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Use of fruits of newly selected Armenian varieties of apricot in functional food

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ABSTRACT

Background: This study identifies and characterizes local apricot varieties from Armenia's gene pool, exhibiting delayed ripening and exceptional qualitative traits, adaptable to the country's diverse elevations (800-2000m above sea level). Our research selected nine early ripening varieties optimized for Armenia's vertical zonation, mitigating spring frost risks. These varieties will establish new, ecologically sustainable orchards, extending the harvest period from 50-55 days to 100-110 days. The high-quality fruits produced will provide a stable, long-term supply for processing industries, enhancing product quality and nutritional value. Notably, these apricots offer essential health benefits as functional food, rich in vital nutrients.

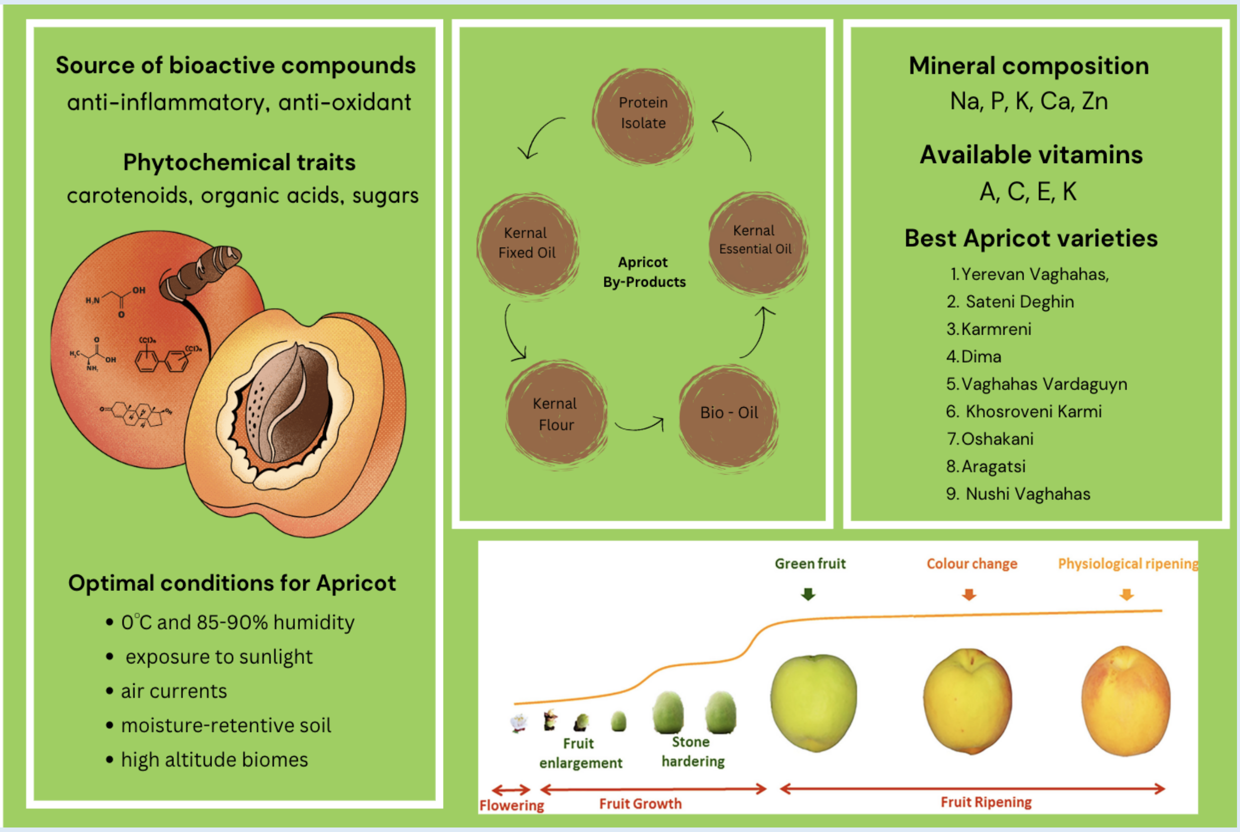
Objective: Responding to climate change and global warming impacts in Armenia, this study identified nine high-potential apricot varieties from the local gene pool, distinguished by their diverse ripening times, superior quality traits, and adaptability. These varieties are suited for establishing resilient apricot orchards across Armenia's vertical zonation, expanding cultivation into the high agricultural zone (800-2000 meters above sea level). This strategic approach will enhance annual harvest stability, ensure consistent fruit supply for processing industries, and optimize the utilization of essential nutrients and health benefits as a functional food.

Material and methods: For this study, 9 apricot cultivars (Yerevani Vaghahas, Vaghahas Vardaguyn, Nushi Vaghahas, Sateni Deghin, Dima, Khosroveni Karmir, Oshakani, Karmreni, and Aragatsi) were selected from the Armenian gene pool based on their unique ripening times, disease resistance, and desirable fruit characteristics. Yerevani Vaghahas served as the control variety due to its high yield, attractive fruit habitus, and prevalence (80%) in Armenian apricot plantations. A comparative study was conducted across different elevations (800-2000 meters above sea level) to evaluate cultivar performance.

