Research Article **Open Access**

Novel functional confectionery: incorporating blueberry extract for nutritional enhancement and quality improvement

Slavik Dadayan[1], Lilit Arstamyan[1], Danik Martirosyan*[2,3], Asya Badalyan[4], Hegine Mkhitaryan[4], Syuzanna Abrahamyan[4], Kristine Khanamiryan[4], Galust Petrosyan[4], Liana Grigoryan[5], Valery Grigoryan[5], Armen Solomonyan[6], Ani Dadayan[7], Narine Hovhannisyan[4]

[1]Armbiotechnology SNPO NAS RA, Yerevan, Armenia, [2]Functional Food Center, Dallas, TX, USA; [3]Functional Food Institute, San Diego, CA, USA; [4]Scientific Research Institute of Biotechnology and Nutrition, Division of Plant Origin Products and Raw Material Processing Technology, Armenian National Agrarian University, 0009, Yerevan, Armenia; [5]Research Center of Veterinary and Veterinary Sanitary Expertise, Armenian National Agrarian University, 0009, Yerevan, Armenia; [4]Voskehat Educational and Research Center of Enology, Yerevan, Armenia. [7]Yerevan State University, Institute of Pharmacy, 0025, Yerevan Armenia

***Corresponding author:** Syuzanna Abrahamyan, Scientific Research Institute of Biotechnology and Nutrition, Armenian National Agrarian University, Teryan 74, Yerevan 0009, Armenia.

Submission Date: July 11th, 2025, **Acceptance Datae:** August 5th, 2025, **Publication Date:** August 18th, 2025

Please cite this article as: Dadayan S, Arstamyan L, Martirosyan D, Badalyan A, Mkhitaryan H, Syuzanna Abrahamyan S, Kristine Khanamiryan K, Petrosyan G, Grigoryan L, Valery Grigoryan V, Solomonyan A, Dadayan A, Hovhannisyan N. Novel functional confectionery: Incorporating blueberry extract for nutritional enhancement and quality improvement. *Functional Foods in Health and Disease 2025*; 15(8): 551 – 560. DOI: https://doi.org/10.31989/ffhd.v15i8.1746

ABSTRACT

Background: Blueberries are renowned for their rich composition of beneficial ingredients, including essential organic acids such as citric, lactic, malic, and succinic acids. They also contain numerous vital minerals essential for normal physiological functioning, such as iron, potassium, manganese, copper, sulfur, phosphorus, chromium, and zinc, with manganese content being particularly exceptional among plants. Furthermore, these berries provide carotene (a precursor to vitamin A), B vitamins, vitamin C, vitamin PP, and tannins. They are particularly rich in flavonoids, which are potent natural antioxidants.

Literature shows the beneficial role of blueberries and blueberry extract in human consumption, highlighting their importance in promoting a healthy diet. However, blueberry by-products in confectionery production remain widely underutilized. Characterizing this opportunity to enhance confectionery products with functional food qualities may significantly improve the nutritional profile of flour-based products, such as muffins. Evaluating different qualitative doses can help optimize health benefits while supporting the development of a novel category of functional muffins.

Objective: This research aimed to utilize blueberry extract as a functional ingredient for the development of a novel confectionery product. A key objective was to scientifically substantiate the positive effects of this extract on the chemical composition and overall quality of cupcakes.

One of the main objectives of this study is to increase the content of essential minerals in food through the addition of blueberry extract and, by doing so, increase its functional properties.

Materials and Methods: Blueberry samples were sourced from the Aparan region, where preliminary studies revealed a high concentration of valuable compounds within them. Subsequent investigations focused on determining comparative indicators of quality and anthocyanin content in fresh fruit extracts via direct spectrometry. Environmentally friendly extracts were prepared with minimized levels of potentially undesirable macro- and microelements (e.g., Fe, Cu, Zn, Ca, Mg, Mn, Co, Cd, V, Se, Cr, As, Pb) through ion-exchange sorption and desorption. All research utilized highly precise, state-of-the-art equipment. Raw materials and finished products were analyzed using the gravimetric method with KERN analytical balances (accuracy 0.95), while vitamin and mineral compositions were determined via an integrated HPLC system.

