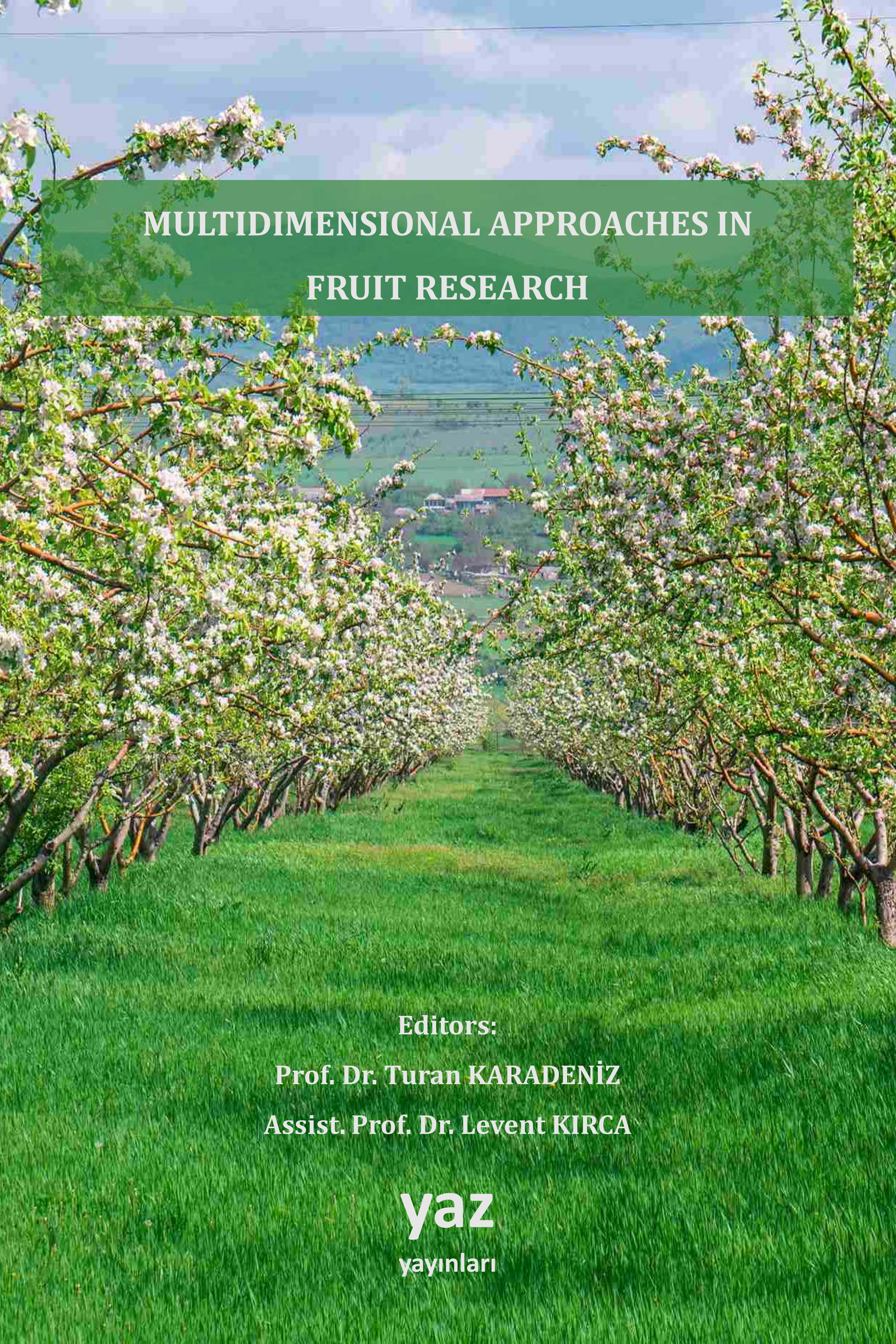

MULTIDIMENSIONAL APPROACHES IN FRUIT RESEARCH

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Multidimensional Approaches in Fruit Research

