The use of secondary raw materials in confectionary production

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ABSTRACT

Background: The development of new flour confectionery products is among the innovative developments in the world. Developing functional food technologies plays a vital role in advancing the food industry.

In recent years, the introduction of new technologies in production has created an opportunity to obtain higher quality products in a shorter period. Investing in non-traditional and locally sourced raw materials for confectionery production opens up exciting opportunities to create innovative products for mass consumption. These new offerings can be enriched with essential microelements and dietary fibers, enhancing their nutritional value while reducing the overall sugar and fat content. This approach not only benefits consumers' health but also contributes to a more sustainable production process.

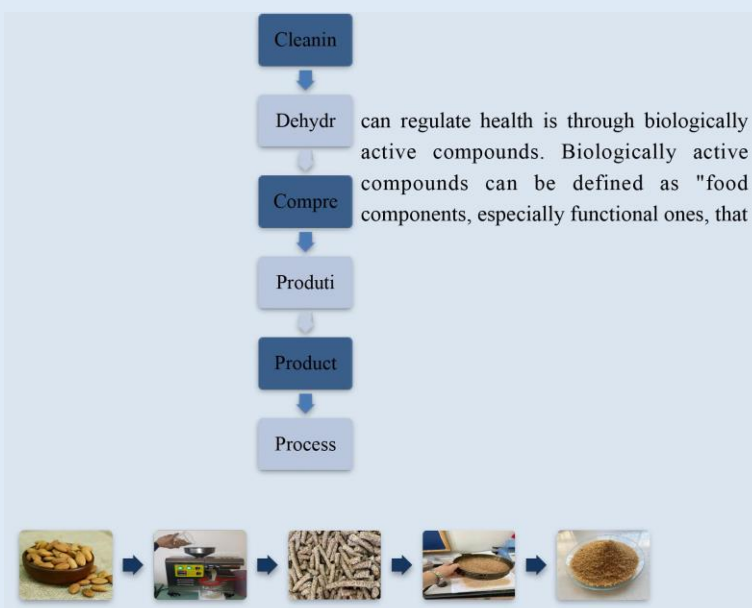
Objective: In light of the current trends in food product development aimed at enhancing health benefits and expanding the variety of nutritious options, this research aims to create a technology for producing cookies with high nutritional value. This will involve utilizing secondary raw materials derived from apricots, thereby promoting sustainability and innovative ingredient use in the baking industry.

Methods: Before carrying out the experimental research, a survey of the apricot growing areas belonging to the stone family growing under endemic conditions in the Republic of Armenia was carried out.
Obtaining cold-pressed medicinal oils from apricot kernels was carried out in the "Armbiotechnology SNPO NAS RA, using the "Rawmid Dream modern odm-01" pressing device. The resulting cusp is left for 2 days on the shelves of umbrellas protected from the sun's rays and from time to time the moisture level is checked, which should not exceed 8%. At the last stage, the dried raw materials are crushed in small quantities with a copper sieve with 0.5 mm holes. As a result, 250 g. of primary cusp yields 122 g. high grade flour.

Results: Studies were conducted using both control and experimental samples to determine the ideal quantity of apricot oil meal through experimentation. The following dosages for the use of apricot oil meal were chosen: 10% 50% 100% with flour replacement, according to 1 kg. finished product. Tests revealed that while a small amount of the substance didn't affect the taste, it significantly altered the appearance. In the case of using 100% Apricot oil meal, the method of cold processing of the dough is applied, as a result of which the appearance of the finished product becomes more stable, and the taste properties are pleasant. It became clear from the research of microelements that the amounts of A, B-group, Ca, Na, Fe have significantly increased.

Conclusion: Based on experimental studies, a technology for the production of cookies using gruel obtained from the extraction of apricot oil as a flour substitute has been developed: The study showed that a significant amount of micro- and macronutrients were found in the experimental sample, which confirms the fact that a new type of raw material can be used in functional nutrition: The technology is adapted to the existing production and does not require additional investments:

Keywords: Apricot oil meal, secondary row materials, confectionary products, functional food.



