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STUDY OF THE USE OF EDIBLE POWDERS IN TOMATO SAUCE TECHNOLOGIES

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Abstract. In the article, the technology is considered for the production of edible powders from vegetal raw materials (berries). The technology for producing powders from berries is developed to produce a high-quality product in which all ingredients of raw materials are kept in a concentrated form.

The current trend in nutrition is related to the expansion of the range of functional products whose daily use contributes to the prevention of hypovitaminosis and metabolic disorders, and ultimately to the rehabilitation of the population. New, non-traditional sources of local raw materials, including plant based products, need to be found and used to create a new generation of instantiated healthy food products, and technologies should be developed of obtaining functional additives. The use of fruit crops, the main source of biologically active substances, is very promising in this respect.

The Department of Canning Technology of the National University of Food Technologies has conducted a study to enable the use of fruit and berries for food powders. To this end, powder has been obtained from common bilberry, with determining its physical and chemical properties. The patterns of the influence of bilberry powder on the functional properties of foodstuffs were investigated in the example of tomato sauces.

The analysis of the results of the studies has shown that bilberry powder can be used in the production of canned and other products not only to enrich their functional ingredients but also to provide them with new technological properties. The food powders received do not contain harmful impurities, are of high food value, easily absorbed by the body, compact and stored for long periods of time. Studies have shown that bilberry powder is a rich source of vitamins (c acid, β-carotene, tocopherol) and can be used successfully in the manufacture of tomato sauces with functional properties.

Keywords: tomatoes**,** powders**,** sauces**,** bilberry**,** antioxidants

ДОСЛІДЖЕННЯ МОЖЛИВОСТІ ЗАСТОСУВАННЯ ХАРЧОВИХ ПОРОШКІВ У ТЕХНОЛОГІЯХ ВИГОТОВЛЕННЯ ТОМАТНИХ СОУСІВ

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Анотація. У статті розглянуто технологічні властивості харчових порошків із ягід. Наведено результати теоретичних та експериментальних досліджень якості порошку із чорниці, отриманого методом сушіння з використанням валкової сушарки та подальшим його подрібненням. Дослідження показали, що порошок чорниці є багатим джерелом вітамінів, антиоксидантів та комплексів фенольних сполук. На прикладі томатних соусів досліджено закономірності дії порошку чорниці на функціональні властивості харчових продуктів. Комплексом фізико-хімічних та органолептичних досліджень встановлено, що додавання 15%-го чорничного порошку дозволяє збільшити кількість вітаміну С на 220%, β-каротину на 151% і загального числа фенолів на 225% від початкової кількості в томатному соусі, отриманому за класичною схемою. Актуальність представлених досліджень полягає в розширенні можливості застосування порошків із плодово-ягідної сировини в технологіях консервованих продуктів із підвищеною біологічною цінністю.

Ключові слова: томати, харчові порошки, соус, чорниця, антиоксиданти

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Introduction. The problem statement

A current problem is the quality and safety of food produced. The deteriorating environmental situation results in food contamination by radionuclides, toxic elements, nitro compounds, pesticides, antibiotics, etc.

It should be noted that this situation has a negative impact on people's health and results in reduction of life expectancy and increase in morbidity and pathology of newborns. There is a need to rehabilitate the structure and quality of food, to develop products enriched with biologically active substances, and to expand the use of foods with high biological value.

The current trend in nutrition is the expansion of the range of functional products which, used daily, contribute to prevention of hypovitaminosis and metabolic disorders, and, ultimately, to improving people's health. New, non-traditional sources of local raw materials, including plant based products, need to be found and used to create a new generation of instantiated healthy food products, and technologies should be developed of obtaining functional additives. The use of fruit crops, the main source of biologically active substances, is a very promising direction.

Consumption of fruit and berries is seasonal in nature, which raises the problem of long-term storage and selection of processing techniques, with the possibility of retaining the maximum food and biological value of raw materials. The vegetable and fruit industry plays an important role in solving this task.