Results: Comprehensive studies have identified optimal apricot varieties for vertical zonation, enabling the establishment of resilient orchards. This strategic approach ensures extended harvest periods (50-55 to 100-110 days), ecologically clean production, and high-quality fruits with enhanced nutritional value. This innovative approach ensures a stable, long-term supply of premium apricots, supporting regional food security, economic growth, and human well-being.

Conclusion: Building on decades of research in the Republic (1931-2023) and insights from global warming data, we conclude that cultivating carefully selected apricot varieties in high-altitude zones (1400-2000m) offers a strategic solution. This targeted approach optimizes physiological adaptability, economic viability, and production efficiency. While minimizing climate-related risks, this method also yields high-quality fruits rich in eco-friendly raw materials, ideal for functional food products, pharmaceutical applications, cosmetic development, and other fields.

Keywords: Armenian apricot, zonality, variety, dried fruit, biochemical characteristics, vitamin



Graphical Abstract: Use of fruits of newly selected Armenian varieties of apricot in functional food

INTRODUCTION:

Armenia's significant contributions to the development of the apricot tree, preservation of its gene pool, and creation of internationally recognized varieties are widely acknowledged. The country has hosted prominent international conferences, including the 6th and 15th World Apricot Conferences (1977 and 2011, respectively) and conferences in 1967 and 2007. These events highlight Armenia's leadership in advancing apricot research and addressing contemporary agricultural demands. Since 2007, the international scientific community has recognized Apricots as an Armenian brand. Prunus armeniaca, a member of the Rosaceae family, is extensively cultivated in Mediterranean countries, Russia, Pakistan, the United States, and Iran [1, 28].

Armenia is an ancient center of apricot cultivation and a significant apricot-producing country. According to the RA Statistical Committee's 2023 data, the area of orchards and berry fields is 46,228 ha, of which stone fruits occupy 25,475 ha (apricots approximately 10,500 ha. or 40% of stone fruits). The total harvest amounted to 3,611,757 centners, of which 2,222,572 centners were obtained from stones. Apricot cultivation in Armenia is expanding through vertical zonation, mirroring global trends in industrial apricot production.

Apricots hold a unique position among stone fruits due to their versatility and substantial functional potential. The growing demand for functional foods [40-44] reflects increasing consumer interest in health-conscious products offering benefits beyond basic nutrition." Apricots are a nutrient-rich fruit, packed with antioxidants, fiber, potassium, and essential vitamins (A, C, E), contributing to disease prevention [45]. Fresh apricots are available from May to September, while dried apricots are accessible year-round [2, 3, 18]. Their unique aroma makes them ideal for jams, juices, wines, and sauces. Apricots have been used in traditional medicine for various disease treatments [26]. Apricot stones, a by-product, can be consumed raw or roasted as a snack [21, 28, 30].

Research highlights apricot seeds as a potential source of oil for dietary and cosmetic applications [6,11]. The kernel's valuable oil is crucial in the oleochemical industry for refining oils, benzaldehyde, and cosmetics [23, 24]. Apricot kernels possess antioxidant, anti-asthmatic, and anti-spasmodic properties, making them valuable in Chinese traditional medicine [21]. Shredded apricot stone shells can also be used for water filtration. Nutritionists are increasingly interested in exploring edibles enriched with bioactive substances for nutraceutical properties. Apricots are rich in sugars (60%+), proteins (8%), crude fibers (11.50%), crude fats (2%), total minerals (4%), vitamins (A, C, K, and B complex) and organic acids (citric acid and malic acid). Apricot fruit pulp contains significant phenolic compounds and flavonoids, making them a valuable functional food. Studies link dietary fiber in apricots to reduced cardiovascular disease risk [10, 13]. Advances in food and nutrition have shifted consumer preferences toward functional and nutritionally rich foods [30].

Apricots have diversified effects on liver regeneration and myocardial ischemia reperfusion [7, 22, 26]. Further research is necessary to fully understand apricot's medicinal effects, particularly in treating eating disorders [4, 5, 8]. Recent studies have identified and characterized the polyphenolic constituents of apricot leaves, a by-product of Prunus armeniaca cultivation [27].

Despite limited literature on Prunus armeniaca leaves, their polyphenolic constituents were identified and characterized using LC-ESI-QTOF-MS/MS and in vitro biological screening [27]. Apricot kernel shells (AKS) represent a significant source of biological carbohydrate waste [12]. Geographically distinct wild apricot fruits exhibit high antioxidant polyphenolic compound concentrations, showcasing their promotional potential [13,25]. Apricots demonstrate diverse pharmacological effects, including anticancer, cardiovascular protection, hemostasis regulation, antiparasitic, antiaging, antiatherosclerosis, renoprotective, hepatoprotective, and antioxidant properties [20, 29 31].