INTRODUCTION

The prevalence of chronic diseases has only increased over the years. Chronic diseases not only reduce the quality of life but also raise the mortality risk and the expenses incurred by those suffering from these illnesses [1].

As a result, chronic diseases have become a serious issue that requires solutions. One of the solutions to this problem is the use of functional foods, which can reduce the risk of diseases and thereby improve health [2]. Functional foods are natural or processed foods that contain biologically active compounds. The way in which functional food can regulate health is through biologically active compounds. Biologically active compounds can be defined as "food components, especially functional ones, that Obtaining oil meal from cold-pressed method have beneficial properties for health". Bioactive food compounds influence how the body's organs and systems function. These ingredients control cellular metabolism and create stable homeostasis at different periods of life [3-5].

The consumer characteristics of functional foods include three components: nutritional value, taste quality, and physiological effect. Unlike functional foods, traditional food products are characterized only by the first two components.

Obesity, according to the definition of World Health Organization, is a condition where an individual possesses an accumulation of body fat that has negative effects on the individual's health [6].

Compared to conventional daily foods, functional foods should provide health benefits and ensure safety in terms of balanced nutrition and nutritional value. Currently, consumers are showing significant interest in safe, beneficial, minimally processed, and fresh-tasting natural foods. To meet consumer demands, producers are seeking alternative technologies that consider food freshness, safety, shelf life, nutritional properties, ecological cleanliness, affordability, personalization, and their therapeutic aspects [8-9].

Additionally, in 2009, the Functional Food Center (FFC) presented a definition of functional food at the 6th conference following the conceptual framework of functional food, "Natural or processed foods that contains known or unknown biologically active compounds; which in defined amounts provide a clinically proven and documented health benefit for the prevention, management, or treatment of chronic disease" [10-12] .

Food bioactive compounds (FBCs) are nutritive and non-nutritive compounds naturally found in food that elicit a bioactive impact on the human body, ideally to promote health. Plant based foods contain bioactive compounds that promote positive health and reduce the risk of disease [13].

Bioactive compounds (BC) found in functional foods demonstrate beneficial biological activities, offering extra-nutritional benefits due to their antioxidant properties and preventative capabilities [14].

Experts have highlighted that functional food is a distinct consumer product, either organic or processed, that boasts a high concentration of unique biologically active compounds. In the Republic of Armenia, 50 varieties of apricot are cultivated. The most common ones are Yerevani, Sateni, Ghevondi, Karmratush, Masis, and VagahasVardagyun[15].

Apricot fruits contain 14% dry matter, 0.9% proteins, 10% sugars, 1.3% organic acids, numerous mineral salts, vitamins, as well as pectin and aromatic substances. Oil is extracted from the seeds, and the seeds of sweet fruit varieties are replaced by almonds [13-17].

The production of major agricultural products is associated with the processing of large amounts of waste. The output of the main product sometimes constitutes 15-30% of the initial raw mass. The remaining part, which contains significant amounts of valuable materials, is not used in the production process, turning into so-called waste, which often serves as secondary raw material for production and is regarded as an additional product.

Plants can be used fresh or dried and come in various forms, including leaves, roots, flowers, seeds, bark, tubers, and herbs. They may also be utilized in crushed, ground, or extracted forms. Those rich in secondary compounds are categorized as medicinal and aromatic plants. Oilseeds are secondary by-products from the production of vegetable oils (cake), which typically contain up to 8-10% vegetable oil. As we know, these residues are produced from the cold pressing of fruit seeds. The defatted cakes produced in this manner retain all their beneficial properties and nutrients. After defatting, they are often employed as flavoring additives in culinary technology, particularly in salads. For example, flours made from almond, apricot, and white sesame seeds are also utilized in confectionery production, added to flour as flavoring and decorative supplements. The beneficial properties of apricot oil meal are attributed to its unique chemical composition. 100 grams of oil meal contains:

