UDC 663.252.61

RESEARCH ON THE PRODUCTION OF FUNCTIONAL BREAD AND PASTRY PRODUCTS USING WINEMAKING BY-PRODUCTS

https:// doi.org/ 10.15673/fst.v20i1.3357

H. Fataliyev[1], Professor
G. Hacıyeva[2], PhD student
Sh. Fataliyeva[1], assistant
[1]Department of Food Engineering and Winemaking
Azerbaijan State Agricultural University
Ataturk avenue 450, Az2000, Ganja, Azerbaijan
[2]Azerbaijan State University of Economics
6 Istiglaliyyat, Baku, Azerbaijan

Correspondence:
H. Fataliyev
E-mail: hasil.fataliyev@mail.ru

Cite as Vancouver style citation

Fataliyev H., Hacıyeva G., Fataliyeva Sh. Research on the production of functional bread and pastry products using winemaking by-products. Food Science and Technology. 2026;20(1):4-12. https:// doi.org/ 10.15673/fst.v20i1.3357

Цитування згідно ДСТУ 8302:2015

Fataliyev H., Hacıyeva G., Fataliyeva Sh. Research on the production of functional bread and pastry products using winemaking by-products // Food Science and Technology. 2026. Vol. 20, Issue 1. P. 4-12. https:// doi.org/10.15673/fst.v20i1.3357

Abstract The object of the research is dietary fibers obtained from winemaking by-products and the technology for producing functional bread using these materials. Although a number of studies have been conducted on resource-saving technologies in winemaking, the use of winemaking by-products in bread production has not been sufficiently investigated. The results showed that the total content of phenolic compounds in pomace obtained from the Rkatsiteli variety was 4.1 g/kg, while in Isabella it was 9.6 g/kg, and in the Madrasa variety it was significantly higher, reaching 21.4 g/kg. The content of polysaccharides was lowest in the Madrasa samples and highest in Rkatsiteli, with Isabella occupying an intermediate position. In the grape skin, easily hydrolysable fractions (pectic substances and hemicelluloses) of the Rkatsiteli variety were mainly represented by L-arabinose (6.2 mg/100 g), D-xylose (4.4 mg/100 g), D-galacturonic acid (3.1 mg/100 g), and D-glucose (2.1 mg/100 g). In the Madrasa variety, these fractions exhibited a somewhat different profile, being represented by D-glucose (9.9 mg/100 g), D-galactose (5.4 mg/100 g), D-xylose (4.5 mg/100 g), L-arabinose (4.3 mg/100 g), and other components. Among the hardly hydrolysable fractions in the Rkatsiteli variety, D-glucose (10.3 mg/100 g), D-mannose (5.9 mg/100 g), D-xylose (5.7 mg/100 g), and D-galacturonic acid (3.6 mg/100 g) predominated. In the Madrasa grape variety, the hardly hydrolysable fractions were represented by the same compounds, but their contents were somewhat lower. The mineral content of the pomace was found to be 2.6–2.7%. Compared to fresh pomace, fermented pomace showed a decrease in tartrate content by 0.7–2.5% and phenolic compounds by 20–30%. The content of pectic substances ranged from 2.5–3.5% in seeds and 2.7–5.8% in skins, with higher values observed in the Samukh and Shamkir samples and relatively lower values in the Goygol samples. The highest pectin content in grape skins was recorded in Shamkir, while the lowest was observed in Goygol. Grape skin, seed, and stem additives were incorporated into the dough at a level of 3%. The addition of grape seeds increased the β-carotene content from 1.4 mg/% to 7.9 mg/%, while the vitamin C content decreased slightly from 5.8 mg to 5.6 mg. A multiple increase in zinc content was observed, accompanied by a decrease in macroelements and calcium, while an improvement in organoleptic quality was noted.

Keywords: grape, pomace, skin, seed, pulp, stem, bread, flatbread

Introduction. Formulation of the problem

The intensity of modern life and the lack of time for many people are considered among the main reasons for disturbances in the intake of essential nutrients by the human body. This leads to qualitative and quantitative changes in the diet, resulting in excessive consumption of refined, high-calorie foods and a deficiency of plant proteins, polyunsaturated fatty acids, dietary fiber, vitamins, minerals, and other essential nutrients. Deficiencies of macro- and microelements, proteins, polyunsaturated fatty acids, vitamins, dietary fiber, and biologically active compounds are commonly observed in the population's diet. An imbalance of these components in consumed food products is noted, which is explained by technological processing and the deterioration of environmental conditions, leading to the use of nutritionally inferior raw materials.

Improving the dietary structure of the population and ensuring the quality and safety of food products are among the priority objectives of state policy. Global experience shows that one of the most effective ways to compensate for vitamin and mineral deficiencies is the fortification of food products with essential micronutrients required for daily consumption. Bread and flour-based confectionery products are among the most widely consumed foods. Therefore, to address this issue, technologies for producing functional foods should be developed that not only meet physiological nutritional needs but also provide health-promoting effects.

In this regard, the use of additives derived from plant raw materials and their processing by-products to enrich bread and flour confectionery products with biologically active substances and environmentally friendly natural components, thereby enhancing their nutritional value, is highly relevant. Since bread is one of the most frequently consumed foods, the inclusion of beneficial components, particularly dietary fiber, has a positive impact on human health. Grape pomace is considered one of the most important sources for obtaining dietary powders containing approximately 20% cellulose and 5–8% pectic substances. The enrichment of bread and flour confectionery products using additives derived from such plant sources has been investigated by some researchers. However, these studies have not sufficiently addressed the problem of utilizing winemaking by-products. Thus, the field faces a scientific challenge that requires a novel and comprehensive solution

Analysis of recent research and publications

The application of winemaking by-products in bread production enables the creation of products with high organoleptic properties and enriches wheat bread with nutrients. In one study, two batches of secondary plant raw materials—brewer's grains and flax pomace—were added in amounts ranging from 5% to 30%, with seven samples prepared for each batch. The results showed that the additives significantly affected the texture of the crumb, appearance, and color of the bread, while taste and aroma were preserved. This indicates the feasibility of using economically valuable secondary raw materials to optimize bread formulations [1].