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CONTENTS

SOME FRUIT TYPES USED AS FURNITURE

Turan KARADENİZ[1]

1. INTRODUCTION

The fruit, flowers, and leaves of fruit trees can be used as ornamental plants in landscaping, as shade trees in the courtyard or the field, as boundary trees at the separation of lands, as good perches for birds, as good filter trees that clean the polluted air of the city, as a good confidant that protects and beautifies the land of the country. Those who are old and have no economic value are friends who contribute to the family budget, such as good furniture and raw materials. This is because fruit species are mainly cultivated for dual purposes, as their fruits and timber are valuable. This study will present information about the use of fruit species grown in our country, especially for fruits that have completed their economic life or have no commercial value, grow as under-forest plants, and are more valuable when processed into furniture.

2. CORNELIAN CHERRY

Cornelian cherry is a type of tree that is used in different areas. The wood of the tree, which is hard, heavy, and dense, has a fibrous structure, is flexible and durable, and sinks in water because of its high density. Its yellow-red core and pink-white wood are suitable for polishing. This tree is widely used in the production of walking sticks and clubs. Devrek and Ahlat walking sticks are made especially from the cornelian tree. Paint is

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obtained from its bark and tannin from its leaves. In addition, chairs, textile shuttles, weaving shuttles, and mill teeth are produced from cornelian cherry. Handicraft products such as chip figurines and office supplies are also made from this tree. Cornelian cherry is essential in terms of beekeeping due to its early flowering. It is preferred for decorative purposes in garden landscaping because it is resistant to cold weather. In some regions, it is grown in belts to prevent erosion.

Stages of the Production of Devrek Walking Stick

It is done in eight stages.

2.1a-Baking: Cornelian cherry is a tree that grows in the form of branches, and its branches are generally not smooth. The most striking feature of this tree is that it softens when heated at 180-240°C for 8-15 minutes and then shaped on a smoothing board (a thick, durable board with holes of various sizes on it, where wood pieces are processed in these holes and flattened). Then, a cooling process is applied.

2.2- Turning: The most critical stage in cane making is turning. This process varies in thickness and aesthetics depending on the handle's shape and the carvings' design. In the turning process, the section where the handle will be attached, the body to be processed, and the parts to be connected to the tip are arranged by pulling.

2.3- The trunk: The cornelian cherry trunk is shaped on the lathe, and patterns such as snakes and diamonds are pre-marked and carefully arranged in the most aesthetically pleasing way. This is done by hand; some patterns are challenging and laborious, while others are simpler. The price of the canes is determined by the degree of difficulty of this artistry. The body is then cleaned, sanded, and painted, and a coat of varnish is applied. The motif to be engraved on the body is temporarily pasted with photocopied motif papers, and the lines of the motifs are transferred to the body with drills attached to the end of a spiral tool. This process continues until the inner part of the motifs reaches the tree's white part. This way, the motifs gain a pleasing arrangement and a classical appearance.

2.4- Cutting the stem: The harmony between the stem and the processed body is significant. Not every shank model is suitable for everybody and every machining style. Each design has its unique handle shape. The stems are meticulously cut on wooden strip machines under the molds and then processed so that holes are drilled. Through these holes, the handles are mounted to the body with glue. Since the first cut is usually rough, the strip is then trimmed and trimmed to match the body. The corners of the cut handle are rounded with a milling cutter, and then final aesthetic adjustments are made on unique benches using rasps and files.

2.5-Inserting tip: In the turning process, the area where the bit is to be inserted is first treated. Then, the bit is drilled and glued to the end of the body. After the adhesive dries, the body is cleaned to make it visually pleasing. These ends' durability and aesthetic appearance are essential for Devrek walking sticks.

2.6—Sanding: After the carving and filing processes are completed, start with coarse sanding to remove the rasp marks on the handle and body. The roughness is removed with fine sanding until the cane's shapes become apparent and the body shiny.

