The object of the study is the production of the national fermented milk product "Gatyg" based on sprouts of buckwheat varieties grown in Azerbaijan. Buckwheat is one of the most important grain food crops, contains protein of high nutritional value and a significant amount of dietary fiber, vitamins B1, B2 and E, as well as minerals. Rutin and quercetin are the main antioxidants in buckwheat. Due to the high rutin content, buckwheat is used to maintain the functional capabilities of the vascular system. The biological value of buckwheat proteins is more than 90 %.

A recipe and technology for the fermented milk product "Gatyg" based on buckwheat varieties grown in Azerbaijan were developed. The conducted studies allowed determining the best parameters of BAS extraction to achieve extractive substances in the extracts up to 20–25 %. The yield of flavonoids is 93 %.

The content of BAS and flavonoids during the germination of buckwheat seeds, as well as the conditions for their extraction from sprouts of buckwheat grown in Azerbaijan, were studied. The quality indicators of the obtained product, enriched with sprouted buckwheat seeds, are distinguished by high taste and aromatic characteristics. It was found that it is advisable to include 7 % buckwheat sprouts in the composition of a product for therapeutic and prophylactic nutrition

Keywords: buckwheat sprouts, flavonoids, biologically active substances, functional properties, fermented milk products

UDC 663.1:637.146
DOI: 10.15587/1729-4061.2024.312155

DEVELOPMENT OF TECHNOLOGY FOR FERMENTED MILK PRODUCT "GATYG" BASED ON BUCKWHEAT VARIETIES GROWN IN AZERBAIJAN

Nazilya Akhundova
Corresponding author
Candidate of Biological Sciences, Associate Professor*
E-mail: nazilya.akhundova@mail.ru
Aynur Babashli
Candidate of Biological Sciences, Associate Professor*
Natavan Gadimova
Candidate of Technical Sciences, Associate Professor*
*Department of Engineering and Applied Sciences
Azerbaijan State University of Economics (UNEC)
Istiqlaliyyat ave., 6, Baku, Azerbaijan, AZ 1001

Received date 10.07.2024
Accepted date 20.09.2024
Published date 30.10.2024

How to Cite: *Akhundova, N., Babashli, A., Gadimova, N. (2024). Development of technology for fermented milk product "gatyg" based on buckwheat varieties grown in azerbaijan. Eastern-European Journal of Enterprise Technologies, 5 (11 (131)), 16–23. https://doi.org/10.15587/1729-4061.2024.312155*

1. Introduction

The desire of modern man for a healthy lifestyle and healthy products pushes the food industry to create new assortment groups. These products should have antioxidant, anti-inflammatory, anti-carcinogenic and many other beneficial properties [1].

Functional nutrition is a style of nutrition for living, adapted to modern possibilities, conditions and habits. Functional nutrition eliminates the obvious shortcomings of modern diets: natural food supplements compensate for the deficiency of vitamins, minerals, microelements and other substances. All this leads to an increase in life expectancy [2].

Buckwheat is one of the most important grain food crops. Russia, China, and several other countries are recognized as global leaders in buckwheat production. In the 21st century, world production of buckwheat grain, according to FAOSTAT, is about 2 million tons. Currently, production, consumption and trade of buckwheat are carried out in 24 countries around the world [3].

In Azerbaijan, buckwheat is grown in the Ganja-Gazakh region, which is one of the important economic areas of our republic, particularly in terms of the sustainably developing agricultural sector [4].

Buckwheat grain is unique in its chemical composition and serves as an important product in providing the population with balanced nutrition [5].

Buckwheat contains glycosides, rutin, chlorogenic, gallic, and caffeic acids [6].

Buckwheat seeds contain up to 67 % starch, 10–16 % protein, 0.3–0.5 % sugar, 2–3 % fat, citric and malic acids, and vitamin C. Phototoxic fagopyrins have been identified in the leaves. The plant contains large amounts of Fe, Ca, P, Cu, I, B and other salts [7].

Buckwheat surpasses all cereals in its antioxidant properties due to the presence of phenolic compounds and anthocyanins [8].

A large amount of antioxidant substances is contained in buckwheat flowers and grass. The antioxidant properties increase during buckwheat fermentation with lactic acid bacteria [9].

Many therapeutic properties of buckwheat, such as antioxidant, hypoglycemic, anti-inflammatory, hypolipidemic, and antiviral effects, are attributed to its high rutin content [10].

It should be noted that buckwheat grain is characterized by relatively high protein content and a balanced composition of amino acids. The most important property of proteins is their good solubility.

Water-soluble proteins (albumins) constitute 58 % of their total amount, and salt-soluble proteins (globulins) – 28 %. Proteins are characterized by a good balance in amino acid composition, a high content of essential amino acids, including lysine and threonine, lacking in other grains and bread. The only deficient amino acid is leucine, which is abundant in grain protein [11].

The exceptional value of sprouted buckwheat seeds is that the sprouts possess all the natural biological properties of a whole living organism in the phase of maximum vital activity [12].

