Research Article **Open Access**

Preliminary analysis of growth potential and prospects of two Iranian pistachio varieties as functional food ingredients in Armenia

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Submission Date: June 26th, 2024**; Acceptance Date:** September 8th**,** 2024**; Publication Date:** September 12th, 2024

Please cite this article as: Stepanyan E., Beketovski D., Ter-Grigoryan A., Badalyan A., Minasyan K., Gasparyan N. Preliminary analysis of growth potential and prospects of two Iranian pistachio varieties as a functional food ingredients in Armenia. *Bioactive Compounds in Health and Disease* 2024; 7(9): 398-417. DOI: https://www.doi.org/10.31989/bchd.v7i9.1408

ABSTRACT

Background: Two of the best Iranian pistachio varieties were brought to the Republic of Armenia for preliminary research on the possibility of cultivation in the conditions of the Republic of Armenia. For this purpose, a plot of land with an area of one hectare was selected, ameliorative and agrotechnical measures were carried out, and the garden was planted in two stages with the Iranian "Akbari" (large yielding) and " Ahmad Aghaei " (bearing) varieties on the root of the Pistacia vera L. species.

Objective: The pistachio crop, especially in recent years, enjoys a growing demand in the world market. In addition, pistachio crop cultivation has several economic advantages: economic efficiency of cultivation, productivity, product quality, and pistachio, in addition to being delicious, also has a number of positive medical benefits, for example, it is rich in vitamins B1 and B6, digestible fats, calcium, potassium, magnesium, copper, phosphorus. In recent years, the products

of Iran's phytosterol gardens have taken first place in the world in terms of export volume. Several valuable varieties were created there, which are being tried to be introduced into the assortment in the Republic of Armenia.

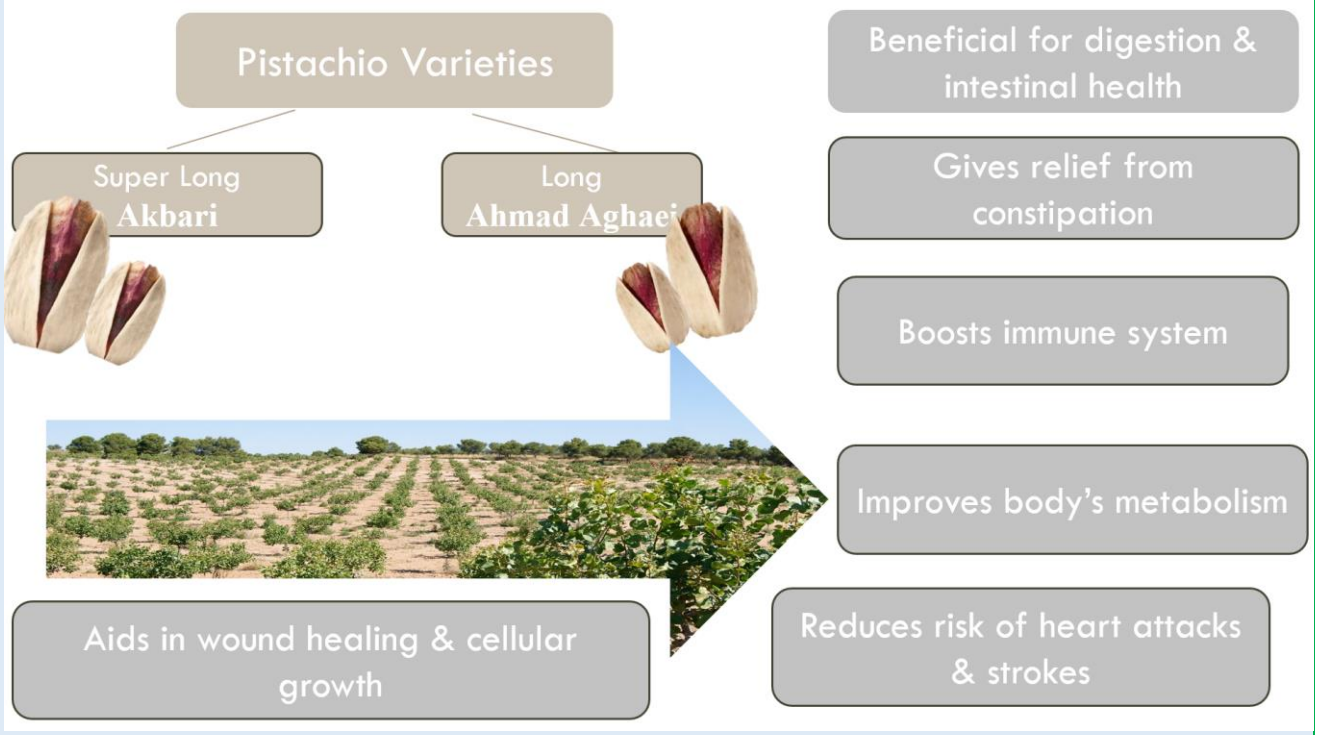
Methods: The research was conducted following the methodological guidelines of Khachatryan, Labanov, and Dospechov, as adopted in the Republic of Armenia. The soil was analyzed in the soil science laboratory in accordance with the requirements of the customs services of the European Union, CIS. In order to evaluate the quality of the harvest, the obtained fruits were sent to "Standard Dialog" LLC for laboratory examination. The contents of the following substances were determined: intestinal yeast bacteria, fungi, heavy metals, pesticide residues, dry matter, carbohydrates, proteins, and fats.In order to substantiate the experiment, a study of several pistachio orchards of the Republic of Armenia was carried out. Research and selection of the most favorable area for growing pistachio crops in the Republic of Armenia was carried out.

Results: According to the results of the survey of favorable soil and climate conditions for pistachio growing, the conditions of the territories of Armavir Marz were revealed. an analysis of the relative air humidity data for the years 2009-2021 was carried out. It was found that during the mentioned period, that indicator had a significant decreasing trend in the area where the garden was planted, which is very favorable for the cultivation of this crop. Soil samples were taken on 06.04.22, 09.07.22, and 02.08 2022 to identify the strategy for the implementation of agrotechnical measures. The first two samples were taken from a depth of 70 cm, the third from a depth of 50 cm, and were submitted to "Ecoplant Agricultural Laboratory" for research. In all areas, ions were found in different concentrations: calcium, magnesium, potassium, phosphorus, iron, and zinc in the first and second, nitrogen in the second and third, and copper in the first. To determine the degree of intensity of pistachio seedling's growth, periodic measurements were made in areas A, D, and E to determine their total height and trunk thickness at 10 cm above the soil surface. Areas A, D, and E, each containing 10 plants with four replicates, were selected for measurements. The results of the study of the nutritional value of the kernel content of the two cultivars show that their dry matter content ranges from 96.82 to 96.88, which is an insignificant difference. Also, in terms of fat content, the difference is not significant: 45.45 and 44.53. At the same time, Akbar cultivar differs significantly in protein content by 3.16%.

Conclusions: Based on the results of soil and climate studies, areas for pistachio cultivation were selected in the Armavir region. The large-fruited varieties "Akbari" and " Ahmad Aghaei " were selected from Iranian pistachio varieties. P. vulgare seedlings grew best in plot E2 3.8. Seedlings grew better in the same area. The Ahmad aghaei variety had the best survival rate of 85%. The Akbar variety was the leader in terms of protein content.

Pistachio culture has certain prospects for further development under the conditions of the Republic of Armenia. It is the basis for wide use as a functional food.

Keywords: pistachio, varieties, protein, biochemistry, oil, aflatoxin, export



INTRODUCTION

The pistachio has a rich history dating back millennia, with its earliest known mentions tracing back to around 7000 BC in what is now Turkey and the Middle East. The word 'pistachio' derives from the Italian 'pistah,' which in turn originates from Persian. [1]. Native to western Asia, pistachios were disseminated to the Middle East, Mediterranean countries, and Europe by traders [1-3]. Evidence of pistachio consumption dates back 300,000 years, with carbonized remains discovered from the Mousterian period in Kebara Cave, Israel, suggesting Neanderthal consumption. [4]. In more recent history, pistachio remains have been found in Afghanistan and southeastern Iran dating to the sixth millennium BC, suggesting these areas were among the first to cultivate pistachios where they grew wild [5,6]. The pistachio was widely cultivated in the ancient Persian Empire, from where its cultivation gradually expanded westward. Alongside almonds, pistachios were among the most popular nuts for human consumption, even earning a mention in the Bible [7].

Assyrians also used pistachios as medicine and antidote [8-11]. The pistachio arrived in Italy from Syria during the Roman period, around 1000 BC. In the first century, it was known as the "Syrian walnut" and commanded an extremely high price [12].