2.7- Coloring: The color on the cane is not painted in the traditional sense. This unique color application distinguishes the Devrek walking stick from others worldwide. This is where the distinctive place of dogwood in cane-making comes into its own. The dyeing process is usually done with china ink or pure nitric acid. Pure nitric acid can be diluted with water to produce a yellow color, or iron can be dissolved with acid and mixed with water to make brown tones. The color is applied carefully to the designated parts of the cane without touching it by hand. These colors are permanent on the surface of the cane and cannot be removed without a scrap.

2.8-Varnishing: The finished cane is usually varnished with a fast-drying cellulosic varnish, thinned in a long pipe using dipping and filtering. The dipping method is the most effective technique, allowing the varnish to spread evenly over all areas. This process is repeated regularly until a good varnished surface is obtained (Figure 1).

Figure 1. Devrek cornelian cherry canes (Anonymous, 2024a).

3. PLUM

Plum is a member of the genus *Prunus* of the *Rosaceae* family. In Türkiye, it grows everywhere except the high plateau regions of Eastern Anatolia and some arid and hot parts of Southeastern Anatolia. Early-ripe plums (*Prunus cerasifera*) are followed by Japanese or Italian plums (*Prunus salicina*) that ripen mid-summer. European plums (*Prunus domestica*), which begin to ripen in August, can be eaten until October. The fruits of the plum ripen in different periods, and the fruits of various shapes and sizes attract attention with their thin skins, which are usually green, yellow, red, and purple. Türkiye's most common plum species are the Can, Mürdüm, Papaz, and sweet Üryani plums.

Plum trees, depending on their species and varieties, can be large, small, or shrubs. In plum, a stone fruit, a hard seed shell is formed by the hardening of the inner part. The eaten part has a fleshy and juicy structure. Fruits vary greatly in shape, color, and taste. The seeds (kernels) are bitter.

Plum varieties are classified into three main groups in terms of seed formation: self-fertile, partially self-fertile, and self-fertile. Seed-forming varieties are needed to obtain good yields from partially self-fertile varieties.

Although the plum tree can grow in different soil conditions, it grows most efficiently in nutrient-rich, humus-rich, warm, moderately deep, or profound soils with sufficient moisture. Cuttings and grafting usually produce cultivated plums.

Plums are divided according to their ripening period and intended use. They contain sugar, pectin, and organic acids. The fruits can be consumed fresh or dried and used to produce sweets and, in some regions, pulp.

Plum wood is used in many areas, such as lathe products, musical instruments, inlay work, knife handles, furniture, box making, jewelry boxes, and dowry chests (Figure 2).

Figure 2. A vase made of plum wood (Anonymous, 2024b).

4. CHESTNUT

Chestnut grows naturally in southern Europe and central Europe, Yugoslavia, Bulgaria, and Greece in the Balkans, Türkiye, the Caucasus, the Alps region of Italy, and the southern slopes of the Alps, Spain, and North Africa. In our country, it grows along the Black Sea coast, around Istanbul, in the Aegean region, and east of Antalya.

There are about ten different species of chestnut trees throughout the Northern Hemisphere. The most common and well-known species is the Anatolian chestnut (*Castanea sativa*), native to Southern Europe, North Africa, Turkey, and the Caucasus. However, this is the only chestnut species in our country.

Preferring temperate climates and shady areas, chestnuts can grow up to 30 meters. It has an awe-inspiring appearance with its dense branches and wide top—the trunk bark, which is smooth when young, cracks when it ages. The tip of the long spear-like tip, which can grow up to 30 centimeters, is sharp; the teeth of the particles and the upper part are rubber.

Chestnut tree products generally grow in the Marmara and Black Sea forests. The chestnut tree rate in Türkiye's forests is 1.4%.

Chestnut wood is often preferred in furniture production because it is resistant to moisture and maintains its structure even when in contact with water. Its high tannin content makes it easy to paint. Chestnut has a heartwood; its outer wood is narrow, and its inner wood is wider. Its hoop structure is porous, and these pores can be observed in spring tissue. However, the pores in autumn tissue are smaller and invisible to the eye. Since the sap rays are not visible, this is an important feature distinguishing chestnut wood from oak wood. The color of the outer wood is usually dirty yellow, sometimes white or gray, and the inner wood is yellow-brown.