The production of canned fruit, dried vegetables and fruits, powdered products, quick-frozen products, and semi-finished goods makes it possible to provide people with these products evenly throughout the year, and to create reserves.

The Department of Canning Technology of the National University of Food Technologies has conducted a study to find out whether fruit and berries can be used to produce food powders. To this end, powder has been obtained from berries of common bilberry, and its physico-chemical properties have been determined. The patterns of the influence of the bilberry powder on the functional properties of the foodstuffs were investigated by the example of tomato sauces.

In this article, we considered the problem of producing functional products of natural origin intended for regular daily consumption and having an effect on biochemical reactions and physiological functions through restoration of their microecological status. It is shown that one of the sources of vital substances for an organism is berry cultures. They play an essential role in nutrition of people. Dry berries almost completely retain all vitamins and biologically active materials, and thus are valuable raw materials in various food industry branches. The use of products on the basis of dry berries allows compensating for the deficiency of some vitamins, edible filaments and other useful substances, and also normalizing the intestinal microflora of an organism.

Analysis of recent research and publications

The recent explosive development of manufacturing and consumption of functional and specialized products enriched with natural food additives proves that this research topic is relevant. Most developed countries produce food powders in drum, spray-type, infrared, or microwave driers. The powders obtained by these methods contain biologically valuable components, are simple and economical in production, have a long shelf life.

A number of researchers have developed functional nutrition products and determined how practical it is to use powdery semi-finished products made of fruits, berries, and vegetables in food industry. The works of such famous scientists as L.M. Aksenova, L.V. Antipova, F.N. Vertyakov, N.M. Derkanosova, A.I. Zubchenko, S.Y. Koryachkina, G.O. Magomedov, A.N. Ostrikov, L.P. Paschenko, Y.F. Roslya-kov, T.V. Savenkova, V.A. Tutelyan, T.B. Tsygano-va, Z.N. Khatko, L.N. Shatnyuk, and others focus on the theoretical and practical foundations of production of functional products. Basing on these studies, new technologies for obtaining powders from fruits, berries, vegetables, and grain raw materials have been developed [1–4]; the mechanisms have been studied of thermal destruction of plant tissues while drying fruit and vegetable raw materials; the processes of dehydration of plant raw materials have been improved [5,6]; the physical, chemical, rheological, and hygroscopic properties of plant raw materials suitable for the production of powdered food additives have been studied [7,8]; powder additive mixes made of fruits and vegetables have been created [9,10].

A number of works describe options for improving the technology of manufacturing functional food products by adding food additives in the form of dry powdered fruits and vegetables [11–13]. However, the authors do not focus on the optimization of thermal drying modes, which would allow maximum preservation of the useful properties of the feedstock. Considerable attention in publications has been paid to the use of natural food additives, mostly in bakery, where an improvement in the quality of bakery products by enriching them with food additives has been noted.

Our **purpose** is, basing on the existing literature data, to study the possibility of using food powders in canned food products, with tomato sauces as an example. To achieve this aim, the following **tasks** have been accomplished:

1) obtaining food powders from common bilberry,

2) determining the chemical composition and technological properties of the powders obtained;

3) studying the effect of enrichment of tomato sauces with bilberry powder by conducting organoleptic, physical and chemical studies of the product obtained.

Research Materials and Methods

Fresh, undamaged berries of the common bilberry (Vaccinium myrtilus L.) collected in June 2016 in Kyiv Region, Ukraine; tomatoes of the Aurora F1 variety used further on for pilot studies at the Department of Canning Technology of the National University of Food Technologies, Kiev. The raw materials were collected at the maturity stage in the ripening period.