Pistachio plants are dioecious, and the wide genetic variation is primarily due to cross-pollination [17].

As of 2020, the United States is the world's leading producer of pistachios, contributing approximately 47% of global production. Following the U.S., Turkey produces 30%, and Iran accounts for 19% of the global pistachio

supply. In the U.S., commercial pistachio cultivation is predominantly concentrated in California, which accounts for 99% of the production, with additional contributions from Arizona and New Mexico [18].

In 2002, the Golden Hills and Lost Hills cultivars were introduced and now constitute more than 95% of the orchards planted in California over the past seven years. Iran boasts over 70 female pistachio cultivars and genotypes, alongside numerous male genotypes, making it a crucial source of pistachio germplasm globally. The most popular pistachio varieties in Iran include Koleghoochi, Akbari, Mumtaz, Badami Zarand, Sefid Pistachio Nogh, Ahmad Aghaei, Ouhadi, Khanjari Damghan, Shah Pasand Damghan, and Qazvini Pistachio [19].

Pistachios have been part of the human diet since prehistoric times, with a long history of consumption across various populations worldwide. Scientific consensus supports the notion that pistachio consumption has beneficial effects on human health [20]. Their widespread use underscores the nutritional value of this fruit. In this review, we explore the production, nutrient profile, phytochemical composition, and emerging research trends related to the health benefits of pistachio nuts (Pistacia vera L.) [21].

Pistachio consumption may play a role in modulating cognitive function and human gut microbiota, and it may also have beneficial effects on skin and retinal health [13]. Pistachio polyphenol extracts might influence enzymes involved in glucose regulation, potentially aiding in the management of type 2 diabetes. Additionally, these polyphenols have shown antimicrobial and antiviral potential [14].

This growing body of evidence supports the inclusion of pistachios in a nutritious diet that promotes a healthy lifestyle and aids the aging process. With their rich nutrient profile, pistachios are a tasty and versatile alternative to many foods [15-16]. They serve as healthy snacks and can enhance a variety of dishes, including spicy savory recipes, salads, and yogurts.

Pistachios are an excellent source of protein, fiber, monounsaturated fatty acids, minerals, and vitamins. They also contain carotenoids, phenolic acids, flavonoids, and anthocyanins [22]. The polyphenols in pistachios are particularly noted for their significant antioxidant and anti-inflammatory effects, as demonstrated by in vitro and in vivo animal studies, as well as clinical trials [23]. Health promotion and disease risk reduction are key benefits of functional foods, though the definition of functional foods remains somewhat ambiguous. Bioactive compounds, which naturally occurring in plants and animal products, perform various physiological functions within the body. They contribute to overall health and help prevent certain fatal diseases [24].

Pistachios, like all nuts, have a high-fat content, predominantly comprising mono- and polyunsaturated fatty acids, along with smaller amounts of saturated fatty acids. Oleic and linoleic acids together make up more than half of the total fat content in pistachios [25].

Additionally, pistachios are a good source of protein, constituting about 21% of their total weight. Roasted pistachios have a protein digestibility-corrected amino acid score (PDCAAS) of 81, which decreases to 73 when raw. The Digestible Indispensable Amino Acid Score (DIAAS) values for raw and roasted pistachios are 86 and 83, respectively. Pistachios are also a good source of fiber, containing 10% insoluble fiber and 0.3% soluble fiber [26].

Their practical benefits can cater to different population groups by promoting a healthy, balanced, and more plant-based diet. Furthermore, pistachios can be considered a promising functional food, addressing issues in both nutrition and sustainable agricultural production [27].

To evaluate the export potential of pistachio nuts, it is essential to adhere to the regulatory requirements of the target country. For instance, exporting to European Union countries necessitates that the quality indicators of pistachio nuts comply with the UNECE STANDARD DDP-09. These standard outlines several key provisions:

- **Definition of Produce**: Clearly identifying what constitutes pistachio nuts.
- **Provisions Concerning Quality**: Including minimum requirements, moisture content, and classification criteria.
- **Provisions Concerning Sizing**: Specifying acceptable size ranges for the nuts.
- **Provisions Concerning Tolerances**: Including quality tolerances for allowable defects and variations.
- **Provisions Concerning Presentation**: Ensuring uniformity and appropriate packaging.
- **Provisions Concerning Marking**: Including requirements for identification, nature of the produce, origin, commercial specifications, and official control marks. [28].

According to the international food standard Codex Alimentarius, the product shall be presented in one of the following styles: (a) Raw pistachio, and (b) Roasted pistachio. The product may be presented in one or more of the following sub-styles: (a) Salted, (b) Lime-juice treated.

It's important to know the regulation of aflatoxin levels in pistachios. Aflatoxins are mycotoxins produced by certain species of Aspergillus, which develop at high temperatures and humidity levels. Aflatoxins are genotoxic carcinogenic substances and may be present in a large number of foods. For substances of this type, there is no threshold below which no harmful effect is observed. No tolerable daily intake can therefore be set. Current scientific and technical knowledge and improvements in production and storage techniques do not prevent the development of these molds and consequently do not enable the presence of the aflatoxins in food to be eliminated entirely. It is, therefore, advisable to set limits as low as reasonably achievable [29].

MATERIALS AND METHODS

The research was carried out according to the methodological guidelines of Khachatryan, Labanov, and Dospechov adopted in the Republic of Armenia. The soil was analzsed in the soil science laboratory in accordance with the requirements of the customs services of the European Union, CIS. To evaluate the quality of the harvest, the fruits were sent to 'Standard Dialog' LLC for laboratory examination. The contents of the following substances were determined: intestinal yeast bacteria, fungi, heavy metals, pesticide residues, dry matter, carbohydrates, proteins, and fats. During the laboratory examination, the laboratory was guided by the following normative documents: GOST 31747-2012, GOST 31659-2012, GOST 10444.12-2013, STB EN 15763-2015, ST RK 2011-2010, GOST 30711-2001, GOST 29031-91, GOST 34111- 2017, GOST 8756.13.87, GOST 8756.21-89, where the methodology is described.

In order to substantiate the experiment, a study of several pistachio orchards of the Republic of Armenia was carried out. Research and selection of the most favorable area for growing pistachio crops in the Republic of Armenia was carried out. In the Armavir region, in the Artamet area of the Baghramyan community of Andersan LLC, a pistachio orchard with Iranian varieties was established, which has an area of 150 hectares. Since the pistachio is a dioecious plant, in order to increase the

efficiency of pollination, the arrangement of pollinating varieties in the garden was in the ratio of 9:1, where, based on the accepted rule, one male plant (stemmed trees) was planted for pollination for every 9 female plants (fruit trees). The seedlings were produced in the nursery farm of Andersan Ltd., grafting was carried out on Pistacia vera seed plants with coupons of Akbari and Ahmad Aghaei varieties brought from Iran. During 2023 and early in 2024, measurements were made on the development of two pistachio cultivars, planted 6 m (inter-row) x 3.5 m (inter-plant), with a 21 m2 feeding area. For centimetric measurements, 10 plants were randomly selected with four replicates of the experiment.

RESULTS

Analysis of Pistachio Cultivation Conditions in the Republic of Armenia

Analysis of Meteorological Data

According to averaged data from the RA Agromet Service spanning 2009 to 2021, the relative humidity of the air in Armenia exhibited distinct trends over the twelve-year period. The analysis reveals three notable stages:

1. **2009-2011:** During this period, relative air humidity slightly decreased and ranged between 65% to 55%.
2. **2011-2018:** There was a slight increase in relative air humidity by a few percentage points.
3. **2018-2021:** A sharp decrease in relative air humidity occurred, plummeting from 55% to 20%.

Overall, over the span of twelve years, the relative humidity decreased by 45%. This phenomenon correlates with global climate warming trends, indicating a shift towards drier conditions, potentially transitioning Armenia from a temperate climate zone to a dry steppe zone.

