`Vol. 5, No. 4, pp. 415-431, (December2024)
DOI: https:// 10.21608/aujes.2024.291137.1246
Aswan University Journal of Environmental Studies (AUJES)
Online ISSN: 2735-4237, Print ISSN: 2735-4229
Journal homepage: https://aujes.journals.ekb.eg/ E-mail: AUJES@aswu.edu.eg
Original research

Pomegranate (*Punica Granatum* L.) in Azerbaijan

Suleymanova S., Garagurbanly I., Mammadova U., Askerova A.

Scientific Research Institute of Fruit and Tea Growing of Ministry of Agriculture of Azerbaijan, Guba, Azerbaijan

Received: 15/6/2024 Accepted: 21/9/2024

Abstract:

The review article describes the current state of pomegranate growing in Azerbaijan. Pomegranate is a very ancient breed and culture of prehistoric times. It was taken into culture directly from nature, from endemic forms. In the origin of the pomegranate culture, conscious selection, plant domestication, and hybridization, which contributed to the development of new forms, played a major role. The presence of large thickets of pomegranate, their widespread distribution, the diversity of many original local varieties of high quality, reflecting extremely careful selection in specialized areas, point to Azerbaijan as the region of its formation. The Azerbaijani subtropics are rich sources of crop production; they can reliably enrich fruit growing with valuable original varieties of pomegranate. Currently, when mastering the methods of modern selection with their enormous prospects, it is possible to update aging varieties in a shorter period, improve them, and using the accumulated source material, create new productive and high-quality varieties that satisfy all production requirements.

***Key words**:* pomegranate, variety, breeding, Azerbaijan

1. Introduction

The pomegranate is a valuable fruit and, a medicinal, technical, and attractive ornamental plant. Since ancient times, in the East, pomegranate has been considered the king of all fruits. Probably due to precisely the original shape of the sepals, which forms the "crown".

Due to the rich chemical composition of the fruit, pomegranate occupies one of the leading places among subtropical fruit crops [Al-Said et al., 2009; Holland et al., 2009; Teixeira et al., 2013]. As many researchers point out, the pomegranate fruit is a storehouse of useful vitamins and microelements [Finetto, 2009; Hafizov and Hafizov, 2022; Hafizov, 2016; Gasanov et al., 2013; Jing et al., 2012]: 27-52% of the fruit is peel, 36-75% juice, 7-21% seeds. Pomegranate juice contains 8-20% invert sugar, 4-10% citric, malic, oxalic acid, up to 14% vitamin C, vitamins B1, B2, B9, 33, as well as anti-anthocyanins, catechins, tannin, minerals (calcium, magnesium, potassium, manganese, cobalt), bioflavonoids and phytoncides are noted [Basu and Penugonda 2009; Fahmya et al., 2020; Hafizov and Hafizov, 2022; Hafizov, 2016]. Pomegranate juice contains more antioxidants [Su et al., 2011; Viuda-Martos et al., 2010] than any other drink, be it red wine, green tea, blueberry, or cranberry juice. The pericarp, roots, and bark contain up to 32% tannins.

Corresponding author*: E-mail address: *suleymanovas81@mail.ru*

All parts of the tree (fruits, leaves, flowers, and roots) are used for medicinal purposes [Jurenka, 2008; Miguel Maria et al., 2010]. The edible part of the grana fruit contains a significant amount of sugars, vitamins, polysaccharides, polyphenols, and minerals [Al-Said et al., 2009; Ozgen et al., 2008]. Numerous scientific studies have shown that pomegranate contains antioxidant, anticancer, anti-inflammatory, antidiabetic, and antimicrobial compounds [Lansky and Newman, 2007; Miguel Maria et al., 2010; Sharma et al., 2017; Su et al., 2011; Turrini et al., 2015; Viuda-Martos et al., 2010]. Anthelmintic drugs are prepared from pomegranate peel; tincture of flowers is used for inflammatory processes of the throat and women's diseases [Jurenka, 2008]. Pomegranate juice improves appetite, promotes digestion, and is used against scurvy, in the treatment of atherosclerosis, uric acid diathesis, headaches, and gastrointestinal disorders [Colombo et al. 2013; Miguel Maria et al., 2010]. Pomegranate seed oil is used by patients with diabetes [Vroegrijk et al., 2011], and pomegranate juice also helps with the exhaustion of the body after surgery and infectious diseases, as well as with anemia [Basu and Penugonda, 2009]. Pomegranate membranes, dried and added to tea, help strengthen the nervous system, get rid of anxiety, and relieve agitation [Miguel Maria et al., 2010].

In addition, tannins present in the bark of the trunk, roots, and peel of the fruit are used in the leather industry. Fruit peel and flowers are a good and high-quality dye for various products. Pomegranate flowers, which contain large amounts of the bright red anthocyanin pigment punicin, are used to produce dyes that are used to dye silk, cotton, linen, and wool fabrics. Decorative forms of pomegranate with double, multi-colored flowers are widely used in ornamental gardening and landscape architecture.

2. Materials and methods

A literature review of scientific works was conducted using the resources of search engines and the National Library of Azerbaijan. For this review, we mainly used articles containing experimental evidence on the issue under study.

Purpose of the work: to summarize the available literature data on the pomegranate culture, its prevalence, environmental factors, varietal composition, as well as the results of breeding work in Azerbaijan to obtain its new and improved forms.

3. Results and discussion

3.1. The role of pomegranate in Azerbaijani cuisine

In Azerbaijan, the pomegranate is considered the king of fruits [Gasanov et al., 2013; Hafizov, 2016; Gaziyev, 1949]. Many songs and poems are dedicated to him. It symbolizes love and fertility. It can often be seen in carpet patterns, and pomegranate peel is used as a dye in their production. In addition, pomegranate is widely used in national cuisine.

In 2020, UNESCO included the Azerbaijani Pomegranate Festival, which takes place every year in Goychay, in the Representative List of the Intangible Cultural Heritage of Humanity.

According to the nature of their use, numerous varieties of pomegranate are divided into three groups: sweet varieties with acidity up to 0.9%, used fresh and for making drinks; sweet and sour varieties with acidity from 0.9 to 1.8%, used fresh and for making drinks; sour varieties with acidity above 1.8%. Pomegranate juice is one of the important sources of bioactive substances [Hafizov and Hafizov, 2022; Hafizov, 2016; Miguel Maria et al., 2010; Su et al., 2011]. In terms of therapeutic and prophylactic properties, pomegranate juice is superior to grape juice. Based on this, different types of drinks are produced from pomegranate juice. Technologies

have been developed for various types of blended drinks from natural pomegranate juice when mixed with beet juice, tomato, celery, and other vegetables. Blended pomegranate juices have good organoleptic properties. Pomegranate juice is obtained by pressing. After squeezing the pomegranate, 46–48% of the pomace remains, which is considered secondary raw material. Pomegranate marc contains a large number of valuable substances (pectin, tannin, tannins, polyphenolic and phenolic compounds, anthocyanidins) with therapeutic and prophylactic, antibacterial and phytoncide properties [Miguel Maria et al., 2010; Su et al., 2011]. Aqueous and alcoholic extracts are obtained from them. An alcoholic extract from pomegranate squeezes is used as an additive to toothpaste, shampoos, and hand and foot creams. The resulting products have a wide range of physiological effects on the human body and can be successfully used in the food, pharmaceutical, and perfume industries [Jing et al., 2012].