It has been reported that residues from plant raw material processing contain valuable compounds and can be used in the production of functional foods. It is recommended that up to 10% of wheat flour be replaced with plant-based additives [2]. A new processing method using enzymes to efficiently hydrolyze excess sugars in bread has been developed. The use of sugar-rich suspensions and syrups did not negatively affect bread quality compared to control samples [3]. Another study investigated the conversion of stale bread waste into freshly baked bread, where wheat flour was replaced with stale bread residues at levels of 0, 20, 40, 60, 80, and 100 g/100 g [4].

The effects of sorghum bran addition on the antioxidant activity, sensory properties, and starch digestibility of Chinese steamed bread were studied [5]. In another investigation, the influence of tomato and bell pepper processing by-products on dough characteristics and bread quality was evaluated. The amount of added residues ranged from 3% to 12% of flour weight. It was found that up to 9% addition improved the nutritional profile of bread while maintaining baking quality [6].

Bread production with the addition of 5% rice bran and 10% buckwheat bran was also studied. These brans influenced dough and bread quality and reduced sugar content by 5% in dry form and by 29% in fermented beverages, which is significant for diabetes prevention and cholesterol control [7]. The incorporation of fruit and oilseed by-products into bread formulations has been reported to enhance dietary fiber content, biologically active compounds, and antioxidant potential, thereby exerting positive health effects [8].

The possibility of producing bread yeast using white bread waste was investigated [9], and starch extraction from bread waste using enzymatic methods was studied [10]. The addition of flax components to bread increased its nutritional value while reducing caloric content. The study demonstrated that incorporating 10% flax pomace yielded bread with high nutritional value and acceptable organoleptic properties [11]. Solid residues of aromatic plants were boiled and roasted before being added to wheat bread at levels of 1–2%. Their effects on physicochemical, organoleptic, antioxidant, and volatile profiles were investigated [12].

This review focuses on the efficient reuse of processing residues and the maximum utilization of plant-based food waste or food industry by-products, creating potential opportunities for effective dietary fiber extraction and its application in food and non-food industries [13]. The results also indicate the practical relevance of enriching low-extractable juices and wines with extracts obtained from solid parts of grape clusters to produce functional beverages [14]. An effective strategy for enhancing the bioactivity and extractable phenolic content of grape stem seeds through solid-state fungal fermentation has been proposed, offering new opportunities for the valorization of winemaking by-products [15].

Furthermore, buckwheat extract powder has been shown to be suitable as a beverage ingredient, as a standalone product, and as a recommended food for individuals with gluten intolerance [16]. Optimal methods for producing functional juices and wines enriched with rosehip pomace extract have been identified. Rosehip pomace powder obtained during processing was also used in the production of functional yogurt and bakery products, with optimal addition levels of 3.0% for yogurt and 2.5% for cakes [17].

These findings demonstrate that the use of plant-based additives in bread and confectionery production has become a practical reality. Among such additives, by-products generated during grape processing play an indispensable role in enriching products with essential nutrients. Grape pomace, which is generated during grape processing at primary winemaking enterprises, is largely underutilized and is typically discarded as organic fertilizer.

Aim and Objectives of the Study.The aim of this study is to improve the technology of bread and flour confectionery production through the use of grape-derived additives. To achieve this aim, the following objectives were set: to investigate the composition of the studied additives and the effects of grape variety and growing conditions;to assess the influence of grape variety and cultivation conditions on the composition and quality of pomace components; to study pomace drying methods, dietary fiber extraction from skins, and the application of seeds and other additives

Research materials and methods

The research materials included juice, pomace, skins, stems, pulp, berries, mash, pomace flour, technological methods, and extracts. Pomace remaining after juice extraction for each grape variety was used. The pomace was separated into skin and seed fractions and analyzed individually. Seed fermentation was carried out in a manner similar to that used for stems and pomace. Drying was performed in a thermostat at 60–80 °C. The dried pomace samples were ground using a coffee grinder, sieved through a fine mesh (0.3–0.5 mm), and stored in sealed polyethylene bags at −20 °C until analysis [18].

The pH of samples was measured using a pH meter (Sartorius PB-II, Germany). Total acidity, dry matter, ash content, and reducing sugars were determined. The total monomeric anthocyanin content in juice was measured by the pH differential method and expressed as malvidin-3-glucoside equivalents (mg/dm³).

The physicochemical and organoleptic characteristics of raw materials, semi-finished products, and finished products were determined using standard methods applied in oenochemistry [19]. Modern analytical methods, including High Performance Liquid Chromatography (HPLC), computer-assisted statistical data processing, and statistical analyses were performed using the SPSS 18 software package. Experimental results were accepted after statistical processing of 3–6 replicates, with a confidence level of 95% [20,21].

The mass concentration of phenolic compounds in wine was determined using the Folin–Ciocalteu method. When the reagent is added to wine, it oxidizes phenolic groups, forming a blue-colored complex, the intensity of which is proportional to the phenolic compound concentration.

Flavonoids are heterocyclic oxygen-containing compounds, typically yellow, orange, or red in color. Literature data indicate that no other class of natural compounds exhibits biological activity as beneficial to human cells as bioflavonoids. The total flavonoid content was determined photocolorimetrically based on the intensity of the reaction with sodium nitrite and aluminum chloride solutions. Absorbance was measured at 510 nm, and results were expressed as catechin equivalents (mg/100 g of raw material) using calibration curves.