Chemical and reagents. The quality of fresh and dried raw materials, the berries, was technologically assessed according to generally accepted methodologies. The consumer properties, chemical composition, microbiological and safety indicators of fruit and berries were studied for possible use in producing functional products [14]. For this, the following indicators were determined: the mass fraction of carbohydrates; sucrose by the polarimetric method [15, 16], starch by the Evers method [17]; fiber by Kurisner and Hanek [18]; pectin by calcium pectate [19]; the mineral composition of the powder by atomic emission spectrometry [20]; the organic acids content by titration [15]; the mass fraction of phenolic compounds by the Folin-Ciocalteu method [21–23]. The ascorbic acid content in berries and powders received from them was determined by GOST 7047-55. The mass fraction of

carotene in berries and fruits was assessed by the photo-colorimetric method by GOST 8756.22-80.

Total polyphenol content measurement: for quantification of total polyphenol content, the Folin-Ciocalteu method was used [23]. 0.5 ml of the Folin-Ciocalteu reagent was added into a dark flask containing 0.5 ml of each extract sample and 10 ml of distilled water. After 5 minutes, 8 ml of a 7.5% aqueous sodium carbonate solution was added to the mixture, and the content was stirred thoroughly. The samples were kept in the dark for 2 hours, and then, the absorbance was measured at 765 nm with laboratory colorimeter. Three parallel samples were analyzed.

The obtained powders from the bilberry fruit were examined for the possibility of mixing them with tomato sauces. For this, prepared tomato puree with a mass fraction of solids of 15% was used. The resulting semi-finished product was boiled with a rotary evaporator to produce tomato sauce with a fraction of solids amounting to 20%. Bilberry powder was added in amounts of 5, 8, 12, 15% of the total mass of the tomato puree, with 18% of solids.

To obtain sauces, the amounts of basic biologically active substances were determined, i. e. the content of ascorbic acid, β-carotene, the total amount of phenolic substances, and the acidity of the product (based on the acidity of malic acid). For the studies, samples were used with the addition of 5% (sample 1), 8% (sample 2), 12% (sample 3), 15% (sample 4) of the bilberry powder into the total mass of the tomato puree. Such concentrations were chosen because they did not influence the change in the organoleptic characteristics of the main product, tomato puree.

Statistical analysis. A variance analysis of the results was carried out by the least squares method. The coefficient Student was applied, and Microsoft Office Excel, version 2007, was used. Differences were considered statistically significant if the probability was greater than 95% (p-value <0.05). All assays were triplicate, performed at room temperature of 20 ± 1^0C. the experimental results are expressed as an average ± SD (standard deviation).

Results of the research and their discussion

Bilberries have many health benefits, mostly due to their high antioxidant content. To extend their short shelf life, fresh bilberries are frozen and then further processed. One of the methods of preserving bilberries consists in drying. To create higher quality dried products, we should develop drying methods to optimize the final bioactive compounds content, and to understand how drying affects the taste and quality.

Traditional hot air drying makes the products shrunken and hard, with noticeable browning, little rehydration ability, and low nutritive value. In a number of studies, the quality, drying kinetics, and energy consumption of dried products obtained by hot air drying are compared with those of products obtained by other drying technologies, in an attempt to improve the quality and increase the efficiency. Temperature has a large effect on the drying of products. Drying at 100°C was twice as short as at 70°C, but drying at temperatures higher than 80°C resulted in the Maillard reaction and caramelization, which was not observed at lower temperatures. Decreasing temperature from 95°C to 82°C in a continuous explosion puffing system prevented bilberries from rupturing and reduced pigment bleeding, leading to improved drying (Fig. 1).