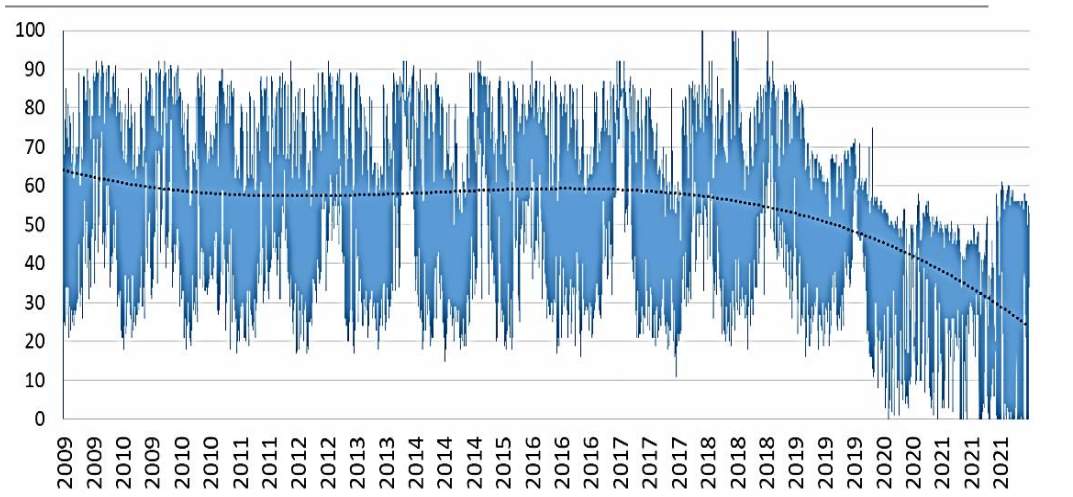


Figure 1: Annual average percentage of relative air humidity

The annual average percentage of relative air humidity in the years 2009-2021, according to the RA Hydrometeor Service Center, is presented in Figure 1.

- Agrochemical testing of soil conditions.

The soil analysis was conducted within the orchards of "Ander San" company, situated in the Armavir region of the Republic of Armenia.

Figure 2: The location of "Ander San" company's orchards in the Armavir Marz, Republic of Armenia

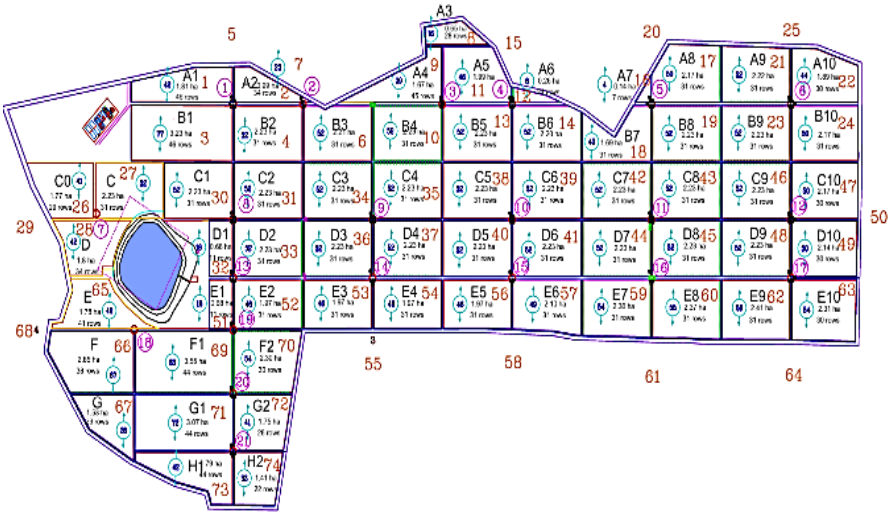


Figure 3: Map scheme of the orchards of “Ander San” LLC. The total area covers 150 hectares, divided into 74 sections labeled from A1 to H2 for efficient operational implementation.

The agrochemical analysis of soil was conducted across garden plots designated from east to west (rows 1 to 10) and north to south (columns A to H). Soil samples were taken at two different depths: 50 cm and 70 cm on April 6, 2022, and July 9, 2022. The analysis was performed at the Ecoplant Agro Laboratory. Key parameters analyzed include:

- Organic matter content (%)
- Soil pH (unit)
- Specific gravity (ms/sm)
- Macro and microelement content (mg/100g)
- Calcium (Ca)

Table 1: Agrochemical Analysis of Soil 1

Soil Expertise Results												
No.	Coordinates	Sample Depth (cm)	Organic matter	pH	EC	Ca^{2+}	Mg^{2+}	NO_3^-	K_2O	P_2O_5	Fe	Zn
	X;Y		%	units	mS/cm	mg/ 100g	mg/ 100g	mg/ 100g	mg/ 100g	mg/ 100g	mg/ 100g	mg/ 100g
1	40.11093 43.78272	0…70	2.3	7.78	1.773	164.5	17.16	8.79	10.3	5.29	0.149	0.027
2	40.10968 43.78226		1.85	7.76	2.105	225.4	2.59	3.14	2.97	5.1	0.167	0.039
3	40.10791 43.78183		3.57	8.12	0.604	33.2	4.9	6.79	6.55	4.12	0.128	0.1
4	40.10730 43.77732		2.64	9.04	0.3	5.2	0.88	1.86	3.99	6.56	0.187	0.093
5	40.10670 43.77620		4.02	8.46	0.315	12.99	2.28	3.76	3.56	4.75	0.139	0.131
6	40.10484 43.77587		1.38	9.91	0.505	6.74	7.63	1.5	3.01	2.66	0.138	0.066
7	40.10357 43.77519		0.92	8.95	0.186	8.66	4.48	1.48	1.88	5.94	0.131	0.071
8	40.10944 43.78521		0.87	8.07	2.315	221.2	12.87	3.25	75.2	9.86	0.18	0.021
9	40.10899 43.78642		2.6	8.64	0.316	10.9	6.04	3.1	14.3	6.35	0.123	0.058
10	40.10815 43.78987		2.6	8.44	0.415	23.09	4.7	2.41	3.67	4.2	0.123	0.069
11	40.11372 4378798		0.4	7.86	2.586	225.09	11.29	2.35	4.07	5.55	0.191	0.061
12	40.11511 43.78696		1.724	8.5	0.425	22.5	2.92	1.35	0.738	4.13	0.161	0.05

Table 2. Agrochemical Analysis of Soil 2

Soil expertise results											
No.	Site Description	Sample Depth (cm)	pH	EC	Ca^{2+}	Mg^{2+}	K_2O	P_2O_5	Fe	Zn	Cu
			units	mS/cm	mg/100g	mg/100g	mg/100g	mg/100g	mg/100g	mg/100g	mg/100g
1	Fld1#1 by highway	0…70	8.33	1.495	149.74	4.864	0.479	3.87	0.119	0.054	0.052
2	Fld1#2-E from road		8.38	3.26	189.64	10.37	2.79	5.14	0.168	0.052	0.135
3	Fld1#3-w		8.3	2.364	224.5	9.15	5.73	4.61	0.175	0.007	0.147
4	Fld2#1-NW corner		8.24	2.446	227.93	14.5	10.9	4.85	0.148	0.04	0.055
5	Fld2#2 mid		8.14	2.451	260.92	9.2	2.96	5.82	0.173	0.003	0.128
6	Fld2#3-SW		8.28	2.565	248.47	9.17	2.55	7.52	0.183	0.005	0.134
7	Middle between fld2 and fld3		8.12	2.131	229.4	9.38	3.63	5.06	0.189	0.02	0.186
8	Low SE of shop		8.61	0.321	12.83	3.02	8.04	3.84	0.121	0.072	0.057
9	Fld3#1 SE		8.44	0.75	64.98	4.09	1.68	5.7	0.116	0.087	0.095
10	Fld3#2 mid-bottom		8.69	0.376	18.6	3.12	4.38	5.54	0.119	0.076	0.072
11	Fld3#3-NW hill	0…70	7.99	2.084	250.83	6.54	3.41	6.93	0.178	0.034	0.117
12	South#1-near road		7.98	2.035	253.7	6.5	2.97	5.75	0.161	0.036	0.105

Soil expertise results											
13	South#2 road bend		8.62	0.392	18.92	4.09	2.72	5.81	0.175	0.042	0.131
14	South#3-hill		8.15	2.571	211.99	4.99	1.72	3.21	0.134	0.022	0.068
15	South#3-hill		7.99	2.249	253.35	11.5	2.29	3.34	0.163	0.025	0.059
16	South#3-hill		8.47	0.466	24.048	3.9	5.5	3.48	0.136	0.134	0.067
17	South#3-hill		8.1	2.473	261.93	12.26	4.15	5.53	0.173	0.062	0.127
18	South#3-hill		8.05	3.69	264.29	12.67	2.82	4.64	0.135	0.062	0.07
Soil expertise results											

Tables 1, 2, and 3 show the viability of soil samples taken from 3 different parts of the experimental area.