However, bitter apricot kernels contain amounts of toxic hydrogen cyanide, despite their traditional use in treating asthma, cough, and constipation [17]. Apricot stones are a valuable by-product and have various industrial applications [9,14,15,16,19]. Historically, high-quality dried apricots were a prominent trade product with neighboring countries [18]. Although most apricots were consumed locally, a small portion was exported in dried form. Apricot genotypes possess unique traits, such as High Total Soluble Solids (TSS) content, late and extended flowering and fruit maturity, and a white kernel phenotype. These characteristics enable the global expansion of apricot production [16,17]. Recent publications (2023) highlight the valuable properties and antioxidant characteristics of apricot processing by-products in various applications [32-39].

MATERIALS AND METHODS

This study examined the biological, physiological, and economic features of apricot varieties, focusing on phenological stages, cold resistance, yield, and mechanical analysis of fresh and processed fruits. Methods were based on established programs and guidelines from A.R. Khachatryan (2002), G.A. Lobanov (1973), E.N. Sedov (1999), Yermakov AI (1987), and B.A. Dospechov (1985) programs.

The research was conducted at the "Viticulture, Winemaking and Fruit Growing" scientific center's experimental bases and laboratories, encompassing sensory evaluation of fresh and processed fruits, phenological stage assessment, mechanical characteristic analysis, and biochemical and bioactive substance analysis. This article synthesizes the research findings of various scientists: Kostina (1931), African (1936), Dilanyan (1943), Eisenberg (1970), Yesayan (1977), Morikyan (1988), Abovyan (1990), Snapyan (2007) and compares them with our research results (2014-2023). Apricot variety approbation (2017-2023) was conducted at the Scientific Center of Agriculture, Ministry of Economy, Republic of Armenia, Nalbandian expert base, NAUA "Scientific Center of Viticulture of the Republic of Armenia, and Farms and homesteads in various agricultural zones of the Republic.

RESULTS

Our result analyzed the composition of biologically active substances in 45 Armenian apricot varieties. The top-performing varieties for establishing new orchards were: Yerevani Vaghahas, Sateni Deghin, Karmreni, Dima, Vaghahas Vardaguyn, Khosroveni Karmir, Oshakani, Aragatsi, and Nushi Vaghahas. Notable varieties exhibited high levels of Flavonoids (FC): 18.5 ml/%, Chlorogenic acid (CGA): 120.0 ml/%, Phenolic acids (PA) 5.59 ml % (Khosroveni Karmir), Vitamin C: 6.6 ml/% (Oshakani), Group B vitamins: Thiamin: 0.8 ml/% (Sateni Deghin), Niacin: 10.9 ml/% (Oshakani), Pyridine: 0.55 ml/% (Sateni Deghin) and Inosite: 950ml/% (Oshakani). These substances contribute to improved metabolism, immune and nervous system regulation, antioxidant activity, and more. Varieties excelled in dry matter content in the kernel: 96.02% (Dima), dry matter content in pulp: 25.51% (Karmreni), total solids and fats in the kernel: 7.46% and 57.01% (Nushi Vaghahas), organic acid content: 2.1% (Nakhichevan Karmir), protein content in pulp: 1.07% (Karmreni). According to the evaluation of the 5-point system of the fresh tasting of fruits, Yerevani vaghahas and Dima varieties (5 points), Karmreni and Dima varieties stand out (5 points) in the results of the dry apricot tasting. According to the taste of juices, jams, compotes, Vaghahas vardaguyn (5 points).

DISCUSSION

Armenian apricots are renowned for their taste, richness in chemical and biologically active substances, and suitability for processing and fresh consumption. The chemical composition of apricot pulp and kernel supports healthy human diets and functional food development. The dynamics of (DM) dry matter [accumulation and anatomical-morphological data show that depending on the winter weather conditions, apricot flower buds develop even during the rest period of the plant. The intensity of their further growth is directly related to cold resistance. It is significantly dependent on thermal factors.

It was found that for the normal development of the archesporial tissues in flower pollen, a temperature as low as +5° is necessary, the upper limit of which is +18°, and the lower one is -2°. For unicellular pollen, it coincides with biological 0°. Flower buds exhibit maximum cold resistance during the male archespore stage. The longer this period lasts, the more frost-resistant the variety is.

The speed of winter-spring development of flower buds can become an indicator of their cold resistance. Apricot cultivars whose parental forms have slow bud development, and a long male archespore period can be cold-resistant. Physicochemical characteristics of fruits at different stages of growth and ripening have important theoretical and practical significance.

Long-term research reveals that spring frosts recur every 3-4 years in low-lying areas, notably the Ararat Plain, coinciding with apricot flowering. This results in devastating crop losses, often reaching 100%. To mitigate this issue, we recommend relocating apricot cultivation from low-lying areas (800-1000m) to higher altitudes (1400-2000m). This shift offers several benefits including delayed apricot vegetation in high-altitude zones (15-30 days), significantly reduced risk of late spring frosts, stabilized tree yields, and increased garden productivity.