In food production, pomegranate juice, due to its sour taste, is used as a food additive to improve the taste of food - narsharab, nardashi and nardancha are prepared from it. Soft drink grenadine, alcohol, and high-quality wine are also prepared [Mena et al., 2012; Nguyen, 2020; Sevda and Rodrigez, 2011].

Grenadine is a special type of sugar obtained from the young roots of the pomegranate tree [Miguel et al., 2010]. It has a pleasant aroma and high purity. Easily crystallizes. Used in sugar confectionery in the Middle East to prepare various types of halva. Lipid-rich flour was obtained from pomegranate waste (rinds and seeds) [Gül and Şen, 2017].

3.2. Area, production, and productivity indicators

According to the data of 2022, the area of pomegranate orchards in Azerbaijan was 22.6 thousand hectares. 21.6 thousand hectares or 95.6% of the existing pomegranate orchards are of fruit-bearing age (Fig.1) [www.stat.gov.az].

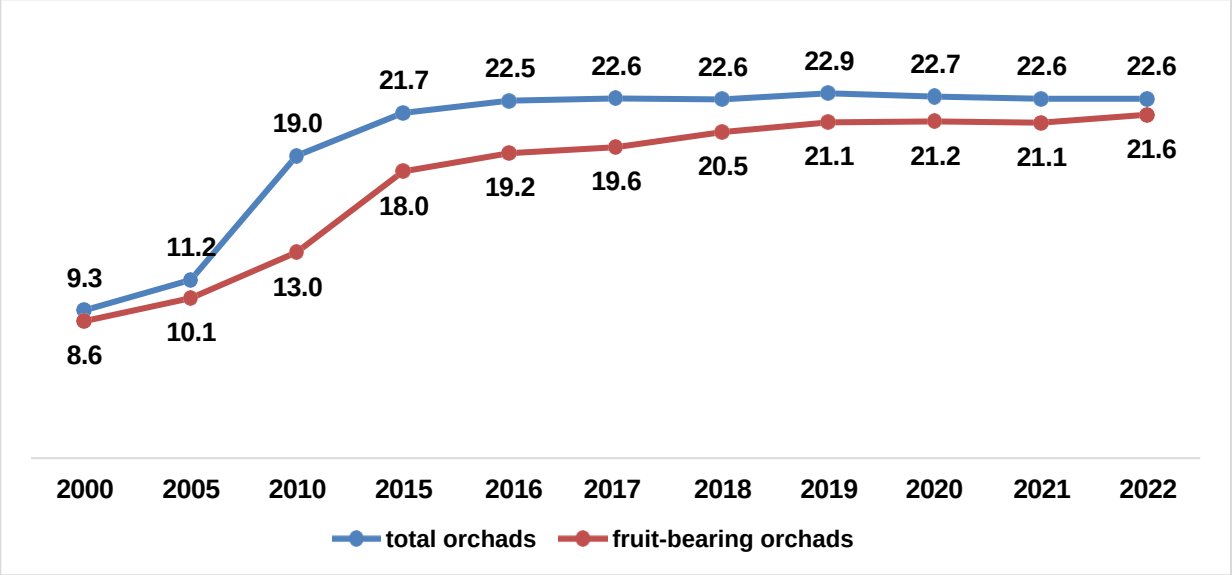

Figure 1. *Area of pomegranate orchards in Azerbaijan, thousand ha*

In total, 84.2% of pomegranate orchards are traditional, and 15.8% are intensive orchards.

In 2022, 14.9% of the total pomegranate orchards will be in Goychay, 14.2% in Kurdamir, 10.1% in Agsu, 8.6% in Ujar and 6.4% in Saatli, a total of 54.3% will be shared by 5 districts (Table 1) [www.stat.gov.az].

Table 1. *Structure of pomegranate orchards by region in 2022, ha*

Regions	Total orchads	Fruit-bearing Orchads	Newly planted gardens
Country	**22,636.4**	**21,592.5**	**302.9**
Goychay	3,378.4	3,301.4	45.0
Kurdamir	3,222.6	3,130.6	21.6
Agsu	2,295.7	2,209.2	56.3
Ujar	1,944.0	1,944.0	-
Saatli	1,456.4	1,242.4	48.6
Sabirabad	1,379.3	1,290.0	82.8
Hajıgabul	1,228.0	1,226.0	-
Agdash	877.7	838.0	18.9
Bilasuvar	867.3	866.5	0.4
Goranboy	559.9	559.9	-
Other	**5,427.1**	**4,984.5**	**29.3**

Pomegranate production in 2022 increased by 18.5% compared to 2015, and by 1.1% compared to 2021, reaching 187.4 thousand tons (Fig.2).

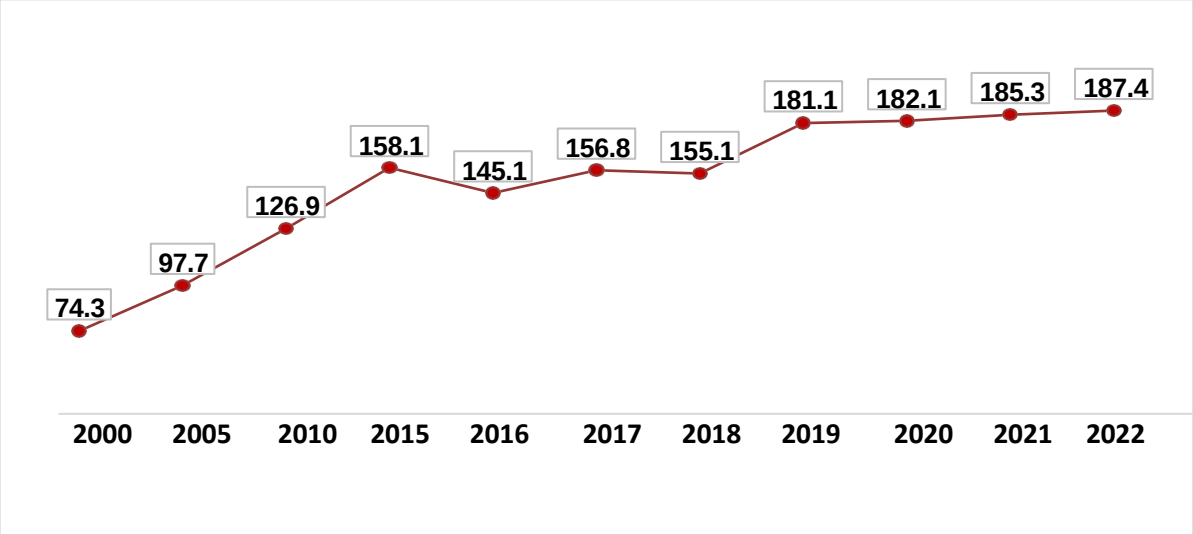

Figure 2. *Pomegranate production in Azerbaijan, thousand tons*

In 2022, 58.8% of pomegranate production fell to 5 regions. The main producing regions: Goychay-22.0%, Kurdamir-17.3%, Sabirabad-7.3%, Shamkir-6.8%, Hajigabul-5.4% share [www.stat.gov.az].