Table 3. Agrochemical Analysis of Soil 3

No.	Coordinates	Sample Depth (cm)	Organic matter	pH	EC	Ca^{2+}	Mg^{2+}	NO_3^-	K_2O	P_2O_5
	X;Y		%	units	mS/cm	mg/ 100g	mg/100g	mg/ 100g	mg/ 100g	mg/ 100g
1	40.1313, 44.1307	0…50	3.9	8.73	0.373	10.1	5.96	2.83	7.76	4.35
2	40.1313, 44.1311		4.3	9.06	0.172	12.7	26.1	1.59	5.53	3.93
3	40.1330, 44.1243		2.6	9.17	0.262	8.08	6.83	2.56	3.32	3.54
4	40.1303, 44.1305		2.01	8.76	0.903	20.2	3.33	3.77	3.12	3.01
5	40.1259, 44.1304		3.57	8.64	1.081	21.92	2.8	6.8	11.8	7.23
6	40.1300, 44.1255		4.2	8.93	0.211	8.37	3.5	4.21	16	3.4
7	40.1306, 44.1238		-	8.76	0.338	13.5	6.42	3.14	7.25	4.39
8	40.1312, 44.1236		-	8.85	0.261	8.98	1.87	5.28	34.6	6.06
9	40.1321, 44.1245		4.77	8.9	0.152	10.1	6.13	2.8	26.6	5.42
10	40.1320, 44.1244		4.31	8.95	0.156	7.7	2.92	2.43	16.2	8.22
11	40.1321, 441252		4.6	8.79	0.158	9	2.82	3.37	13.7	4.59
12	40.1321, 44.1259		-	8.41	0.328	12.12	4.73	9.39	21.2	10.5
13	40.1300, 44.1317		4.02	8.96	0.154	8.42	5.84	2.35	25.2	3.92

During the water analysis, parameters such as pH, specific gravity of water, and magnesium (Mg) content were determined. Mg content in water is a measure of water hardness. Based on the results of the irrigation

water analysis, the water was found to be quite hard with a Mg content of 2.75, which contributes to its hardness. Additionally, the pH of the water was measured at 8.59, indicating a tendency towards basic conditions.

Table 4. Irrigation Water Analysis

Water Expertise Results				
No.	Name	Hardness, mg-equ/l	pH	EC, mS/cm
1	Water	2.75	8.59	0.375

Obtaining and studying planting material in the Republic of Armenia: To obtain pistachio planting material at Andersan company, Pistacia vera seeds imported from Iran were initially sown in their nursery area. Once the seedlings reached a diameter of 1 cm in thickness, eye grafting was performed using scions from two Persian varieties, namely “Akbari” and “Ahmad Aghaei”.

Table 5: Graft Union Success Rates of Pistachio Cultivars

Variety	P. vera		
	Grafted	Successful Grafting	Successful graft union
	unit	unit	%
Akbari	20.000	8000	40
Ahmad Aghaei	40.000	34.000	85

From the data presented in Table 5, it is evident that there is a notable difference in the graft union success rates between the two pistachio cultivars, Akbari and Ahmad Aghaei. Specifically, Akbari exhibited a graft union success rate of 40%, whereas Ahmad Aghaei showed a significantly higher success rate of 85%. This indicates that Ahmad Aghaei had more than twice the graft union success compared to Akbari. These grafting activities were conducted between 2020 and 2021.

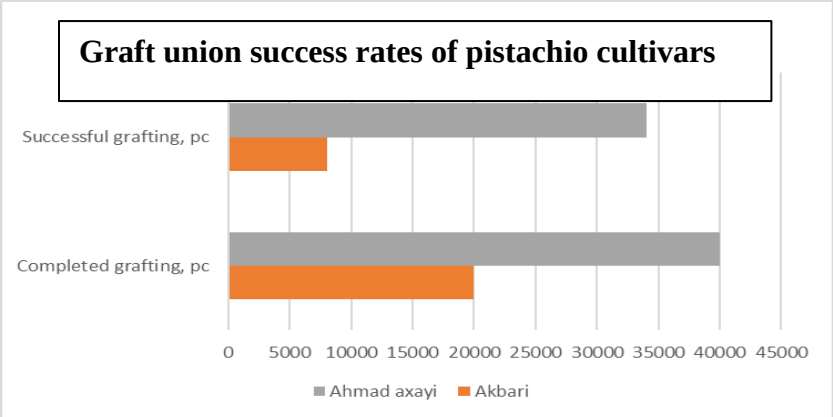


Chart 1. Graft union success rates of pistachio cultivars

Chart 1 clearly demonstrates the superior graft union success of Ahmad Aghaei (85%) compared to Akbari (40%). To preserve the original qualities and promising traits of pistachio varieties, a method of vegetative reproduction known as "eye grafting" is employed. During grafting, the surface of the central stem of the plant, approximately 5-7 cm above the soil, was prepared to a diameter of 0.8 cm. Grafting operations were conducted during morning and evening hours, avoiding peak daily temperatures to ensure optimal conditions for successful grafting.

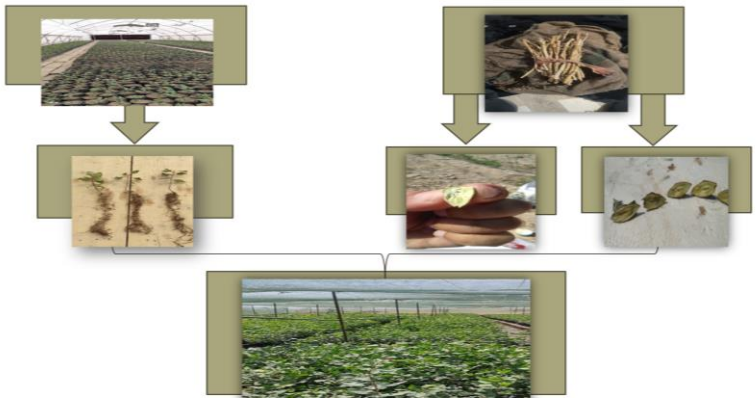


Figure 4: Production of pistachio planting stock in the greenhouse

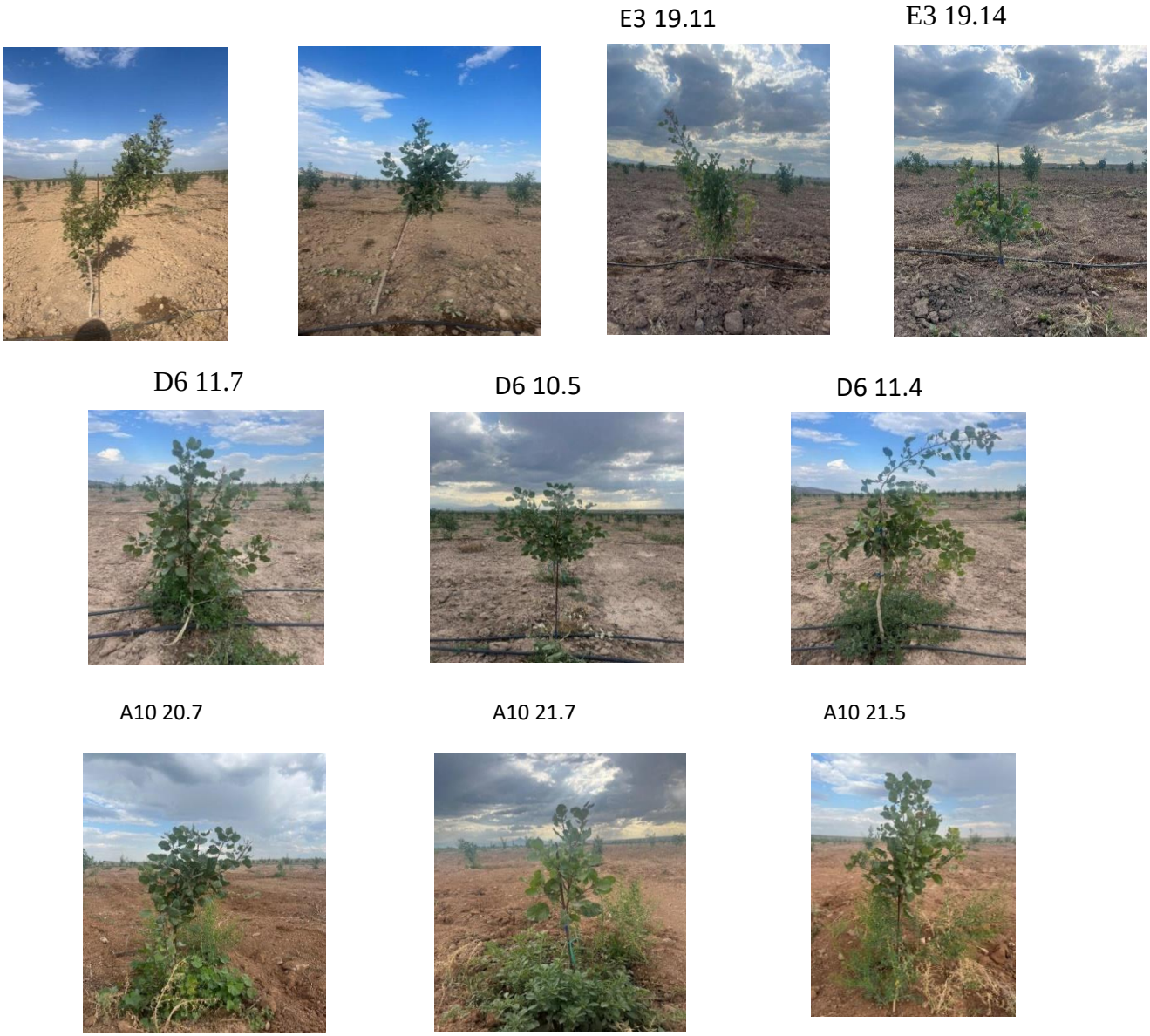


Figure 5. E2 3.8, E2 3.23, E3 19.11, E3 19.14, D6 10.5, D6 11.4, D6 11.7, A10 20.7, A10 21.7, A10 21.5

After the plants reached sufficient maturity and the soil preparation was completed, planting occurred multiple times throughout 2021 and 2022. Specifically, plantings were conducted on June 15, October 15, and November 15, 2021, followed by April 15 and June 15, 2022. The orchard maintained a pollinated-pollinating variety ratio of 9:1, ensuring one male plant per nine female plants across a planting scheme covering a nutritional area of 21m² (6m x 3.5m). The experiment included 10 trees with 4 replicates.