Fats – 5 grams,

Protein – 40 grams,

Carbohydrates – 8 grams:

In addition to this composition, it also contains Ca, Mg, K, Na, Fe, Zn, folic acid, pantothenic acid, riboflavin, thiamine, pyridoxine, and other essential nutrients. Research has shown that regular consumption of apricot oil meal is of great importance for the maintenance of cardiovascular health, enhances the immune system, and normalizes the function of the digestive system. It is also used in the treatment of dermatological diseases. Daily consumption of oil meals improves the condition of hair and has a calming effect.[18].

MATERIALS AND METHODS

The purpose of this research is to develop functional food products, including a new type of cake, by utilizing secondary raw materials. The goal is to decide the possibility of including apricot oil meal in the formulation of the product as well as to define the technological parameters for the desired production methods. Additionally, it aims to decide the quantity of food dietary fibers, vitamins, and minerals in 100 grams of the finished product and to analyze the potential increase in the content of vitamins in the final product, along with the relevant indicators.

Determination of dietary fibers: Regarding the decision on nutritional fiber, highly accurate new measuring devices have been utilized during the procedures. The properties of the dietary fibers have been established through methods based on the oxidation, degradation, and solubility of different chemical compounds. In summary, the fibers are not soluble in the production process, are filtered, and weighed. A precisely weighed 1 g of ground sample was placed in 120 cm^3 of solution, and 40 cm^3 of acid mixture was added (3.6 cm^3 of pure acid, 36.4 cm^3 of 80% sulfuric acid solution). After sealing, the solution was kept at room temperature for 1 hour. Following this, it was filtered using an N2 glass filter. After extraction, the residue was washed several times with 0.2M sodium hydroxide hot ethanol solution, and then multiple times, additionally rinsed with small portions of distilled water and a mixture of 10 cm^3 of ethanol and water. The clean white residue was dried at 100-105 °C until a stable weight was achieved, and then it was packaged and weighed on an analytical scale. [19].

Determination of moisture: The moisture content in the raw material was measured using the gravimetric method with the KERN MRS analyzer, which has a precision of 0.95 [20].

Determination of vitamins: In this study, B-vitamin analysis was performed using a sophisticated HPLC system to assess both the composition of the final product and the purity of raw materials. Samples were first filtered through a 0.45 µm Millipore filter and then introduced into HPLC vials. The HPLC analysis was conducted with a Shimadzu LC-2010 system.

For vitamin B1 (thiamine) analysis, a standard stock solution was prepared by dissolving 26.7 mg of thiamine hydrochloride in 25 ml of double-distilled water. Similarly, for vitamin B2 (riboflavin), 6.9 mg of riboflavin was dissolved in 100 ml of extraction solution, with a maximum solubility of 7 mg riboflavin. The buffer solution was made by dissolving 1.36 gm of potassium dehydrogenate phosphate and 1.08 gm of hexane sulfonic acid sodium salt in 940 ml of HPLC-grade water, adding 5 ml of triethylamine, and adjusting the pH to 3.0 with orthophosphoric acid. Extraction solution was prepared by mixing 50 ml of acetonitrile with 10 ml of glacial acetic acid and making up the volume to 1000 ml with double-distilled water.

For sample preparation, 10 gm of each sample was homogenized, transferred to conical flasks, and mixed with 25 ml of extraction solution. The mixture was shaken in a water bath at 70°C for 40 minutes, then cooled, filtered, and diluted to 50 ml with the extraction solution. The filtered samples (20 µl aliquots) were injected into the HPLC system using an autosampler. A Waters Symmetry C18 column (4.6×150 mm, 5 µm) was employed, with a buffer composition of menthol (96:4), a flow rate of 1 ml/min, and a pressure of 2300 psi. Detection was performed using a UV detector at 210 nm with a 5 nm bandwidth. Solutions were degassed by sonication before injection.