Copyright © 2024, Authors. This is an open access article under the Creative Commons CC BY license

Such food has a tremendous energy potential, which provides a person with a boost of energy [13]. The high content of histidine in buckwheat has a positive effect on children's growth. The protein substances of buckwheat grain do not form gluten, therefore buckwheat flour is not used independently in baking but is mixed with wheat flour to prepare special types of bread, cookies, pancakes, and fritters.

One source of biologically active compounds of phenolic nature is buckwheat [14].

Buckwheat is also a valuable crop for tonic products and fermentation products of buckwheat leaf extracts and whey [15].

Using plant-based fillers in fermented milk products will improve their physicochemical properties and enrich the product with minerals [16].

Therefore, research devoted to the properties of buckwheat, its bioactive compounds and their impact on human health is of scientific relevance. In particular, we are talking about complex works on identifying and analyzing the antioxidant, anti-inflammatory and hypoglycemic properties of buckwheat, as well as on developing new technologies to preserve and enhance these properties during processing and production of food products. In addition, research on using buckwheat as a basis for functional nutrition and new products, such as fermented milk products with plant fillers, is also very relevant. This is due to the growing interest in products, compliance with the requirements of general health and life extension, making such research necessary for the modern food industry.

2. Literature review and problem statement

The paper [17] presents the results of a study of buckwheat, showing that it has a fairly wide practical application, but there are still unresolved issues related to research and development to improve the organoleptic properties of gluten-free buckwheat products. This may be due to objective difficulties associated with the limitation of experimental work, making relevant research impractical.

The paper [18] presents the results of studies on various food products made from buckwheat flour and buckwheat leaf flour. The analysis shows that buckwheat leaf flour contains 2,700 mg/kg of rutin, which is much more than in buckwheat flour – 218 mg/kg, but there remain unresolved issues related to the parallel study of other cereals in order to determine the amount of rutin in them. The reason for this may be objective difficulties associated with the cost, breadth of experiments, making relevant research impractical. Such studies were carried out in [19]. All this suggests the expediency of further research in this area.

The paper [20] presents the results of research related to the conduct of breeding work on creating new varieties adapted to the action of abiotic and biotic factors. It is shown that they are mostly assessed by morphophysiological parameters, resistance to lodging and pathogen damage, yield and grain quality. But there are still unresolved issues related to the accumulation of phenolic compounds in buckwheat plants. This may be due to objective difficulties associated with limited research. In [21], phenolic compounds were studied, which are secondary metabolites most common in higher plants. They are extremely diverse in structure and chemical properties. Flavonoids have been proven to be non-toxic to humans by any route of administration. All this suggests the feasibility of conducting research in this area and using buckwheat as a raw material for obtaining flavonoids and their practical application in functional products.

The paper [22] presents the results of studies, showing that phenolic compounds are of great practical interest. This is also shown in [23], stating that phenolic compounds, including the so-called bioflavonoids, are of great interest worldwide. Their role in the adaptation of plants to stressful conditions was shown, but issues related to successful practical application remained understudied. After all, it is the high biological and antioxidant activity of bioflavonoids that makes their successful practical use possible. All this suggests the feasibility of more in-depth research in this area.

The paper [24], unlike previous studies, shows a more in-depth study of the physicochemical and functional properties of buckwheat; it is shown that mixing buckwheat with other grains and legumes improves the physical and functional properties of raw materials. This is exactly the approach used in this paper, but unlike [25], the antioxidant properties of buckwheat, allowing the mass production of individual food components: rutin, citrine, quercetin, hesperidin and many others (about 150 flavonoids), were not studied.

The paper [26] presents the results of a study showing that in order to optimize nutrition, microwave-processed hawthorn extract can be used as an additive to fermented milk products. Unlike our studies, this work describes the preparation of a dry extract for use in a fermented milk product. However, limitations of this study include possible changes in fermentation conditions, sources of hawthorn extract, environmental conditions and milk composition, which may affect the generalizability and reliability of the results. All this suggests that more in-depth research on the synergies between probiotics, prebiotics and natural extracts, as well as consumer preferences, is warranted to improve market application.

The paper [27] presents the results of a study on the effect of Tartary buckwheat flavonoid (TBF) capsules on the physicochemical properties of yogurt using polymer whey protein (PWP) as a wall material, showing that encapsulation using PWP effectively delivers TBF to the small intestine through the stomach. It also masks the bitter taste, enhances the color of TBF-containing yogurt, and improves the physicochemical properties of yogurt, but there are still unresolved issues related to practical application. This may be due to objective difficulties associated with financing, making relevant research impractical.

All this speaks about the feasibility of conducting research on buckwheat grown in Azerbaijan, as it is a valuable source for functional food products.

3. The aim and objectives of the study

The aim of the study is to develop the technology of fermented milk product "Gatyg" based on buckwheat varieties grown in Azerbaijan. This will create an innovative product with improved nutritional and functional properties, ensuring minimal reduction of bioactive compounds such as rutin and improved organoleptic properties. In particular, it is expected to create a new fermented milk product "Gatyg" enriched with buckwheat sprout extracts, which will expand the range of food products.

To achieve this aim, the following objectives are accomplished:

– to study the content of biologically active substances and flavonoids during the germination of buckwheat seeds;

– to study the conditions for flavonoid extraction from sprouts of buckwheat grown in Azerbaijan;

– to develop a specific "Gatyg" recipe that combines buckwheat sprout extracts, paying special attention to improving the nutritional and functional properties, and process flowchart.