3.3. Botanical characteristics and biological features

Pomegranate belongs to the genus *Punica* L., to the family of *Punicaceae* [Awamleh et al., 2009; Holland et al., 2009; Mars, 2000; Teixeira da Silva et al., 2013]. The genus is represented

by two species. One of them, *P.protopunica* Balf, grows wild on the island of Socotra in the Indian Ocean. The fruits of protopunica, in the form of dry capsules, have no economic significance. In 1980, G.M. Levin separated this species from the genus *Punica* and defined it as an independent genus Sokotran, which has only one species *S.protopunica* Balf., Lebinevin [Levin, 1981; Levin, 1990].

Another species *P.granatum* L. (2n=16) - pomegranate, which is of great importance as a fruit crop, is found in the wild and feral form in Azerbaijan, Iran, Turkey, Afghanistan, Tajikistan, Turkmenistan, Uzbekistan, India, and many other Asian countries [Akparov et al., 2015; Al-Said et al., 2009; Finetto, 2009; Holland et al., 2009].

Pomegranate in its natural growth is a bush with 8-12 curved trunks. It is characterized by high shoot-forming and shoot-restoring ability. The shoots are thin, straight, and smooth, located oppositely on the branch. There are thorns on the trunk and branches.

The leaves are small, lanceolate-shaped, reddish-brown when they appear, then green, located oppositely on the shoot. Short shoots, up to 10-12 cm long, end in thorns. The next year, short shoots with 4-8 leaves appear on these shoots, which form flower buds the same year or the next. The duration of pomegranate flowering is 2-3 months, and at the same time, there are fruits, ovaries, and flowers on the tree, which is typical for remontant plants.

The flowers are large, bisexual, with free petals, the sepals are fleshy, the receptacle is wide, and all of them are red. They are placed on the shoot singly or in groups. They have one pistil and many stamens. Based on their appearance, there are two types of flowers: 1. Bell-shaped and 2. Pitcher-shaped. Bell-shaped flowers are short-distilled and have an underdeveloped ovary. Most often in groups of 3-5. Such flowers, without setting fruit, fall off. The pitcher-shaped flowers are long-pistillate, with a well-developed ovary, often solitary, and, as a rule, turn into fruit. Ovary inferior, multilocular.

The fruits are mostly round large (200-500 g or more), 15-20 cm in diameter. The pericarp is thick, depending on the varietal characteristics, red, pink, orange-yellow, and sometimes even black. The pomegranate fruit is divided into 9-12 membraned nests. Each nest contains two rows of arils, in which the seeds are wrapped in juicy edible pulp. One fruit contains 400-700, sometimes 1000-1200 edible seeds, divided into segments by thin membranes.

Each tiny seed is surrounded by clear, smooth red pulp. Seeds are juicy and numerous.

The root system is powerful, fibrous, and deeply penetrating. The bulk (60-70%) of the roots are located on the arable horizon, at a depth of 40-60 cm. The rest of the roots go to a depth of 1.5-2 m or more. The location of roots in soil horizons (architectonics) largely depends on the type, fertility, and moisture supply of the soil. In thin soils with a thin arable horizon, light granulometric composition, and high water-carrying capacity, the roots go far beyond 3-4 m.

In addition to fruit forms, several decorative varieties of pomegranate are also distinguished [Vitkovskiy, 1984]: *var. Albescens* – white-flowered, *var. rubrum* – red-flowered, *var. nana* Pers. – dwarf, var. multiplex - with white double flowers, *var.plenifloraHayn.* - with red double flowers. As a result of gamma radiation on the dwarf form Ciko imported from the USA, obtained a fruiting form and named it Khirdanar [Akhundzade, 1981].

The pomegranate is a light-loving short-day plant. Warm and moisture-loving. In areas with annual precipitation less than 600 mm, irrigation is required. The duration of the growing season, with the sum of active temperatures exceeding 4600°C, is more than 7 months. Flowering

begins 30-40 days after the start of the growing season, at an average daily temperature of 20°C, and lasts 60-70 days. The flowers are cross-pollinated by insects. The period from the beginning of the growing season to the harvesting of fruits, with the sum of active temperatures of 3500℃, is 5.5-6.5 months. Withstands winter frosts down to -16°C. A pomegranate bush lives and bears fruit, with normal care, for more than 120 years.

3.4. Ecological properties and geographical distribution of pomegranate

The life and behavior of plants are closely related to the environment. A large distribution area from deserts to humid subtropics, habitation on different reliefs, exposures, and soils, and the ability to quickly recover after freezing and drying out indicate the exceptional plasticity of garnet. The orography, soils, vegetation, as well as climate, and microclimate of Azerbaijan are very diverse. Despite this, pomegranate settled in almost all regions of the republic, except of high-mountain and highly saline areas.

The culture of pomegranate long before our era is evidenced by ancient legends, ancient literature, as well as paleontological and geological data.

During archaeological excavations in Azerbaijan, pomegranate fruits dating back to the 11th century BC were found. [Akhundzade et al., 1977; Gumel, 1940]. Bronze Age pomegranate seeds were discovered near modern Khanlar. Remains of a 1st century BC pomegranate were found in a jar burial in Azerbaijan [Gaziyev, 1949]. Arab scientists and travelers in the 8th-10th centuries pointed out in their writings that the subtropical gardens extended for several kilometers. In the 12th century, many gardens were destroyed by the Mongols. Only since the 17th century does information about subtropical crops in Azerbaijan reappear.

In the long historical process of its development, pomegranate acquired an increased ability to accumulate nutrients beneficial to humans, increasing its ability to vary [Parashuram et al., 2023]. Centuries-old selection since prehistoric times has been directed towards the improvement of plants [Sharma et al., 2020; Singh et al., 2019]. In cultivation, pomegranates of Azerbaijani origin have gone far along the path of evolution, and currently, compared to endemic and intermediate forms, they have high-quality properties and greater polymorphism. In Azerbaijan you can see the whole gamut of changes, the whole variety of forms from extremely small-fruited savages to very large-fruited cultivated ones with their diverse characteristics, and increased variability, thanks to better nutritional conditions [Strebkova, 1970; Strebkova, 1976]. Pomegranate plants easily transition from cultivated forms to a wild state and vice versa. For millennia, selection has invariably moved in the same direction towards improving the fruit and its taste [Sharma et al., 2020; Shukla and Vashishtha, 2004].