Tannins are complex mixtures characterized by a high content of polyphenolic compounds. The total tannin content (T, mg catechin equivalents per 100 g of raw material) was determined photocolorimetrically based on the interaction of the extract with vanillin reagent.

Antioxidant activity was determined using the TEAC (Trolox Equivalent Antioxidant Capacity) method. This method is based on measuring the decolorization of a blue-colored radical cation under the action of antioxidants. A stable $ABTS^{+}$ solution was prepared by reacting an aqueous ABTS solution (2,2′-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)) with potassium persulfate at a defined concentration. Absorbance was measured at a wavelength of 734 nm. The results were expressed in mol/kg as Trolox equivalents.

The antioxidant activity of the samples was also determined in a linoleic acid system. This method is based on the inhibition of linoleic acid oxidation by antioxidants present in the tested raw materials under conditions close to those of living cells. The process was carried out in a model system at 40 °C and pH 7.0 for 120 hours. Subsequently, the degree of oxidation was measured based on the formation of hydroperoxides reacting with NH_4SCN and $FeCl_2$. Antioxidant activity was expressed as the percentage inhibition of linoleic acid oxidation (AOA, % inhibition).

Total nitrogen content was determined according to the Nessler method. A weighed portion of the analyzed material was first digested in the presence of sulfuric acid, resulting in the formation of ammonium sulfate. To accelerate the process, a catalyst or hydrogen peroxide was added.

The concentration of ammonium ions was determined by a colorimetric method using Nessler reagent. The reagent contains potassium hydroxide, which reacts with ammonium sulfate to form a yellow-colored compound. The intensity of the color is directly proportional to the concentration of ammonium cations. Colorimetric measurements were carried out at a wavelength of 420 nm, and nitrogen concentration was determined using calibration curves.

In many protein preparations, the nitrogen content is relatively constant and averages about 16% of the protein mass. Therefore, knowing the nitrogen content in the sample, the protein content can be calculated with sufficient accuracy using the following formula (assuming that all nitrogen is protein nitrogen):

B=N×6.25B = N \times 6.25B=N×6.25

Where

B– protein content in the sample;

N – nitrogen content in the sample;

6.25 – conversion factor (100/16).

Results of the research and their discussion

The composition of the studied additives, as well as the effects of grape variety and cultivation conditions, were investigated. The structure and physical properties of pomace obtained during the processing of the Rkatsiteli grape variety and its components are presented in Table 1 and Figure 1.

Table 1 – Structure and physical properties of Rkatsiteli grape pomace and its components ($n = 6$, $p < 0.05$)

Components	Density, g/cm^3	Bulk density, kg/m^3	Moisture capacity per 100 cm^3
Grape pomace	1,10	417	47
Grape skin	1,05	375	60
Grape seed	1,15	597	11
Stem fraction	1,00	203	60
Pulp	1,05	357	80

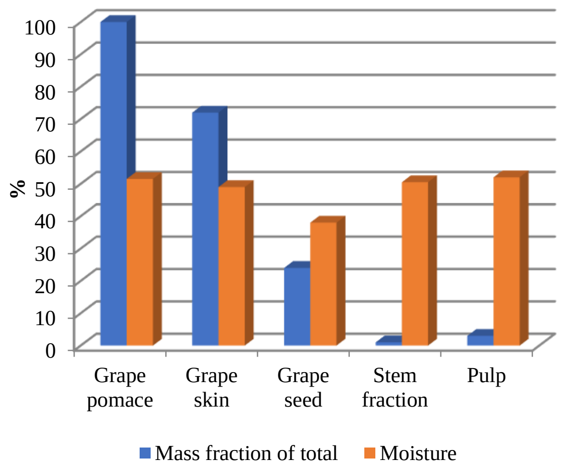

Fig. 1. Content and moisture of pomace components ($n = 6$, $p < 0.05$)

As shown in Figure 2, in the pomace obtained during the processing of the Rkatsiteli grape variety, grape skins accounted for 72% of the total mass, seeds for 24%, stem residues for 1.0%, and pulp fragments for 3.0%. The moisture content of the components was 49% for skins, 38% for seeds, 50.5% for stem residues, and 52% for pulp fragments (up to 3 mm in diameter).

The water-holding capacity was 60% for skins, 11% for seeds, 6% for stem residues, and 80% for pulp. The bulk density of the loose mass was 375 g/dm^3 for skins, 597 g/dm^3 for seeds, 203 g/dm^3 for stem fragments, and 357 g/dm^3 for pulp.

The contents of phenolic compounds and polysaccharides in the pomace of different grape varieties were also investigated (Figure 2).

As shown in Figure 3, the total content of phenolic compounds in sweet pomace obtained from the Rkatsiteli grape variety processed by the white method was 4.1 g/kg. In sweet pomace derived from the Isabella grape variety, this value was 9.6 g/kg, whereas in sweet pomace obtained from the Madrasa grape variety, the content was significantly higher, reaching 21.4 g/kg.

