the deactivation of free radicals, preventing their accumulation, as well as the breakdown and binding of phenolases and peroxides. In addition, they interact with heavy metal ions, which are catalysts of oxidation processes. The role of antioxidants can also be performed by alkaloids and carotenoids, which are rich in aromatic raw materials.

An important role is played by the synergism of vitamins C and P. Polyphenols, reducing the action of the enzyme ascorbate oxidase, and blocking the copper in its composition, slow down the oxidation of ascorbic acid, and it, in turn, has a stabilizing effect on the bioflavonoids of plant raw materials. Flavanols, contained in fruit and berry raw materials in the form of glycosides, have the highest antioxidant properties. They are able to protect other more labile substances (vitamin C, catechins, anthocyanins, leucoanthocyanins) from destruction by binding metals, in particular copper ions, and by inhibiting enzymes. The revealed high stability of flavanols in fruit and berry masses based on cherries and blackcurrants with the addition of aromatic additives contributes to better preservation of all polyphenol fractions.

It is important to note that a certain value in the stabilization of fruit and berry polyphenols belongs to the property of phenolic compounds to inactivate enzymes, the mechanism of which is as follows. Enzymes present in berries catalyze the oxidation of polyphenols. In turn, the products of polymerization of flavonoids, which are soluble in water (oligomers), affect the action of enzymes, inhibiting them. Oligomeric forms of flavonoids inhibit pectolytic enzymes by binding their protein carriers. It has been proven that the leaves of black currant, cherry, walnut, chamomile flowers,

linden, oregano, and elderflower contain a large number of monomeric and oligomeric forms of flavonoids.

Studies conducted on laboratory animals have shown that the addition of cherry and blackcurrant sauces to the diet of rats promotes the removal of cesium-137 from the body and reduces the dose of internal radiation.

The revealed effect can be explained by the property of binding cesium ions by such natural sorbents as polyphenolic compounds due to phenolic hydroxyls, as well as by the interaction of carboxyl groups of pectin substances and protein with Cs^{2+} and the formation of "bridge structures".

The addition of orchis sauces to the recipe makes it possible to solve the problem not only of creating a given consistency but also adds certain new qualities to the developed product. Namely, the composition of orchis includes linear glucomannan polysaccharides, in which the D-mannose residue is the main monosaccharide, and glucose residues are also included. Monosaccharide residues in the molecule are connected by a β-1-4 bond. Mannans are easily soluble in water, combine well with food products and have a high capacity to adsorb bound moisture. With the help of the interaction of carboxyl groups of pectin substances, mannans, protein with Cs^{2+} and the formation of "bridge structures", radioisotope ions are bound and removed from the body.

It should be noted that the use of plant additives is justified only under certain technological regimes (temperature, duration of heat treatment) and under the condition that the volume of additives introduced, and the method of their addition correspond to the technological process of production. When trying to go beyond these limitations to increase the biological activity of ready-made sauces, objective difficulties arise, which are associated with such consequences as the destruction of polyphenolic compounds and the deterioration of the quality of the obtained sauces.

As part of the study, a way to overcome these difficulties is proposed. It is based on the fact that as a stabilizer of biologically active substances (bioflavonoids, carotenoids, vitamins) aromatic plant raw materials (blackcurrant leaves, walnut leaves, oregano, elderflower, chamomile flowers) are selected. The selected raw material has antimicrobial, antispasmodic, sedative, general strengthening, antioxidant, radioprotective, and many other properties. Adding selected additives to fruit and berry puree helps reduce the activity of oxidizing enzymes and inhibit the process of oxidative transformation of polyphenols into condensation and polymerization products. The peculiarity of the selected aromatic additives is the organic combination with the main raw materials, the absence of consumption restrictions, and the ability to obtain a high-quality product. A unique combination of ingredients, techniques, and methods of adopted technological solutions, gentle thermal regimes allowed achieving the set goal.

The resulting effect is explained by the use of all the selected additives in the complex in the accepted optimal concentrations under certain gentle thermal regimes. From a practical point of view, the identified stabilizing effect of plant additives under the accepted technological conditions and regimes makes it possible to determine the conditions of their use in the technology of making sauces from cherries and black currants.

The addition of blackcurrant sauce to the diet of rats reliably and significantly accelerated the rates of cesium removal and reduced the elimination half-life (Fig. 2). Thus, in the rats of the third group, the content of cesium in the body decreased by 29.50 % compared to the control. In the group of animals that received blackcurrant sauce with their diet, the acceleration of cesium-137 excretion was 20.30 %.