Azerbaijan, being the world geographical center of pomegranate origin, has also concentrated its varietal wealth. There are several dozen varieties of centuries-old folk selection. Among them are several high-quality varieties that are famous outside of Azerbaijan [Akparov et al., 2015; Strebkova, 1976].

First of all, Azerbaijan, Iran, and Afghanistan should be recognized as the homeland of pomegranate [Finetto, 2009; Ghasemi-Soloklui et al., 2019; Holland et al., 2009; Teixeira da Silva et al., 2013]. These countries were a place of concentration and mass distribution of wild pomegranate and ancient centers of its wide formation. From here, pomegranate spread to new human habitats [Ghasemi-Soloklui et al., 2019; Parashuram et al., 2023].

Azerbaijan is located at parallel 38°42" northern latitude; this provides the area with a large amount of solar warmth and light throughout the year, which is necessary for the long growing season of pomegranate.

At longitude 45-50° east of Greenwich, Azerbaijan lies in the continental part of the mainland, in the so-called eastern Aral-Caspian region. This position, on the contrary, creates unfavorable conditions for pomegranate: a significant degree of dry air, and severe insolation. Due to this, relatively large daily temperature fluctuations are observed here, mechanical weathering of soils predominates, and gray soils and solonchaks dominate. The presence of the Greater and Lesser Caucasus mountain ranges in Azerbaijan contributes to the formation of condensation moisture and improves the climate.

The places where pomegranate grows are characterized by a large amount of solar heat, the sum of active temperatures up to 4000-4600°, and annual precipitation up to 560 mm. The amount of evaporation is large, it ranges from 727 to 1000 mm. The moisture deficit is especially great in the Salyan, Mugan, Mil, Karabakh, and Shirvan steppes.

The best pomegranates are grown in areas with dry or semi-arid climates. In humid areas, its fruits are of lower quality and during the ripening period, if it rains, they crack. In tropical places, it goes into wood and produces almost no harvest. Ecologically, pomegranate is a transitional type from mesophyte to xerophyte. Pomegranate is located in the dry subtropics, however, within them, it chooses semi-mesophilic habitats: coastal strips of seas, rivers, and former river beds.

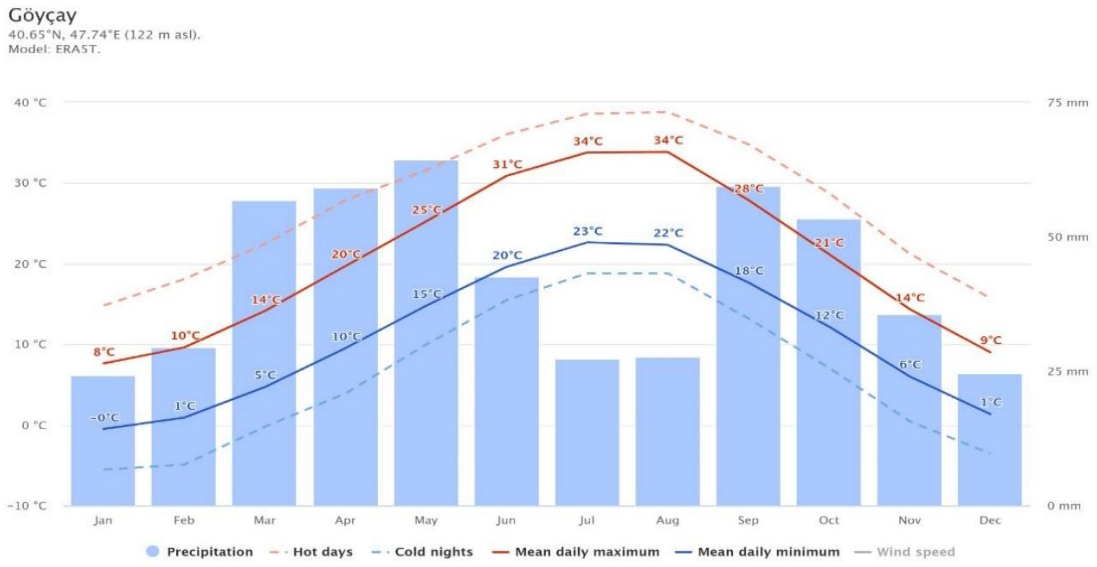

Figure 3. *Average temperatures and precipitation in the Goychay region of Azerbaijan, 2023*

High humidity without stagnant moisture in the soil does not harm pomegranate plants. At the same time, it can withstand long periods of drought without noticeable damage. Dry soil mainly affects the quality of the crop: the fruits become smaller and crack. The best growth of pomegranate is observed in areas with mild winters, where the absolute minimum does not drop below -12°C.

The pomegranate is very light-loving. In the shade it grows long, weak branches, has a small number of leaves, blooms poorly, bearing mostly short-pistillate flowers.

The regions of Azerbaijan with ideal climatic conditions for growing pomegranate are Goychay (Figure 3), Kurdamir and Agsu, which are respectively the leaders in pomegranate production in Azerbaijan (Table 1). Similar climatic conditions are in the other regions listed in Table 1.

3.5. Widespread pomegranate varieties in Azerbaijan

More than 500 varieties of pomegranate are known. Of these, about 60 varieties are most widely used in production in various countries of the world. Here is a description of the varieties that are most widespread in the world.

Azerbaijani Guleysha *(Azerbaijan).* Bush of medium (3 m) height, densely branched. The fruits are large (300-400 g), rounded or rounded-elongated, with a medium narrow cup and a cylindrical neck. The crust is thin, shiny, red-pink. The berry is large, red, medium-sized seeds. The juice is sweet and sour, tasty, and bright red. Contains up to 20% sugar and 1.8% organic acids. The juice yield is 55%. The fruit ripens in October. The fruit is harvested in October. The yield of the bush is on average 45-50 kg.

Pink Guleysha *(Azerbaijan).* The bush is of medium height, up to 3-4 meters, densely branched. The fruits have a rounded-elongated shape, large (200-250 g), with a low yield the fruit reaches 400-600 g. The peel is thin, creamy-pink. The neck is cylindrical, with a narrow cup. The berry is medium, dark cherry color. The juice yield is 54.5%, sugar content is 15.6%, and cidity is up to 1.3%. The juice is sweet and sour. The fruits ripen in October. The bush yield is 35-45 kg.