The chestnut tree attracts attention with its complex, tight texture, flexibility, and easy breaking. It can be easily bent thanks to its long threads. It shows minor deformation and is relatively easy to process. It adapts very well to paint and varnish applications. It is extraordinarily resistant to water and forms strong bonds with nails or glue. Being easy to break and bend allows chestnut trees to be processed effortlessly. Chestnut, generally preferred for windows, garden furniture, and parquet flooring, is also used to produce decorative accessories. Chestnut, which has an air-dried specific gravity of 0.56 gr/cm^3, is also evaluated in producing solid and veneered furniture, apart from structures such as joinery, bridges, and pier legs. It is also a widely sought-after material in bending furniture.

The sapwood of the chestnut tree consists of 2-5 rings and has a very narrow, dirty, yellowish-white color. The heartwood varies between light and dark brown tones. The heartwood is quite resistant to decay because it contains tannin. Chestnut wood is moderately hard and heavy, with low bending ability and medium shock resistance. Rich in tannin, this wood can be quickly processed.

The fruits of the chestnut tree are known to be rich in carbohydrates and have been an important food source throughout history. Chestnut wood is widely used in furniture making. In addition, large chestnuts are grown in Bursato, which produces chestnut candy. Chestnut wood is also used as fuel.

The wood of the chestnut tree is used in various areas of furniture production. Apart from structures, it is also preferred in joinery works, bridges, and pier legs. The areas of use of the chestnut tree in the wood industry include making bent furniture, veneer production, shipbuilding, wire poles, lower handle production, garden fence production, pannier, and basket production (Figure 3). The timber of the chestnut tree is similar to the wood of the oak tree in terms of durability and decorative features. However, since it tends to crack and warp during drying, it isn't easy to produce large-sized timber from this tree.

Nevertheless, due to its durability, it is preferred in some garden woodwork. In Italy, it is used in barrel production. In addition, the smooth branches of the chestnut tree produce poles for shaking olives.

Figure 3. A side table made of chestnuts (Anonymous, 2024c)

5. MULBERRY

Mulberry leaves, the only food source for silkworms in our country, have an essential place in our country's economy. However, mulberry trees should not be viewed only as food for silkworms. Mulberry leaves are as valuable as clover for small and large cattle and can be used in fresh and dried animal feed.

Mulberry trees have been grown for their fruit and leaves for many years. Their yellow and durable wood produces wheels, agricultural tools, home furniture, walking sticks specific to the

Bitlis/Ahlat region in Türkiye, clogs, and musical instruments such as bağlama (Figure 4).

Mulberry tree branches can be used as poles, and the strong and durable fibers obtained from them can be used in processes such as grafting, cuttings, and sapling binding. Due to its resistance to pruning, mulberry wood plays a significant role in meeting farmers' fuel needs. In addition, tree bark is used for paper production in China and Europe. Mulberry wood's polishable, durable, complex structure makes it valuable; therefore, it is also preferred among home-building materials.

Mulberry trees are used in furniture making, carpentry, and lathe work. Some mulberry species are essential in garden arrangements as ornamental plants. Mulberry trees also make excellent hedges; when planted in a single row, an effective hedge can be achieved within a few years.

Trees with male flowers should be preferred for road use.

Mulberry trees are used as both ornamental and shade-providing trees for parks. Research conducted in North Africa has shown that mulberry leaves have antipyretic properties and can treat diabetes.

Figure 4. A table made of mulberry tree (Anonymous, 2024d).

6. OLIVE

The trunk of the olive tree has a structure consisting of functionally different sections, each independent of the other. This allows the shape of the trunk to change dynamically depending on the development of each main branch. The part of the tree trunk that remains underground is called a "radish", and the swollen areas around it are called "tuber". Every part of the olive tree can form roots. The primary root constantly produces new roots, providing the trunk and branches nutrition.

