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Research article

The use of bioactive components of plant raw materials from the far eastern region for flour confectionery production

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Abstract: The article describes the results of a study of flour confectionery products produced with the use of raw materials of plants and berries origin, growing on the territory of the Far Eastern Region of Russia, as well as dihydroquercetin to enrich the ready product with natural biologically active substances with functional properties. The production technology of *«Medovaya»* honey-cake with no filler has been improved. Chemical values of black chokeberry berries and flour confectionery products (*«Medovaya»* honey-cake with no filler) produced according to standard formulation and enriched by adding black chokeberry powder have been identified. The use of black chokeberry berries processed products and dihydroquercetin in the production technology of flour confectionery products improves their quality and enriches them with the natural biologically active substances, meets the daily requirement for a number of physiologically functional ingredients, extends the storage life.

Keywords: ginger bread; food enrichment; biological value; black chokeberry; dihydroquercetin

1. Introduction

Human nutrition and lifestyles are the most important determinants of health. Numerous studies [1–4] of natural food products have reliably shown the presence of different compounds in food, so called minor biologically active components, which, in case of regular use help to improve the quality of life, health and reduce the risk of many diseases. Besides, at present ecological state, unfavorable environmental factors have an active and negative impact on human health, which also requires changes in composition of food products in terms of increasing the micronutrients and minor biologically active substances content [5–9].

Flour confectionery products are particularly high in protein, fat and carbohydrate, they are of a high-energy value and taste qualities, and are in big demand among people of all age groups. Unfortunately, cookies also fall within the category of high-energy easily digestible food, as they are usually made from wheat flour and fat. Because cookies are a popular food, they are consumed on a regular basis. This addiction can affect the health adversely because of what they are made from [10]. The significant drawback of these products is a low level of biologically active substances (BAS) in their composition due to the use of raw material with low content of vitamins and amino acids (sugar, fats, protein, molasses, etc.) and additional destruction of BAS during the technological processing. Accordingly, the chemical composition of such products should be significantly corrected, namely the energy value and sugar content should be decreased, while simultaneously the BAS and physiologically functional food ingredients content should be increased [11,12].

According to GOST R (Russian National Standard) 52349-2005 physiologically functional food ingredients are substances or groups of substances of different origins (animal, plant, microbiological, mineral) or identical to the natural, as well as living microorganisms which are a part of functional food product. They (physiologically functional ingredients) have a favorable impact on one or several physiological functions, and on the process of metabolism in the human body, if consumed regularly in a quantity that is from 10 to 50% of daily physiological requirements. Recently, there has been a considerable interest in the use of fruit and berry resources, which are a good source of biologically active compounds. Processing them is a much better practice than chemical synthesis, since special conditions are not needed for the cultivation of berries and fruits, and this source is available even in the third world countries. Fruit plants are of a relatively stable and high productivity and have the relative resistance to unfavorable climate conditions [13–15].

At present time, this type of resources is either processed for production of a small number of products or not used at all. It is caused by the lack of technology for their comprehensive processing. The current state has contributed to the fact that a large number of valuable natural compounds remain practically unused. In this regard, there is a need of development and introduction of advanced and scientifically based technology of comprehensive use of raw materials of plant origin [15–17].

A distinctive feature of the Far Eastern Region of Russia is richness and diversity of the plant raw materials. Berries, fruits and vegetables are significantly beneficial for human health as they are rich in vitamins, minerals, organic acids and other biologically active substances, which are necessary to satisfy physiological requirements of the human body. Creating means to introduce cellulose, pectin, organic acids, mineral salts, sugar and other biologically active substances into the human body in the form of nutrient additives by extracting raw material from local berries is considered to be appropriate. This is caused by the fact that raw materials from local berries occupy a very insignificant place in a diet of a modern human.

Fresh, processed and dried berries can be used in production of plant food additives. There is an unlimited source of berry raw materials for this purpose on the territory of the Amur Region. The basis for accomplishing this work is the fact that there have been no studies of comparative chemical composition of some berries growing on the territory of the Amur Region that can be used in the form of food supplements. Accordingly, the study of issue on proving the possibility and usefulness of using the black chokeberry berries (*aronia mitschurinii*) in the production technology of flour confectionery products is of a greatest interest at this stage. At the same time, the change in the chemical composition of food products caused by introduction of a new plant functional ingredient effects the change in traditional technology, which must be studied in order to obtain necessary technological and consumption characteristics of the produced products [18]. Elaborating of flour confectionery products of a high biological value and stability in quality characteristics during the storage is no less a relevant issue [19].