Gyrmyzy Guleysha *(Azerbaijan).* The bush is large, dimensional, and has well-defined spines. When ripe, the fruits reach large (350-500 g) or medium (250-300 g) size, round in shape. The peel is carmine-red with pronounced stripes at the very top of the fruit. The neck is very high, but not very thick, the teeth are large and long, and the narrow ones are bent inward or bent outward. The berries are large, dark cherry color, with sweet and sour juice. The juice yield is 53.5%, sugar content 15.5%, and acidity 1.5%. The juice is sweet and sour. The fruits ripen at the end of October. The yield of the bush is 50-55 kg.

Gyrmyzy gabyk *(Azerbaijan).* The variety is distinguished by its large bush size (4 m or more), with smaller spines. The fruits are large (350-450 g), and spherical. The peel is medium thick, and bright red. The berry is large, and raspberry-red. The juice is dark red, sweet and sour, and very tasty. Juice yield 52.4%, sugar content 14.5%, acidity up to 2.1%. The fruits ripen at the end of October and are stored for 4-5 months. Productivity per bush is 45-50 kg.

Nazik gabyk *(Azerbaijan).* The bush is vigorous (up to 4 m high). The fruits are large (400 g), and dark red. The crust is thin. The berries are large. The juice yield is 48.8%, sweet and sour, and contains up to 12.3% sugar and up to 2.6% acid. The fruits ripen in early or mid-October. Productivity is high. 35-40 kg of fruits are collected from each bush. The fruits are stored for 3-4 months.

Bala mursal *(Azerbaijan).* It is considered one of the best varieties grown in sunny Azerbaijan. The bushes reach 3 m in height, with a small number of thorns. The fruits are flattened-round in shape, small in size, and medium, weighing about 300 grams, with a light raspberry-red blush. The crust is thick. The berries are medium-sized and, dark red. Juice yield

54.3%, juice varies from rich red to raspberry color. The taste is sweet and sour, and contains up to 16% sugars and 1.5% acids. The fruits ripen in early October and are stored for 3-4 months. An average of 30-40 kg of crop is collected from each bush.

Shah nar *(Azerbaijan)*. Medium-sized bush, densely branched. The fruits are medium-sized (300-350 g), round or pear-shaped. The rind is medium thick, light coffee-red in color. Medium-sized berries. The juice yield is up to 53.9%, sweet and sour, the taste is pleasant, and contains up to 13.4% sugars and up to 2.1% acid. The fruits ripen in the second half of October. Productivity is good. From the bush, you get 30-35 kg of fruit. The fruits are stored for up to 6 months.

Veles nar *(Azerbaijan)*. Medium-sized bush. The fruits are medium-sized (200-250 g), round-oval. The rind is thick, light cream in color, and covered with a dark brown shell, reminiscent of hornbeam bark. The fruit is medium-sized, pink-red. Juice yield 50.2%, sweet, low acidity. The fruits ripen by the end of October and are stored for 3-4 months. Productivity is high. 40-45 kg of fruits are obtained from the bush.

VIR No.1 *(Azerbaijan)*. A bush of medium height (2.5-3 m), with a spreading crown. The flowers are large, and light red. The fruit is large (350-400 g), spherical, sometimes pear-shaped. The peel is thick, and light yellow. The berry is light red, with a pleasant taste. The juice yield is high (56.7%). The fruits ripen at the end of October. About 45 kg of the crop is harvested from each bush.

Akdona *(Uzbekistan)*. A popular large-grained form of garnet is called Tyuyatish (camel's tooth). The size of the bush is big, but at the same time compact. The fruits are flattened-round or spherical. The weight of the fruit is approximately 250 g, sometimes the fruit reaches a weight of up to 600 g or more. The peel is smooth, shiny, and light in color, with a slight crimson blush. The small calyx is cone-shaped, with curved teeth. The grains (berries) are pink, the seeds are elongated. The juice is pale pink, very sweet, and contains approximately 15% sugar and about 0.6% acids. The fruits ripen in early October and are stored for about two months. The yield is 20-25 kg per bush or more.

Kyzyl anor *(Uzbekistan).* It is considered one of the best varieties grown in Uzbekistan with round-flat fruits and small sizes, but sometimes the fruits are large and reach 600-800 g. The skin is thin or medium thick. The berries are medium, dark red. The color of the juice is from red to dark cherry, sweet and sour taste, sugar content of up to 15.5%, and acid content of up to 1.9%. Early ripening variety. The fruits ripen around the beginning of October. They are stored for approximately 3-4 months.

Kay-achik-anor (Central Asian variety). The bush is large. The fruits are large (300-400 g), spherical. Contains up to 16% sugar and up to 1.4% acid. The fruits ripen in mid-October. Transportability and keeping the quality of the fruit are good. Productivity up to 50 kg of bush.

Kazake anor (Uzbekistan). The fruits are large (300-400 g), spherical, greenish-yellow in color. The crust is medium thick, the grains are large. The juice is raspberry-red, sweet and sour, pleasant, and contains up to 20% sugar and up to 1.85% acid. Juice yield up to 45%. The fruits ripen in the first half of October. Productivity is high.

Wonderful *(California, USA).* This variety is most widespread in the USA. Here, more than half of the area is occupied by the Wonderful variety (seedless pomegranate). The fruit is small, weighing 180-220 g, but very tasty and sweet. The color of the fruit is white-yellow with a

delicate crimson blush. The fruits ripen in early October. The seeds are very small, the juice is light raspberry. Ripe fruits contain up to 13% sugar and approximately 0.4% acids. The yield of the variety is about 15 kg per bush. The fruit is stored for 2 months.

Siyah Dane *(Iran).* The fruits are very large, up to 640-700 g, round, dark crimson, bright, shiny. The thin skin and partitions occupy 25.6% of the weight of the fruit: juice with seeds up to 74.4%, dark raspberry, dark cherry juice, sweet-sour, tender, pleasant, its yield is 61.89%. Sugar content is 19.63%, acid 1.62% and vitamin 5.63 mg%. All family 12.51%. The fruits ripen in the first ten days of October. With full fruiting, the yield is 35-40 kg per bush.

Saveh (Iran). The fruits are large, up to 400-600 g. Red, bright. The average peel and partitions make up 33.4% of the weight of the fruit: Juice with seeds takes up to 66.6%, red, juicy, dark crimson, colorful, sweet, and sour, its yield is 52.17%, sugar content is 19.55% , acid - 1.83% and vitamin C 5.46 mg%. All families - 14.43%. The fruits ripen in mid-October. The yield from one bush during the period of full fruiting is 30 kg.

Malta (Spain). The fruits are large, up to 350-400 g. Greenish, with a bright red blush. The skin and partitions are thin, making up 26.56% of the weight of the fruit: Juice with seeds takes up to 73.44%, red, light red, sweet, and tender, its yield is 60.03%. Seeds are soft, edible - 13.41%. The sugar content is 18.0%, acid 1.05%, and vitamin C 5.4 mg. All families - 14.43%. The fruits ripen in the first ten days of October. With full fruiting, the yield is up to 32 kg per bush. An excellent dessert variety.