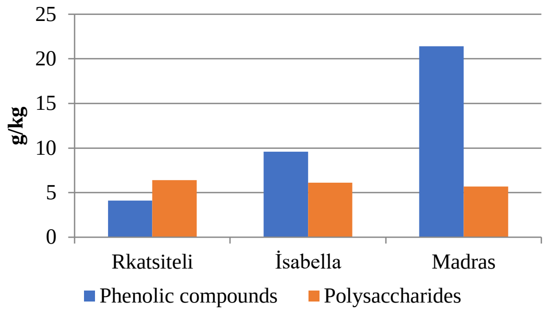

Fig. 2. Content of phenolic compounds and polysaccharides in pomace samples ($n = 6$, $p < 0.05$)

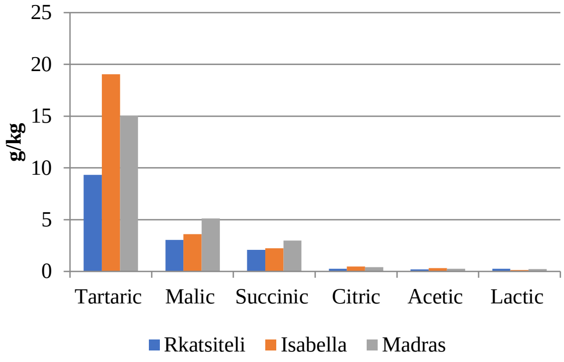

Fig. 3 .Mass concentration of organic acids in pomace samples (g/kg, $n = 6$, $p < 0.05$)

In contrast, the distribution of polysaccharides exhibited an opposite trend. The lowest polysaccharide content was observed in the Madrasa sample (5.7 g/kg), while the highest content was recorded in the Rkatsiteli sample (6.4 g/kg). The Isabella sample occupied an intermediate position with a polysaccharide content of 6.1 g/kg.

In addition, the content of organic acids in pomace samples was investigated for each variant (Figure 3).

As shown in Figure 4, the content of organic acids varied across the studied variants within different ranges. Tartaric acid was the predominant organic acid, with concentrations ranging from 9.34 to 19.06 g/kg. The highest content was observed in the second variant, corresponding to the Isabella sample, while the lowest value was recorded in the first variant (Rkatsiteli sample). The third variant (Madrasa sample) occupied an intermediate position.

Malic acid ranked second after tartaric acid in terms of concentration, although its content was several times lower. The malic acid content ranged from 3.05 to 5.11 g/kg. Succinic acid followed malic acid, with concentrations varying between 2.08 and 2.98 g/kg across the variants. The total content of citric, acetic, and lactic acids in each variant did not reach 1.0 g/kg.

The mass concentration of cations in pomace samples varied among the variants, as shown in Fig. 4.

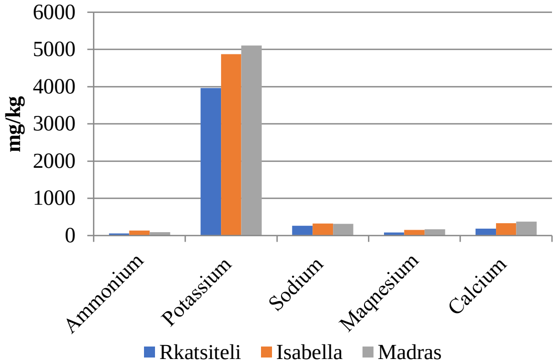

Fig. 4. Mass concentration of cations (mg/kg, n = 6, $p < 0.05$)

As shown in Figure 5, among the detected cations, the non-metal ammonium ion was also present, with concentrations ranging from 55 to 134 mg/kg. Among metallic cations, potassium was predominant, exhibiting the highest concentration, which ranged from 3960 to 5110 mg/kg. The remaining cations were present at significantly lower concentrations compared to potassium.

In terms of abundance, potassium was followed by sodium and calcium ions, while magnesium ions were present in the lowest concentrations.

Due to its chemical composition, grape pomace is considered a valuable raw material, as it contains a rich polysaccharide complex, including L-cellulose, as well as nitrogen-containing compounds, ash, substantial amounts of phenolic compounds, and lignin (Figure 5).

The mineral content of grape pomace ranged from 2.6 to 2.7%. Among the ash components, potassium and phosphorus were predominant. In sweet grape pomace, the mass fraction of sugars varied between 5 and 10%, while tartrate compounds ranged from 0.5 to 2.0%. At the same time, tartrate compounds consisted mainly of free tartaric acid (approximately 40%) and potassium bitartrate (10–12%). It should be noted that malic acid is also present in sweet pomace, and during the processing of grapes at technological maturity, its content is comparable to that of tartaric acid.

In addition to the compounds listed above, pomace contains pentosans (1.0–4.5%), pectin (0.5–3.8%), mineral substances (1.2–3.6%), and phenolic compounds (up to 11%). Fermented pomace contains no sugars; its main component is ethyl alcohol, with a volume fraction of 4–5%. Fermented pomace also contains tartrate compounds (0.7–2.5%) and phenolic substances, the levels of which are 20–30% lower than those in fresh pomace.

The polysaccharide complex of grape pomace is characterized by a highly complex composition of high-molecular-weight compounds (Table 2).

The easily hydrolysable fraction of grape skins (pectic substances and hemicelluloses) is characterized by a wide range of monomeric components and considerable variability in their composition. As shown, among the easily hydrolysable fractions in the Rkatsiteli variety, the predominant components were L-arabinose (6.2 mg/100 g), D-xylose (4.4 mg/100 g), D-galacturonic acid (3.1 mg/100 g), and D-glucose (2.1 mg/100 g). In the Madrasa variety, these fractions exhibited a somewhat different profile, being mainly represented by D-glucose (9.9 mg/100 g), D-galactose (5.4 mg/100 g), D-xylose (4.5 mg/100 g), and L-arabinose (4.3 mg/100 g), among others.

Among the hardly hydrolysable fractions, the Rkatsiteli variety was characterized by higher contents of D-glucose (10.3 mg/100 g), D-mannose (5.9 mg/100 g), D-xylose (5.7 mg/100 g), and D-galacturonic acid (3.6 mg/100 g). In the Madrasa grape variety, the hardly hydrolysable fractions were represented by the same compounds; however, their contents were slightly lower than those observed in the Rkatsiteli variety.