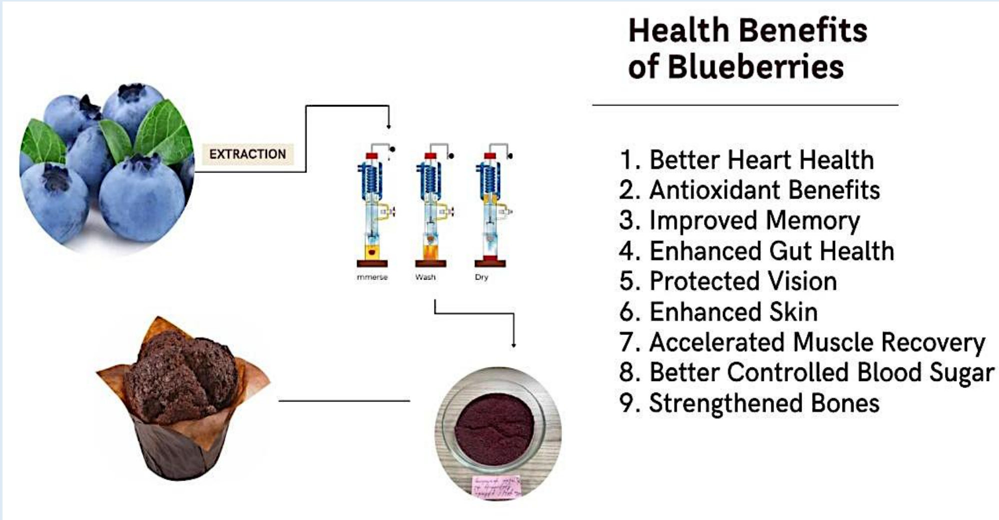
Results: During the study, various forms of blueberry extract were prepared. The extract was used in two forms: powder and liquid solution. Subsequently, three distinct application dosages were tested, and the qualitative parameters of each resulting cupcake sample were analyzed. The optimal application option was identified, successfully increasing the micronutrient content of the cupcakes while preserving their desirable physicochemical parameters.

Novelty: This study pioneers the systematic incorporation of blueberry fruit extract, in both powder and liquid forms, into flour-based confectionery products (muffins) to create novel functional foods. The research extends beyond simple addition by optimizing the extract's dosage to enhance the micronutrient profile (including anthocyanins and tannins) while simultaneously demonstrating a positive effect on key physicochemical parameters such as cupcake volume, thus maintaining the balance between nutritional enrichment and product quality.

As a scientific novelty, it can be observed that with the addition of blueberry extract and a reduction in the corresponding amount of flour, it was possible to reduce the nutritional value of the new product.

Conclusion: Blueberry fruit extract, rich in anthocyanins, tannins, and other valuable compounds, was successfully utilized to produce functional muffins. This resulted in a new type of food product characterized by an enriched nutritional composition. The research also demonstrated that the extract's application positively influenced cupcake volume, a crucial quality indicator for such products.

Keywords: Blueberry, extract, new technology for muffins, bioactive compounds, functional products.



Graphical Abstract: Extract of blueberry as a functional additive.

INTRODUCTION

Life cycle assessment is one of the most general and comprehensive tools for comparing environmental burdens arising from the agri-food segment [1]. The development of effective technologies for incorporating functional additives into food products, to enhance their nutritional quality, remains an objective in modern food production [2-3].

Global experiences indicate that addressing the problem of healthy nutrition requires the industrial development of specialized food products, enriched with vitamins and macro- and microelements to a level corresponding to physiological requirements [4]. The most effective way to promote a healthy diet is to reinforce basic products and develop new technologies for their manufacture [5-6]. Food production is a constant worldwide process, and interest in healthy food is increasingly focused on edible plants, secondary raw materials, and the functional benefits of bioactive compounds [7].

The Functional Food Center (FFC) emphasizes the importance of understanding food bioactive compounds to substantiate health claims, as they serve as core components of functional foods [8-10]. Beyond basic nutrition, functional foods offer additional health benefits and can play a significant role in addressing challenges such as food security, malnutrition, and chronic diseases [11].