In the field of food supplements containing components with antioxidant, prophylactic and therapeutic effect, Dihydroquercetin (DHQ)—a chemical compound of vitamin R group, extracted from Siberian larch timber and known as "Taxifolin" in Europe, is of a particular interest [18,20,21].

Dihydroquercetin is one of the most important representative of flavonoids, classified as polyphenol and included in the State Register of Medicinal Products, has a favorable impact on human's health. It is a catalyst of many biochemical processes in the human body, it protects cell membranes against destruction, activates the functioning of capillaries, prevents the development of tumor cells, and has an antitoxic effect, meaning its capability of neutralizing free radicals just like an antioxidant does. Besides, it improves the functioning of practically all internal organs of the human body; heart, liver, gallbladder, prostate, kidneys, urinary bladder and gastrointestinal tract. It is recommended as a preventive agent in the areas of radioactive environmental pollution, in an unfavorable ecological environment, and approved for use in food industry as a food antioxidant [21,22].

The objective of the study is to improve the formulation and to develop the flour confectionery production technology with the use of plant raw materials from berries and dihydroquercetin. In the course of the study, we set the following goals**:** to study chemical composition of black chokeberry berries (*aronia mitschurinii*) and samples of flour confectionery products enriched with black chokeberry berries powder; to make an assessment of the antioxidant properties of «*Lavitol*» (dihydroquercetin) food supplement; to provide scientific basis and develop the technology and formulation of flour confectionery production with the use of biologically active components; to undertake a complex assessment of the ready product quality, according to the main principles of HACCP system.

2. Materials and Methods

The experimental part of the work was performed in the laboratories of Department of Food Production Technology and Catering, Department of Processing of Crop Production Products, Department of Chemistry of Technological Faculty, in the Laboratory of Soil Sciences and Agricultural Chemistry Ecology of Agronomics and Ecology Faculty of the Far Eastern State Agrarian University, in the testing laboratory of All-Russian Scientific Research Institute of Soybean, Blagoveshchensk town, on request of sole proprietor Matveeva E.V. (#Chaikofskii coffee shop chain, Blagoveshchensk town). Objects of research were black chokeberry berries (*aronia mitschurinii*), food supplement «*Lavitol*» (Dihydroquercetin) extracted from Dahurian (Siberian) larch supplied by Ametis JSC. Physicochemical, microbiological and organoleptic indexes were defined with standard methods according to regulatory and technical documentation. Technological operations were performed with the use of traditional scheme for control and proof samples. Before use, all plastic containers were immersed in a 10% solution of close-to-boiling nitric acid for at least 24 hours, and then washed thoroughly with ultrapure de-ionized water. For avoiding the influence of metals, all kinds of glassware were excluded. All plastic containers, polyethylene flasks, pipette tips, teflon vessels for heat treatment and related reagents were analyzed for contamination.

2.1. Lavitol analysis

The chemical composition of the Larch oil is complex and various. It consists of the blend of terpene hydrocarbons, resin acids, phytosterols, tocopherols, diterpene and fatty acids, dihydroquercetin, Lavitol (*Dihydroquercetin*) is the active antioxidant. The antioxidative activity was tested using the ORAC-hydro assay, which reflects the oxygen radical absorbance capacity of water-soluble antioxidants. The test results showed that Lavitol (*Dihydroquercetin*) has very high ORAC value, which exceeds that of some known antioxidants. Content of residual quantity of food supplement *«Lavitol»* in the storage process was defined by liquid chromatography method. In very small amounts, the sample mixture to be separated and tested is sent into a stream of mobile phase percolating via the column. The thin layer chromatography (TLC) plates (silica gel 60 F254, 20 × 20 cm) were purchased from Merck (Darmstadt, Germany). Mathematical treatment of experimental data obtained in 3–5 replications was performed according to the standard programs and generally accepted algorithms with the use of correlation dependence and optimization plan of multivariate analysis.

2.2. Chokeberry berries analysis

The amino acid and fatty acid composition of the berries has been determined with the "InfraScan" IR analyzer, operating in the infrared wavelengths. To determine the accuracy of the device operation, a sealed control sample has been used. Prepared, ground and dried samples were sealed in standard cuvettes and using the analyzer-receiving unit, the spectrum of all samples was plotted. Each culture studied had its own spectrum and its standard file. Then, using the files obtained, the computer showed the data on the required components. Fatty acids content of berries was determined on essential oils made of dried berries. This was done for one simple reason: berries go into the final confectionery product wholly, in the form of powder, so fatty acids that are in a berry will be in the confection in full. Among other things, fatty acids content is a must to know to determine the nutritional value of a final product.