Table 1. The course of apricot phenological stages in the lowland zone (2014-2023 averaged data)

Name of Varieties	Swelling of Generative Buds	Blossom		Ripening		End of the fall	Vegetation Period Day
		Beginning	End	Beginning	End		
Yerevani vaghahas	23/2	15/3	23/03	13/06	25/06	22/11	273
Vaghahas vardaguyn	26/2	20/3	29/3	12/06	21/6	22/11	269
Nushi vaghahas	25/02	20/03	02/04	14/06	23/06	28/11	245
Sateni deghin	23/02	22/03	30/03	25/06	10/07	27/11	275
Dima	28/2	23/3	04/4	27/6	10/7	29/11	274
Khosroveni karmir	24/2	22/3	31/3	26/6	10/7	26/11	273
Oshakani	02/3	23/3	04/4	25/6	05/7	27/11	269
Karmreni	01/3	24/3	01/4	29/6	14/7	30/11	271
Aragatsi	01/3	25/3	06/4	30/6	15/7	30/11	272

Table 2. The process of apricot phenological stages in the lowland zone (1977-86)

Name of Varieties	Swelling of Generative Buds	Blossom		Ripening		End of the fall	Vegetation Period Day
		Beginning	End	Beginning	End		
Yerevani vaghahas	13/03	04/04	10/04	25/06	05/07	16/11	251
Vaghahas vardaguyn	16/03	03/04	10/04	26/06	05/07	17/11	248
Nushi vaghahas	13/03	02/04	09/04	20/06	30/06	17/11	250
Sateni deghin	14/03	05/04	11/04	05/07	15/07	18/11	248
Dima	15/03	04/04	12/04	01/1	10/07	17/11	248
Khosroveni karmir	15/03	07/04	14/04	05/07	15/07	17/11	249
Oshakani	16/03	05/04	12/04	15/07	24/07	17/11	248
Karmreni	14/03	05/04	12/04	10/07	22/07	17/11	257
Aragatsi	17/03	06/04	13/04	15/07	25/07	16/11	246

Comparing apricot phenology between 1977-1986 and 2014-2023, our analysis reveals a significant shift. Vegetation now begins 15-20 days earlier, between February 23 and March 2, compared to March

13-17 in the earlier period. While vegetation duration remains relatively consistent (246-257 days and 246-275 days, respectively), apricot varieties' main phenological stages occur earlier and with increased intensity, mirroring global warming trends.

Figure 1 and 2 illustrates the impact of global warming on apricot cultivation. Specifically, the Sateni Deghin variety's beginning of vegetation shifted from March 13 (1977-1986) to February 26 (2014-2023), indicating a 15-day advancement over the past 40 years. Similarly, fruit ripening timelines exhibited a comparable trend, demonstrating the significant effects of climate change on apricot development.