Functional food products are defined as foods that contain bioactive compounds which, in specific dosages, provide clinically proven health benefits [12]. Functional foods play a significant role in reducing the risk of disease by providing additional health benefits beyond their fundamental nutritional value, being enriched with bioactive compounds that can modulate physiological functions and improve overall health [13]. The United States and Japan are the world's leading functional food markets, followed by the Asia Pacific and Europe. In the early 1980s, the Japanese scientific academic community pioneered the definition and introduction of the "functional food" concept. While in the United States, the term "functional foods" lacks a legal definition, serving more as a marketing term than one with regulatory significance [14]. Blueberries and their processed products are valuable food raw materials that represent a multi-component, multifunctional, biologically active system with great biotechnological and biogenic potential [15-16]. According to several studies, blueberry berries contain nutritional and biologically active substances (BAS): vitamins (C, PP, B1, carotenoids), trace elements (manganese, zinc), carbohydrates (glucose, fructose, sucrose, pectin), organic acids (citric, lactic, quinic, oxalic acid, malic acid and succinic acid), triterpenoids (ursolic acid), essential oils, phenols and their derivatives (hydroquinone, asperuloside, monotropeoside), phenolic acids (caffeic acid and chlorogenic acid), catechin (gallocatechin, epicatechin, epigallocatechin)[17-19].

Blueberries are distinguished less by their generally recognized high sensory characteristics and more by their diverse chemical composition. Most of the substances contained in blueberries have potent antioxidants, anti-carcinogenic, neuroprotective, anti-inflammatory, and protective properties [20-21]. Due to the content of the BAS complex, blueberries are actively used as an enriching ingredient in food products [22]. The nutritional composition of blueberries has increased their popularity among various population segments and demand in the production of healthy food products, whether in fresh, frozen, or canned form [23].

Blueberries also contain a significant amount of various mineral elements and are rich in catechins (flavan-3-ols), which are an extensive group of plant organic compounds that demonstrate antimicrobial properties [24].

MATERIALS AND METHODS

The objects of this study were blueberry extracts collected in the foothill region of Aparan, RA, harvested in 2022.

During muffin development, blueberry fruits were typically used in two forms: extract and powder. Studies have shown that the powder supplements are less effective than the extract; therefore, further research will focus on the addition of the extract. A control sample of the muffins was prepared without the use of extract, and experimental samples were prepared by replacing 30%, 40%, and 50% of the wheat flour with flour using blueberry extract.

Experimental sample moisture determination: The moisture content of blueberry extract, flours, and muffins was determined using a state-of-the-art Kern DAB analyzer with an accuracy of 0.95. Samples were dried in SOFT mode, designed for complete dehumidification. The drying temperature continuously rose to 120 °C until the samples were dehydrated, after which the temperature was maintained constant. Samples were evenly distributed on a flat drying tray, with at least 15 grams of material per tray [2,24].

Density determination: To determine density, samples are weighed, and their volume is measured. First, a container is filled with millet, leveling any excess off using a ruler. Part of the millet is then removed, and the wafer sample is placed in the container. The remaining millet is poured on top, and the excess is once again leveled off. The millet that did not enter the container is collected in a volumetric cylinder, and its volume is measured. The following formula determines the density of the product:

$x = \frac{m}{P}$, (1)

Where m - is the mass of the sample, g,

P - is sample volume, cm^3 [25]

Analysis of minerals in food: Mineral content was derived from the mass fraction of ash after combustion. Ash is the residue left after burning and calcining natural materials. During combustion, carbon, hydrogen, and some oxygen are converted into carbon dioxide and water vapor, which then evaporate, while nitrogen is also released. The non-volatile oxides of elements, including calcium, magnesium, silicon, aluminum, iron, phosphorus, potassium, and sodium, remain as ash. The process was conducted slowly, with the addition of loosening agents such as calcium acetate or magnesium carbonate, or a mixture of alcohol and glycerin to ensure adequate air access. To determine the ash content, the product is dried in a drying cabinet, carefully charred on an electric stove, and then calcined in a muffle furnace at

450°C. The mass fraction of ash is determined using the appropriate formula.

$$Z = (m2 - m0)/(m1 - m0) * 100\% \quad (2)$$

Where m^1 is the mass of the crucible with the product under study, g; $m^2$is the mass of the crucible with ash, g; m^0 is the mass of the crucible, g [24-25].