To get the powder from black chokeberry (*aronia mitschurinii*) we used berries growing in the Far East, in the Amur Region on experimental plantation. Black chokeberry powder was obtained using the following technological scheme: inspection and selection of raw materials → preparation of raw materials → drying at t not higher than 40 °C for 7–14 days → milling of raw materials → packaging → storage at temperature not higher than 20 °C. The berries were collected during June to November at the stage of commercial maturity. Seeds were isolated manually from the fruits just before analysis at the laboratory. The oils of the whole berries, pulp/peel and seeds were extracted from 5 g of samples using a methanol/chloroform extraction procedure [23,24]. The sample was homogenized in methanol (50 mL) for 1 min with a high-power homogeniser, chloroform (100 mL) was added, and homogenization was continued for a further 2 min. The mixture was filtered and the solid residue resuspended in chloroform: methanol (2:1, v/v, 150 mL) and homogenized for another 3 min. The mixture was filtered again and washed with 150 mL chloroform: methanol (2:1, v/v). The filtrates were combined and cleaned with 0.88% potassium chloride water solution and methanol: water (1:1, v/v) solution. The bottom layer containing the purified lipids was filtered before the solvent was removed on a rotary evaporator.

The lipid samples were transferred to vials with 4 mL chloroform (stock solution), and stored at −18 ℃ until they were analyzed. Fatty acid methyl esters (FAMEs) were obtained from lipids using acid-catalysed transesterification procedure described by Christie (Christie 1989). For total FAME analysis, 0.2 mL of each oil extract (stock solution) was dissolved in 1 mL toluene and then methylated with 1% sulfuric acid in methanol (2 mL), using a 15 mL screw-cap Pyrex culture tube at 80 ℃ for 2 h. After cooling to room temperature, 5 mL of water (with 5% NaCl) and 2 mL hexane were added. The hexane layer was collected and concentrated before the FAMEs were applied to TLC plates. The loaded TLC plates were developed in a mixture of petroleum ether: diethyl ether: acetic acid (85:15:1, v/v/v), sprayed with 2’,7’-dichlorofluoroscein/methanol (0.1% w/v) and viewed under UV light (254 nm).

The corresponding FAME band was scraped and eluted with chloroform. The eluent was removed with a gentle nitrogen stream. The FAMEs were dissolved in 1 mL hexane and placed into a gas chromatography (GC) vial. The vial was capped and placed at −18 ℃ until GC analysis. The lipid classes (PLs, FFAs, TAGs and SEs) were separated also by TLC. For fractionation, 0.2 mL of each oil (stock solution) was applied on the TLC plates, developed and viewed under UV light as above. The polar lipids remained at the origin of the plates (the first band). The other major lipid class bands from TLC plates, were identified using commercial standards (which were run in parallel with the samples) and then scraped from the plates. The bands for PLs and FFAs were eluted with methanol: chloroform (1:1, v/v), and the upper two major bands corresponding to TAGs and SE respectively, were eluted with chloroform. After the chloroform was evaporated under a nitrogen stream, the lipid classes were methylated (20 min at reflux for PLs and 2 h at reflux for the other lipid fractions).

The *Lavitol* residues were determined by means of liquid chromatography. A sample mixture was sent in a very small amount into a stream of mobile phase percolating via the column. The thin-layer chromatography plates (silica gel, 60 F254, size: 20 × 20 cm) were produced by the Merck KGaA company (Darmstadt, Germany). Experimental data obtained in 3–5 replications were processed by multivariate and correlation analysis.

At the first stage of research biochemical composition of black chokeberry (*aronia mitschurinii*) was studied.

2.3. Formulation of flour confectionary and analysis of the final product

Dried black chokeberry berries (*aronia mitschurinii*) powder was added into the dough during dough preparing stage in the quantity of 2.5; 5 and 7.5% of flour mass of the standard formulation. «*Lavitol*» (dihydroquercetin) food supplement was added in the form of 40% alcohol solution, which did not cause the changes in organoleptic characteristics of a flour semi-finished product in the quantity of 0.025, 0.050, and 0.075% of the raw material weight.

3. Results and Discussion

Tables 1 and 2 show the data on epy amino acid composition of black chokeberry berries (*aronia mitschurinii*).

Table 1. Content of essential amino acids in black chokeberry berries (*aronia mitschurinii*), gr per 100 gr of the product, (average, Standard deviation—0.05%).