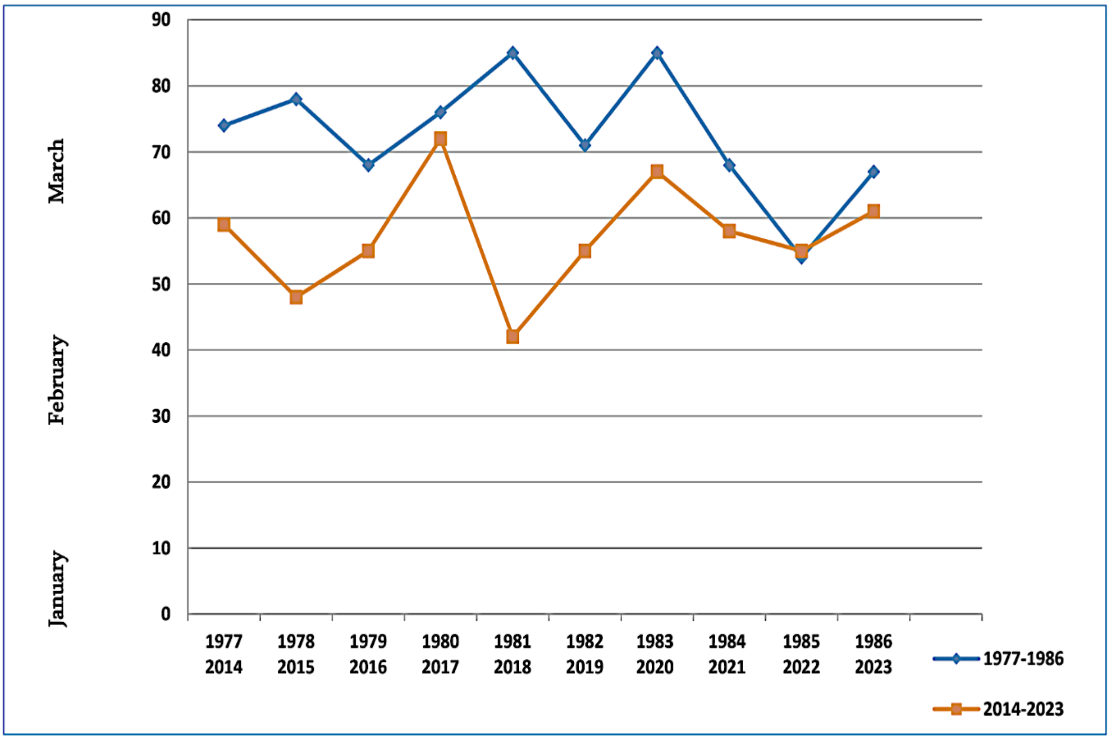


Figure 1. Comparison chart of the beginning of vegetation of the yellow Sateni variety of apricot by year (1977-1986 and 2014-2023

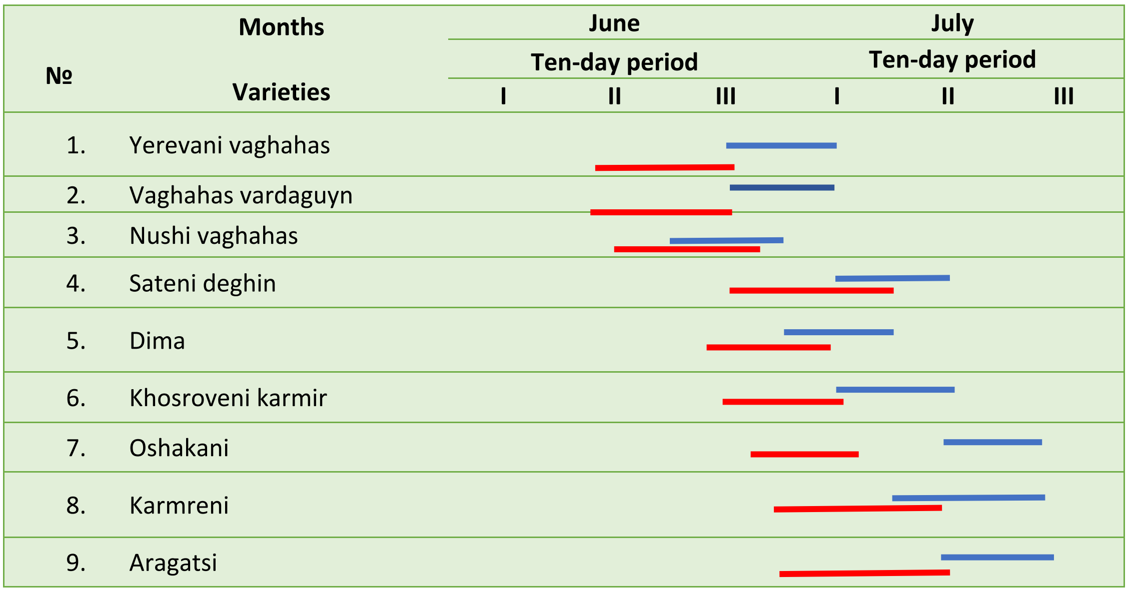


Figure 2. Comparative image of different periods of physiological ripening of apricot fruits (1977-1986, 2014-2023 with averaged data)

Note: **1977-1986** **2014-2023**

Figure 2 illustrates that, compared to 40 years ago, apricot varieties now reach physiological ripeness 8-13 days earlier. Thus, in 1977-1986, the beginning of the ripening of the Yerevani vaghahas variety, on average, took place on June 23, and the end on July 5. Meanwhile, in 2014-2023, on June 13 and 25. Figure 2 demonstrates that all presented varieties thrive in the high-altitude zone (1400-2000m above sea level) of RA, characterized by favorable soil and climate conditions. Notably, the foothill zone's temperature conditions mirror those of the Ararat Plain. In contrast, apricot trees in the foothills bloom approximately 10 days later, often avoiding these late frosts. In the conditions of the foothill zone, the processes of maturation of different organs of the tree take place more intensively, because of which more dry materials are accumulated, which is the basis for increasing the cold resistance of trees. In the foothill zone, the presence of air currents is also a positive feature, which prevents the accumulation of masses of cold currents in the winter, and the location of pathogens and insects during the summer, as well as the intensity of direct sunlight, is greater, which contributes to the bright coloring of the fruits and to their being stronger, firmer and squeamish.