4. Materials and methods

The object of the study is the production of the national fermented milk product "Gatyg" based on sprouts of buckwheat varieties grown in Azerbaijan.

The hypothesis of the study suggests the possibility of using buckwheat sprouts, which are a valuable source of BAS, for the production of functional products. To achieve this, buckwheat seeds were washed, soaked in water for 3 hours, placed in a vessel with a tray and grown in a dark place for 7 days at a temperature of 24–26 °C. Buckwheat sprouts are white, elastic sprouts up to 11–12 cm in length. The taste is pleasant, delicate, slightly sweet and sour, the smell is fresh, not musty. The appearance of the sprouts is shown in Fig. 1.

a

b

Fig. 1. Photos of sprouts: *a* – 3-day-old; *b* – 7-day-old

The technology for obtaining functional products includes several stages, the key one being extraction. The Soxhlet extraction method was used [28]. A Soxhlet extractor (Soxhlet apparatus) is a device for continuously extracting poorly soluble solids from solid materials. The simplest and most accessible method of analysis for most laboratories, which uses cold extraction. The essence of the method is to wash out fats using a solvent, and then determine the difference in the mass of the dry flask and the flask after extraction containing fat.

The effectiveness of extraction was assessed by the amount of extracted flavonoids. The content of flavonoids in the extracts was determined by differential spectrophotometry [29, 30].

5. Results of production of functional products based on sprouted buckwheat seeds

5. 1. Determination of the content of biologically active substances (BAS) and flavonoids during the germination of buckwheat seeds

Among the large number of natural plant-based components, flavonoids play a central role. Buckwheat contains various antioxidant compounds, such as flavonoids, including rutin, quercetin, quercitrin, etc. [10].

Three buckwheat varieties were studied, being rich in rutin, but differing much in quantity (Table 1).

Table 1

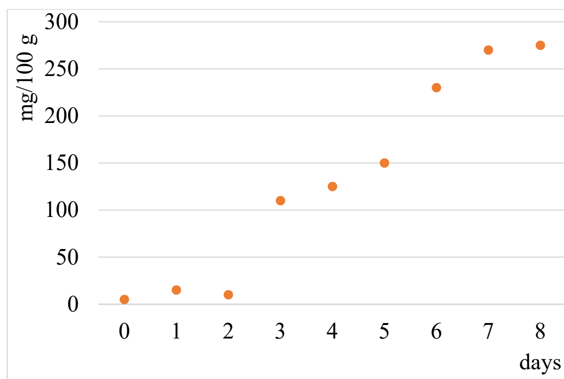
Flavonoid content in buckwheat sprouts, mg/g

No.	Variety	Parts of the plant	Rutin	Bioflavonoids (BF)
1	Dikul	Sprout	2.84±0.16	55.21±0.50
2	Krupinka	Sprout	4.97±0.43	38.65±0.35
3	Bogatyr	Sprout	6.91±0.23	34.22±0.37

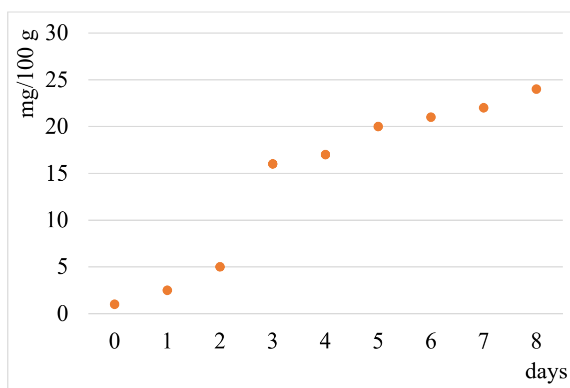
It was determined that the rutin content does not depend on the color diversity of different buckwheat genotypes. Early maturing forms of buckwheat were found to accumulate more rutin than late maturing buckwheat genotypes, characterized by a high rutin concentration during the mass flowering period. When analyzing the component composition of buckwheat PF, no quantitative relationship was found between rutin and other flavonoids, but genotypes with a brighter color were shown to accumulate more flavonoids.

Due to the widespread use of buckwheat sprouts in the technology of functional food products, it is necessary to track the dynamics of rutin and quercetin accumulation during the germination process (Fig. 2).

The graphs in Fig. 2 show that during the first two days of growth, the rutin and quercetin concentrations remain almost unchanged, then progressive growth is observed and by the seventh day the concentration of rutin increases by 27 times, and quercetin by 22 times.



a



b

Fig. 2. Dynamics of flavonoid accumulation during buckwheat seed germination: *a* – rutin; *b* – quercetin

The content of flavonoids in the extracts was determined by differential spectrophotometry, based on the flavonoids' ability to be colored with an alcoholic solution of aluminum chloride (Fig. 3) [29].