Determination of alkalinity by titration: The method involves the neutralization of alkaline substances present in flour confectionery products using an acid in the presence of a bromothymol blue indicator, until a yellow color appears. Results are then processed according to the formula provided in the standard [25-26].

Calculation of nutritional value: The nutritional value per 100 g of the edible product of bread and bakery products was calculated based on the quantity of raw materials used, chemical composition, and moisture content of the finished product. The calculation is based on a unified product formulation per 100 g of flour. Calculations are performed by the relevant guidelines and formulas, after which the nutritional value of the product is output [27-28].

Statistical analysis: Data were collected from scientific databases (ISI Web of Knowledge, Research Gate, Elsevier, Scopus, and Google Scholar) and traditional texts. Field experiments were replicated three times, along with analyses in four copies. Data were expressed as means ± standard deviation. Comparative study of the results was carried out using parametric analysis of ANOVA data. The statistical calculations were made with SPSS Version 16.

RESULTS AND DISCUSSION

In food processing technology, achieving stable quality indicators is crucial, and equally important as the ability to manage the technological process [29].

Three doses of the blueberry extract were:30%, 40%, and 50% of the flour mass. The muffin was prepared in the following order and using the following ingredients: muffin mix-250 g, wheat flour-350 g, sugar-400 g, eggs-300 g, vegetable oil-300 g, blueberry extract-40 g. To choose the most optimal formulation that also satisfies the consumer's expectations for appearance, a sensory assessment was carried out at the initial stage. The sensitivity parameters of the study are presented in Table 1.

Table 1. Sensitivity parameters of control and extract-enhanced muffins

Parameters	Control, mg/100g.	Sample No. 1 Muffins prepared with 30% extract mg/100g	Sample No. 2 Muffins prepared with 40% extract mg/100g	Sample No. 3 Muffins prepared with 50% extract mg/100g
Appearance and Color	With a characteristic, light yellowish color with a reddish tinge	Stretched in appearance, with cracks, and a light yellowish color	More loft structure, dark pink color, without characteristic cracks	With cracks, light, and dark pink color
Taste and smell	According to the product name, without side flavors and odors		With a pleasant blueberry extract aroma	
Porosity	According to the product name, Porosity		Evenly porosity	

According to sensory assessment indicators, the study found that incorporating 40% extract significantly improved the sensory characteristics, such as its texture and flavor. Examples of experimental samples are shown in Figure 1.

Figure 1. Experimental samples

The muffin labeled N1 was prepared without blueberry extract, while the other was produced using 30%, 40%, and 50% blueberry extract. Figure 1 demonstrates that the muffin labeled N2 has the most significant volume, which is likely to be due to the extract performing additional functions within the dough during baking, resulting in increased volume and expansion. The next component of the qualitative assessment was the product's physicochemical properties. These parameters are summarized in Table 2.

Table 2. Physicochemical parameters of control and extract-enhanced muffins

Quality indicators of muffins	**Extract Content in Products (%)**			
	Control	**30%**	**40%**	**50%**
Moisture content of finished products, %	16.0±0.01	15.1±0.01	13.0±0.02	12.4±0.02
Alkalinity,^{0}	1.6±0.01	1.66±0.01	1.7 ±0.01	1.81±0.01
Density, g/cm^{3}	0.55±0.01	0.53±0.01	0.52±0.01	0.51±0.01

$P<0.01$

Analysis of the physicochemical parameters (Table 2) reveals that the additive, depending on dosage, influences product quality. Moisture content decreased from 16.0% (control) to 12.4% (50% extract). The acidity and density of the products followed a similar trend. Higher acidity at higher extract levels may be undesirable, however, because such products have an adverse effect on people with stomach problems.

Previous studies have demonstrated that the blueberry dry extract contains calcium-1517.45 mg/kg, iron-40.20 mg/kg, sodium-1762.37 mg/kg, magnesium-646.30 mg/kg, and potassium-820.50 mg/kg, as well as other elements in smaller quantities [30].