3.6. Improving the pomegranate varieties in Azerbaijan

Azerbaijan, being one of the most important centers of pomegranate genetic resources, has collected Azerbaijani local and breeding, as well as introduced pomegranate varieties (Figure 4) on the territory of the field collection of the Goychay Research Station of the Scientific Research Institute of Fruit and Tea Growing of Ministry of Agriculture of Azerbaijan (SRIFTG) [Akhundzade et al., 1977; Strebkova, 1970; Strebkova, 1976].

Although pomegranate genotypes grow in different climates around the world, only about 10% of the genotypes are cultivated commercially [Parashuram et al., 2023].

Improvement of the pomegranate assortment in Azerbaijan is carried out using the method of clonal selection, hybridization, and introduction.

Local pomegranate varieties of folk selection have gone through a long stage in their development. Over time, changes have occurred: in size (from 20 to 1000 g), amount of juice (30-70%), and taste (from tart-sour to sweet). Through selection, pomegranate varieties have been brought to high quality.

Figure 4. *Some varieties and forms of pomegranate collected in the collection garden of the Goychay Research Station of the SRIFTG*

The subject of clonal variability is mutations [Iskenderova, 1981; Iskenderova, 1980]. They represent changes in the hereditary basis of the genotype itself and its response to external conditions [Jalikop, 2010; Jalikop and Kumar, 1998; Levin, 1990].

Spontaneous mutations in pomegranate and differences from the original variety are expressed in: changes in the color of the fruit, their quality, ripening time, yield, and bush development [Jalikop, 2010; Karimi and Mirdehghan, 2013; Mars, 2000]. Among the main standard varieties (Pink Guleysha, Gyrmyzy Guleysha, Bala mursal, Gyrmyzy gabyk, Nazik

gabyk, Meles-Shelly, as well as VIR), plants with both positive and negative deviations are noted.

In clonal selection, the task is to improve and improve existing varieties. For this, strict control over the purity of the variety and intra-varietal selection are necessary [Mars, 2000; Singh et al., 2019; Sharma et al., 2020].

Accurate identification of genotypes is considered an important component for developing a plant breeding program. Studying the morphological characteristics of fruits is useful for identifying different genotypes of pomegranate. Morphological characteristics of fruits, such as the number of fruits and yield per tree, weight and shape of fruits, color, quantity, and quality of juice are important indicators for selecting a genotype as a commercial product [Wani et al., 2012].

At the same time, data on the metabolic composition of different pomegranate genotypes can help in choosing varieties for medicinal purposes.

Experimental data from many breeders [Jalikop, 2010; Mars, 2000; Levin, 1981; Levin, 1977; Sharma et al., 2020; Shukla and Vashishtha, 2004] showed the very important importance of repeated crossings with one of the hybrids or the best cultivars. Each new generation is a carrier of the properties of both parents or ancestors, which increases life potential [Awamleh et al., 2009; Ghasemi-Soloklui et al., 2019]. In the second generation, more promising forms were selected, medium and more resistant to low temperatures, and the healthiest and most productive forms of pomegranate were selected. Thus, the new qualities required of hybrids are enhanced to a degree not inherent in the original forms. These qualities must be strengthened in subsequent generations, then it will be possible to create completely winter-hardy plants.

Among the varieties selected by the Azerbaijan SRIFTG, the following can be noted:

Nasimi (Spring x Bala mursal+Agdam+Gyrmyzy Guleysha+Garabagh). The fruits are medium to large (350-400 g), round or flat-round, red, blurry, with creamy gaps with red spots, streaks, and dots. The calyx is small: the neck is slightly cone-shaped, and the teeth are bent. The skin and septum are medium, making up 30.2% of the weight of the fruit. Juice with seeds takes up 69.8%; the juice is sweet and sour, cherry, in an amount of 59.2%. Sugar content is 18.3%, acid content is 2.03%, vitamin C is 6.9 mg%. Total seeds 10.6%. Very productive. The harvest at 7 years is 40 kg per bush.

Vurgun (Spring x Azerbaijan). The fruits are large (415 g), and round, with a basic cream color, an integumentary red color, blurred throughout the fruit with stripes and dots. The calyx is wide, the neck is straight, slightly conical: the teeth are curved, sometimes straight. The skin and membranes are of medium thickness. The juice with seeds makes up 70.6%, and the juice is sour-sweet, dark red, in the amount of 53.8%. The weight of 100 seeds is 5.7 g. Sugar content is 18.8%, acid is 1.98%, vitamin C is 7.9 mg%. Total seeds 16.8%. The variety is productive. Harvest 7 years bush - 36 kg per bush.

Pomegranate varieties are multi-seeded, containing 300-1000 or more seeds. They are usually very hard, and inconvenient for dessert use. Even in ancient times, people sought to get rid of this deficiency in the fruit. In Palestine in prehistoric times there were soft-seeded pomegranate fruits. Among our varietal collections, there are soft-seeded Malta, Paper, and Iranian. All these are varieties with a sweet taste, very tender, and less stable at low temperatures than local ones. Malta is a high-quality variety/, but of non-standard color. Paper - also pale in

color, severely damaged by the codling moth, Iranian - cream with a bright blush, has insufficient juiciness. In the progeny of the Paper variety, 2 soft-seeded seedlings were isolated.

Among the selection seedlings from repeated crossings, soft-seeded plants with fruits with sweet juice were selected. In terms of quality and color of juice, the highest quality ones are (NP2-12-13) - Mekhseti and (NP2-7-14) - Dessert Azerbaijani.

Mekhseti (Spring x Azerbaijan). The fruits are large (350-400 g), round and flat, dark crimson, and bright, red. The calyx is small. The skin and partitions are average - 32.6% of the weight of the fruit. The yield of juice with seeds is 67.4%. The juice is sweet, tender, dark raspberry, red, in the amount of 56.3%, sugars 20.29%, acids 0.31%, vitamins 4.58 mg%. The seeds are small, soft, edible - 11.1%. The fruits ripen in early October. Productive the 7-year bush - 26.7 kg.

Dessert Azerbaijani (Azerbaijan x Malta). The fruits are medium to large (350 g), round, dark crimson. The calyx is small, the neck is funnel-shaped. The skin and partitions are thin - 28.3% of the weight of the fruit: juice with seeds is 71.7%, of the weight of the fruit: sweet, cherry juice, in the amount of 59.3%, contains sugars 17.01%, acids - 0.73 %, vitamin 6.2 mg%. Seeds make up 12.4%, fragile, edible. The fruits ripen in early October. Productive the 7 years bush – 22,0 kg.