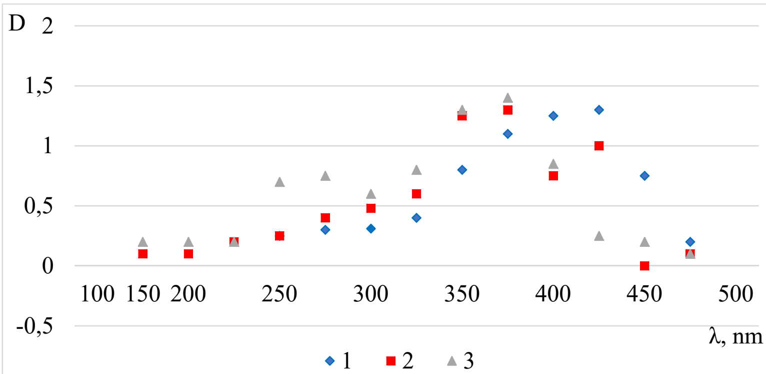


Fig. 3. Absorption spectra of flavonoids with $AlCl_3$: 1 – quercetin standard; 2 – rutin standard; 3 – for buckwheat sprouts

The absorption spectra of the studied extracts have close absorption maxima to the spectrum of the rutin-aluminum complex, so we chose this flavonoid (rutin) as a standard sample.

5. 2. Determination of conditions for flavonoid extraction from sprouts of buckwheat grown in Azerbaijan

The yield of dry matter in these extracts was determined to scientifically substantiate the production technology of functional products.

Table 2 presents the parameters of flavonoid extraction from buckwheat sprouts with water and alcohol.

Table 2

Conditions for flavonoid extraction from sprouted seeds of buckwheat grown in Azerbaijan

Studied parameter	Mass fraction of flavonoids in raw material, mg/g dry matter in terms of rutin	Studied parameter	Mass fraction of flavonoids in raw material, mg/g dry matter in terms of rutin
Extragent (temperature 70 °C; time 2.5 h)		Ratio of raw material: extractant (40 % ethanol solution; temperature 70 °C; time 2.5 h)	
Water	108±0.56	1:3	153±0.57
Ethyl alcohol 40 %	162±0.65	1:30	168±0.63
Ultrasound (time 15 min)		Ultrasound (time 20 min)	
Water	108.4±0.36	1:15	107±0.38
Microwave (time 5 min)		Microwave (time 10 min)	
Water	115±0.21	1:15	108±0.24

Thus, using microwaves for 5 minutes accelerates the extraction degree of biologically active substances and increases the yield by 7 %, and at the same time, the use of microwaves for 10 minutes slows down the extraction degree of BAS and reduces the yield by 3.8 %. This is due to the destructive effect of microwaves on the components of buckwheat sprouts.

Extraction methods and physical factors influencing the rutin concentration in sprout extracts were also examined (Table 3).

As can be seen from Table 3, the most complete isolation of target substances from the feedstock is achieved by extraction with a 40 % ethanol solution. This solution allows extracting more flavonoids compared to water and other extractants. Ultrasonic and microwave extraction are also effective methods, but their efficiency depends on the processing time and conditions.

Table 3

Rutin content in buckwheat sprout extracts, mg/l

Extragent	Method	
	Standard	Acoustic
Water	163±7.8	178±7.5
Alcohol 40 %	253±6.2	274±8.4

5. 3. Development of the recipe and flow chart of the fermented milk product "Gatyg" based on buckwheat varieties grown in Azerbaijan

Currently, it is advisable to expand the range (assortment) of functional products by using plant-based raw materials.

In the production of the new fermented milk product "Gatyg", industrial cultures of lactic acid bacteria were used:

– *Streptococcus thermophilus* and *Lactobacillus bulgaricus*;

– *Streptococcus thermophilus* and mesophilic *Leuconostoc mesenteroides cremoris*;

– *Lactococcus lactis cremoris*. Before adding the starter to the milk, the pH and temperature values at which lactic acid bacteria are most active were studied.

So, the optimal temperature for the *Streptococcus thermophilus* strain is 37 °C, for the *Leuconostoc mesenteroides cremoris* strain; *Lactococcus lactis cremoris* 30–32 °C, for *Lactobacillus bulgaricus*; *Streptococcus thermophilus* – 29–31 °C, pH from 4.1 to 5.

The activity of biochemical processes during fermentation was assessed by the dynamics of titratable and active acidity.

The obtained results indicate that the studied ferments have high biochemical activity and are capable of fermenting milk by direct addition, which speeds up the technological process.

The production process is carried out in the following sequence: acceptance and preparation of raw materials and main components; pasteurization and cooling of the mixture; fermentation and souring of the mixture; introduction of buckwheat sprouts in an amount of 7 %, mixing and cooling; bottling, packaging, labeling; before cooling and storage of the product. The research was conducted for the quality indicators of a product enriched with sprouted buckwheat seeds compared to the local national fermented milk product "Gatyg" with 2.5 % fat content. The comparison results are presented in Table 4.

Table 4 shows the comparison of quality indicators between the traditional Gatyg product and the new Gatyg product enriched with buckwheat sprouts. As can be seen from the table, the dry matter mass fraction in the enriched product is increased (11.2 % versus 9.2 % in the control), indicating a higher concentration of solids. The protein mass fraction is much higher in the enriched product (4.4 % versus

2.9 % in the control), which is beneficial for the nutritional value. The fat mass fraction is much higher in the enriched product (8 % versus 2.4 % in the control), which may be due to the fat content in buckwheat sprouts or changes in the fermentation process. The carbohydrate mass fraction does not change much, remaining comparable between the products. The acidity level of the enriched product is higher (81 °T versus 69–109 °T in the control), which may affect the taste and texture.