To validate the method, standard solutions at concentrations of 5 µg/mL, 10 µg/mL, 20 µg/mL, and 40 µg/mL were prepared and injected into the HPLC. The analyses were conducted in triplicate, and calibration curves were used to determine the coefficient of correlation, slope, and intercept values. The concentration of B-vitamins in the samples was calculated using the equation $y = mx + c$, where y represents the peak areas, and x represents the vitamin content. The results were then adjusted by the dilution factor [21].

Analysis of minerals in food: A quantitative assessment of mineral content can be derived from the mass fraction of ash formed during the combustion of the product. Ash is the residue left after burning and calcining natural materials. When a biological substance is burned in air, 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 various chemical elements remain as ash, including calcium, magnesium, silicon, aluminum, iron, phosphorus, potassium, sodium, and others.

To ensure adequate air access during combustion, the process is conducted slowly, often with the addition of loosening agents such as calcium acetate or magnesium carbonate, or a mixture of alcohol and glycerin. To determine the ash content, the analyzed product is first dried in a drying cabinet and then carefully charred on an electric stove. Following this, the charred product is calcined in a muffle furnace at 450°C. The mass fraction of ash is determined using the appropriate formula.

$$Z = \frac{m2 - m0}{m1 - m0} * 100\%$$

Where m_1 is the mass of the crucible with the product under study, g;

$m_2$is the mass crucible with ash, g;

m_0 is the mass of the crucible, g [22].

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.

To begin, 25 g of the crushed sample, selected according to section 8.2 and weighed to the second decimal place, is placed in a 500 cm³ conical flask. Then, (250 ± 1) cm³ of distilled water, measured with a graduated cylinder, is added. The mixture is thoroughly mixed, and the flask is closed with a stopper and left to stand for 30 minutes, shaking it every 10 minutes.

After the 30-minute period, the contents of the flask are filtered through a paper filter into a dry flask or glass. Next, (50 ± 0.5) cm³ of the filtrate, measured with a graduated cylinder, is transferred into a 250 cm³ conical flask. Two to three drops of bromothymol blue solution are added, and the mixture is titrated with a sulfuric acid solution with a concentration of c(1/2 H2SO4) = 0.1 mol/dm³ or hydrochloric acid with a concentration of c(HCl) = 0.1 mol/dm³ until a yellow coloration appears.

The results are then processed according to the formula provided in the standard [23].

Statistical analysis: Data was gathered from scientific databases such as ISI Web of Knowledge, ResearchGate, Elsevier, and Scopus, along with several traditional books and texts. Field experiments were performed in triplicate, and all analyses were conducted in quadruplicate. Results were reported as means ± standard deviation. Comparative analysis was done using parametric ANOVA, with Bonferroni correction applied for multiple comparisons. For data not following a normal distribution, the Mann-Whitney test was used. Statistical calculations were performed using SPSS Version 16.

RESULTS AND DISCUSSION

During the experiment, a control sample of the cake was tested without the use of alternative raw materials and experimental samples were prepared by replacing 10%, 50%, and 100% of wheat flour with flour made from apricot oil meal. The corresponding amount of flour was also adjusted according to the specified percentages. The selection of apricot oil meal composition but also by its economic efficiency. In Armenia, apricots are a common fruit and relatively inexpensive. During the production of juices and preserves, residues are generated, which can be used to extract oil and oil meal.

In such technologies, it is crucial to achieve finished products with stable quality indicators, and equally important is the ability to manage the technological process. Based on the conducted research, a methodology for dough preparation has been established. In samples N1 and N2, the traditional method for dough processing has been processed at room temperature. Sample 3 was processed immediately after freezing the dough at -18°C.