Therefore, in this study, we evaluated the extent to which these elements are retained in the chemical composition of the finished muffins. The results are presented in Table 3.

Table 3. Comparative indicators of mineral composition for control and extract-enhanced muffins

Minerals (mg/kg)	**Control**	**Extract Content in Products (%)**		
		30	40	50
Iron, ***mg/kg***	1.2±0.02	1.8±0.02	2.4±0.02	3.1±0.02
Calcium, ***mg/kg***	16.0±0.02	20.1±0.02	23.0±0.02	26.5±0.02
Sodium, ***mg/kg***	1.3±0.02	3.4±0.02	4.5±0.02	5.1±0.02
Magnesium, ***mg/kg***	1.1±0.02	2.1±0.02	2.9±0.02	3.5±0.02
Potassium, ***mg/kg***	122.0±0.02	156.2±0.02	165.1±0.02	178.4±0.02

$P<0.02$

Analysis of the mineral compositions between samples showed that the increase in the mineral content between products was directly attributable to the addition of the extract. Most noticeable is the increase in potassium content, which rose from 122.0 mg/kg in the control sample to 178.4 mg/kg in the 50% extract.

The low nutritional value of many flour confectionery products is relevant to this study [31]. Therefore, analysis of the extract-enhanced muffin's profile revealed differences in its nutritional value, shown in Figure 2.

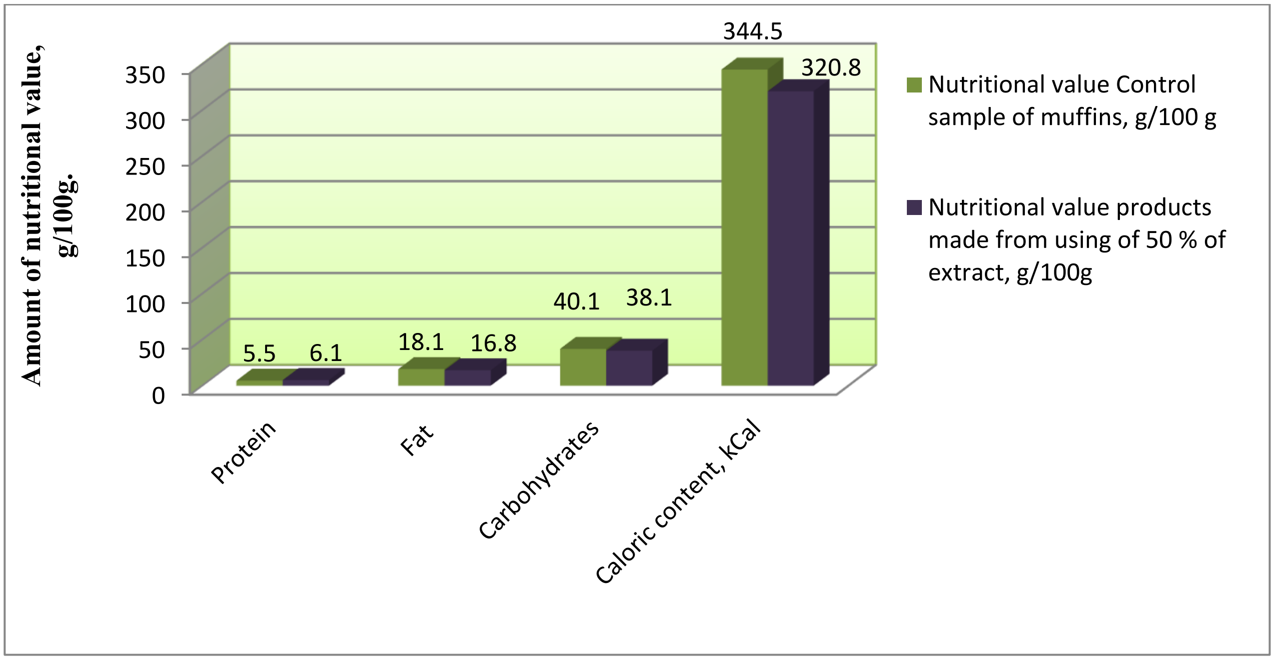


Figure 2. Comparative assessment of the nutritional value of products

Comparison between the products' nutritional values revealed a decrease in certain components in the enriched muffins. Due to the replacement of wheat flour with extract, nutrients that are derived in higher proportion from wheat flour (fat, carbohydrates) are reduced in extract-enhanced muffins. The caloric content of the products also decreased, which may be considered a desirable result, especially for consumers seeking lower-calorie options during dieting.