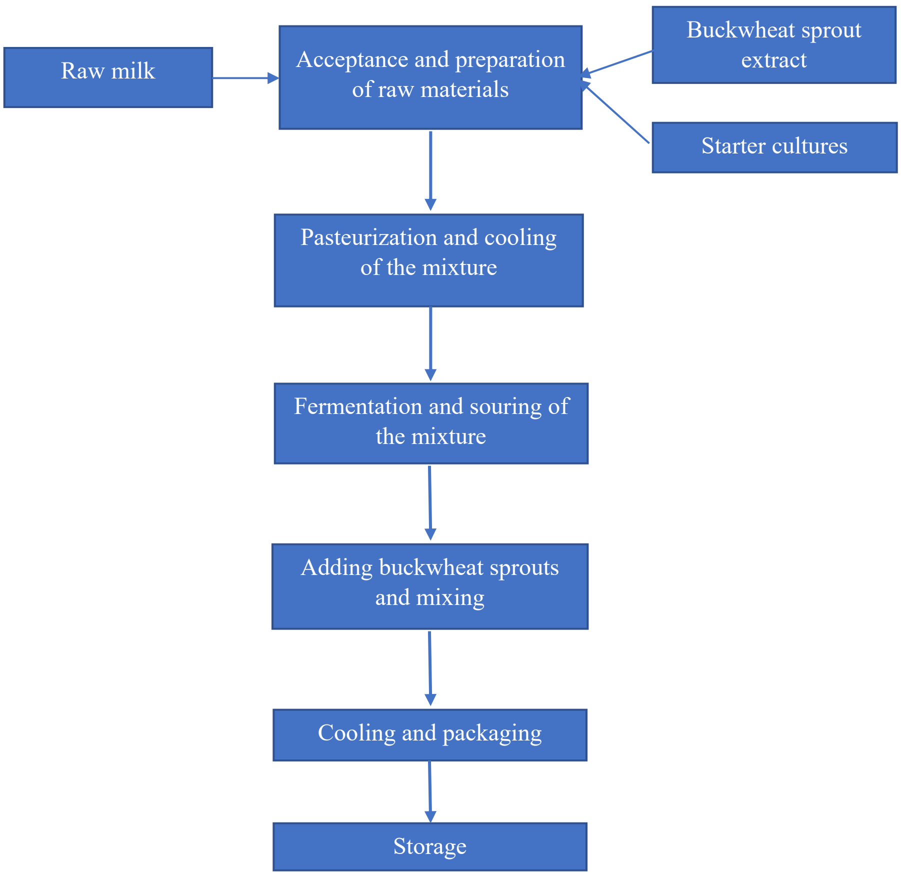


Fig. 4. Production flowchart of the fermented milk product "Gatyg"

Table 4

Quality indicators of the obtained new product "Gatyg" enriched with sprouted buckwheat seeds

Indicator	Control "Gatyg", 2.5 %	"Gatyg" enriched with buckwheat sprouts with probiotic ferment		
		Streptococcus thermophilus	*Streptococcus thermophilus; Lactobacillus bulgaricus*	*Lactococcus lactis cremoris; Leuconostoc mesenteroides cremoris*
Mass fraction of dry matter, %	9.2	10.2	10.1	11.2
Mass fraction of protein, %	2.9	3.4	3.5	4.4
Mass fraction of fat, %	2.4	2.6	2.5	8
Mass fraction of carbohydrates, %	4.1	4.4	4.5	4.3
Acidity, °T	69–109	71	70	81

The obtained product has a dense and homogeneous structure; when buckwheat sprouts are added, the product surface becomes smoother, resulting in improved texture and increased viscosity.

Thus, adding buckwheat sprout extract to the Gatyg product not only increases its nutritional value but also improves its physical properties. The study shows that the new product has improved organoleptic and structural characteristics, which can increase consumer attractiveness and expand its market.

6. Discussion of the results of growing buckwheat seed sprouts and using them in the production of the functional product "Gatyg"

The conducted research allows us to develop a technology for functional products and their components, which have antioxidant, immunocorrective and other effects with improved technological and biological properties.

The feasibility of using additives from natural raw materials based on buckwheat flavonoids in functional products is shown.

As can be seen from Table 1, the content of rutin (on a dry weight basis) in the studied samples varies within the following ranges: in sprouts from 2.84 to 6.91 mg/g (average of 4.9±0.43). The buckwheat variety "Bogatyr" was distinguished by the highest percentage of rutin content.

The experiment showed that incorporating buckwheat extracts into the recipe of the new product "Gatyg" does not change its structure. For the production of the new functional product "Gatyg" using buckwheat flavonoids, it is recommended to add them to the recipe in the amount of 2.2 grams per 10 liters of milk, having previg ously diluted rutin in a 1 % glucose solution.

The graphs in Fig. 2 show that during the first two days of growth, the rutin and quercetin concentrations remain almost unchanged, then progressive growth is observed, and by the seventh day the concentration of rutin increases by 27 times, and quercetin by 22 times.