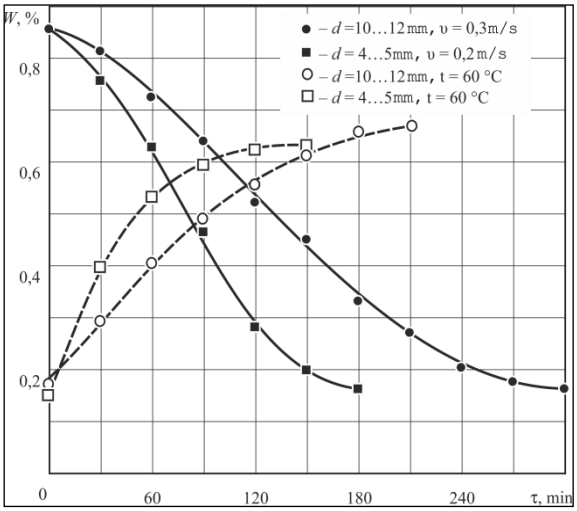

Fig. 1. Kinetics of drying/regeneration of bilberries

The content of the components of the carbohydrate complex and the organic acids in the bilberry powder was determined by the authors in order to give scientific evidence for the technologies and formulation of tomato sauces with bilberry powder added, and to find their food value [18]. The results are shown in table 1.

Table 1. Mass fraction of carbohydrates and organic acids in bilberry powder, mg%, (p<0,05)

Parameter	Bilberry Powder
Sugars:	
Monosaccharides	20.5
Sucrose	3.0
Polysaccharides:	
Starch	4.7
Cellulose	18.6
Pectin substances:	
Pectin	2.1
Soluble protopectin	1.7
Organic acids in terms of malic acid	6.6

The table shows that the pectin substances in the additive obtained from the common bilberry have a good moisture-binding capability. This binding ability of powder can be attributed to the presence of low esterified pectin substances containing free carboxylic groups that link heavy metals to the formation of complex compounds. That is why powder from berries can be recommended as a functional supplement to food that binds heavy and radioactive metals and removes them from the organism [19].

Among the nutritional factors that are of particular importance to health, the full and regular supply of mineral resources is essential. The content of the macro and micronutrients in powdered bilberries is shown in table 2. Calcium and phosphorus potassium are present in the largest quantities in bilberry powder. It also has a low sodium content as compared to that of potassium, which is a positive factor in the prevention of atherosclerosis and hypertensive diseases. The powder from berries is quite rich in elements of the hematopoietic complex – iron, manganese, cobalt [20].

Table 2. Mineral composition of bilberry powder, mg%, (p<0,05)

Parameter	Powdered bilberries
Ash	2.90
Macroelements, mg% potassium	514.00
Calcium	229.00
Magnesium	177.00
Sodium	62.10
Phosphorus	185.00
Microelements, mg% iron	6.72
Cobalt	0.29
Manganese	26.70

The data on phenolic compounds in berries and powder from bilberries are shown in table 3.

Table 3 – Mass fraction of phenolic compounds in fresh berries and in powdered common bilberry, mg%, (p<0,05)

Substance	Bilberries	Powdered bilberries
Anthocyanins	9752	1014
Flavanols: free catechins	913.3	343.2
Proanthocyanidins	1520	1050
Catechins condensed	739.6	637.7
Total flavanols	3173	2031
Flavanols: quercetin glycosides	229.7	88.98
Glycosides kaempferol	58.55	71.31
Flavonol the aglycone (quercetin)	-	58.98
Total glycosides and aglycone, flavonols	288.3	219.3
Chlorogenic acid	42.77	-
Total bioflavonols	13256	3264

The results show that in the bilberry, anthocyanins is 74% of the total bioflavonoids. They are found 9.6 times less in the powder than in berries. The number of free, condensed catechins and proanthocyanidins is less in the powder of berries as compared to the original content in fresh berries, by 2.7, 1.2, and 1.4 times respectively [21].

In addition to R-active substances, in bilberries and processed products, carotene, vitamins C and E were discovered, known as powerful antioxidant and antihypoxant agents (table 4). The most heat-resistant components are β-carotene and tocopherol. Vitamin C losses with drying are much smaller than those indicated in literary sources. This is probably due to the presence of P-active substances in bilberry that have an antioxidizing effect on ascorbic acid and reduce its oxidizing and recovery potential.