Scientific Innovation and Practical Implications: The study innovatively improves confectionery technology and functional food development through the use of blueberry extract. While the use of food by-products in functional foods has been explored many times, this research uniquely focuses on optimizing the chemical content of muffins. This research aims to discover the uses of bioactive compounds in blueberries, ensuring maximum retention of essential minerals.

Secondary raw materials can always be used in products as an enrichment agent, but it is not always possible to achieve the desired results in terms of their bioactive compounds. Confectionery products are products processed at high temperatures (greater than 180°C), which means that the preservation of biological substances in them is not always possible. It is essential to explore further technological methods for preserving such compounds and identify the raw resources needed to create the desired product.

This study systematically determines the optimal and easily reproducible dosage (40% of the extract additive in dry form) to improve the organoleptic and physicochemical properties of confectionery products, thus providing a new model for the development of functional foods.

This research not only advances the field of functional food science but also contributes to the creation of a sustainable food system through the use of functional additives, offering consumers access to staple foods with improved nutritional properties.

CONCLUSION

This study focuses on producing local blueberry extract and its possible use in the production of one of the most popular confectionery products: muffins. Muffins are typically high in caloric content and have a low concentration of beneficial ingredients, particularly mineral elements. In this study, dried blueberry extract was used as a functional ingredient in the production of muffins. An optimal ratio of 40% extract was selected, as it increased the mineral content of the product while also enhancing its visual appeal. When incorporated in its dry form, the extract produced muffins with a more stable structure and pleasant color, while also reducing the caloric content and enriching the concentration of its mineral elements. However, results also indicate that the extract must be added to the composition at the expense of flour, since without adjustment, products can exhibit undesirable qualities such as low moisture and an unappealing appearance.

List of abbreviations: A: Republic of Armenia; HPLC: High-Performance Liquid Chromatography, mg: milligram, g: gram, FFC: Functional Food Center.

Authors' Contributions: All authors contributed to this article. AD and AD have developed technology for obtaining blueberry extract. NH conceived the research topic and served as the lead scientist. LG, AB, and VG analyzed mineral composition and performed comparative evaluations. HM provided statistical analyses. GP, LA, and AS contributed to the study of physicochemical parameters. DM provided detailed guidance and review of the article, advised on the writing process, and participated in result discussions and manuscript preparation. KK develops nutritional value calculation.

Competing Interest: The authors declared that there is no competing interest.

Acknowledgment: The work was supported by the RA Higher Education and Science Committee, which provided basic financial support for infrastructure.

REFERENCES

1. McAuliffe G.A., Takahashi T. and R. F. Lee Michael. Applications of nutritional functional units in commodity-level life cycle assessment (LCA) of agri-food systems. *The International Journal of Life Cycle Assessment 2020*; 25:208–221.DOI:https://doi.org/10.1007/s11367-019-01679-7
2. Hovhannisyan N., Abrahamyan S., Badalyan A., Abrahamyan V., Grigoryan V., Abovyan A., et al. Development of technology for the production of Dutch waffles (stroopwaffels) from the using of domestic soy flour. *Bioactive Compounds in Health and Disease 2024;* 7(8): 348-360. DOI: https://www.doi.org/10.31989/bchd.v7i8.1409.
3. Varzakas, T., Smaoui S. Global Food Security and Sustainability Issues: The Road to 2030 from Nutrition and Sustainable Healthy Diets to Food Systems Change. *Foods* 2024; 13: 306. DOI: https://doi.org/10.3390/foods13020306
4. Aleta A., Brighenti F., Jolliet O., Meijaard E., Shamir R., Moreno Y. et al. Need for a Paradigm Shift in Healthy Nutrition Research*. Front. Nutr* .2022; 9:881465. DOI: https://doi.org/10.3389/fnut.2022.881465
5. Huberts-Bosch A., Bierens M., Verena L., Van der Velde J., De Boer H., Van Beek G., et al. Short-term effects of an elimination diet and healthy diet in children with attention-deficit/hyperactivity disorder: a randomized-controlled trial. *European Child & Adolescent Psychiatry 2024; 33:1503–1516* DOI: https://doi.org/10.1007/s00787-023-02256-y
6. Frank S.M., Jaacks L.M., Meyer K., Rose D., Adair L.S., Avery et al. Dietary quality and dietary greenhouse gas emissions in the USA: a comparison of the planetary health diet index, healthy eating index-2015, and dietary approaches to stop hypertension. *International Journal of Behavioral Nutrition and Physical Activity* 2024; 21: 36 DOI: https://doi.org/10.1186/s12966-024-01581-y
7. Martirosyan D., Stratton S. Advancing functional food regulation. *Bioactive Compounds in Health and Disease* 2023; 6(7): 166–171. DOI:https://doi.org/10.31989/bchd.v6i7.1178

