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NEW TYPES OF PLANT RAW MATERIALS IN THE PRODUCTION OF FUNCTIONAL FOODS

Abstract. Functional foods are healthy foods that help maintain and preserve human health when consumed daily. The expansion of the range of functional products will contribute to the health improvement of the population, thereby prolonging the duration and activity of life. The range of functional products increasingly includes products that include non-traditional herbal raw materials. One of these types is products based on mulberry fruits. Mulberry fruits contain valuable food ingredients that determine not only their nutritional, but also their pharmacological value. The high content of vitamins, minerals and coloring substances makes it possible to use mulberry fruits as a variety of desserts and medicinal products. The developed new fruit desserts based on mulberry fruits will help expand the range of functional products from non-traditional types of plant raw materials.

Keywords: functional products, vegetable raw materials, mulberry fruits, nutritional value, fruit dessert.

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Introduction. The expansion of the range of functional food products based on plant raw materials requires in-depth knowledge of the chemical composition of the components included in the product. The presence of high levels of vitamins, mineral compounds, dietary fiber, and other biologically active substances in plant components that provide direct benefits to the human body is a fundamental factor determining the inclusion of a particular ingredient in a product formulation.

For this reason, new types of raw materials that were previously little used or undeservedly forgotten are increasingly being incorporated into traditional recipes. One such raw material is mulberry fruit.

Mulberry, or the mulberry tree (Latin: *Morus*), belongs to the Mulberry family (*Moraceae*). This genus includes about 20 species of woody plants that are most widely distributed in subtropical and warm temperate climates of North America, Africa, and Asia. In the eastern part of the range, the wild species *Morus macroura* is most widespread, whereas in the western part, white mulberry (*Morus*

alba) predominates. In Russia, only *Morus bombycis* has been found growing wild. References to mulberry fruits date back to ancient times. Three species of mulberry, black, red, and white, are cultivated in different countries. Black and white mulberries are the most common, while red mulberry is much rarer. In Russia, mulberry grows in Crimea, the North Caucasus, and the European part of the country [1,2].

Mulberry fruits vary not only in color but also in shape, size, and taste. Fruit color ranges from white to pinkish-white or yellow. Red mulberry fruits range from bright red to dark red or purple, while black mulberry fruits are dark purple or nearly black. Mulberry fruits are very delicate and aromatic; they are consumed fresh and widely used for processing. Mulberries are used to produce jam, juice, jelly, marmalade, various fillings for the confectionery industry, and wine. They are also dried, used to prepare mulberry honey, sherbet, and fruit leather, and employed in alcohol production. The variety of mulberry-based products is extensive [1].

Mulberry has long been used in traditional medicine. Not only the fruits but also the leaves, bark, and young shoots have been utilized. Mulberry fruits have been used in the treatment of hypertension, anemia, digestive disorders, diabetes mellitus, cardiovascular diseases, and other conditions.

The beneficial properties of mulberry have also been confirmed by scientific studies, which have demonstrated the hypolipidemic, antioxidant, antitumor, neuroprotective, immunomodulatory, and anti-atherosclerotic effects of the fruits [3-6].

Scientists have experimentally proven that extracts of black mulberry fruits affect cholinergic and muscarinic receptors, thereby enhancing the antidiarrheal effect. Nutrients present in mulberry fruits influence monoamine oxidase by inhibiting its activity, thus exerting a positive effect in the treatment of Parkinson's disease and hypertension.

Mulberry fruits contain a wide range of biologically active substances, including organic acids, minerals, essential oils, vitamins, pectic substances, and anthocyanins (as part of the coloring compounds).

Anthocyanins are natural pigments belonging to the class of flavonoid compounds. Chemically, they are polyphenolic compounds and occur in nature as mono- and diglycosides. Anthocyanins are powerful antioxidants that prevent the destruction of cell membranes, slow down cellular aging, bind free radicals, and inhibit tumor development [7-11].

The highest content of anthocyanins is found in black mulberry fruits. Mulberry fruits are rich in potassium, which is especially important for individuals suffering from cardiovascular diseases. The chemical composition of the fruits also includes vitamins C, E, K, A, and B-group vitamins. Among macronutrients, phosphorus, calcium, and sodium are the most significant, while among trace elements, iron, manganese, zinc, and selenium are present [12-16].

The nutritional value and chemical composition of mulberry fruits (per 100 g) are shown in Figure 1.