Several physicochemical parameters of pomace samples obtained from the processing of the studied grape varieties were analyzed (Table 3).

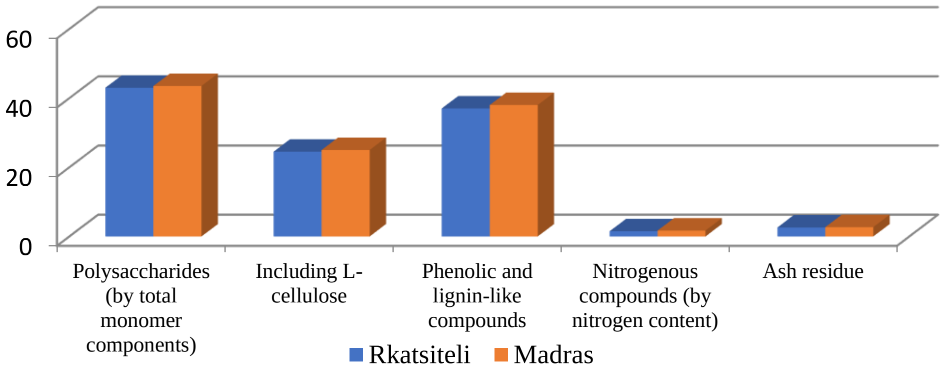

Fig. 5. Chemical composition of grape berry skins from different grape varieties (n = 6, $p < 0.05$)

Table 2 – Carbohydrate composition of grape berry skins from white and red grape varieties ($n = 6$, $p < 0.05$)

Monosaccharides	Composition, mg/100 g, in grape varieties and fractions			
	Rkatsiteli		Madrasa	
	Easily hydrolyzable fractions	Difficult-to-hydrolyze fractions	Easily hydrolyzable fractions	Difficult-to-hydrolyze fractions
D-galacturonic acid	3,1	3,6	2,8	0,7
D-glucuronic acid	Trace	-	Trace	-
L-rhamnose	0,9	-	Trace	-
D-galactose	1,5	-	5,4	-
D-glucose	2,1	10,3	9,9	9,8
D-mannose	1,8	5,9	1,4	4,7
D-xylose	4,4	5,7	4,5	5,3
L-arabinose	6,2	-	4,3	-

Table 3 – Initial composition of pomace obtained during the processing of different grape varieties ($n = 6$, $p < 0.05$)

Parameters	Grape variety		
	Rkatsiteli	Isabella	Madras
Dry matter content, %	39,62	41,15	42,31
pH	3,70	3,73	3,76
Crude protein (on dry matter basis), %	9,86	10,35	11,22
Crude cellulose, DM %	27,72	27,05	26,95
Crude ash, DM %	6,98	8,05	9,22
Lactic acid, DM %	3,71	3,30	3,15
Carbohydrates insoluble in neutral solvents, DM %	55,71	5,60	53,42
Carbohydrates insoluble in acid solvents, DM %	52,11	5,35	50,15
Lignin insoluble in acid solvents, DM %	43,05	39,24	37,11
Water-soluble carbohydrates, g/kg	45,60	47,16	49,14
NH3N (ammonia nitrogen), g/kg	0,33	0,34	0,36

As shown in Table 3, the Rkatsiteli pomace sample contained 39.62% dry matter, had a pH value of 3.70, crude protein content (on a dry matter basis) of 9.86%, crude cellulose content of 27.72%, crude ash content of 6.98%, neutral detergent–insoluble carbohydrates of 55.71%, and water-soluble carbohydrates of 45.60 g/kg. In contrast, these parameters differed in the pomace of the pink Isabella and red Madrasa grape varieties.

It was found that the dry matter content in Isabella and Madrasa pomace was slightly higher than that in Rkatsiteli pomace, while the crude cellulose content was somewhat lower. The contents of ash and water-soluble carbohydrates were higher in the pomace of the Isabella and Madrasa grape varieties compared to Rkatsiteli.

The impact of different cultivation conditions on the composition of seeds and skins obtained from grape pomace was evaluated (Table 4 and Fig. 6).

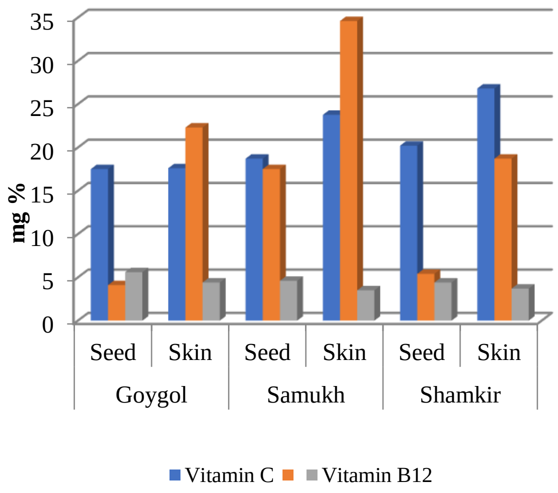

Fig. 6. Effect of cultivation conditions on the content of selected vitamins in seeds and skins obtained from grape pomace ($n = 6$, $p < 0.05$)

It was found that the total sugar content was highest in seeds obtained from the Samukh region, followed by seeds from the Shamkir and Goygol regions. The pectin content in the seeds ranged from 2.5 to 3.5%, while in the skins it varied from 2.7 to 5.8%. The highest seed pectin content was observed in samples from the Samukh and Shamkir regions, whereas the lowest was recorded in seeds from the Goygol region. In the skins, pectin content was highest in Shamkir and lowest in Goygol samples. The titratable acidity was highest in the skins from the Shamkir region and in the seeds from the Goygol region.