Valin	Methionine	Gistidin	Lisoleucine	Leucine	Lysine	Threonine	Tryptophan	Phenylalanine
0.05	0.029	0.067	0.061	0.172	0.094	0.011	0.04	0.04

Table 2. Content of nonessential amino acids in black chokeberry berries (*aronia mitschurinii*), gr per 100 gr of the product, (average, Standard deviation—0.05%).

Alanine	Arginine	Asparagin acid	Glycin	Glutamic acid	Proline	Serine	Tyrosine
0.013	0.067	0.029	0.07	0.15	0.045	0.05	0.041

Tables 1 and 2 showed that black chokeberry is not a high energy value product but at the same time it is rich in plant carbohydrates. Amino acid composition of proteins in black chokeberry (*aronia mitschurinii*) is represented by 18 amino acids, 9 of which are essential (with no arginine) and 9 are nonessential. The presence of essential acids indicates a biological value of black chokeberry berries proteins.

Table 3 contains values of fatty acid composition of black chokeberry berries.

Table 3. Fatty acid composition of black chokeberry berries, gr per 100 gr of the product.

Acid name	Content, gr per 100 gr of the product
Unsaturated fatty acids	
Oleinic C 18:1 (omega-9)	0.06
Linoleic C 18:2 (omega-6)	0.11
Linolenic C 18:3 (omega-3)	0.07
Saturated fatty acids	
Palmitic C 16:0	0.02
Stearinic C 18:0	0.01

Table 3 has shown that fatty acid composition of black chokeberry berries includes not only saturated fatty acids (stearic and palmitic) and monounsaturated oleic acid, but also has essential polyunsaturated fatty acids (linoleic and linolenic acids), which are highly rare nutrients in human diets. Saturated fatty acids in the human body are a source of energy; at the same time the oleic fatty acid, which is resistant to oxidation, has cardioprotective properties and helps in normalization of metabolic processes in the body, including oncopathologies in ecologically unfavorable territories, etc.

Essential fatty acids, linoleic and linolenic, that are being the material for the synthesis of biological membranes of cells, regulate numerous physiological processes in the human body, including the function of the cardiovascular system, help in strengthening the immune system, exhibit antitumor properties, normalize allergic conditions. The essentiality of linoleic fatty acid is due to the fact that it takes direct part in synthesis of arachidonic fatty acid (in the presence of vitamin B6 in the body), which is the part of the phospholipid cell membranes. Thus, the black chokeberry berries contain a number of natural biologically active substances, which suggested the possibility of its use as a functional ingredient in the production of flour confectionery products to improve the product quality.

For preparing of black chokeberry (*aronia mitschurinii*) powder, the berries growing in the Far East of Russia, Amur Region were used. Black chokeberry powder was prepared according to the following technological scheme: inspection and grading of raw materials → preparation of raw materials → drying at t below 40 ℃ for 7–14 days → raw materials grinding → packaging → storage at temperature below 20 ℃.

At the next stage of the research the assessment of antioxidant qualities of «*Lavitol*» (dihydroquercetin) food supplement was performed. The development of oxidative changes after adding the dihydroquercetin was assessed by the quantity of oxidation products—peroxide and acid values in lipid fraction that was extracted from the samples of flour semi-finished product. The dynamics of change of peroxide value of all samples studied corresponds to the increase in the acid value.

The adding of «*Lavitol*» (dihydroquercetin) food supplement into a flour semi-finished product in a quantity of 0.050 and 0.075% of the raw material weight caused the significant inhibition of the oxidation process. On the 30th day of storage the peroxide value was 17.6% lower compared to the control sample. In case of adding the «*Lavitol*» food supplement in a quantity of 0.025% of the raw material weight, the peroxide value was 13.5% lower compared to the value of control sample.

Microbiological study of a flour semi-finished product with the use of «*Lavitol*» food supplement during the storage of control and proof samples in the period of 30 days have not indicated significant difference in quantity and quality values of microflora. Analysis of chemical and microbiological values has showed that «*Lavitol*» food supplement inhibits oxidation process of secondary degradation products.

Thus, the use of natural antioxidant as a component of a flour confectionery product not only helps to regulate the quality characteristics of the product, but also increases its shelf life. Accordingly, it can be concluded that adding a certain quantity of «*Lavitol*» food supplement into the composition of flour confectionery product improves quality values at different periods of storage.