Aleko (Spring x pollen mixture Bala mursal + Agdam + Gyrmyzy Guleysha + Garabagh). The fruits are large (500 g), flat-round, round, intense crimson, with subcutaneous light greenish dots. The calyx is small, the neck is high, and straight: the teeth are small, straight, and slightly curved. The skin and partitions are thin - 26.4% of the weight of the fruit. The juice is sweet and sour, dark cherry, tender, wine-like, and very tasty - 63.5%. Contains sugars - 20.8%, acids - 2.01%, vitamin C - 8 mg%. The seeds are small, fragile 7x3.7x4 mm, elongated, and weighing 10.1%. The fruits ripen in the first ten days of October. Productive the 7-year bush - 28.8 kg.

4. Conclusions

The pomegranate crop still faces many challenges that modern breeding programs must overcome. The future of this fruit depends on the selection of high-quality varieties with soft seeds and fruit that are resistant to cracking. Direct use of existing varieties and "wild types" may be more effective than new hybridization. Most of the genetic combinations that breeders may look for are likely to be common in varietal populations and wild ecotypes. Since the collection cannot exceed a limited number of specimens, it is difficult to preserve the evolutionary potential of the species. Thus, the need to conserve genetic resources must be taken into account. The role of traditional local producers in preserving this primary gene pool is very valuable. However, in many countries further searching, collection, evaluation, and selection of local material is necessary. The list of descriptors needs to be adopted on a large scale. New methods (biochemical, molecular methods, etc.) need to be developed for cultivar identification and genetic studies. Many restrictions are imposed by the characteristics of trees and fruits, and new approaches (methods, etc.) must be developed for pomegranate breeding.

On the other hand, the exchange of plant material should be encouraged at the regional and international level. Specific guidelines for the safe movement of pomegranate genetic resources need to be developed. Adaptation and screening trials should be carried out, paying particular attention to fruit quality, physiological abnormalities, and pest resistance.

Features such as reducing plant size to increase plant density in the garden, selecting self-fertile genotypes to maintain higher, consistent yields over time, and selecting genotypes with higher fruit nutritional value also need to be considered in breeding depending on the fruit crop being targeted. Genetic improvement of most types of fruit crops poses several obstacles. These include the long period of youth of some species, frequent inter- and intraspecific incompatibility, high heterozygosity, infertility, and the presence of specific characteristics only in wild species. These characteristics make breeding methods difficult, expensive, and time-consuming. This explains why some fruit crops have been improved almost entirely by clonal selection, exploiting variability resulting from spontaneous mutations or selecting from plants resulting from natural hybridization.

Recent molecular and biotechnological approaches such as somaclonal variation, gene transformation, or protoplast technology offer the potential to introduce significant changes in varieties, but limited progress has been made in this fruit crop. Such goals can be achieved through systematic and well-planned breeding programs, both traditional and biotechnological approaches.

References

Akhundzade I.M., Fedorova E.E., Mamedov G.M. and Iskenderova Z.D. (1977). Study of the cytogenetic characteristics of pomegranate. Ispol-biofiz-metodov-v-genet-seleksion-eksperimenti, 8-9

Akhundzade I.M. Radiation mutagenesis in subtropical crops. (1981). 1-ya-Vses-konf-po-prikl-radiobiol: -Teor-prikl-aspekty-radiats-biol-tekhnol., 50-51

Akparov Z.I., Bayramova D.B., Mustafayeva Z.P., Babayeva S.M. and Mammadov A.T. (2015). Pomegranate (*Punica granatum* l.) genetic diversity in Azerbaijan. *Acta Horticulturae*, 1089. 253-256. DOI: 10.17660/ActaHortic.2015.1089.32

Al-Said F.A., Opara L.U. and Al-Yahyai R.A. (2009). Physico-chemical and textural quality attributes of pomegranate cultivars (*Punica granatum* L.) grown in the Sultanate of Oman. *Journal of Food Engineering*, 90, 129–134. DOI:10.1016/j.jfoodeng.2008.06.012

Awamleh H., Hassawi D., Migdadi H. and Brake M. (2009). Molecular characterization of pomegranate (*Punica granatum* L.) Landraces grown in Jordan using amplified fragment length polymorphism markers. *Biotechnology*, 8, 316–322. DOI:10.3923/biotech.2009.316.322

Basu A. and Penugonda K. (2009). Pomegranate juice: A heart-healthy fruit juice. *Nutrition Reviews*, 67, 49–56. DOI:10.1111/j.1753-4887.2008.00133.x

Colombo E., Sangiovanni E. and Dell'Agli M. (2013). A Review on the Anti-Inflammatory Activity of Pomegranate in the Gastrointestinal Tract, Evidence-Based Complementary and Alternative Medicine. DOI: 10.1155/2013/247145.

Fahmya H., Hegazi N., El-Shamya Sh. and Farag M.A. (2020). Pomegranate juice as a functional food; A comprehensive review of its polyphenols, therapeutic merits, and recent patents. *Food Funct*. DOI:10.1039/D0FO01251C

Finetto G.A. (2009). Pomegranate industry in Afghanistan: opportunities and constraints. II International Symposium on Pomegranate and Minor - including Mediterranean - Fruits: ISPMMF. DOI:10.17660/ActaHortic.2011.890.2

Gasanov Z., Mikeladze A., Kopaliani R. and Suleymanova Y. (2013). Subtropicheskiye kultury. "East-West" Publishing, 21-31

Gaziyev S.M. (1949). Materialnaya kultura Azerbaijana, v.1

Ghasemi-Soloklui A., Gharaghani A., Oraguzie N., Saed-Moucheshi A. and Vazifeshenas M. (2019). Genetic diversity, heritability and inter-relationships of fruit quality and taste attributes among Iranian pomegranate (*Punica granatum* L.) cultivars using multivariate statistical analysis. Fruits, The International Journal of Tropical and Subtropical Horticulture, 74, 303–318.DOI:10.17660/th2019/74.6.5

Gumel Y.I. (1940). Archeologicheskiye ocherki

Gül H. and Şen H. (2017). Effects of pomegranate seed flour on dough rheology and bread quality. *Cyta–Journal of Food*, 15 (4), 622-628. DOI: 10.1080/19476337.2017.1327461

Hafizov S. and Hafizov G. (2022). Estimation of transparency of pomegranate juice during its storage. *Progress in Chemical Science Research*, 4, 70-83. DOI: 10.9734/bpi/pcsr/v4/7892F

Hafizov G. (2016). Pomegranate and pomegranate juice are the business cards of Azerbaijan. *World Science*, 8(12), 1, 10-17

Holland D., Hatib K. and Bar-Ya'akov I. (2009). Pomegranate: Botany, Horticulture, Breeding. In: Janick J, editor. *Horticultural Reviews*, 127–191. DOI: 10.1002/9780470593776.ch2

Iskenderova Z.D. (1979). Breeding works with forms of pomegranate with double flowers. Vses-shkola-molod-uchenykh-i-spetsialistov-po-teorii-prakt-selektsii-rast, 1981-1982

Iskenderova Z.D. (1980). Double forms of pomegranate and their use in ornamental horticulture. *Byelleten Glavnogo Botanicheskogo Sada*, 115, 58-62