8. Grigoryan L., Grigoryan V., Sargsyan M., Melkonyan Z., Yeribekyan S., Grigoryan R., et al. Amino acid and hematological alterations in beef from BLV-infected cattle: Implications for functional food safety. *Bioactive Compounds in Health and Disease* 2025; 8(7): 230 - 242. DOI: https://doi.org/10.31989/bchd.8i7.1707
9. Shimizu N., Shimizu R., Yagihashi M., Goto K., Shimoda H., Hirano M. et al. Seaberry ursolic acid improves daytime frequency and urgency of urination in healthy Japanese subjects: A randomized, placebo-controlled, double-blind trial. *Functional Foods in Health and Disease* 2025; 15(6): 316-332. DOI: https://doi.org/10.31989/ffhd.v15i6.1631
10. Williams K., Oo T., Martirosyan D. Exploring the effectiveness of Lactobacillus probiotics in weight management: A literature review. *Functional Food Science. 2023; 3(5): 45-54* DOI: https://doi.org/10.31989/ffs.v3i5.1115
11. Beglaryan I., Gasparyan G., Khachatryan S., Yeritsyan S., Eloyan A., Jhangiryan T. The change in functional components in mulberry fruits (Morus alba L.) through the development of an optimal land transformation scheme for different land types. *Bioactive Compounds in Health and Disease* 2025; 8(3): 113 - 129. DOI: https://www.doi.org/10.31989/bchd.8i3.1583.
12. Chai Z., Herrera-Balandrano D., Yu H., Beta T., Zeng Q., Zhang X., et al. Comparative Analysis on the Anthocyanin Composition of 74 Blueberry Cultivars from China. *J. FoodCompost. Anal.* 2021; 102: 104051. DOI: https://doi.org/10.1016/j.jfca.2021.104051.1932.
13. Son J., Martirosyan D. Salient Features for GRAS Status Affirmation. *Functional Food Science* 2024; 4(8): 299-308. DOI: https://doi.org/10.31989/ffs.v4i8.1417
14. Martirosyan D. Stratton S. Quantum and tempus theories of functional food science in practice. *Functional Food Science* 2023; 3(5): 55-62. DOI: https://www.doi.org/10.31989/ffs.v3i5.1122
15. Zhou J. V., Martirosyan D. Functional Foods for Cholesterol Management: A Comparison Between the United States and Japan. *Functional Food Science* 2024; 4(6): 228-250. DOI: https://www.doi.org/10.31989/ffs.v4i6.13
16. Banerjee S., Nayik G. A., Kour J., Nazir N. Blueberries. In Antioxidants in Fruits: Properties and Health Benefits; Nayik, G.A. and Gull, A., Eds.; *Springer Singapore: Singapore* 2020; 593–614. DOI:https://doi.org/10.1007/978-981-15-7285-2_31
17. Michalska A. and Lysiak G. Bioactive Compounds of Blueberries: Post-Harvest Factors Influencing the Nutritional Value of Products. *Int. J. Mol. Sci*. 2015; 16: 18642-18663. DOI: https://doi.org/10.3390/ijms160818642
18. Wang L.J., Wu J., Wang H.X., Li S.S., Zheng X.C., Du H., et al. Composition of phenolic compounds and antioxidant activity in the leaves of blueberry cultivars. *Functional Food Science* 2015; 16: 295–304. DOI: https://doi.org/10.1016/j.jff.2015.04.027
19. Brevis P.A., Bassil N.V., Ballington J.R., Hancock J.F. Impact of wide hybridization on highbush blueberry breeding. *J. Am. Soc. Hortic. Sci.* 2008; 133: 427–437. DOI: https://doi.org/10.21273/JASHS.133.3.427