The dough was prepared as follows: butter and sugar were mixed under high-speed conditions in a mixing machine, and then the egg was added. In the final stage, wheat flour and apricot oil meal were incorporated, while in sample 3, only apricot oil meal was used. The mixing lasted for 4-6 minutes.

The prepared dough was baked for 15-20 minutes at 180°C. The results of the analysis of the sensory parameters are presented in (Table 1).

Table 1. Determination of sensitivity parameters of control samples of cookies and products prepared with different doses of additives.

The name of the indicator	Control sample, mg./100g.	Sample No. 1 Cookie prepared with 10% apricot oil meal mg/100g	Sample No. 2 Cookie prepared with 50% apricot oil meal mg/100g	Sample No. 3 Cookie prepared with 100% apricot oil meal mg/100g
Appearance and Color	With characteristic, different sizes, light yellowish in color with a reddish tinge	Stretched in appearance, with cracks, light yellowish color	Hard structure, light yellowish, without characteristic cracks	With a fragile structure, with cracks, light yellowish color
Taste and smell	According to the product name, without side flavors and odors		With a pleasant apricot flavor and aroma characteristic of this product	
Porosity	According to the product name, Porosity		Evenlyporosity	

According to sensory assessment indicators, the study indicates that incorporating 100% apricot puree significantly improves the sensory characteristics of the product, such as its texture and enhances the pleasant apricot flavor. However, such quality can only be achieved by using a cold dough preparation method. Examples of experimental samples are shown in Figure 1. The physico-chemical parameters of the study are presented in (Table 2).

Figure 1. Examples of experimental sample

Table 2. Determination of physico-chemical parameters of control samples of cookies and products prepared with different doses of additives

Quality indicators of cookies	Products made from using apricot oil meal, %			
	Control sample	10%	50%	100%
The moisture content of finished products, %	15±0.01	14,1±0.01	13,6±0.02	12,9±0.02
Alkalinity,^{0}	0,8±0.01	0,7±0.01	0,6±0.01	0,5±0.01

*P<0.05

The physicochemical indicators also show changes based on these parameters. With the increase in the addition of ingredients, the moisture and alkalinity levels decrease. Given the high nutritional fiber content of the apricot oil meal, it likely absorbs the free liquid in the dough, resulting in reduced moisture levels in the samples. Nevertheless, these remain within normative limits and do not affect quality indicators.

The objective of using apricot oil meal is not only to utilize a secondary raw material but also to enrich the product with vitamins and minerals. An important next step in the research is to determine the changes in vitamins and minerals resulting from the use of apricot oil meal. The outcomes of the conducted studies are presented in Figure 1.

The daily requirement of the human body for vitamin B_1 is 1.4 mg, and for B_2, it is 1.4 mg, while for vitamin PP, it is 20 mg daily [23]. The data from the study show that the prescribed dosages of vitamins in samples N2 and N3 nearly fulfill the daily requirement of these vitamins for the human body.

The composition of minerals has also registered positive results. According to established norms, the human body's requirement for Kalium is 2500 mg, for Natrium, it is 1300 mg, for calcium, it is 1000 mg, and for Ferrum, it is 18 mg. It is evident that the daily demand for these specific minerals in the human body is quite high, and individuals may not always be able to meet that demand through their current diet. The studies conducted have shown that samples N2 and N3 contained a significantly high level of minerals, and a cookie made with 100 grams of apricot oil meal can substantially contribute to meeting the daily requirement for these four mineral elements. The results of the conducted research are presented in Figure 2.