The vitamin C content in the samples varied from 17.5 to 20.2 mg/% in the seeds and from 17.6 to 26.8 mg/% in the skins. The content of vitamin B12 was higher in the seeds compared to the skins. Among the samples, the highest vitamin B12 content (5.6 mg/%) was observed in the seeds from the Goygol region.

The effect of cultivation conditions on the mineral composition of grape pomace was studied using the Rkatsiteli variety as an example (Table 5).

Table 5 Effect of cultivation conditions on the mineral composition of seeds and skins obtained from Rkatsiteli grape pomace (n = 6, p < 0.05)

Parameters	Goygol		Samukh		Shamkir	
	Seed	Skin	Seed	Skin	Seed	Skin
Mineral substances, mg %: Fe	1,57	43,1	35,56	107,0	18,4	40,1
Mn	0,33	1,34	1,75	2,67	1,38	1,8
Zn	6,4	1,03	3,77	3,35	1,74	1,61
Cu	0,024	4,05	3,93	4,11	2,3	2,61
Na	40,1	16,8	8,21	9,05	8,42	10,34
K	72,3	827,6	76,7	805,8	191,3	755,8
Ca	41,2	14,8	153,5	135,9	84,1	77,3
Mg	58,3	33,4	90,7	83,1	91,1	73,3
J, mkg %	41,3	37,4	37,1	22,8	43,0	32,0

As shown, eight metals and iodine were detected in the pomace samples. Among the metals, potassium was the most abundant, with concentrations ranging from 72.3 to 827.6 mg/% across the samples. It was accompanied in smaller amounts by calcium, magnesium, and sodium. Among the mineral elements, manganese, copper, and zinc were present in the lowest concentrations. Iodine was also detected in relatively low amounts, with content ranging from 37.4–41.3 µg/% in the Goygol sample, 22.8–37.1 µg/% in Samukh, and 32–43 µg/% in Shamkir.

The content of mineral compounds is one of the key indicators affecting product quality. The significant presence of these elements in pomace underscores its importance as a raw material for the production of functional foods.

Complete separation of the components extracted from pomace is performed using continuously operating presses. After sugar removal, the pomace is subjected to drying. High-quality drying is essential when using high-temperature drum-type dryers, during which the seeds are separated and the grape skins are ground.

Seed cleaning from residues is carried out using specialized cleaning machines. Separation of grape seeds from dried pomace can be performed using OBC-2 machines, with a throughput of 0.56 kg/s. Post-drying seed cleaning can be conducted using OS-45 cleaners at 100°C and up to 16% moisture content. Non-standard equipment for the processing of secondary agricultural resources is also produced by Russian manufacturers.

It is recommended to dry and use the stems remaining in pomace as a source of dietary fiber. If processing facilities are not available, these residues can be used as feed for ruminant animals.

The pomace samples obtained in the study were brought to the laboratory for drying. Drying was performed in drying cabinets at 60–80°C (Figure 7).

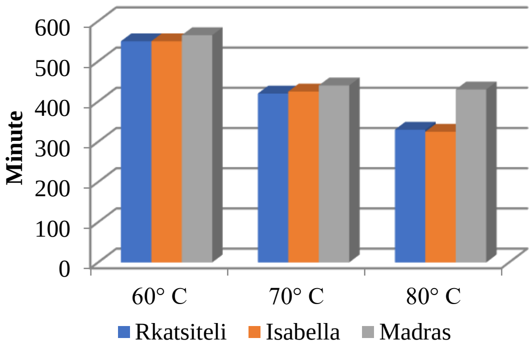

Fig. 7. Drying regime of pomace fibers in a drying cabinet (n = 6, p < 0.05)

After completion of the drying process, it was observed that samples dried at 80°C underwent more pronounced changes during visual inspection. These samples exhibited darkening and burnt tones in color. Therefore, a drying temperature of 70°C, which provides a more optimal drying condition, was selected.

The procedure for obtaining dietary fiber from grape skins is illustrated using the Rkatsiteli variety (Figure 8).

As shown in Figure 10, the grape seeds are first separated from the pomace. The remaining grape skins are then washed several times in water at room temperature. After washing, the skins are pressed, and the resulting mass is dried under the experimentally determined conditions to obtain the grape skin fiber.

The moisture content and total extractable substances in the seeds of various grape varieties were determined (Table 6).

Table 6 – Quality indicators of seeds from different grape varieties (n = 6, p < 0.05)

Grape variety	Moisture content, %	Fat content, %	Color	Appearance
Rkatsiteli	5,4	17,8	Brown -gray	Whole seeds, normal condition
İsabella	5,3	18,2	Brown -gray	Whole seeds, normal condition
Madras	5,8	14,3	Brown -gray	Whole seeds, normal condition

As shown in table 6, the seeds obtained from all three grape varieties were brownish-gray in color, with an intact appearance and normal seed shape. Their oil content ranged from 14.3 to 17.8%, and moisture content varied between 5.3 and 5.8%. Special attention has been paid to improving methods for obtaining seed flour from grape seeds.