Table 3. Cold resistance of vegetative and generative buds of apricot cultivars (-30°C)

№	Variety	The Studied Buds, pcs		Frosted Buds, pcs/%			
		Vegetative	Generative	Vegetative		Generative	
				pcs	%	pcs	%
	1	2	3	4	5	6	7
1	Yerevani vaghahas	130	180	13	10	120	66
2	Vaghahas vardaguyn	107	156	41	38	98	64
3	Nushi vaghahas	100	200	23	23	126	63
4	Sateni deghin	103	125	16	15	77	62
5	Dima	100	200	49	49	122	61
6	Khosroveni karmir	92	140	22	24	110	71
7	Oshakani	80	93	24	30	65	70
8	Karmreni	100	152	30	30	144	95
9	Aragatsi	100	144	8	8	102	71

Table 3 reveals the frost damage of vegetative and generative buds of apricot varieties at -30°C. Particularly, generative buds are less frost-resistant, with damage ranging from 61-95%, whereas vegetative buds sustained damage between 8- 49%. The Dima and Sateni deghin varieties showed relatively higher frost tolerance, with 61% and 62% damage to their generative buds, respectively. In contrast, the Karmreni variety proved most susceptible, with 95% damage. Therefore, it is advisable to avoid planting Karmreni in high-altitude areas. During ripening, apricot fruits undergo significant changes. The weight and volume increase substantially before ripening, while the specific weight decreases and then increases in overripe fruits. Conversely, the stone weight increases, but its ratio to fruit weight decreases. Moreover, the dry matter content rises significantly, especially two weeks before technical ripening.

Table 4. Average data of mechanical analysis of fruit, kernel, and pulp

№	Name of varieties	Fruit weight, gr.	Stone weight, gr.	Pulp weight, gr.	The ratio of the stone to the fruit, %	The ratio of kernel to stone, %
1	Yerevani vaghahas	70	2.2	0.6	3.1	27
2	Vaghahas vardaguyn	50	2.6	0.7	5.2	35
3	Nushi vaghahas	50	2.0	0.8	4.0	40
4	Sateni deghin	35	2.0	1.0	5.8	50
5	Dima	41.6	3.0	1.3	7.2	24
6	Khosroveni karmir	50	2.1	0.7	4.2	33
7	Oshakani	50	2.2	0.8	5.4	36
8	Karmreni	30	1.7	0.7	5.7	41
9	Aragatsi	60	2.4	1.2	4.0	50

According to Table 4, the Yerevani Vaghahas and Aragatsi varieties stand out for their relatively large fruits, weighing 70.0g and 60.0g, respectively. The ratio of stone weight to fruit varies significantly among varieties, ranging from 3.1% (Yerevani Vaghahas) to 7.2% (Dima). Similarly, kernel weight as a percentage of fruit weight differs among varieties, from 0.6% (Yerevani Vaghahas) to 1.3% (Dima). Notably, the kernel-to-stone ratio also exhibits considerable variation, spanning from 24% (Dima) to 50% (Sateni Deghin and Aragatsi).

Table 5. Average data of biochemical analysis of apricot kernel pulp

№	Name of varieties	Amount in the pulp, %		
		Dry matter (DM)	Total sugar (TS)	Fats
1	Yerevani vaghahas	95.32	5.98	41.96
2	Vaghahas vardaguyn	93.01	4.16	47.55
3	Nushi vaghahas	95.13	7.46	57.01
4	Sateni deghin	95.32	5.13	45.76
5	Dima	96.02	6.27	53.28
6	Khosroveni karmir	95.27	5.56	50.62
7	Oshakani	94.03	3.91	48.35
8	Karmreni	94.65	3.26	55.16
9	Aragatsi	96.21	4.83	46.21

Table 5 presents the biochemical analysis of apricot stone kernels, revealing significant variations among varieties. The dry matter (DM) content ranged from 94.65% (Karmreni) to 96.2% (Dima), while total solids (TS) varied from 3.26% (Karmreni) to 6.27% (Dima). Notably, total fats ranged from 41.96% (Yerevani Vaghahas) to 57.01% (Nushi Vaghahas), surpassing even almond stone kernel fat content in some varieties. The unique biochemical composition of apricot stone kernels makes them an excellent source of essential nutrients, equivalent to almond kernels. These kernels offer numerous health benefits, including immune system support, cancer prevention, and hypertension management. Additionally, apricot kernels are valued for their protein, carbohydrate, and vitamin content, making them suitable for traditional medicine and functional food applications. The processing industry can also leverage apricot kernels through solvent extraction using microwave-assisted ultra-cooling, enabling the separation of diverse bioactive compounds. Varieties with high bioactive compound content in their fruit pulp, such as sugars, organic acids, and proteins, are ideal for fresh consumption and processing. Armenian apricots stand out globally for their distinctive taste and exceptional quality indicators, rendering them a valuable resource.