In three plots (E1, D2, A3), seedling heights were measured in centimeters on March 22, April 22, June 20, August 5, and September 18, 2023, as well as on February 20, 2024. On June 20, 2023, in plot E2 3.8, the tallest sapling reached a height of 239 cm, and in plot E2 3.23, the thickest sapling had a diameter of 3.35 cm. Conversely, in plot E3 19:14 on June 20, 2023, the shortest sapling measured 100 cm in height and 1.71 cm in thickness. In plot D6 10.7 of version D, the minimum height recorded on June 20, 2023, was 115 cm, with a minimum thickness of 1.76 cm. Meanwhile, plot D6 11.4 of the same version saw a maximum height of 173 cm and a maximum thickness of 2.32 cm. For version A, in plot A10 21.5, the lowest height recorded was 80 cm, with a minimum thickness of 0.85 cm. In contrast, plot A10 21.7 displayed a maximum height of 114 cm and a thickness of 1.82 cm.

As of February 20, 2024, in plot E2 3.8 of version E, the tallest sapling measured 158 cm in height, and in plot E2 3.23, the thickest sapling reached a diameter of 3.6 cm. Conversely, in plot E3 19:11, the shortest sapling had a height of 78 cm and a thickness of 2.2 cm. In plot D6 11.7 of version D, the minimum height recorded was 62 cm, with a thickness of 2.0 cm. Plot D6 11.4 showed a maximum height of 93 cm and a maximum thickness of 2.5 cm. Finally, in plot A10 21.7 of version A, the maximum thickness recorded was 2.0 cm, while the minimum thickness in plot A10 25.5 was 1.4 cm. The maximum height in plot A10 20.7 was 63 cm, whereas the minimum height in plot A10 21.7 was 57 cm.

Table 6. Height and Thickness of Saplings in 2023

№	Location	Planting date	Height, cm	Thickness, cm	Height, cm	Thickness, cm	Height, cm	Thickness, cm
			22.03.2023		22.04.2023		20.06.2023	
1	E2 3.8	June 2021	180	2.35	184	2.52	239	3.12
2	E2 3.23		96	1.70	105	1.41	180	3.35
3	E2		125	2.60	-	-	-	-
4	E3 19.14	October 2021	49	1.00	55	1.11	100	1.71
5	E3 19.11		100	1.50	94	1.61	144	2.28
6	E3 20.10		155	1.60	104	1.79	170	3.18
7	D6 10.7	November 15	61	-	67	1.41	115	2.00
8	D6 11.5		86	1.30	88	1.39	125	1.76
9	D6 11.4		133	2.00	130	2.04	173	2.32
10	A10 21.5	April 2022	32	0.5	47	0.59	80	0.85
11	A10 20.7		86	1.1	79	1.52	100	1.51
12	A10 21.7		140	1.6	79	1.45	114	1.82

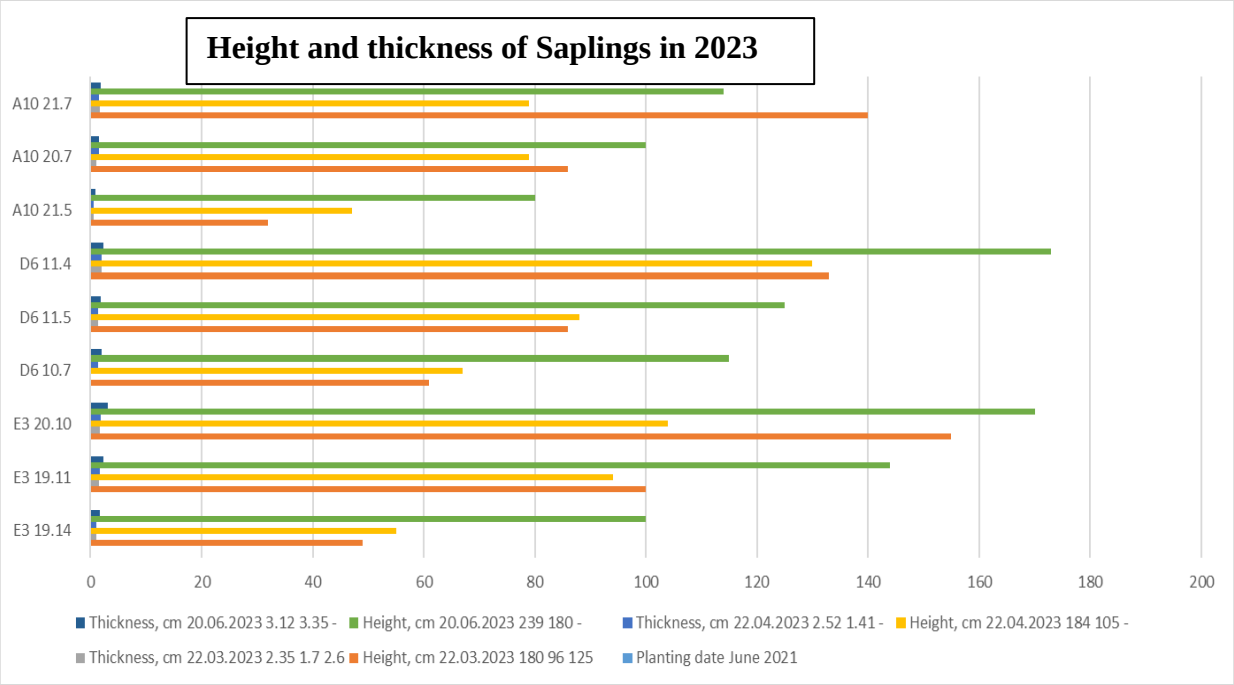


Chart 2. Height and thickness of Saplings in 2023

Chart 2 demonstrates the height and thickness of saplings in three plots (E1, D2, A3) measured in centimeters. The measurements were taken in 2023 with three repetitions.

Table 7. Height and Thickness of Saplings in 2023-2024

№	Location	Planting date	Height, cm	Thickness, cm	Height, cm	Thickness, cm	Height, cm	Thickness, cm
			05.08.2023		18.09.2023		20.02.2024	
1	E2 3.8	June 2021	100	3.23	160 (80)	3.75	158 (72)	3.4
2	E2 3.23		85	3.92	123 (40)	3.81	111 (37)	3.6
3	E2		-	-	-	-	-	-
4	E3 19.14	October 2021	70	2.25	100	2.32	100	2.2
5	E3 19.11		80	2.74	77 (27)	2.44	78 (26)	2.2
6	E3 20.10		62	2.32	150	3.00	151	3.0
7	D6 11.7 (29)		54				2.33	68 (15)
8	D6 10.5 (31)	April 2022	47	2.30	85 (50)	2.50	87 (47)	2.2
9	D6 11.4 (32)		57	2.60	97 (45)	2.70	93 (41)	2.5
10	A10 21.5		50	1.86	70 (30)	2.40	58 (16)	1.4
11	A10 20.7	Planted from 15 of June 2022	70	1.9	66 (24)	1.98	63 (22)	1.9
12	A10 21.7		70	2.12	68 (30)	2.20	57 (24)	2.0