Based on research experiments, the most significant factors that have the greatest impact on the quality characteristics of flour confectionery product – «*Medovaya*» honey-cake, were identified: the content percentage of black chokeberry berries (*aronia mitschurinii*) powder; quantity of «*Lavitol*» food supplement and storage period of the ready product. Table 4 contains the factors and variation levels data. Based on the results obtained, regression analysis of $y_i = f(x_1, x_2, x_3)$ dependencies have been performed, and mathematical models of the flour confectionery product quality values have been created.

y_1—quality values of the flour confectionery product—«*Medovaya*» honey-cake.

Table 4. Factors and their variation levels.

Designations	Factors		
	X1 Quantity of «*Lavitol*» food supplement, C, %	X2 %—percentage of black chokeberry (powder), Z	X3 Storage periods of the flour confectionery product, T
High level (+1)	0.075	7.5	30
Average level(0)	0.050	5	25
Low level (−1)	0.025	2.5	20
Variability interval	0.025	2.5	5

Mathematical models of the flour confectionery product quality values showed that optimal parameters of the factors are:

Quantity of «*Lavitol*» food supplement—0.037–0.041%;

Percentage of black chokeberry—5.3–5.8%;

Storage period—23–27 days.

Furthermore, taking into account the set objectives, the formulation and production technology of the «*Medovaya*» honey-cake flour confectionery product have been developed.

The production technology of the «*Medovaya*» honey-cake flour confectionery product includes the following operations: adding into the premium quality wheat flour the baking powder, the black chokeberry berries powder with the quantity of 5% of the total weight of flour and «*Lavitol*» food supplement with the quantity of 0.025%, dissolution of sugar sand in water at the temperature of 75 ℃; adding the soft margarine and mixing; adding the wheat flour of premium quality (40–45%) into the resulting mixture and mixing for 10–15 minutes; cooling the prepared mass to 25 ℃; dissolution of honey in water of a room temperature and adding into the cooled mass; mixing the resulting mass, while adding the residual flour and mixing the dough for 10–15 minutes; rolling the dough in a layer of 11–13 mm thickness, placing it on a preliminarily oiled and dusted with flour sheet. Wetting the surface of honey-cake with cold water before baking, pricking it in several places (to prevent swelling of the top layer); baking at a temperature of 180–200 ℃ for 25–40 minutes; cooling and forming the product.

Under laboratory conditions the production technology of the flour confectionery product has been approved, the quality metrics based on main principles of HACCP system (Table 5) have been defined, the nutritional qualities and energy value have been calculated.

Table 5 contains organoleptic quality values of «*Medovaya*» honey-cake.

Table 5. Organoleptic values of quality of «Medovaya» honey-cake enriched with black chokeberry berries powder and «Lavitol» food supplement.

Appearance	The product retained its shape well, small cracks on the surface
Flavor and aroma	The flavor is pleasant, sweet, typical to a baked of brewed gingerbread dough product, with a flavor of honey and black chokeberry aroma
Colour	Homogeneous, light brown with a purple shade
Consistency	Heavy body, with no undermixing, with fine pores at the fracture

It has been determined, that adding the black chokeberry berries powder in the amount of 5% of the flour mass into the «*Medovaya*» honey-cake results in the change in organoleptic values. The flour confectionery product acquires the flavor and aroma typical to black chokeberry berries, and a distinctive purple shade. The results of organoleptic assessment have shown that the sample containing the black chokeberry berries powder with a quantity of 5% of flour mass has the best parameters and the highest score (Figure 1). Tasting analysis has been performed according to a scoring system of evaluation of organoleptic characteristics, elaborated by the authors.

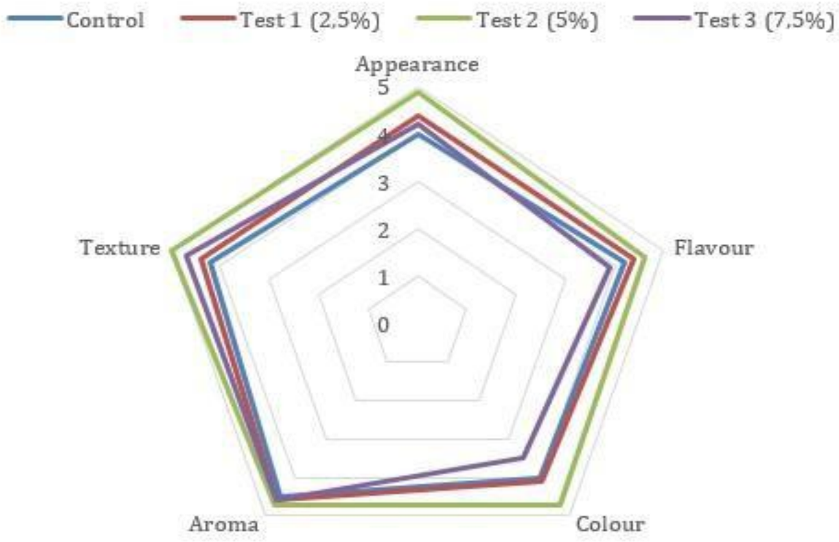

Figure 1. Tasting analysis of «Medovaya» honey-cake organoleptic properties.