Table 6. The data of the biochemical analyses of the fruit pulp

№	Variety	Dry matter DM	Total sugar TS	Sucrose	Titratable Acid (TA)	Index	Protein	Ashes
		%	%	%	%	%	%	%
	1	2	3	4	7	8	9	10
1	Yerevani vaghahas	14.8-17.8	9.6-13.6	5.95-8.9	0.36-0.74	13.61	0.94	0.58
2	Vaghahas vardaguyn	12.5-18.2	11.2-15.1	8.58-12.7	0.39-1.5	23.79	0.62	0.62
3	Nushi vaghahas	14.6-17.6	9.3-13.8	7.8-10.7	0.8-0.85	16.94	0.83	0.85
4	Sateni deghin	16.5-22.4	10.5-18.7-	5.29-14.5	0.3-0.51	38.5	0.90	0.67
5	Dima	17.8-19.6	12.8-18.3	9.2-14.4	0.51-0.9	32.92	0.87	0.65
6	Khosroveni karmir	15.5-19.7	12.5-17.1	7.01-8.14	0.42-0.62	16.47	0.99	0.65
7	Oshakani	17.9-20.5	12.3-17.9	7.15-14.2	0.4-0.52	28.13	0.95	0.62
8	Karmreni	22.4-25.5	14.8-18.7	9.7-13.3	0.29-0.91	42.22	1.07	0.98
9	Aragatsi	20.48-23.3	9.48-16.7	9.8-14.0	0.1-0.5	30.66	0.93	0.63

According to Table 6, Armenian apricot varieties exhibit significant variations in their biochemical composition. The dry matter (DM) content ranges from 13.5-18.2% in Vaghahas Vardaguyn to 22.4-25.5% in Aragatsi. Total solid (TS) varies from 9.3-13.8% in Nushi Vaghahas to 14.8-18.7% in Karmreni. Specifically, the Khosroveni Karmir, Sateni Deghin, Dima, and Oshakani varieties stand out for their high sugar content, ranging from 10.5-18.7%. Acidity levels also differ among varieties, with Aragatsi displaying the lowest acidity (0.1-0.5%) and Vaghahas Vardaguyn the highest (0.9-1.3%). The sugar-acid index ranges from 13.61 in Yerevani Vaghahas to 42.22 in Karmreni. Karmreni variety excels in protein content (1.07%), while other varieties range from 0.62% (Vaghahas Vardaguyn) to 0.99% (Khosroveni Karmir). Ash content varies from 0.58% (Yerevani Vaghahas) to 0.98% (Karmreni).

These findings demonstrate that Armenian apricot varieties are rich in dry matter, carbohydrates, proteins, and ash, making them attractive ingredients for functional food applications. The multi-year data from the biochemical analysis highlights the potential of Armenian apricots as a valuable resource for the food industry.

Table 7. Analysis of bioactive substances (mg/%)

№	Variety	Free Catechins (FC)	Chlorogenic acid (CGA)	Vitamin C	B group vitamins				
					Thiamine	Pantothenic acid (PA)	Nicotinic acid (NA)	Pyridine	Inosite
	1	2	3	4	5	6	7	8	9
1	Yerevani vaghahas	12.2	100	3.0	0.35	1.65	10.4	0.2	745
2	Vaghahas vardaguyn	18.5	120	3.6	0.76	5.59	4.72	0.37	781.2
3	Nushi vaghahas	7.8	61	3.7	0.53	3.8	5.24	0.45	764
4	Sateni deghin	6.7	43	3.0	0.8	3.95	10.9	0.55	700
5	Dima	17.0	94	3.7	0.68	4.27	3.29	0.44	752
6	Khosroveni karmir	13.1	53	3.5	0.37	2.68	5.32	0.37	801
7	Oshakani	6.4	65	6.6	0.5	3,0	7.1	0.33	950
8	Karmreni	7.2	53	3.1	0.38	2,91	5.4	0.28	735
9	Aragatsi	5.45	57	2.4	0.49	4.4	8.5	0.47	773

The exceptional nutritional and medicinal value of apricot fruits can be attributed to their diverse biochemical compounds and significant reserves of bioactive substances. These active substances play a crucial role in enhancing human immunity and are preventing various diseases. Table 7 and Figure 7 illustrate the substantial variability in bioactive compounds among apricot varieties. Flavonoids (FC) range from 5.45 mg/% (Aragatsi) to 18.5 mg/% (Vaghahas Vardaguyn), with Vaghahas Vardaguyn and Dima varieties exhibiting particularly high levels. Chlorogenic acid (CGA) content is also remarkable, with Vaghahas Vardaguyn (120 mg/%), Yerevani Vaghahas (100 mg/%), and Dima (94 mg/%) varieties leading the way. Vitamin C levels vary from 2.4 mg/% (Aragatsi) to 6.6 mg/% (Oshakani), while thiamine content ranges from 0.35 to 0.8 mg/%, with Sateni Deghin (0.8 mg/%) and Vaghahas Vardaguyn (0.78 mg/%) varieties showing the highest levels.