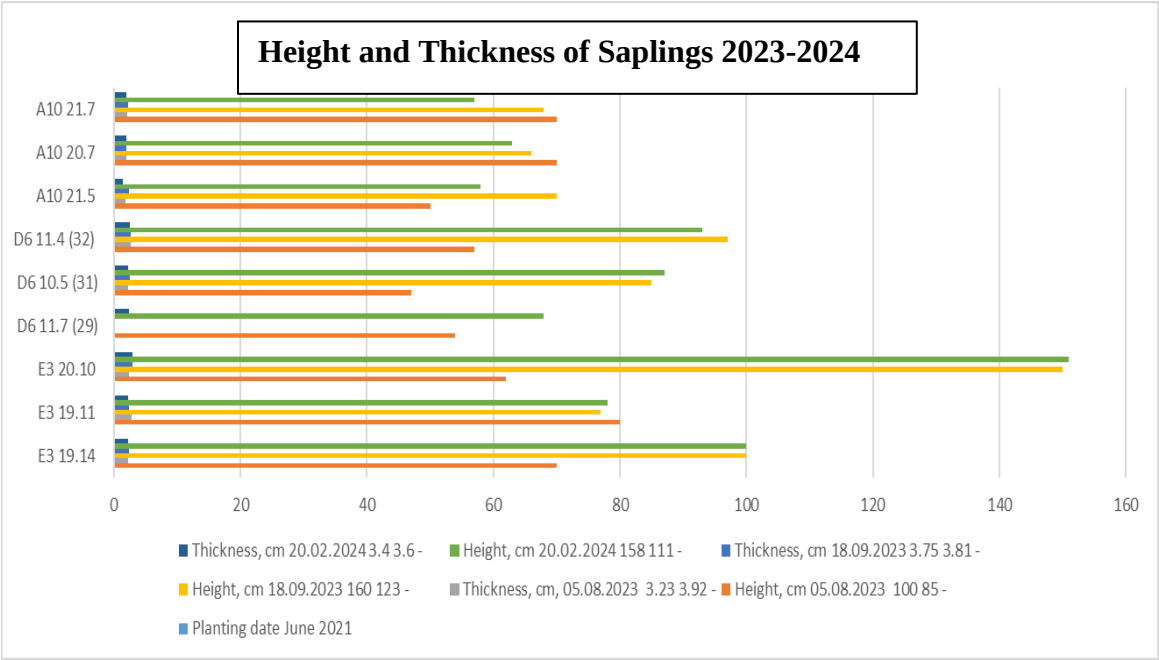


Chart 3. Height and Thickness of Saplings 2023-2024

Chart 3 demonstrates the height and thickness of saplings in three plots (E1, D2, A3) measured in centimeters. The measurements were taken in 2023-2024 with three repetitions. The highest recorded height was 239 cm for the seedling in plot E2 3.8, and the maximum thickness was 3.35 cm in plot E2 3.23. These results indicate the optimal conditions for the saplings and their growth dynamics.

Table 8. Phenological transition dates and vegetation duration of Akbari and Ahmad Aghaei cultivars for the year 2023

Experimental Locations	Bud Swelling and Scale Separation	Flowering		Fruit Development		Leaf Fall		Vegetation, days
		Beginning	End	Beginning of consumer maturity	Biological maturity	Beginning	End	
Akbari	06.04	21.04	30.04	02.10	15.10	24.10	29.11	242
Ahmad Aghaei	27.03	13.04	20.04	14.10	27.10	28.11	08.12	251
Baghramyan district of Armavir marz Average indicator	01.04	17.04	25.04	08.10	21.10	11-11	03-12	246
Meghry district of Syunik marz Average indicator	20.03	05.04	15.04	25.08	05.09	25-11	05-12	260
Enzeli, Iran Average indicator	10.04	21.04	30.04	02.10	15.10	25-10	05-11	207

The comparison of vegetation stages for the Akbari and Ahmad Aghaei varieties in the Anderson organization's orchards, Meghri sub-region of Syunik Region, and Enzel sub-region of Iran:

Akbari Variety

Anderson Organization (Armavir Region, Armenia):

- **Vegetation Duration:** 242 days (06.04 - 29.11)
- **Flowering:** 21.04 - 30.04 (9 days)

- **Economic Maturity:** 15.10
- **Defoliation:** 24.10 - 29.11 (36 days)

Meghri Sub-Region (Syunik Marz, Armenia):

- **Vegetation Duration:** 260 days
- **Start of Vegetation:** Began 14 days earlier (20.03)
- **Flowering:** Approximately 10 days earlier
- **Harvest:** Approximately 10 days earlier

Enzel Sub-Region (Iran):

- **Vegetation Duration:** Shorter by 207 days compared to Armavir
- **Start of Vegetation:** Began 10 days earlier than Armavir
- **Harvest:** Ripened in the second half of October
- **Leaf Fall:** Occurred earlier

Ahmad Aghaei Variety

Anderson Organization (Armavir Region, Armenia):

- **Vegetation Duration: 251 days (27.03 - 08.12)**
- **Flowering: 13.04 - 20.04 (7 days)**
- **Ripening: 14.10 - 27.10**
- **Leaf Fall:** 28.11 - 08.12 (10 days)

Meghri Sub-Region (Syunik Marz, Armenia):

- **Vegetation Duration:** 260 days
- **Start of Vegetation:** Began approximately 14 days earlier than Armavir
- **Flowering:** Approximately 10 days earlier
- **Ripening:** Approximately 10 days earlier
- **Leaf Fall:** Similar timing

Enzel Sub-Region (Iran):

- **Vegetation Duration:** Shorter by 207 days compared to Armavir
- **Start of Vegetation:** Began 10 days earlier than Armavir
- **Harvest:** Ripened in the second half of October
- **Leaf Fall:** Occurred earlier

Conditions for Exporting Crops Abroad and Conducting Quality Assessments: Considering the quality standards outlined in interstate and international regulations, it was essential to assess the yield of locally produced pistachios. To evaluate the harvest quality, the harvested fruits underwent laboratory examination at "Standard Dialog" LLC. The analysis included testing for intestinal yeast bacteria, fungi, heavy metals, pesticide residues, dry matter, carbohydrates, proteins, and fats. Detailed findings from these tests are compiled in Tables 10 and 11.

Table 9. The results of the examination of various indicators for nuts of Akbari and Ahmad Aghaei varieties of pistachios.

N	Sample number	Index Name	Regulatory document defining the testing methodology	Regulatory document defining indicator value	Unit of measure	Indicator Value		Conclusion
						Due to regulatory document	Received	
1	2	3	4	5	6	7	8	9
1.	1/271-1	Intestinal yeast group (AGBM)	GOST 31747-2012	Technical Regulations of the Customs Union (TR CU) 021/2011	0.01g	Not allowed	Found	Not relevant
		Pathogenic bacteria, including salmonella (Salmonella spp)	GOST 31659-2012	(TR ECU) 021/2011	25g	Not allowed	Not found	
		Fungus	GOST 10444.12-2013	(TR ECU) 021/2011	GFU/g	≤$1x10^3$	$3x10^3$	
		Lead	STB EN 15763-2015	(TR ECU) 021/2011	mg/kg	<0.5	<0.0003	
		Arsenium	STB EN 15763-2015	(TR ECU) 021/2011	mg/kg	<0.3	<0.0005	
		Cadmium	STB EN 15763-2015	(TR ECU) 021/2011	mg/kg	<0.1	<0.0005	
		Mercury	STB EN 15763-2015	(TR ECU) 021/2011	mg/kg	<0.05	<0.001	

N	Sample number	Index Name	Regulatory document defining the testing methodology	Regulatory document defining indicator value	Unit of measure	Indicator Value		Conclusion
						Due to regulatory document	Received	
		α,β,γ-isomers	ST RK 2011-2010	(TR ECU) 021/2011	mg/kg	<0.5	<0.005	
		DDT Metabolites	ST RK 2011-2010	(TR ECU) 021/2011	mg/kg	<0.15	<0.005	
		Aflatoxin B1	GOST 30711-2001	(TR ECU) 021/2011	mg/kg	<0.005	<0.0001	
		Dry Matter	GOST 29031-91	-	%	-	96.88	-
		Protein content	GOST 34111-2017	-	%	-	18.69	
		Carbohydrates	GOST 8756.13.87	-	%	-	7.09	
2.	1/271-2	Intestinal yeast group (AGBM)	GOST 31747-2012	(TR ECU) 021/2011	0.01g	Not allowed	Not found	Relevant
		Pathogenic bacteria, including salmonella (Salmonella spp)	GOST 31659-2012	(TR ECU) 021/2011	25g	Not allowed	Not found	
		Fungus	GOST 10444.12-2013	(TR CU) 021/2011	GFU/g	≤1x10^3	9x10^2	
		Lead	STB EN 15763-2015	(TR CU) 021/2011	mg/kg	<0.5	<0.0003	
		Arsenium	STB EN 15763-2015	(TR CU) 021/2011	mg/kg	<0.3	<0.0005	
		Cadmium	STB EN 15763-2015	(TR CU) 021/2011	mg/kg	<0.1	<0.0005	
		Mercury	STB EN 15763-2015	(TR CU) 021/2011	mg/kg	<0.05	<0.001	
		α,β,γ-isomers	ST RK 2011-2010	(TR CU) 021/2011	mg/kg	<0.5	<0.005	
		DDT Metabolites	ST RK 2011-2010	(TR CU) 021/2011	mg/kg	<0.15	<0.005	
		Aflatoxin B1	GOST 30711-2001	(TR CU) 021/2011	mg/kg	<0.005	<0.0001	
		Dry Matter	GOST 29031-91	-	%	-	96.82	-
		Protein content	GOST 34111-2017	-	%	-	21.85	
		Carbohydrates	GOST 8756.13.87	-	%	-	5.4	