In addition, some integral indicators of physical development and condition of animals were studied during the experimental studies. It was established that the studied sauces do not affect the dynamics of the mass, the condition of the wool coat, and the physical activity of the animals. The animals of the experimental groups had smooth, shiny fur with no signs of baldness. The consumption of sauces was complete and uniform throughout the day. The introduction of berry sauces into the diet of rats contributes to the increased elimination of the radionuclide.

The obvious effect obtained as a result of our research confirms that the devised cherry and blackcurrant sauces have radioprotective properties. New products have an increased content of biologically active substances (bioflavonoids, vitamins, polysaccharides (pectin, fiber), macro- and microelements, organic acids). The effect is achieved due to the adopted technological methods and regimes, which makes it possible to accelerate the exchange of cesium and promotes its removal from the body. The most significant effect on the removal of the radionuclide is the addition of blackcurrant sauce to the diet of animals.

The further development of the research is the development of technological modes of preservation of cherry and blackcurrant sauces. The main goal of canning is to extend the storage period of fruit and berry raw materials and to provide the population with the necessary biologically active substances evenly throughout the year. Also, it would be advisable to study the physical-chemical and microbiological indicators of canned sauces.

7. Conclusions

1. The significant stabilizing effect of all selected aromatic plant additives on all investigated fractions of flavonoids (catechins, anthocyanins, flavanols) of cherries and black currants was theoretically substantiated and experimentally proven. Plant additives (blackcurrant leaves, walnuts, cherries, oregano, elderflower, chamomile flowers) are added to the puree in dry, crushed form. The optimal dosage of aromatic additives used is established, which is 0.10...0.50 % of the raw material. This made it possible to significantly reduce the oxidative destruction of polyphenols due to the antioxidant properties characteristic of the selected additives and preserve them by 14...99 % more compared to traditional products. According to organoleptic indicators, the developed products differ favorably from fruit masses without the use of additives in a more intense color and pleasant aroma, which are characteristic of the original raw materials.

Adding selected additives to fruit and berry puree helps reduce the activity of oxidizing enzymes and inhibit the process of oxidative transformation of polyphenols into condensation and polymerization products.

The high stabilizing effect of aromatic raw materials on the bioflavonoids of cherries and black currants, which was revealed as a result of our research, is not so much due to their own chemical composition but due to the antioxidant activity characteristic of the selected additives. Biologically active substances contained in the vegetable raw materials used act as antioxidants, causing the deactivation of free radicals, preventing their accumulation; and also, they inter-

act with heavy metal ions, which are catalysts of oxidation processes.

The accepted method of stabilization of cherry and blackcurrant polyphenols is acceptable and appropriate. Due to their high content of bioflavonoids, finished products have increased nutritional value and have the taste and color characteristic of the raw materials.

2. Research conducted on laboratory animals showed that the addition of cherry and blackcurrant sauces to the diet of rats promotes the removal of cesium-137 from the body and reduces the dose of internal radiation.

Thus, the use of selected plant additives under certain technological regimes makes it possible to obtain cherry and blackcurrant sauces of increased biological activity with high organoleptic indicators, which reliably possess radioprotective immunomodulating properties.

So, the introduction of aromatic raw materials and orchis to the composition of cherry and blackcurrant sauces gives the products new properties, in particular, the ability to bind and remove toxic substances, some metabolic products, environmental food pollutants from the body. Due to their high content of biologically active substances, ready-made products have increased nutritional value and have the taste and color characteristic of the raw materials.

Our results theoretically substantiate the expediency of using selected additives to give new sauces certain physiological effects. The devised products have high detoxification properties, characterized by the ability to bind heavy metal ions (cesium) with the subsequent removal of these substances from the body. The experimental data confirm the results of previous studies regarding the positive effect of fruit and berry sauces on the removal of radionuclides from the body. According to current regulations, cherry and blackcurrant sauce can be classified as enterosorbents of medium importance (intensity).

Thus, an applied aspect of the use of our scientific result is the possibility of using selected aromatic plant additives for the production of a new sauce from cherries and black currants with increased nutritional value, which have the taste and color characteristic of the raw materials. The devised products have certain physiological effects in the human body (they make it possible to reduce the dose of internal radiation) and can be used in medical and preventive and baby nutrition.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study and the results reported in this paper.

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Data availability

The manuscript has associated data in the data warehouse.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the presented work.

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