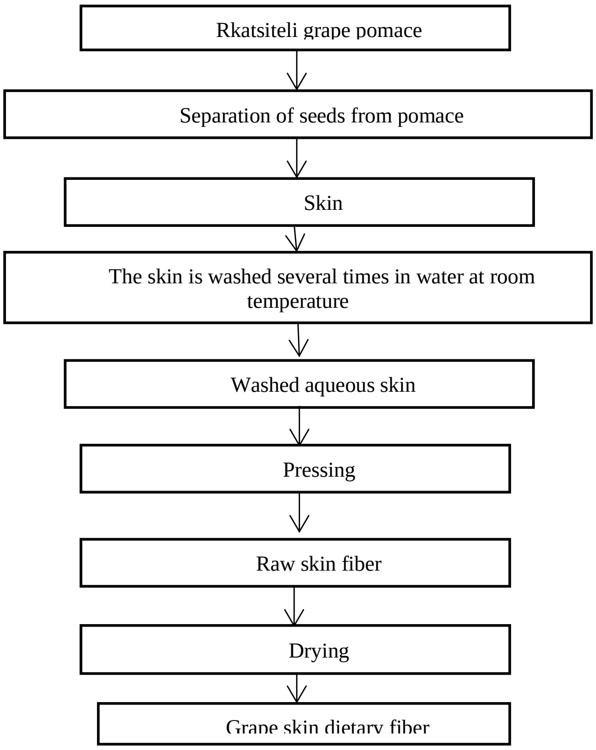

Fig. 8. Technological scheme for obtaining dietary fiber from the pomace of the Rkatsiteli grape variety

As shown in Table 6, the seeds obtained from all three grape varieties were brownish-gray in color, with an intact appearance and normal seed shape. Their oil content ranged from 14.3 to 17.8%, and moisture content varied between 5.3 and 5.8%. Special attention has been paid to improving methods for obtaining seed flour from grape seeds.

It is known that oil can be extracted from grape seeds using pressing and solvent extraction methods. In this regard, extraction methods are preferred to minimize the impact on the raw material. Current technological schemes for oil extraction rely on solvents such as petroleum ether, hexane, or benzene. However, the subsequent separation of these solvents and high energy consumption have prompted the exploration of replacing organic solvents with certain gases, such as carbon dioxide or refrigerants. Gas-based extraction has specific advantages and disadvantages. The main advantage is that the process and separation of the extract can be carried out at low temperatures, which naturally preserves the biologically active compounds in the raw material.

In the preliminary study, three types of grape-derived additives, as well as a mixture of all additives, were used. The amount of additives incorporated was 3% (Table 7).

Table 7 shows that the use of grape-derived additives resulted in an increase in several nutritional indicators. For instance, when grape seed additives were used, the content of β-carotene increased from 1.4 mg/% to 7.9 mg/%, whereas the C vitamin content slightly decreased from 5.8 mg to 5.6 mg. During this process, the zinc content increased several-fold, while the amounts of macroelements, including calcium, decreased. When grape stem additives were used, there was a multiple increase in β-carotene as well as the microelements iron and zinc, while macroelements such as potassium and calcium decreased significantly. The combined use of stems, seeds, and skins resulted in a considerable increase in all indicators except for macroelements.

Table 7 – Effect of various grape-derived additives on the antioxidant properties of functional bread samples

Parametrs	Grape seed powder		Grape stem powder		Stem + seed powder		Stem + seed + skin powder	
	Control, %	T,%	N,%	T,%	N,%	T,%	N,%	T,%
Vitamin C, mg %	5,8	5,6	6,0	9,1	12,1	120	14,1	160,0
β-Carotene, mg %	1,4	7,9	1,22	12,1	1,30	9,1	1,8	43
Fe, mg %	1,64	23,2	1,65	24	1,65	24	1,69	27
Zn, mg %	1,05	14,6	1,25	40	1,13	26	1,08	19,1
J, mkg %	36,5	13,1	35,7	12,1	34,6	8,9	36	12
K, mg %:	146,0	26,3	181,5	44,5	177,2	41,7	170,1	36,2
Ca, mg %	46,01	23,2	43,4	15,1	39,61	8,01	43,3	15,0

Conclusion

The total mass of pomace consists of 72% skin, 24% seeds, 1% stem residues, and 3% pulp, with a composition rich in valuable components. The total phenolic content in the pomace obtained from Rkatsiteli grapes was 4.1 g/kg, from Isabella 9.6 g/kg, and significantly higher in Madrasé at 21.4 g/kg. The polysaccharide content was lowest in Madrasé, highest in Rkatsiteli, and intermediate in Isabella. In both white and red grape varieties, the easily hydrolyzable polysaccharide fraction in the skin was higher than the fraction of difficult-to-hydrolyze polysaccharides.

The total sugar content in the seeds was highest in samples from Samux, followed by Şəmkir and Göygöl. The content of pectin in the seeds varied from 2.5–3.5%, and in the skin from 2.7-5.8%, with higher amounts in Samux and Şəmkir seed samples and lower amounts in Göygöl; in the skin, the highest pectin content was observed in Şəmkir and the lowest in Göygöl. Among mineral elements, potassium was present in the highest concentration (72.3–827.6 mg%). Pomace samples were dried in a laboratory dryer at 60–80°C, and based on quality assessment, drying at 70°C was considered optimal. The seed samples obtained from the studied varieties were intact, brownish-gray, and of normal quality.

In the initial study, three types of powdered additives and their mixture were used at a 3% addition rate. When grape seeds were used, β-carotene increased from 1.4 mg/% to 7.9 mg/%, while C vitamin decreased slightly from 5.8 mg to 5.6 mg. Zinc content increased several-fold, whereas macroelements, including calcium, decreased. When grape stems were used, β-carotene, iron, and zinc increased several-fold, while macroelements such as potassium and calcium decreased. The combined use of stems, seeds, and skins resulted in a significant increase in all parameters except macroelements.