Table 10. Fat Content Analysis of **Akbari** and **Ahmad Aghaei** Pistachio Varieties

N	Sample number	Index Name	Regulatory document defining the testing methodology	Regulatory document defining indicator value	Unit of measure	Indicator Value		Conclusion
						Due to regulatory document	Received	
1	2	3	4	5	6	7	8	9
1.	1/271-1	Fat content	GOST 8756.21-89	-	%	-	45.45	-
2.	1/271-2	Fat content	GOST 8756.21-89	-	%	-	44.53	-

As shown in Table 9, the first sample of the Ahmad Aghaei pistachio variety does not meet normative requirements in two indicators: the presence of bacteria from the intestinal yeast group (AGBM) and fungi. All other indicators fall within the specified limits. This can be attributed to improper preservation conditions before the sample was sent to the laboratory for examination. In contrast, the second sample, comprising fruits of the Akbari variety, meets all normative requirements and submitted standards.

Description of Pistachio Varieties

Akbari

- **Shell Characteristics:** The nutshell of the Akbari variety is the softest among the four varieties, making it the easiest to open.
- **Dimensions:** The nuts typically measure 18-24 mm in width and 20-26 mm in length.
- **Yield and Popularity:** This relatively new variety is known for its good yields and long, large nuts.
- **Common Sizes:** The most common sizes are 20/22, 22/24, and 24/26, with smaller quantities available in size 18/20.

Ahmad Aghaei

- **Yield and Market Demand:** The Ahmad Aghaei variety is the newest, known for its quick yield and high market demand, particularly in India and Greece. However, it is considered inferior to the Akbari variety in terms of flavor.
- **Shell Characteristics:** The nuts of this variety have the lightest coloring compared to other varieties.
- **Dimensions:** The nuts typically measure 20-28 mm in width and 22-30 mm in length.
- **Yield and Popularity:** This variety is favored by farmers for its high yield in a short period. Its cultivation is increasing daily.
- **Common Sizes:** The most common sizes are 22/24, 24/26, 26/28, and 28/30, with smaller quantities available in size 20/22.

Figure 6. Akbari and Ahmad Aghaei pistachio kernels in their natural size

DISCUSSION

Climatic changes are proving advantageous for expanding pistachio cultivation in Armenia. The decrease in relative humidity, coupled with increased temperatures, creates favorable conditions for pistachio growth and development. This analysis underscores the potential for pistachio cultivation to thrive in Armenia's evolving climatic conditions. From the analysis across all three soil tables, several key observations can be made:

1. **pH Levels:** The pH of the soil exhibits basic characteristics, ranging from 7.76 to 9.91 (Table 1).

2. **Specific Gravity:** The specific gravity of the soil varies widely, indicating different soil textures and compositions, ranging from 0.152 to 2.565 ms/cm.
3. **Salinity Indicators - Ca and Mg:** Calcium (Ca) and magnesium (Mg) content in the soil serve as indicators of soil salinity. Ca ranges from 264.29 to 5.2, while Mg ranges from 26.1 to 1.87, highlighting significant variations in salinity levels across different plots.
4. **Macronutrients:**
    - **K2O (Potassium Oxide):** Essential for plant growth and biological activity, K2O content varies considerably among different soil samples, ranging from 0.738 to 75.2.
    - **P2O5 (Phosphorus Pentoxide):** Responsible for plant maturation, yield, and crop quality characteristics, P2O5 content ranges from 0.1 to 10.5.
- **Nitrate (NO3):** A crucial macronutrient affecting plant growth, NO3 content ranges from 1.35 to 9.39.
- **Micronutrients:**
    - **Fe (Iron):** Important for human nutrition as it is part of hemoglobin in red blood cells, Fe content ranges from 0.116 to 0.191**.**
    - **Zn (Zinc) and Cu (Copper):** Essential trace elements for plant growth, Zn ranges from 0.021 to 0.134, and Cu ranges from 0.052 to 0.186.

5. **Organic Matter (Humus):** Soil fertility depends significantly on organic matter content, particularly humus which ranges from 0.4 to 4.77. The humus content is relatively low.

Despite the relatively low organic matter content, the soil environment is humic, indicating a favorable condition for plant growth. The specific gravity is also relatively low, suggesting a sandy texture, which typically allows for good drainage and aeration, beneficial for root development. Importantly, various macro and micro elements crucial for plant growth and development were detected in different soil samples. Overall, the soil conditions are deemed favorable for pistachio cultivation.

Analyzing the dates of vegetation transition, the following conclusions were reached. Comparing Meghri (Armenia) and Armavir (Armenia) we can see that vegetation lasted 2 weeks longer in Meghri, starting 2 weeks earlier. Flowering and ripening stages were approximately 10 days earlier compared to Armavir. As for Enzeli (Iran) and Armavir (Armenia) regions, vegetation was significantly shorter in Enzeli - 207 days, starting 10 days earlier. Harvest occurred in late October, and leaf fall was earlier compared to the Armavir region. According to the laboratory analysis, the dry matter content in both samples ranged from 96.88% to 96.82%, with no significant difference observed. However, the Akbari variety exhibited a 3.16% higher protein content compared to the Ahmad Aghaei variety.

The fat/oil content, as presented in Table 10, varied between 45.55% and 44.53% across the two varieties. Quality indicators related to the appearance of the samples were evaluated in accordance with Codex Alimentarius CXS 131-1981. Based on these standards, the Akbari variety was classified as "large" with 83 fruits per 100 grams, while the Ahmad Aghaei variety was classified as "medium" with 95 fruits per 100 grams.

Other organoleptic indicators were also assessed according to the same standard. The fruit samples of both varieties met the required taste and smell standards, displaying characteristics typical of their species without any rotten or bitter taste.

No live or dead pests were found in any of the samples. Both Ahmad Aghae i and Akbari varieties were rated highly based on the number of unopened, empty, and unripe fruits.

CONCLUSION

Based on the results of soil and climate studies, areas for pistachio cultivation were selected in the Armavir region. The large-fruited varieties "Akbari" and "Ahmad Aghaei" were selected from Iranian pistachio varieties. P. vulgare seedlings grew best in plot E2 3.8. Seedlings grew better in the same area. The Ahmad Aghaei variety had the best survival rate of 85%. The Akbari variety was the leader in terms of protein content.

Pistachio cultivation certainly holds prospects for further development under the conditions of the Republic of Armenia. It provides a strong basis for wide use as a functional food.

In conclusion, the quality of pistachio crops produced in RA meets international standards, making them suitable for export.

Author's Contributions: All authors contributed to this study.

Acknowledgments: We are grateful to the companies "Ecoplant" and "Ander san" for providing the experimental platform and conducting the experiment. We are also grateful to the scientists of Voskehat Educational and Research Center of Enology, ANAU Branch Pomology and Physiology department and the team of "National Agrarian University of Armenia" for the implementation of the joint experiment.