Other essential bioactive compounds, such as phenolic acids (PA), nicotinic acid, pyridine, and inositol, also exhibit significant variability among varieties. These findings highlight the unique composition of bioactive substances in each variety, influenced by factors like local soil, climate, agronomic practices, and nutritional conditions. Apricot fruits are valued for their versatility, being consumed fresh or processed into various products, including jam, confiture, povidlo, dried fruit, compote, juice, and paste. For fresh consumption, characteristics like fruit size, color, ripeness, pulp firmness, and sweetness are essential. Optimal storage conditions for apricots are 0^{o} C and 85-90% humidity. Processing apricot fruits enables year-round availability, overcoming their relatively short shelf life. Table 8 shows the taste ratings of processed products.

Table 8. Taste evaluations of fresh and processed apricot fruits.

№	Variety	Habitus	Pulp composition	Smell	Taste	Overall rating	Dry fruit	Con-fiture	Com-pote	Juice
	1	2	3	4	5	6	7	8	9	10
1	Yerevani vaghahas	5.0	5.0	5.0	5.0	5.0	3.5	5.0	5.0	5.0
2	Vaghahas vardaguyn	4.0	4.0	4.5	4.7	4.2	3.5	4.0	4.9	4.0
3	Nushi vaghahas	4.0	4.0	4.0	4.0	4.0	3.5	3.0	3.5	3.5
4	Sateni deghin	4.0	4.0	4.0	4.0	4.0	4.8	3.6	3.0	3.0
5	Dima	5.0	5.0	5.0	5.0	5.0	5.0	4.0	3.0	5.0
6	Khosroveni karmir	4.2	4.2	4.0	4.0	4.2	4.8	3.2	4.0	4.5
7	Oshakani	4.5	4.5	4.5	4.5	4.5	5.0	4.5	4.5	4.5
8	Karmreni	4.0	4.0	4.0	4.0	4.0	5.0	4.0	4.0	4.0
9	Aragatsi	4.5	4.3	4.5	4.5	4.5	4.6	4.8	3.0	3.0

Table 8 shows a sensory evaluation of selected Armenian apricot varieties was conducted using a 5-point system, assessing fresh fruit habits, pulp composition, aroma, and taste. Additionally, processed products such as dried fruits, jams, compotes, and juices were evaluated based on the same principles. The results showed that Yerevani Vaghahas variety excelled in all indicators, scoring 5 points, except for dried fruits, which received 3.5 points. Dima variety ranked second, with slightly lower scores for compotes (3 points) and jams (4 points), while other varieties demonstrated comparable quality. Our research takes an innovative approach by comprehensively assessing the biochemical and nutritional composition of Armenian apricot varieties for functional food applications.

This led to the identification of nine outstanding varieties- Yerevan Vaghahas, Sateni Deghin, Karmreni, Dima, Vaghahas Vardaguyn, Khosroveni Karmi, Oshakani, Aragatsi, and Nushi Vaghahas-characterized by unique profiles of biologically active substances. Notably, these varieties exhibit high levels of phenolic compounds, chlorogenic acid, and proanthocyanidins, as well as significant amounts of vitamins C and B, supporting their antioxidant properties and health benefits.

These findings contribute significantly to the understanding of Armenian apricots as functional foods, highlighting their potential to adapt to climate change through tailored cultivation strategies. For instance, establishing orchards at varied altitudes can optimize ripening and stability. This work represents a crucial step forward in addressing climate resilience in agriculture and enhancing the bioactive profile of apricots, paving the way for innovative applications in functional food and agriculture.

CONCLUSION

Our research and analysis yielded significant conclusions. A decade-long comparison of apricot varieties' phenological stages (2014-2023) with historical data (1977-1986) revealed a 15–20-day advancement in physiological processes, aligning with global warming trends. Additionally, biochemical analyses demonstrated that Armenian apricot varieties are rich in dry matter, carbohydrates, proteins, and ash, making them valuable ingredients for functional food applications. All studied varieties possess sufficient bioactive substances due to varietal, horticultural climate, and agrotechnical factors, enhancing their value for functional food production. To optimize apricot production, new orchards will be established in Armenia's high-altitude regions, leveraging vertical zonation to ensure a prolonged availability (100-110 days) of high-quality apricots. Recommended varieties include Yerevani Vaghahas, Sateni Deghin, Dima, Khosroveni Karmir, Oshakani, Karmreni, and Aragatsi, representing a novel approach to combating climate change. Our research underscores the strategic importance of these Armenian apricot varieties, showcasing their comprehensive biochemical composition, bioactive substances, and adaptability to climate change, ensuring long-term stable yields and highlighting their potential for functional food applications.

List of abbreviations: AKS: Kernel shell, CGA: Chlorogenic acid, DM: Dry matter, FC: Free catechins NA: Nicotinic acid, PA: Pantothenic Acid, TA: Titratable Acid, TS: Total sugar, TSS: Total Soluble Solids.

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Authors' contributions: GS and DB discussed the idea of the article and compiled the content. DB and ES studied many literary sources. AM, VM, and LO performed analyses. GS, AM, and VM made calculations and compiled tables. GS edited the article. CO participated in editing, formatting of article and designing graphical abstract. All authors read and approved the final version of the manuscript.

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