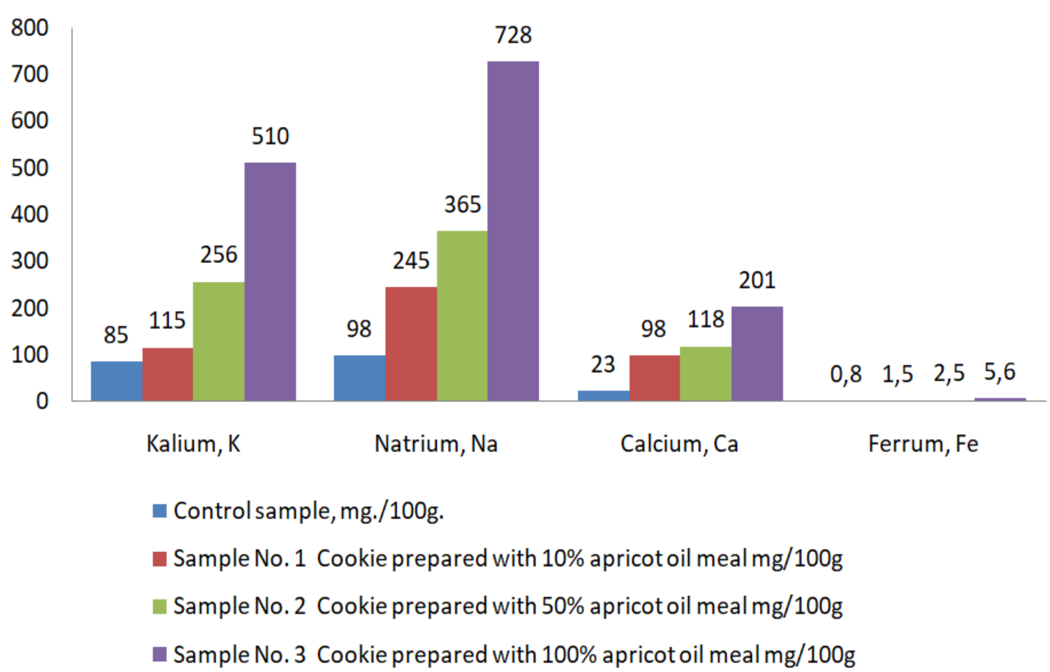


Figure 2. The content of minerals in the finished product, mg./100g.

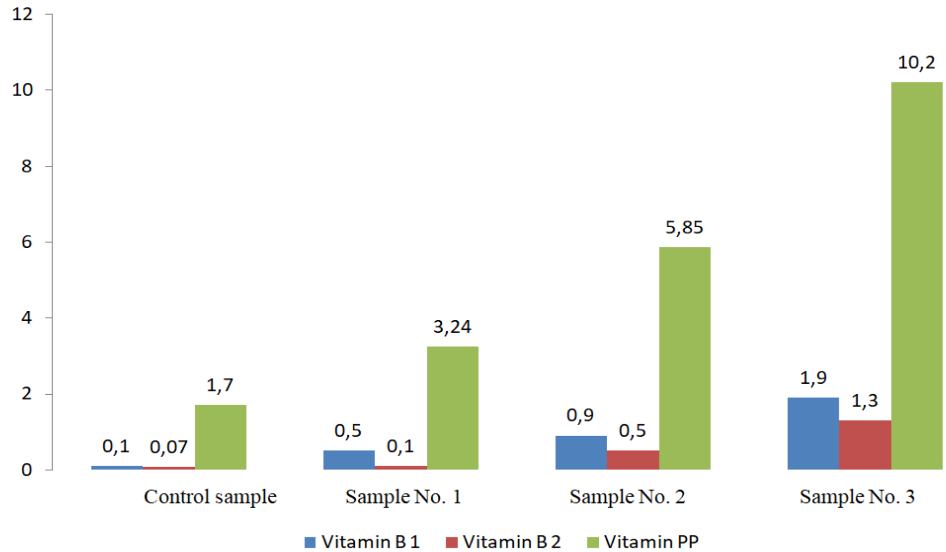


Figure 3. The content of vitamins in the finished product, mg./100g

It is well-established that the product contains dietary fibers, which have notably influenced the structural properties of the samples. In addition, dietary fibers have functional properties, and their increased presence in the samples is of substantial importance in human nutrition. The results of the conducted research are presented in Figure 4.