REFERENCES

1. Ferguson L., Polito V., Kallsen C. Pistachio Production Manual. 4th ed. University of California, Fruit & Nut Research Information Center; Davis, CA, USA: 2005. The pistachio tree. Botany and physiology and factors that affect yield. Pistachio Collection – Field Tour of the USDA National Clonal Germplasm Repository for Tree Fruit, Nut Crops, and Grapes in Davis, California (pressbooks.pub).
2. Bailey H.M., Stein H.H. Raw and roasted pistachio nuts (Pistacia vera L.). Are "good" sources of protein based on their digestible indispensable amino acid score as determined in pigs. J. Sci. Food Agric. 2020; 100:3878–3885. DOI: https://doi.org/10.1002/jsfa.10429
3. Bellomo M.G., Fallico B. Anthocyanins, Chlorophylls and Xanthophylls in pistachio nuts (Pistacia vera) of different geographic origin. J. Food Compos. Anal. 2007; 20: 352–359. DOI: https://doi.org/10.1016/j.jfca.2006.04.002
4. Grippi F., Crosta L., Aiello G., Tolomeo M., Oliveri F., Gebbia N., Curione A. Determination of stilbenes in sicilian pistachio by high-performance liquid chromatographic diode array (HPLC-DAD/FLD) and evaluation of eventually mycotoxin contamination. Food Chem. 2008; 107: 483–488. DOI: https://doi.org/10.3390/nu12071935
5. Hadi A., Pourmasoumi M., Kazemi M., Najafgholizadeh A., Marx W. Efficacy of synbiotic interventions on blood pressure: A systematic review and meta-analysis of clinical trials. Crit. Rev. Food Sci. Nutr. 2022, 62, 5582–5591. DOI: https://doi.org/10.1080/10408398.2021.1888278
6. Harandi H., Khanamani Falahati-pour S.K., Mahmoodi M., Faramarz S., Maleki H., Nasab F.B., Shiri H., Fooladi S., Nematollahi M.H. Nanoliposomal formulation of pistachio hull extract: Preparation, characterization and anti-cancer evaluation through Bax/Bcl2 modulation. Mol. Biol. Rep. 2022, 49, 2735–2743. DOI : https://doi.org/10.1007/s11033-021-07083-5
7. Gunathilake M., Van N.T.H., Kim J. Effects of nut consumption on blood lipid profile: A meta-analysis of randomized controlled trials. Nutr. Metab. Cardiovasc. Dis. 2022, 32, 537–549. DOI: https://doi.org/10.1016/j.numecd.2022.01.006
8. Grosso G., Godos J., Currenti W., Micek A., Falzone L., Libra M., Giampieri F., Forbes-Hernández T.Y., Quiles J.L., Battino M., et al. The effect of dietary polyphenols on vascular health and hypertension: Current evidence and mechanisms of action. Nutrients 2022, 14, 545. DOI: https://doi.org/10.3390/nu14030545
9. Dousti M., Sari S., Saffari M., Kelidari H., Asare-Addo K., Nokhodchi A. Loading Pistacia atlantica essential oil in solid lipid nanoparticles and its effect on apoptosis of breast cancer cell line MDA-MB-231. Pharm. Dev. Technol. 2022, 27, 63–71. DOI: https://doi.org/10.1080/10837450.2021.2022693
10. Hernández-Alonso P., Salas-Salvadó J., Baldrich-Mora M., Juanola-Falgarona M., Bulló M. Beneficial effect of pistachio consumption on glucose metabolism, insulin resistance, inflammation, and related metabolic risk markers: A randomized clinical trial. Diabetes Care. 2014; 37:3098–3105. DOI: https://doi.org/10.2337/dc14-1431

11. Polmann G., Badia V., Danielski R., Salvador-Ferreira S.R., Block J.M. Nuts and nut-based products: A meta-analysis from intake health benefits and functional characteristics from recovered constituents. Food Rev. Int. 2022, 29, 197–210. DOI: doi.org/10.1080/87559129.2022.2045495
12. Mandalari G., Barreca D., Gervasi T., Roussell M.A., Klein B., Feeney M.J., Carughi A. Pistachio nuts (Pistacia vera L.): Production, nutrients, bioactives and novel health effects. Plants 2022, 11- 18. DOI: https://doi.org/10.3390/plants11010018
13. Scott T.M., Rasmussen H.M., Chen O., Johnson E.J. Avocado consumption increases macular pigment density in older adults: A randomized, controlled trial. Nutrients. 2017; 9:919. DOI: https://doi.org/10.3390/nu9090919
14. Yuan W, Zheng B, Li T, Liu RH. Quantification of Phytochemicals, Cellular Antioxidant Activities and Antiproliferative Activities of Raw and Roasted American Pistachios (Pistacia vera L.). Nutrients.2022;14(15):3002, https://www.mdpi.com/2072-6643/14/15/3002
15. Nowrouzi-Sohrabi P., Hassanipour S., Sisakht M., Daryabeygi-Khotbehsara R., Savardashtaki A., Fathalipour M. The effectiveness of pistachio on glycemic control and insulin sensitivity in patients with type 2 diabetes, prediabetes and metabolic syndrome: A systematic review and meta-analysis. Diabetes Metab. Syndr. 2020;14:1589–1595. DOI: https://doi.org/10.1016/j.dsx.2020.07.052
16. Chen C.-Y.O., Smith A., Liu Y., Du P., Blumberg J.B., Garlick J. Photoprotection by pistachio bioactives in a 3-dimensional human skin equivalent tissue model. Int. J. Food Sci. Nutr.2017;68:712–718. DOI: https://doi.org/10.1080/09637486.2017.1282437
17. Barreca D., Laganà G., Leuzzi U., Smeriglio A., Trombetta D., Bellocco E. Evaluation of the nutraceutical, antioxidant and cytoprotective properties of ripe pistachio (Pistacia vera L., Variety Bronte) hulls. Food Chem. 2016; 196:493–502. DOI: https://doi.org/10.1016/j.foodchem.2015.09.077
18. Parham M., Heidari S., Khorramirad A., Hozoori M., Hosseinzadeh F., Bakhtyari L., Vafaeimanesh J. Effects of pistachio nut supplementation on blood glucose in patients with type 2 diabetes: A randomized crossover trial. Rev. Diabet. Stud. 2014; 11:190–196. DOI: https://doi.org/10.1900/rds.2014.11.190
19. Paterniti I., Impellizzeri D., Cordaro M., Siracusa R., Bisignano C., Gugliandolo E., Carughi A., Esposito E., Mandalari G., Cuzzocrea S. The anti-inflammatory and antioxidant potential of pistachios (Pistacia vera L.) in vitro and in vivo. Nutrients. 2017;9:915. DOI: https://doi.org/10.3390/nu9080915
20. Higgs J., Styles K., Carughi A., Roussell M.A., Bellisle F., Elsner W., Li Z. Plant-based snacking: Research and practical applications of pistachios for health benefits. J. Nutr. Sci. 2021;10: e87. DOI: https://doi.org/10.1017/jns.2021.77
21. Neveu V., Perez-Jiménez J., Vos F., Crespy V., du Chaffaut L., Mennen L., Knox C., Eisner R., Cruz J., Wishart D., et al. Phenol-explorer: An online comprehensive database on polyphenol contents in foods. Database J. Biol. Databases Curation. 2010; 2010: bap 024. DOI: https://doi.org/10.1093/database/bap024
22. Ballistreri G., Arena E., Fallico B. Influence of ripeness and drying process on the polyphenols and tocopherols of Pistacia vera L. Molecules. 2009; 14:4358–4369. DOI: https://doi.org/10.3390/molecules14114358
23. Barreca D., Trombetta D., Smeriglio A., Mandalari G., Orazio R., Felice M.R., Gattuso G., Nabavi S.M. Food flavonols: Nutraceuticals with complex health benefits and functionalities. Trends Food Sci. Technol. 2021; 117:194–204. DOI: https://doi.org/10.1016/j.tifs.2021.03.030
24. Martirosyan D.M., Lampert T., Lee M. A comprehensive review on the role of food bioactive compounds in functional food science. Functional Food Science 2022; 3(2): 64-79. DOI: https://www.doi.org/10.31989/ffs.v2i3.906
25. Martirosyan D.M., Lampert T., Ekblad M. Classification and regulation of functional food proposed by the functional food center. Functional Food Science 2022; 2(2): 25-46. DOI: https://www.doi.org/10.31989/ ffs.v2i2.890
Mirmiranpour H, Ashoori M.R., Mikaeili A.S., Chen B, Martirosyan D.M. Investigating the changes of the components of the Krebs cycle in patients with type 2 diabetes treated with squalene. Bioactive Compounds in Health and Disease 2023; 6(2): 1-12. DOI: https://www.doi.org/10.31989/bchd.v6i2.1059
26. DDP-09 Inshell Pistachio Nuts, New York and Geneva, concerning the marketing and commercial quality control of inshell pistachio nuts, 2016, https://unece.org/sites/default/files/2023-08/09_InshellPistachio_e.pdf. Retrieved on September 11, 2024
27. Codex Alimentarius international food standard, standard for unshelled pistachio nuts, CXS 131-1981, Adopted in 1981. https://www.fao.org/fao-who-codexalimentarius/sh-proxy/jp/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252FStandards%252FCXS%2B131-1981%252FCXS_131e.pdf. Retrieved on September24, 2024
28. Elloumi W., Maalej A., Ortiz S., Michel S., Chamkha M., Boutefnouchet S., Sayadi S. Pistacia lentiscus L. Distilled Leaves as a Potential Cosmeceutical Ingredient: Phytochemical Characterization, Transdermal Diffusion, and Anti-Elastase and Anti-Tyrosinase Activities. Molecules 2022, 27, 855. DOI: https://doi.org/10.3390/molecules27030855