In addition to the substances presented above, mulberry fruits contain a valuable vitamin and mineral complex that helps the body maintain normal metabolic processes and combat vascular and cardiovascular diseases: vitamin A (1 μg), vitamin B_1 (29 μg), vitamin B_9 (6 μg), vitamin K (7.8 μg), vitamin C (36.4 mg), iron (1.85 mg), zinc (0.12 mg), copper (60 μg), and selenium (0.6 μg). The energy value of the fruits is only 43 kcal.

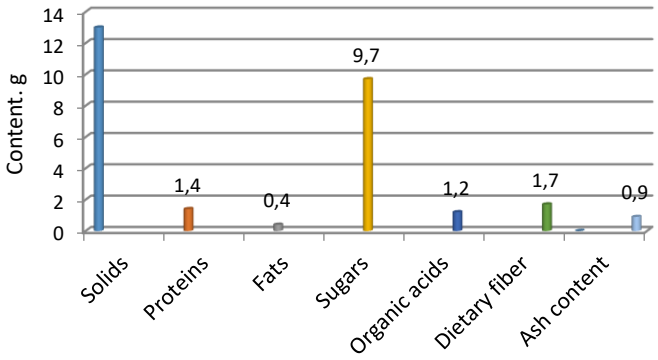

Fig. 1. Content of major nutrients in mulberry fruits, g/100 g

Mulberry is quite widespread in Russia; however, its cultivation is mainly of a private nature, and industrial plantations are absent. Currently, breeding and research are being carried out to develop and introduce new, highly promising mulberry cultivars with high yields into industrial production. This will make it possible not only to expand the range of products with high nutritional value, but also to enable the production of pharmaceutical preparations and natural food colorants from mulberry fruits.

Materials and methods. The objects of the study were fruits of three mulberry cultivars – *Smuglyanka*, *Black Prince*, and *Black Pearl*, grown in the Krasnodar Territory (Russia).

Mulberry cultivar "Smuglyanka". A black-fruited mulberry cultivar bred in the Belgorod Region. The berries are up to 3.5 cm in length, dark purple in color, early ripening, sweet with a slightly perceptible acidity. The cultivar is high-yielding, producing up to 110 kg of berries per tree.

Mulberry cultivar "Black Prince". A black-fruited mulberry cultivar. The berries are very large, up to 4–5 cm in length, sweet, dark purple to almost black in color, with a rich, honey-like flavor. The ripening period is medium. Winter hardiness reaches −30°C, and drought resistance is high. Yield is high, up to 100 kg of berries per tree.

Mulberry cultivar "Black Pearl". A mid-early cultivar intended for southern regions. The fruits are large, up to 4 cm in length and weighing up to 6-9 g. The fruit color is dark purple; the taste is sweet with a barely noticeable acidity, and the fruits are highly aromatic. Yield is stable, at 90-110 kg of berries per tree.

The aim of the study was to develop a functional food dessert based on black mulberry fruits. During the study, the physicochemical parameters of fresh mulberry fruits were determined, including dry matter content, acidity, sugar content, vitamin C, pectic substances, tannins, and coloring substances. After developing the formulation and optimizing the technology of the new products, their organoleptic and physicochemical properties were evaluated.

All studies were conducted at the Kuban State Agrarian University: at the Department of Technology of Storage and Processing of Crop Products and at the Research Institute of Biotechnology and Certification of Food Products. Pilot batches of the developed products were produced at the Educational, Scientific, and Production Complex "Technologist" (Kuban SAU).

Research results and discussion. The chemical composition of fresh raw materials largely determines the quality characteristics of the finished product, including its organoleptic properties and chemical composition. To predict the

possible chemical composition of the finished product, the chemical composition of plant raw materials – black mulberry fruits, was studied.

The main quality indicators of the studied fruits were determined, including the content of titratable (total) acids, dry matter, total sugars, pectic substances, tannins, and coloring substances. The research results are presented in Table 1.

Table 1

Physicochemical parameters of the studied mulberry cultivars

Mulberry cultivar	Dry matter, %	Acidity, %	Sugar content, %	Pectic substances (PS), %			Tannins and coloring substances, mg%
				Soluble PS	Proto-pectin	Total PS	
Smuglyanka	15.6 ± 0.02	0.95 ± 0.01	11.2 ± 0.01	0.56 ± 0.02	0.84 ± 0.02	1.40 ± 0.01	180.6 ± 0.02
Black Prince	14.8 ± 0.01	0.86 ± 0.02	10.8 ± 0.01	0.52 ± 0.02	0.91 ± 0.02	1.43 ± 0.02	182.3 ± 0.02
Black Pearl	15.3 ± 0.01	0.82 ± 0.02	10.6 ± 0.01	0.55 ± 0.03	0.99 ± 0.01	1.54 ± 0.01	181.7 ± 0.03

Note: Soluble PS – soluble pectic substances; PP – protopectin.