20. Vorobyeva, I. V. Current data on the role of anthocyanosides and flavonoids in the treatment of eye diseases. *Bulletin of Ophthalmology* 2015;(5): 104-108. DOI: https://doi.org/10.17116/oftalma20151315104–108
21. Zhang J., Nie. J-Y, Li J., Zhang H., Li Y., Farooq S., et al. Evaluation of Sugar and Organic Acid Composition and Their Levels in Highbush Blueberries from Two Regions of China. *J. Integr. Agric. 2020;* 19; 2352–2361. DOI: https://doi.org/10.1016/S2095-3119(20)63236-1.
22. Pires T. C. S. P., Caleja C., Santos-Buelga C., Barros L. and Ferreira I. C. F. R. Vaccinium myrtillus L. Fruits as a Novel Source of Phenolic Compounds with Health Benefits and Industrial Applications. — A Review. *Current Pharmaceutical Design 2020*; 26(16); 1917–1928. DOI: https://doi.org/10.2174/1381612826666200317132507
23. Arevstrom L., Bergh C., Landberg R., H. Wu, Rodriguez-Mateos H, Waldenborg A. et al. Freeze-dried bilberry (Vaccinium myrtillus) dietary supplement improves walking distance and lipids after myocardial infarction: an open-label randomized clinical trial. *Nutrition Research* 2019; 62: 13–22. DOI: https://doi.org/10.1016/j.nutres.2018.11.008
24. Ivanova E. V., Luksha E. A., Kalinkina G. I., Pogodin I. S. Assessing catechins and leucoanthocyanins in aboveground and underground parts of aconogonondivaricatum. *Vestnik* 2016; 4(60): 118-120
25. Hovhannisyan N., Abrahamyan S., Grigoryan L., Yeribekyan S., Balasanyan H., Grigoryan V., et al. The use of secondary raw materials in confectionery production. *Functional Food Science*. 2024; 4(10): 390-400. DOI: https://doi.org/10.31989/ffs.v4i10.1455.
26. Tipsina, N.N. Technology of flour confectionery products: textbook. Manual. *Un-T. – Krasnoyarsk* 2016; 114
27. GOST 5898-2022. Interstate council for standardization, metrology and certification (isc) confectionery products. Methods for determining acidity and alkalinity. 6-7p. [https://internet-law.ru/gosts/gost/78162/],
28. Tipsina N.N. Calculation of the nutritional value of bakery and confectionery products: guidelines. *Un-T. – Krasnoyarsk* 2016; 41

29. Salikhov A.R. Designing combined products: an introduction to the basics of modeling. *Methodological guidelines UFA* 2024; -12p.
30. Dadayan A. S., Poghosyan A. S., Ghazaryan S. G., Hovhannisyan A. M., Ghazaryan M. S., Dadayan S. A. Comparative study of the content of anthocyanins in the fruits of blueberries, blackberries, and blackcurrants. Development of a technological method for obtaining partially purified new galenical extracts. *Proceedings of the YSU: Chemical and biological sciences* 2023; 57(261): 100-109. DOI: https://doi.org/10.46991/pysu:b/2023.57.2.100
31. Bordoni A., Rossetti L., Rizzo S.A., Dhuique-M. C., Barcena N., and Descalzo A.M. Enhancing nutritional value through semi-solid fermentation of quinoa and mango–orange juice: a sustainable approach to food processing. *Sustainable Food Technol*. 2025; 3: 837–845.
DOI: https://doi.org10.1039/d5fb00086f