Table 4. Mass fraction of vitamins in the common bilberry and dry powder, mg%, (p<0,05)

Vitamin	Bilberries	Powdered bilberries
Ascorbic acid	408	298
β-carotene (provitamin A)	3.16	2.59
Tocopherols	4.15	3.47

It follows from the table that, with heat treatment of bilberries, the losses are: ascorbic acid 27, β-carotene 18, tocopherol 16% of the original content.

From the evidence, it can be seen that bilberry powder is a rich source of vitamins (ascorbic acid, β-carotene, tocopherol) and its introduction into the recipes for canned tomato sauces will increase their vitamin value [23].

After receiving and analyzing the data on the content of biologically active substances, the powders obtained from bilberries were examined for the possibility of mixing them with tomato sauces.

The data obtained are given in table 5. The data show that the nature of adding different amounts of bilberry powder to tomato sauce has a linear relationship with the amount of biologically active substances of the finished product. Thus, the addition of 15% bilberry powder allows an increase in vitamin C by 220%, β-carotene by 151%, and the total amount of phenols by 225% of the initial amount in the tomato sauce obtained according to the classical scheme. It proves the effectiveness of food powders in canned products technologies. Biologically active substances contained in food powders are highly bioavailable, easily dosed, and make it possible to manufacture products without changing their organoleptic properties.

Table 5. The amount of biologically active substances in tomato sauces, with bilberry powder added, mg%, (p<0,05)

Sample	Vitamin C, mg%	β-carotene, mg%	Total phenols, mg%	Organic acids ,%
Reference sample	69.2	7.26	2307.6	1.2
Sample 1	89.2	8.92	2884.5	1.03
Sample 2	88.4	8.65	4307.5	1.04
Sample 3	146.1	10.1	4615.2	1.04
Sample 4	152.2	10.9	5192.1	1.01

Mineral composition of the sauces obtained is given in Table 6. Addition of bilberry powder allows a significant increase in macro and microelements in the product, as compared to the sample obtained by the

classical technology. So, it was possible to achieve a significant increase in the content of potassium and sodium, the elements that take part in water-salt metabolism in the body, as well as of such elements of hematopoietic complex as iron, manganese, cobalt.

Table 6. Mineral composition of sauces with bilberry powder added, mg%, (p<0,05)

Parameter, mg%	Reference sample	№1	№2	№3	№4
Ash	0.7	0.7	0.7	0.71	0.71
Microelements, mg%: potassium	290	301	308	316	320
calcium	14	229.00	28	36	42
magnesium	20	177.00	36	51	56
sodium	57	62.10	57	57	58
phosphorus	12	185.00	26	41	52
Microelements, mg%: iron	0.9	2.90	2.91	2.9	2.91
cobalt	0.81	0.29	0.8	0.8	0.79
manganese	1.24	26.70	1.3	1.3	1.4

Conclusion

The review of existing world technologies and technical literature data has shown that food powders extracted from vegetable and berry raw materials are a modern and convenient form of keeping valuable properties of raw materials. Powder was obtained from bilberries by drying them in a roller dryer, the process preceded by raw materials cooking and followed by grinding.

The research conducted indicates that bilberry powder is a rich source of vitamins, such as ascorbic acid, β-carotene, tocopherols etc., and can be successfully used in the production of tomato sauces with functional properties. Thus, the addition of 15% of bilberry powder allows an increase in vitamin C by 220%, β-carotene by 151%, and the total amount of phenols by 225% of the initial amount in the tomato sauce obtained by the classical methods. It can be a proof of the effectiveness of using food powders in canned products technologies.

A complex of physical, chemical, and organoleptic studies has shown that the addition of bilberry powder significantly increases the content of macro and microelements in the product as compared to a sample obtained by the classical technology. Thus, it is possible to achieve a significant increase in the content of potassium and sodium, the elements that take part in the water-salt metabolism of the body, and elements of the hemopoietic complex – iron, manganese, and cobalt. For the above stated reasons, the research conducted may be considered topical.

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