The research results presented in Table 1 characterize mulberry fruits as raw materials with high nutritional potential, combining a high content of pectic substances (up to 1.54%), sugars (up to 11.2%), organic acids (up to 0.95%), and coloring substances (up to 182.3 mg%).

At the next stage of the study, the content of vitamins and mineral substances in the mulberry cultivars was determined. The obtained data are presented in Table 2.

Table 2

Vitamin and mineral content in the studied mulberry cultivars (mg per 100 g)

Mulberry cultivar	Vitamin C	Vitamin PP (Niacin)	Vitamin B_1 (Thiamine)	Vitamin B_2 (Riboflavin)	Phosphorus	Calcium	Potassium	Magnesium
Smuglyanka	11.6 ± 0.01	0.86 ± 0.02	0.052 ± 0.02	0.031 ± 0.01	36.3 ± 0.02	23.8 ± 0.01	350.6 ± 0.02	50.7 ± 0.01
Black Prince	10.1 ± 0.01	0.76 ± 0.01	0.045 ± 0.02	0.028 ± 0.02	36.1 ± 0.03	24.6 ± 0.01	352.2 ± 0.02	51.3 ± 0.01
Black Pearl	13.4 ± 0.01	0.91 ± 0.02	0.048 ± 0.01	0.029 ± 0.02	34.2 ± 0.02	24.1 ± 0.01	348.4 ± 0.03	52.0 ± 0.01

It was established that mulberry fruits contain the highest amount of vitamin C (10.1-13.4 mg%) and significantly lower amounts of vitamin PP (0.76-0.91 mg%) and B-group vitamins. Among the minerals, potassium is the most abundant (up to 352.2 mg), followed by magnesium (up to 52.0 mg), while phosphorus and calcium are present in slightly lower amounts.

These data allowed the development of a fruit dessert based on mulberry fruits, with the addition of oranges and lemons to balance the flavor and increase vitamin C content. Spices such as cloves, cinnamon, and ginger extract were also

included, along with additional pectin to achieve a jelly-like consistency. Sorbitol was used as a sugar substitute.

The formulations of the developed desserts are presented in Table 3.

Table 3

Formulations of the developed functional fruit desserts
(kg per 1 t of finished product)

Raw material	"Lemon Mulberry"	"Orange Mulberry"
Mulberry	680.0	570.0
Lemon	269.68	-
Orange	-	384.67
Ginger (extract)	0.08	0.08
Sorbitol	45	40
Pectin	5.0	5.0
Cloves	0.08	0.05
Cinnamon	0.16	0.2

The developed desserts are characterized by the following organoleptic properties:

1. Appearance: Homogeneous, non-layering jelly-like mass with evenly distributed particles of mulberry, lemon, or orange, without any foreign impurities.
2. Color: Dark purple.
3. Aroma: Well-defined aroma of lemon (or orange) and ginger, with a subtle pleasant spice note.
4. Taste: Sweet with a slight acidity and a mild pungent aftertaste.

After selecting the best samples based on organoleptic evaluation, the physicochemical properties of the developed samples were studied.

Figure 2 presents the profilograms of the obtained fruit desserts.

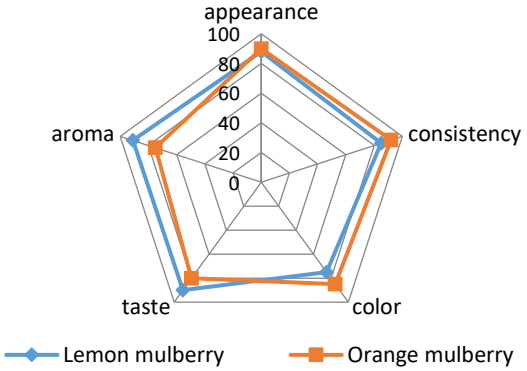

Fig. 2. Profilograms of the organoleptic properties of the fruit desserts

The data shown in Figure 2 indicate a high evaluation of the organoleptic properties of the newly developed functional desserts based on mulberry fruits. Both samples, "Lemon Mulberry" and "Orange Mulberry," have an appealing appearance, firm consistency, sweet-and-sour taste, and a pronounced aroma of citrus fruits and spices.