Moisture (moisture content) index is the most important for assessing the quality of raw materials, semi-finished products and ready products. Moisture content characterizes product energy value, as the higher the moisture value of the product mass unit, the lower the dry components content (proteins, fats, carbohydrates, etc.) Product moisture determines its conditions and storage period, as the high moisture value causes the growth of microorganisms (including those ones that cause decaying and mold formation) and catalyzes fermentation and chemical reactions. Moisture content, % of honey-cake according to National Standard (GOST) 51810-2014 is 14–20%. According to the results of the study all samples meet the requirements of the standard (moisture content of the control and proof samples is 15.5% and 15.9% respectively) (Table 6).

Table 6. Physical and chemical quality indexes of honey-cake enriched with black chokeberry berries powder and «Lavitol» food supplement.

Index	Moisture, %	Alkalinity, degrees	Absorptivity, %
Control sample	15.5	1.7	213.7
Proof sample	15.9	1.6	221.4

Alkalinity is an important index of quality, which affects the organoleptic characteristics of ready products. The results of the study have shown that alkalinity of the control sample of «*Medovaya*» honey-cake with no filler and alkalinity of the proof sample of «*Medovaya*» honey-cake with no filler enriched with 5%-supplement of black chokeberry berries powder meet the standards for gingerbread products (honey-cakes allowed alkalinity is not more than 2.0 degrees).

Absorptivity is determined by the amount of water absorbed by the product during dipping the product in water and characterizes products porosity. Absorptivity of gingerbread products must be not less than 180%. All samples meet the requirements of the standard. The absorptivity index of the proof sample is higher compared to the control sample; thus, the porosity of the proof sample is also higher.

Figure 2 contains food value indexes of the tested samples.

Figure 3 contains data on amino acid composition of the proof and control samples.

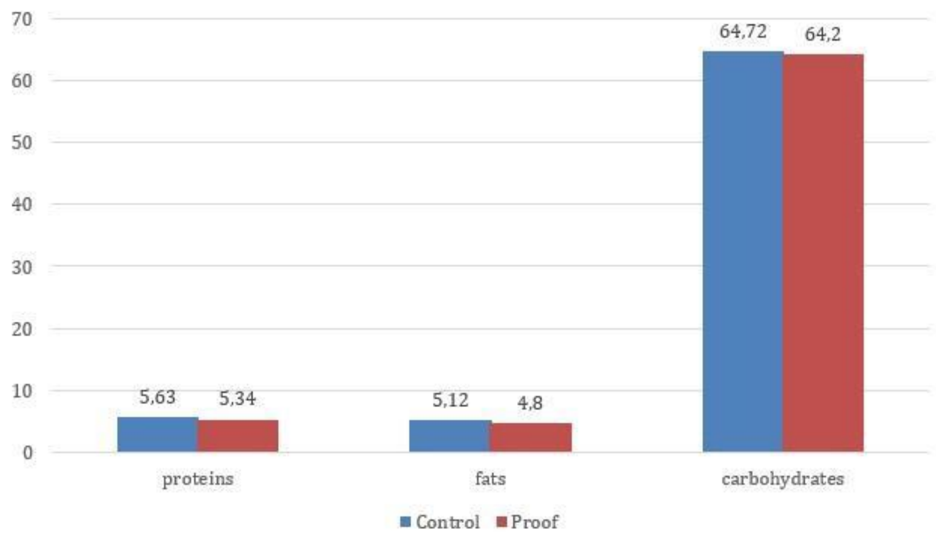

Figure 2. Food value of «Medovaya» honey-cake enriched with black chokeberry berries powder and «Lavitol» food supplement.