References:

1. Bekbolatova ME, Mashanova NS. Influence of flaxseed cake and brewer's spent grain on the characteristics of wheat bread. Vestnik Almatinskogo Tekhnologicheskogo Universiteta. 2024;(4):70-78. doi: 10.48184/2304-568X-2024-4-70-78.
2. Stabnikova E, Shevchenko A, Stabnikov V, Paredes-López O. Utilization of plant processing wastes for enrichment of bakery and confectionery products. Ukr Food J. 2023;12(2):299-308.
3. Rosa-Sibakov N, Sorsamäki L, Immonen M, Nihtilä H, Maina NH, Siika-aho M, et al. Functionality and economic feasibility of enzymatically hydrolyzed waste bread as a sugar replacer in wheat breadmaking. J Food Process Preserv. 2022;46(3):e16378. doi: 10.1111/jfpp.16378.
4. Garcia-Hernandez A, Roldan-Cruz C, Vernon-Carter EJ, Alvarez-Ramirez J. Stale bread waste recycling as ingredient for fresh oven-baked white bread: effects on dough viscoelasticity, bread molecular organization, texture, and starch digestibility. J Sci Food Agric. 2023;103(8):4132-4142. doi: 10.1002/jsfa.12442.
5. Zhang P, Awika JM. Effect of sorghum bran addition on antioxidant activities, sensory properties, and in vitro starch digestibility of Chinese southern-style steamed bread. J Sci Food Agric. 2024;104(15):9652-9659. doi: 10.1002/jsfa.13790.
6. Wirkijowska A, Zarzycki P, Teterycz D, Nawrocka A, Blicharz-Kania A, Łysakowska P. The Influence of Tomato and Pepper Processing Waste on Bread Quality. Appl Sci. 2023;13(16):9312. doi: 10.3390/app13169312.
7. Yessembek M, Tarabayev B, Kakimov M, Gajdzik B, Wolniak R, Bembenek M. Utilization of Secondary Raw Materials from Rice and Buckwheat Processing for the Production of Enriched Bread: Optimization of Formulation, Physicochemical and Organoleptic Properties, Structural and Mechanical Properties, and Microbiological Safety. Foods. 2024;13(17):2678. doi: 10.3390/foods13172678.
8. Zarzycki P, Wirkijowska A, Teterycz D, Łysakowska P. Innovations in Wheat Bread: Using Food Industry By-Products for Better Quality and Nutrition. Appl Sci. 2024;14(10):3976. doi: 10.3390/app14103976.
9. Benabda O, Kasmi M, Kachouri F, Hamdi M. Valorization of the powdered bread waste hydrolysate as growth medium for baker yeast. Food Bioprod Process. 2018;109:1-8. doi: 10.1016/j.fbp.2018.02.007.
10. Ben Rejeb I, Baraketi S, Charfi I, Khwaldia K, Gargouri M. Valorization of bread waste, a nonconventional feedstock for starch extraction using methods: a comparative study. Mediterr J Environ Integr. 2024;9:1485-1498. doi: 10.1007/s41207-024-00572-6.
11. Wirkijowska A, Zarzycki P, Sobota A, Nawrocka A, Blicharz-Kania A, Andrejko D. The possibility of using by-products from the flaxseed industry for functional bread production. LWT - Food Sci Technol. 2020;118:108860. doi: 10.1016/j.lwt.2019.108860.
12. Nouska C, Irakli M, Georgiou M, Lytou AE, Skendi A, Bouloumpasi E, et al. Physicochemical Characteristics, Antioxidant Properties, Aroma Profile, and Sensory Qualities of Value-Added Wheat Breads Fortified with Post-Distillation Solid Wastes of Aromatic Plants. Foods. 2023;12(21):4007. doi: 10.3390/foods12214007.
13. Plakantonaki S, Roussis I, Bilalis D, Priniotakis G. Dietary Fiber from Plant-Based Food Wastes: A Comprehensive Approach to Cereal, Fruit, and Vegetable Waste Valorization. Processes. 2023;11(5):1580. doi: 10.3390/pr11051580.
14. Fataliyev H, Gadimova N, Huseynova S, Isgandarova S, Heydarov E, Mammadova S. Enrichment of functional drinks using grape pomace extracts, analysis of physicochemical indicators. East-Eur J Enterp Technol. 2024;3(11-129):37-45. doi: 10.15587/1729-4061.2024.307039.
15. Zhao Y, Liu D, Zhang J, Cao J, Gu H, Cui M, et al. Improving Soluble Phenolic Profile and Antioxidant Activity of Grape Pomace Seeds through Fungal Solid-State Fermentation. Foods. 2024;13(8):1158. doi: 10.3390/foods13081158.
16. Fataliyev HK, Qadimova NS, Allahverdiyeva ZC, Musayev TM, Akhundova N, Babashli A. Obtaining and investigation of the chemical composition of powdered malt and polymalt extracts for application in the production of nonalcoholic functional beverages. East-Eur J Enterp Technol. 2022;5(11-119):66-74. doi: 10.15587/1729-4061.2022.265762.
17. Fataliyev H, Hajiyeva G, Isgandarova S, Gadimova N, Baloghlanova K. Study of the production of functional food products through the application of resource-conserving technologies. Int J Innov Res Sci Stud. 2025;8(6). doi: 10.53894/ijirss.v8i6.9593.
18. Fataliyev HK, Mammadova SM, Gadimova NS, Aliyeva GR, Tagıyev AT, Baloglanova KV. Production of functional products using grape processing residuals. Food Sci Technol (Campinas). 2020:1-7. doi: 10.1590/fst.30419.
19. Fataliyev HK. Winemaking practicum. Baku: Elm; 2013. 328 p.
20. Sheskin DJ. Handbook of Parametric and Nonparametric Statistical Procedures. 6th ed. Chapman and Hall/CRC; 2020. doi: 10.1201/9780429186196.
21. Gadimova N, Fataliyev H, Heydarov E, Lezgiyev Y, Isgandarova S. Development of a model and optimization of the interaction of factors in the grain malting process and its application in the production of functional beverages. East-Eur J Enterp Technol. 2023;5(11-125):43-56. doi: 10.15587/1729-4061.2023.289421.

Received 15.12.2025 **Reviewed 05.01.2026**

Revised 22.12.2025 **Approved 03.03.2026**