As can be seen from Fig. 3, the high absorption level for buckwheat sprouts is at 406 nm, standard samples of rutin at 406 nm, and quercetin at 431 nm.

The absorption spectra of the analyzed extracts have absorption indices close to the spectrum of rutin with aluminum. Therefore, this flavonoid was chosen as the standard sample.

The mass fraction of moisture in the plant material samples was also determined and amounted to about 12.01 %. Ultrasonic treatment increases the bound moisture in the finished product, which is particularly relevant for reconstituted products. Thus, studying the influence of ultrasound in the production system of the "Gatyg" product allows us to determine and justify the technological properties, and regulate them to obtain a high-quality assortment.

As a result of the research, the best ratio of BAS extraction to achieve extractive substances in extracts up to 20–25 % was determined.

Table 2 shows the best results of flavonoid extraction from buckwheat sprouts by using different extractants. The most complete isolation of target substances from the original raw material is achieved by extraction with a 40 % ethanol solution. Maximum extraction of flavonoids from raw materials is achieved by double extraction in a boiling water bath with a reflux condenser for 95 minutes. The optimal ratio of 1:15 provides the flavonoid yield of 93 %.

Table 2 shows that using ultrasound increases the yield of rutin in aqueous and aqueous-alcoholic solutions by 9 %.

In general, the rutin content in the studied samples is sufficient to satisfy the daily dose of vitamin P, when consuming 125 ml.

The concentration of rutin in the obtained extracts is presented in Table 3.

Thus, extracts from buckwheat sprouts, with a rutin content of 274 mg/l, obtained by different methods can be used in the technology of producing functional products.

As can be seen from Table 4, the quality indicators of the obtained new fermented milk product "Gatyg", enriched with sprouted buckwheat seeds, are much higher compared to the control sample "Gatyg" 2.5 %. "Gatyg" is distinguished by high taste and aromatic characteristics.

The features of the proposed solution allow optimizing the conditions of flavonoid extraction. Unlike traditional extraction methods, often using only water or ethanol, our treatment uses standard methods, as well as modern extraction methods (ultrasound and microwave). This will significantly increase the yield of flavonoids such as rutin and allow for more efficient use of natural resources. Additionally, unlike current products such as traditional fermented milk products, this product contains buckwheat sprout extracts, adding value due to the antioxidant properties of flavonoids. The new product "Gatyg" is enriched with antioxidants, making it more beneficial to health than other dairy products [31].

The research provides an in-depth understanding of extraction processes and optimal conditions for obtaining the desired products, differentiating them from traditional methods and formulations.

These features make the proposed solutions more efficient and competitive than existing analogs, and ensure higher quality and functionality of the final product.

Rutin enrichment has been scientifically proven and tested in products using buckwheat extracts. By the results of biological activity, recommendations have been formulated in the scientific literature on products that are preferable for use in regulating metabolism, the functions of the cardiovascular and immune systems.

The advantages of our research, in contrast to [32], focus on a wider range of applications, provide a more in-depth study of biologically active substances and their use in developing functional products – using both buckwheat extracts and new recipes and technologies. While in [32], research is focused on improving the quality of existing fermented milk products using bean milk.

Thus, the advantage of our research lies in a deeper scientific basis, wider application of the results and an integrated approach to developing functional products using biologically active substances. This makes it more significant for scientific and practical developments in functional nutrition.

Thus, research on using extracts from sprouts of buckwheat grown in Azerbaijan in the production of functional foods is of great importance and prospects. However, to achieve more accurate and generalizable results, a number of limitations and difficulties need to be overcome. This study focuses on three specific buckwheat varieties, which may limit the generalization of the results to other buckwheat varieties. For a wider application of the results, it is necessary to examine other varieties and growth conditions, since this research was conducted for buckwheat grown in Azerbaijan. These results may not fully reflect the properties of buckwheat grown in other climatic and soil conditions, and the results may vary with cultivation methods. The conditions used (temperature, humidity) during germination and extraction may vary, which affects the quality and content of active substances.

The shortcomings of this study are that long-term stability tests of the active substances in the final product "Gatyg" were not conducted. In the future, studies on the stability and shelf life of the product should be carried out to determine how long the active substances are preserved in the final product. The development of this study is to optimize the extraction process and this may require complex mathematical modeling and statistical analysis to achieve the best results. The solution to this can be the use of advanced statistical methods and models for data analysis and process optimization.

7. Conclusions

1. Extraction methods and physical factors influencing the concentration of rutin in buckwheat sprout extracts are examined. In a comparative aspect, extracts of sprouts dried in a dark place were studied. The concentration of rutin in 40 % alcohol was 274±8.4, in water – 178±7.5. The buckwheat variety Bogatyr had the highest percentage of rutin content (6.91±0.23). The results indicate a significant variation in rutin content among buckwheat varieties: Dikul, Krupinka and Bogatyr, with Bogatyr demonstrating the highest concentration (6.91 mg/g) and Dikul the lowest (2.84 mg/g). In addition, the study monitored the dynamics of rutin and quercetin accumulation throughout the germination process, revealing a sharp increase in both flavonoids by the seventh day – rutin increased 27-fold and quercetin 22-fold. This difference is critical for targeted applications in functional foods.