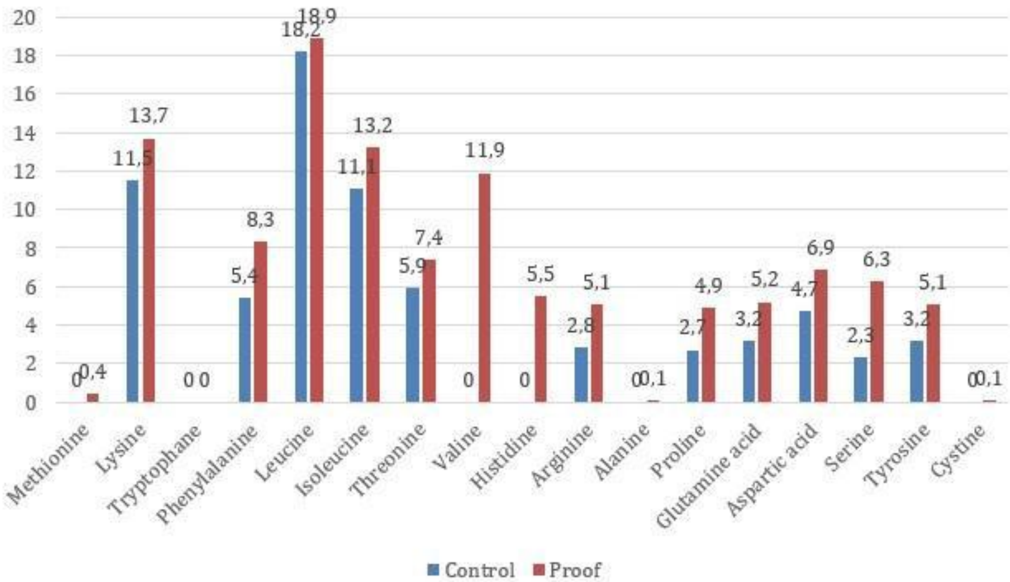

Figure 3. Amino acid composition of «Medovaya» honey-cake enriched with black chokeberry berries powder and «Lavitol» food supplement.

Figure 3 has showed that the proof sample has 16 amino acids, including nine amino acids that are essential (with no tryptophan). Proteins of the proof sample have 11 amino acids, including six amino acids that are essential. There are no following essential amino acids—tryptophan, methionine, valine, histidine. The total relative content of essential amino acids in the proof sample of the flour confectionery product enriched with black chokeberry berries powder is 71.2% of total content of amino acids in proteins of the enriched product, which is 16.3% higher than the same value of the control sample.

Accordingly, the enrichment of «*Medovaya*» honey-cake with biologically active components increased biological value of the protein in the flour confectionery product due to the increased amount of three essential amino acids (methionine, histidine and valine). Black chokeberry berries powder contains all the nine essential amino acids of the enriched product. Thus, the enrichment of flour confectionery products with supplements of plant raw materials origin, namely the black chokeberry berries powder, meets the requirements of a human body in essential amino acids.

The assessment of the amount of vitamins (carotene, R, C, E) in control and proof samples, has established that content of carotene in «*Medovaya*» honey-cake with no filler enriched with 5% black chokeberry berries powder is 24.128 mg/kg after 14–18 hours of resting**,** at thermal regulation of 25 mg/kg (physiological requirement of B-Carotene is 6 mg/day). Black chokeberry berries contain the highest amounts of vitamin R (350.7 mg/100 g). The amount of vitamin R in the proof sample of the ready product is 59.2 mg higher compared to the control sample, it is 294.4 mg per 100 gr of the product. Thus, flour confectionery product enriched with black chokeberry berries powder and «*Lavitol*» food supplement has the properties of a functional product.

Content of vitamin C in a honey-cake enriched with 5% black chokeberry berries powder and «*Lavitol*» food supplement is 88 mg per 100 gr of the product while in the control sample is 47 mg. The daily need of vitamin C is 30–95 mg.

Table 7 contains the quantitative content of vitamin E.

Table 7. Quantitative content of vitamin E in «Medovaya» honey-cake enriched with black chokeberry berries powder and «Lavitol» food supplement.

Studied samples	Content, mg/100 g of the product
Black chokeberry berries	2.10
Proof sample of honey-cake	1.90
Control sample of honey-cake	0.14

Table 7 analysis has showed that the content of vitamin E in the proof sample is 1.90 mg/100 g, which is much higher compared to the content in the control sample (0.14 mg/100 g).

It has been established that the powder of black chokeberry berries from the territory of the Far Eastern Region of Russia contains biologically active components with functional properties—the carotene in amount of 36.192 mg/kg, vitamin C—43 mg/100 gr, vitamin R (rutin)—350.7 mg/100 gr, vitamin E—2.1 mg/100 gr. Physical and chemical study have shown that «*Medovaya*» honey-cake with no filler, enriched with 5% black chokeberry berries powder contains carotene in amount of 2.5 mg, vitamin C—88 mg, vitamin R—294.4 mg, vitamin E—1.9 mg per 100 gr of the ready product. According to the data obtained, biologically active components of black chokeberry powder are partially destroyed during technological process.