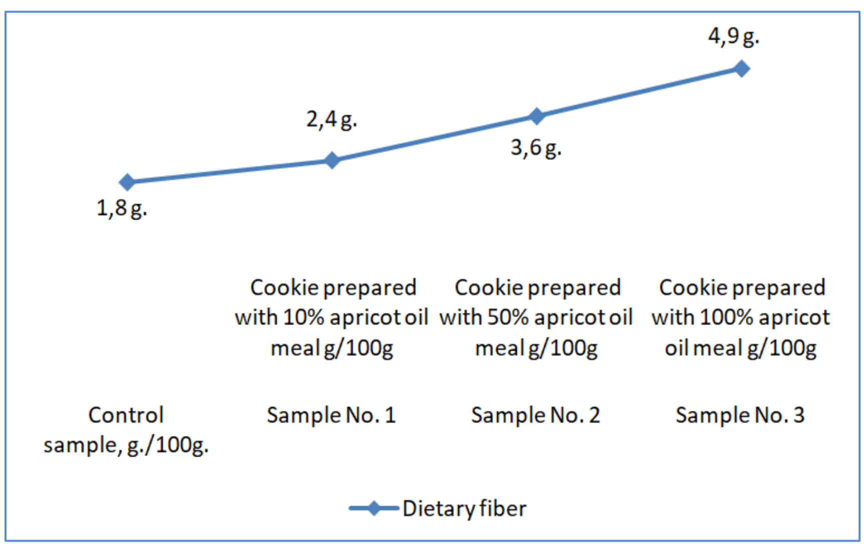


Figure 4. The content of dietary fiber in the finished product, g./100g.

As a result of the study, it is evident that the content of dietary fibers in the control sample was only 1.8 mg per 100 grams. In the case of adding the product, it increased to 4.9 mg per 100 grams of food. The human body's requirement for dietary fibers is 20-25 grams per day [18]. The body can only obtain this from plant-based foods; however, currently, this amount is only about 15 grams at most.

The research has established as a scientific novelty that the secondary raw material (by-product) obtained from apricot processing can be used in the production of confectionery as a biologically active component. It contains a considerable amount of vitamins and minerals, which are transferred to the final product, giving it functional properties.

CONCLUSION

The results of the conducted scientific and experimental research allow us to draw the following conclusions: The waste produced from oils during biotechnological production has been processed, resulting in a high-quality functional ingredient. This has been used in the production of domestic cake, significantly reducing the reliance on more expensive raw materials. The inclusion of apricot kernels in cake recipes, along with the substitution of wheat flour, enables a significant increase in the mass proportion of dietary fibers, vitamins, and minerals in the new product. The consumption of 100 grams of functional cakes partially meets the daily requirements for vitamins (B_1, B_2, PP) and minerals (Ca, Na, Fe, K) for an adult. The optimal use of kernels does not compromise the shelf-life indicators of the finished product and allows for the preservation of the characteristics typical of the control sample, while also improving them. To determine the optimal mass fraction of the ingredient added to the cake dough, it is necessary to consider several indicators of quality simultaneously. The experimental design method used in this work allowed for the establishment of the optimal ratio of using oil meal in the cake formulation and the material costs for acquiring new equipment in the enterprise. In this way, the production of cake promotes, on one hand, the processing of secondary raw materials, on the other hand, the creation of high-quality functional products without additional financial investments.

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

Authors Contributions: Narine Hovhannisyan is the main author and conductor of the research. Liana Grigoryan, Spartak Yeribekyan,Valery Grigoryan, Hrachuhi Balasanyan, contributed to the study of the vitamins and minerals composition of products and comparative evaluation. Armen Badalyan and Suzanna Abrahamyan contributed to the statistical processing. Asya Badalyan and Lilit Arstamyan contributed to the study of physico-chemical parameters.

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

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