Jalikop S.H. (2010). Pomegranate breeding. Fruit, Vegetable and Cereal Science and Biotechnology 5 (special issue 2), Global Science Book, 26-34

Jalikop S.H. and Kumar P.S. (1998). Use of soft, semisoft, and hard–seeded types of pomegranate (Punica granatum) for improvement of fruit attributes. *Indian Journal of Agricultural Sciences*, 68(2), 87-91

Jing P., Ye T., Shi H., Sheng Y., Slavin M., Gao B. and Yu L. (2012). Antioxidant properties and phytochemical composition of China-grown pomegranate seeds. *Food Chemistry*, 132, 1457–1464. DOI: 10.1016/j.foodchem.2011.12.002

Jurenka J.S. (2008). Therapeutic applications of pomegranate (*Punica granatum* L.): A review. *Alternative Medicine Review*,13, 128–144

Karimi H.R. and Mirdehghan S.H. (2013). Correlation between the morphological characters of pomegranate (*Punica granatum*) traits and their implications for breeding. Turkish Journal of Botany, 37, 355-362. DOI:10.3906/bot-1111-14

Lansky E.P., Newman R.A. (2007). *Punica granatum* (pomegranate) and its potential for prevention and treatment of inflammation and cancer. Journal of Ethnopharmacology, 177–206. DOI:10.1016/j.jep.2006.09.006

Levin G.M. (1990). Breeding pomegranate. *Sadovodstvo-i-vinogradarstvo* 10, 31-32

Levin G.M. (1981). Soft seed pomegranate varieties. *Subtropicheskiye Kultury* 1, 153-155

Levin G.M. (1977). Variation in wild pomegranate in the western Kopetdag. *Turkmenistan-SSR-Ylimlar-Akademiy-Habarlary-Biologik-Ylymlaryn* 5, 40-45

Mars M. (2000). Pomegranate plant material: Genetic resources and breeding, a review. Production, processing, and marketing of pomegranate in the Mediterranean

region: Advances in research and technology. Zaragoza: CIHEAM, 55-62. http://om.ciheam.org/om/pdf/a42/00600252.pdf

Mena O., Gironés-Vilaplana A., Martí N. and García-Viguera C. (2012) Pomegranate varietal wines: phytochemical composition and quality parameters. *Food Chemistry*, 133, 108–115. DOI: 10.1016/j.foodchem.2011.12.079

Miguel Maria G., Neves Maria A. and Antunes Maria D. (2010). Pomegranate (Punica granatum L.): A medicinal plant with myriad biological properties - A short review. *Journal of Medicinal Plants Research*, 4(25), 2836-2847. DOI:10.5897/JMPR.9001028

Nguyen M.P. (2020). Study on factors affecting pomegranate (*Punica granatum*) wine fermentation. *Research on Crops Journal*, 21, 257–262. DOI: 10.31830/2348-7542.2020.045

Ozgen M., Durgaç C., Serçe S. and Kaya C. (2008). Chemical and antioxidant properties of pomegranate cultivars grown in the Mediterranean region of Turkey. *Food Chemistry*, 703–706. DOI:10.1016/j.foodchem.2008.04.043

Parashuram Sh., Sowjanya P.R. and Singh N.V. (2023). Pomegranate Genetic Resources: Conservation and Utilization. In the book: Fruit and Nut Crops., 1-42. DOI:10.1007/978-981-99-1586-6_18-1

Sevda S.B. and Rodrigues L. (2011). The making of pomegranate wine using yeast immobilized on sodium alginate /*African Journal of Food Science*, 5(5), 299 – 304

Sharma A., Dogra R.K., Singh G. and Bodh S. (2020). Changing Paradigms in Pomegranate Breeding: A Review. *International Journal of Current Microbiology and Applied Sciences*, 9(09), 1878-1887. DOI: https://doi.org/10.20546/ijcmas.2020.909.237

Sharma P., McClees S.F. and Afaq F. (2017). Pomegranate for Prevention and Treatment of Cancer: An Update. *Molecules*, 22(1), 177. https://doi.org/10.3390/ molecules22010177

Shukla A.K. and Vashishtha B.B. (2004). Fruit breeding approaches and achievements. International Book Distributing Comp, Charbagh, Lucknow, U.P., 342

Singh T.H., Gupta T. and Sharma S. (2019). Development and purity identification of hybrids by using a molecular marker in wild pomegranate (*Punica granatum* L.). *Scientia Horticulturae*, 247. 436-448. DOI: 10.1016/j.scienta.2018.12.007

State Statistics Committee of the Republic of Azerbaijan. URL: https://www.stat.gov.az/

Strebkova A.D. (1970). Pomegranate breeding in Azerbaijan. *Azarb-elmi-tadgigat-bagcyl-uzumcul-va-subtrop-bitkil-inst-asarlari* 7, 80-89

Strebkova A.D. (1976). Improving the assortment of pomegranate varieties in Azerbaijan. *Azarb-elmi-tadgigat-bagcyl-uzumcul-va-subtrop-bitkil-inst-asarlari*, 9, 91-96

Su X., Sangster M.Y. and D'Souza D.H. (2011). Time-dependent effects of pomegranate juice and pomegranate polyphenols on foodborne viral reduction. *Foodborne Pathogens and Disease*, 1177–1183. DOI: 10.1089/fpd.2011.0873

Teixeira da Silva J.A., Rana T.S., Narzary D., Verma N., Meshram D.T. and Ranade S.A. (2013). Pomegranate biology and biotechnology: A review. *Scientia Horticulturae Journal*, 87–107. DOI:10.1016/j.scienta.2013.05.017

Turrini E., Ferruzzi L. and Fimognari C. (2015). Potential Effects of Pomegranate Polyphenols in Cancer Prevention and Therapy, Oxidative Medicine and Cellular Longevity. DOI:10.1155/2015/938475

Wani I., Bhat M.Y., Banday F.A., Khan I.A., Hassan G.I., Lone A. and Bhat T.A. (2012). Correlation studies of morphological and economic traits in pomegranate (*Punica granatum* L.). *Plant Archives*, 12, 943–946

Viuda-Martos M., Fernández-López J. and Pérez-Álvarez J.A. (2010). Pomegranate and its many functional components as related to human health: A review. *Comprehensive Reviews in Food Science and Food Safety*, 9, 635–654. DOI: 10.1111/j.1541-4337.2010.00131.x.

Vroegrijk I.O., Van Diepen J.A., Van Den Berg S., Westbroek I., Keizer H. and Gambelli L. (2011). Pomegranate seed oil, a rich source of punicic acid, prevents diet-induced obesity and insulin resistance in mice. *Food and Chemical Toxicology*, 49, 1426–1430. DOI: 10.1016/j.fct.2011.03.037

Vitkovskiy V.L. (1984). Morfogenez plodovykh rasteniy. "Kolos" Publishing, 207