However, the established quantity of minor biologically active substances is of a sufficient amount to have the therapeutic effect and product functionality with antioxidant properties. Introduction of black chokeberry powder to formulation of the product has had a favorable effect on organoleptic and technological indexes, on food and biological value of the product as well as caloric value. Relevance of the study undertaken is proved by a large-scale research of beneficial for human health biologically active substances, that are a part of raw materials of plant origin, including chokeberry [11,17,25,26], berries anthocyanins, squeezings of fruits and berries, peels of grapes, raspberry, red and black currants, blackberry [27,28], phenol compounds of red grapes with antioxidant properties [29], food fibers of mango peels powder and their antioxidant properties [13,14], processed products of other natural raw materials of fruits and berries origin [8,12,15], dihydroquercetin, arabinogalactan-peptides [18,22,30].

The goal that we set is of interest to many researchers because it implies the solution of an urgent problem. Flour confectionery products that are currently available on the market, such as cookies, usually contain up to 50% of calories, which come exclusively from fats and carbohydrates, and this when 100 grams of random cookies contain more than 400 calories [31]. These days, scientists are concerned with finding ways to enrich confectionery products and to compare the effect of the content of natural and artificial antioxidants in the human diet [10]. Issues associated with the enriching of pastries and increasing their nutritional value are touched upon in [32]. The similar results were highlighted in studies conducted at the Latvia University of Agriculture [33]. In the Central Food Technological Research Institute, a study was conducted on the possibility of adding products of pea processing to pasta formulations. Different levels of substitution—10, 20 and 30% of yellow pea flour in noodles was carried out. Results indicated that noodles with 20% yellow pea flour had favorable sensory attributes, protein content, good texture, yellowness values, reduction in the glucose release and increased protein digestibility [34]. Scientists from the Federal University of Technology, Akure (Nigeria), have developed a formulation of cookies based on the pea-wheat flour mixture. The results revealed that composite cookies are rich in crude fiber, protein, and amylose, but have low glycemic index coupled with low sugar/starch and amylopectin [35].

Thus, one can see that many researchers from different countries are solving problems similar to ours. The approach, which they address to analyze obtained results, is similar to one that is applied in this study, while the differences between this study and others are associated with different choices of vegetable raw materials used as dietary supplements to pastries and flour confectionery products. Such a diversity in the use of raw materials can be explained by local preferences, but in general, the interest to dietary enrichment and data processing methods spread wide.

Production of bakery products with the use of barley flour, flaxseed oil, flaxseed meal as a part of formulation has been developed to enrich them with proteins, food fiber, linolenic acid, the products are recommended against hyperlipidemia [36]. Introduction of food functional ingredients based on the use of raw materials of plant origin to formulation of food products will have a favorable impact on improvement of public health and increase in longevity.

4. Conclusion

The conducted study suggests that amino acid composition of black chokeberry (*aronia mitschurinii*) proteins has 18 amino acids, including 9 of essential and 9 of non-essential. The presence of essential acids proves the biological value of black chokeberry berries proteins. The fatty acid composition of black chokeberry berries contains small amounts of both saturated and unsaturated fatty acids which is a good criterion to their use in functional products. For preparing of black chokeberry powder, the berries growing in the Far East of Russia, Amur Region were used. Analysis of chemical and microbiological indexes has allowed to establish that adding the «*Lavitol*» food supplement inhibits oxidation process of secondary degradation products. The use of natural antioxidant as a component of a flour confectionery product not only helps in regulation of quality characteristics of the product, but also increases its shelf life.

Lavitol was added as an antioxidant to ensure that the valuable amino acids from the berries will keep their nutritional value, so that the finished confection had an acceptable shelf life. This is how the synergistic effect is achieved. Thus, bioactive substances from the berries make up a more rich diet. At this point, Lavitol is not just an antioxidant, but also a natural one with low toxicity.

The formulation and production technology of the «Medovaya» honey-cake flour confectionery product have been developed. Under laboratory conditions the production technology of the flour confectionery product has been approved, the quality metrics based on main principles of HACCP system have been defined, the nutritional qualities and energy value have been calculated. Thus, the introduction of black chokeberry berries and dihydroquercetin processed products to production technology of flour confectionery products improves the quality of products, enriches them with natural biologically active substances, extends shelf life of the ready product.

Conflict of interest

No author of this paper has a conflict of interest, including specific financial interests, relationships, and/or affiliations relevant to the subject matter or materials included in this manuscript.

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