2. The conducted studies allowed determining the best extraction parameters for biologically active substances (BAS) to achieve extractive substances in extracts up to 20–25 %. The yield of dry matter in the studied extracts was determined. The yield of flavonoids was 93 %. The biological activity of buckwheat was evaluated, and factors increasing the yield of BAS, their solubility, and bioavailability were identified.

3. The recipe and technology of the functional product "Gatyg" containing extracts of buckwheat sprouts were developed, which allows obtaining a product with high organoleptic properties. Mathematical modeling has shown

the feasibility of including 7 % sprouted buckwheat seeds in the composition of a product for therapeutic and prophylactic nutrition. This provides 15 % to 50 % of the daily requirement for rutin and allows us to recommend it for use. The recipe and technology of the fermented milk product "Gatyg" based on buckwheat varieties grown in Azerbaijan were developed.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

Financing

The study was performed without financial support.

Data availability

The manuscript has no associated data.

Use of artificial intelligence

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

References

1. Danihelová, M., Šturdík, E. (2012). Nutritional and health benefits of buckwheat. Potravinarstvo Slovak Journal of Food Sciences, 6 (3), 1–9. https://doi.org/10.5219/206
2. Sah, D., Sen, D., Debnath, P. (2012). Buckwheat (Fagopyrum esculentum) - A potential coarse grain crop for food and nutritional security. International Journal of Bio-Resource and Stress Management, 3 (2), 259–262. Available at: https://ojs.pphouse.org/index.php/IJBSM/article/view/266
3. Christa, K., Soral-Śmietana, M. (2008). Buckwheat grains and buckwheat products - nutritional and prophylactic value of their components - a review. Czech Journal of Food Sciences, 26 (3), 153–162. https://doi.org/10.17221/1602-cjfs
4. Aliyev, S., Khalilov, M., Saidov, R., Mammadov, G., Allahverdiyeva, G. (2022). Technology for making drinks based on pectin rich fruits and vegetables grown in Azerbaijan. Eastern-European Journal of Enterprise Technologies, 3 (11 (117)), 45–52. https://doi.org/10.15587/1729-4061.2022.256921
5. Gasanzade, S. R. (2018). Optimization of technological methods of buckwheat cultivation in ganja-kazakh zone of Azerbaijan. Agrarian Science, 320 (11-12), 45–48. https://doi.org/10.32634/0869-8155-2018-320-11-45-48
6. Mazahir, M., Ahmed, A., Akram khan, M., Mariam, A., Riaz, S. (2023). Comparative study of physicochemical and functional properties of different buckwheat varieties and their milling fractions. International Food Research Journal, 30 (5), 1261–1273. https://doi.org/10.47836/ifrj.30.5.14
7. Giménez-Bastida, J. A., Zieliński, H. (2015). Buckwheat as a Functional Food and Its Effects on Health. Journal of Agricultural and Food Chemistry, 63 (36), 7896–7913. https://doi.org/10.1021/acs.jafc.5b02498
8. Sytar, O. (2015). Phenolic acids in the inflorescences of different varieties of buckwheat and their antioxidant activity. Journal of King Saud University - Science, 27 (2), 136–142. https://doi.org/10.1016/j.jksus.2014.07.001
9. Janiak, M. A., Karamać, M., Sulewska, K., Amarowicz, R., Denev, P., Slavova-Kazakova, A. (2023). Phenolic Profile and Antioxidant Potential of Beverages from Buckwheat and Side Streams after Beverages Production. Processes, 11 (11), 3205. https://doi.org/10.3390/pr11113205
10. Steadman, K. J., Burgoon, M. S., Lewis, B. A., Edwardson, S. E., Obendorf, R. L. (2001). Minerals, phytic acid, tannin and rutin in buckwheat seed milling fractions. Journal of the Science of Food and Agriculture, 81 (11), 1094–1100. https://doi.org/10.1002/jsfa.914
11. Guo, Y.-Z., Chen, Q.-F., Yang, L.-Y., Huang, Y.-H. (2007). Analyses of the seed protein contents on the cultivated and wild buckwheat Fagopyrum esculentum resources. Genetic Resources and Crop Evolution, 54 (7), 1465–1472. https://doi.org/10.1007/s10722-006-9135-z
12. Serikbaeva, A., Tnymbaeva, B., Mardar, M., Tkachenko, N., Ibraimova, S., Uazhanova, R. (2021). Determining optimal process parameters for sprouting buckwheat as a base for a food seasoning of improved quality. Eastern-European Journal of Enterprise Technologies, 4 (11 (112)), 6–16. https://doi.org/10.15587/1729-4061.2021.237369
13. Maejima, Y., Nakatsugawa, H., Ichida, D., Maejima, M., Aoyagi, Y., Maoka, T., Etoh, H. (2011). Functional Compounds in Fermented Buckwheat Sprouts. Bioscience, Biotechnology, and Biochemistry, 75 (9), 1708–1712. https://doi.org/10.1271/bbb.110241
14. Skrabanja, V., Kreft, I., Golob, T., Modic, M., Ikeda, S., Ikeda, K. et al. (2004). Nutrient Content in Buckwheat Milling Fractions. Cereal Chemistry, 81 (2), 172–176. https://doi.org/10.1094/cchem.2004.81.2.172
15. Kowalska, E., Ziarno, M. (2021). The Possibility of Obtaining Buckwheat Beverages Fermented with Lactic Acid Bacteria and Bifidobacteria. Milk Substitutes - Selected Aspects. https://doi.org/10.5772/intechopen.94913
16. Polishchuk, G., Kuzmyk, U., Osmak, T., Kurmach, M., Bass, O. (2021). Analysis of the nature of the composition substances of sour-milk dessert with plant-based fillers. Eastern-European Journal of Enterprise Technologies, 6 (11 (114)), 68–73. https://doi.org/10.15587/1729-4061.2021.246309
17. Sofi, S. A., Ahmed, N., Farooq, A., Rafiq, S., Zargar, S. M., Kamran, F. et al. (2022). Nutritional and bioactive characteristics of buckwheat, and its potential for developing gluten-free products: An updated overview. Food Science & Nutrition, 11 (5), 2256–2276. https://doi.org/10.1002/fsn3.3166