The chemical composition of the finished product characterizes its nutritional and biological value. Based on the content of the substances present in

the products, conclusions can be drawn regarding their benefits or potential harm to the human body. The results of the physicochemical analysis of the developed fruit desserts are presented in Table 4.

Table 4

Physicochemical properties of the developed fruit desserts

Dessert name	Dry matter, %	Acidity, %	Sugar content, %	Vitamin C content, mg%	Pectic substances, %	Tannins and coloring substances, mg%
Lemon Mulberry	68,6 ± 0,5	1,25 ± 0,03	33,7 ± 0,2	32,25 ± 0,3	3,16 ± 0,05	152,4 ± 0,5
Orange Mulberry	69,1 ± 0,5	1,08 ± 0,04	34,1 ± 0,2	30,54 ± 0,3	3,2 ± 0,05	154,1 ± 0,4

The obtained data characterize the developed fruit desserts as having high nutritional value, with a high content of vitamin C, pectic substances, and coloring substances (anthocyanins).

Conclusion. Thus, in the process of developing functional products based on unconventional plant raw materials, namely, black mulberry fruits, new fruit desserts were created. These desserts contain a high content of vitamin C (31.4 mg% on average, with a recommended daily intake of 90 mg/day), pectic substances (3.18% on average, with a recommended daily intake of 2-4 g/day), and coloring substances (153.25 mg% on average, with a recommended daily intake of 10-15 mg/day).

Since the content of a functional ingredient in a product should be at least 15% of the daily physiological requirement, the developed desserts can be classified as functional products when calculated per serving.

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ФУНКЦИОНАЛДЫ ТАҒАМ ӨНІМДЕРІН ӨНДІРУДЕГІ ӨСІМДІК ШИКІЗАТЫНЫҢ ЖАҢА ТҮРЛЕРІ

Аңдатпа. Функционалды тағам өнімдері – күнделікті тұтыну барысында адам денсаулығын сақтауға және нығайтуға көмектесетін пайдалы азық-түліктер. Функционалды өнімдер ассортиментін кеңейту халықтың жалпы сауықтануына, соның нәтижесінде өмір сүру ұзақтығы мен белсенділігін арттыруға ықпал етеді. Функционалды өнімдердің құрамында дәстүрлі емес өсімдік шикізаты жиі қолданылып келеді. Осындай шикізаттың бірі – тұт жемістеріне негізделген өнімдер. Тұт жемістерінің құрамында олардың тағамдық қана емес, фармакологиялық

құндылығын да анықтайтын маңызды биологиялық белсенді заттар бар. Витаминдердің, минералды элементтердің және табиғи бояғыштардың жоғары болуы тұт жемістерін әртүрлі десерттер мен емдік тағамдар дайындауда қолдануға мүмкіндік береді. Тұт жемістеріне негізделген жаңа жеміс десерттері дәстүрлі емес өсімдік шикізатынан алынатын функционалды өнімдер ассортиментін кеңейтуге септігін тигізеді.

Тірек сөздер: функционалды өнімдер, өсімдік шикізаты, тұт жемістері, тағамдық құндылығы, жеміс десерті.

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НОВЫЕ ВИДЫ РАСТИТЕЛЬНОГО СЫРЬЯ В ПРОИЗВОДСТВЕ ФУНКЦИОНАЛЬНЫХ ПРОДУКТОВ ПИТАНИЯ

Abstract. Функциональные продукты питания относятся к здоровым продуктам, которые помогают поддерживать и сохранять здоровье человека, при ежедневном их потреблении. Расширение ассортимента функциональных продуктов будет способствовать оздоровлению населения, тем самым продлевая продолжительность и активность жизни. В ассортименте функциональных продуктов все чаще встречаются продукты, в состав которых входит нетрадиционное растительное сырье. Одним из таких видов являются продукты на основе плодов шелковицы. В составе плодов шелковицы содержатся ценные пищевые ингредиенты, обусловливающие не только их пищевую, но и фармакологическую ценность. Высокое содержание витаминов, минеральных веществ и красящих веществ, позволяет использовать плоды шелковицы в качестве разнообразных десертов и лечебных продуктов. Разработанные новые фруктовые десерты на основе плодов шелковицы будут способствовать расширению ассортимента функциональных продуктов из нетрадиционных видов растительного сырья.

Keywords: функциональные продукты, растительное сырье, плоды шелковицы, пищевая ценность, фруктовый десерт.