18. Kreft, I., Fabjan, N., Yasumoto, K. (2006). Rutin content in buckwheat (Fagopyrum esculentum Moench) food materials and products. Food Chemistry, 98 (3), 508–512. https://doi.org/10.1016/j.foodchem.2005.05.081
19. Morita, N. (2017). Functional and nutritional properties of buckwheat, quinoa and adlay, as pseudo-cereals improve lifestyle related diseases. Journal of Experimental Food Chemistry, 3 (2). Available at: https://www.hilarispublisher.com/proceedings/functional-and-nutritional-properties-of-buckwheat-quinoa-and-adlay-as-pseudocereals-improve-lifestyle-related-diseases-8452.html
20. Siró, I., Kápolna, E., Kápolna, B., Lugasi, A. (2008). Functional food. Product development, marketing and consumer acceptance – A review. Appetite, 51 (3), 456–467. https://doi.org/10.1016/j.appet.2008.05.060
21. Kreft, M. (2016). Buckwheat phenolic metabolites in health and disease. Nutrition Research Reviews, 29 (1), 30–39. https://doi.org/10.1017/s0954422415000190
22. Kwon, S. J., Roy, S. K., Choi, J.-Y., Park, J.-H., Cho, S.-W., Sarker, K., Woo, S.-H. (2018). Recent Research Updates on Functional Components in Buckwheat. J. Agr. Sci. Chungbuk Nat'l Univ., 34 (1). Available at: https://www.researchgate.net/publication/336058560_Recent_Research_Updates_on_Functional_Components_in_Buckwheat
23. Nam, T.-G., Lim, Y. J., Eom, S. H. (2018). Flavonoid accumulation in common buckwheat (Fagopyrum esculentum) sprout tissues in response to light. Horticulture, Environment, and Biotechnology, 59 (1), 19–27. https://doi.org/10.1007/s13580-018-0003-5
24. Rani, R. L., Kulkarni, U. N. (2020). Physical and Functional Properties of Buckwheat. International Journal of Current Microbiology and Applied Sciences, 9 (4), 902–907. https://doi.org/10.20546/ijcmas.2020.904.108
25. Pinski, A., Zhou, M., Betekhtin, A. (2023). Editorial: Advances in buckwheat research. Frontiers in Plant Science, 14. https://doi.org/10.3389/fpls.2023.1190090
26. Utebaeva, A., Gabrilyants, E., Abish, Z. (2024). Developing a Symbiotic Fermented Milk Product with Microwave-Treated Hawthorn Extract. Fermentation, 10 (8), 377. https://doi.org/10.3390/fermentation10080377
27. Sun, Y., Zhou, W., Huang, Y. (2020). Encapsulation of tartary buckwheat flavonoids and application to yoghurt. Journal of Microencapsulation, 37 (6), 445–456. https://doi.org/10.1080/02652048.2020.1781943
28. Saini, R. K., Keum, Y.-S. (2018). Carotenoid extraction methods: A review of recent developments. Food Chemistry, 240, 90–103. https://doi.org/10.1016/j.foodchem.2017.07.099
29. Wan, D., Chen, Y., Wang, J. (2010). Determination of total flavonoids in three Sedum crude drugs by UV-Vis spectrophotometry. Pharmacognosy Magazine, 6 (24), 259. https://doi.org/10.4103/0973-1296.71784
30. Kilcast, D., Subramaniam, P. (2013). Stability and shelf life. Dairy products. Saint Petersburg: Publishing House «Profession», 376.
31. Zamaratskaia, G., Gerhardt, K., Knicky, M., Wendin, K. (2023). Buckwheat: an underutilized crop with attractive sensory qualities and health benefits. Critical Reviews in Food Science and Nutrition, 1–16. https://doi.org/10.1080/10408398.2023.2249112
32. Gurbanov, N. H., Gadimova, N. S., Gurbanova, R. I., Akhundova, N. A., Babashli, A. A. (2020). Substantiation and development of technology for a new assortment of combined sour-milk drinks based on bio modified bean raw materials. Food Science and Technology, 40 (2), 517–522. https://doi.org/10.1590/fst.04219