The olive tree, which is durable and rapidly multiplies, comes to life again with shoots emerging from the trunk tubers and roots when it gets old, even if its trunk collapses or dries out, and appears as a new tree. Its wood is hard and sturdy and is also a very effective species in combating erosion. It is also resistant to forest fires; burned trees quickly sprout. The core of the trunk of old olive trees does not become knotted like those of other trees but rather rots over time. For this reason, it is pretty challenging to examine the annual rings in the trunk section to determine the age of the olive.

The height of the olive tree can reach up to 10 meters. It has dense branches and a broad crown. Young olive trees have a single round trunk and a vast, twisted, and tuberous structure. Trees with three different trunks out of the primary root can be seen in some areas. The crown of the olive tree expands each year as it grows taller, and this expansion can cover an area 2-3 times the tree's height. The crown takes on a more open and asymmetrical shape in fertile soils, while it becomes more dense and rounded in infertile soils. The shoots are gray, thornless, almost triangular.

The olive tree has a high morphogenetic potential. Thanks to this feature, it responds very well to processes such as pruning and rejuvenation for shaping purposes. The Olive tree contributes significantly to its production with its fruit, branches, soil, roots, and leaves.

It is generally preferred as a coating material in furniture production. The vein pattern of the olive gives it a unique aesthetic appearance. It also produces brush handles and figurines (Figure 5).

Picture 5. Texture of olive tree (Anonymous, 2024e).

7. WALNUT

Walnut (*Juglans regia*), whose homeland is the Caucasus and Anatolia, can mostly grow up to 30 meters. With its broad crown and branches spreading to the sides, the walnut tree is magnificent. The trunk bark, which is thin, light gray, and smooth when young, thickens and becomes covered with deep cracks as it ages. It reaches its economic productivity age at the age of 20. Under suitable soil and climate conditions, the walnut tree can bear fruit for up to 700 years. Walnut trees prefer warm climates and nutrient-rich soils, and their roots spread out into the environment and go deep into the soil. In Türkiye, it can be grown in every region except the highland climate of Eastern Anatolia, where winters are harsh.

Walnut trees are smooth-grained and can be quickly processed with tools. This tree requires little work and is hard, heavy, and has high-strength properties. It is also quite durable in terms of shock resistance. Especially in the parts close to the ground, galls form as they age, and the annual rings develop correctly. The heartwood of the walnut tree can be in shades of light yellowish gray, reddish brown, or sometimes dark brown close to black. Dark blackish stripes are distributed irregularly between these colors, creating a naturally irregular appearance. The sapwood is wide and ash-colored, in shades of white. Old walnut trunks are especially valuable in veneer production. Galls are found near the root, and breast-shaped protrusions can be observed. One of the most distinctive features of the walnut tree is its flexible structure. This flexibility allows the tree to be quickly processed. At the same time, it stands out with its low-splintery structure. In addition, its relatively low cost makes walnut wood a frequently preferred material in furniture production.

The walnut tree, which exhibits an aesthetic appearance with its vein structure, is especially preferred in furniture produced in a classical style. Walnut, frequently used in the production of carved furniture, is an indispensable element of the traditional style and is generally used as a solid veneer in furniture dominated by modern designs. The wood of the walnut tree takes a perfect polish, and this feature ensures its longevity.

Its durable structure also resists harmful insects. For this reason, it is used as a very valuable material in areas such as furniture production and fine carving (Figure 6).

Figure 6. A chair made of walnut (Anonymous, 2024f).

In the Ahlat and Adilcevaz districts of Bitlis province in Türkiye, elegant walking sticks are made from walnut trees. These walking sticks are meticulously made using centuries-old walnut trees processed with ram, buffalo, and cattle horns. Tamgas, the symbols of the 24 Oğuz tribes, are stamped on them, turning them into unique handicrafts. These special walking sticks are offered to the market (Figures 7, 8).

Figure 7. Making a walking stick from walnuts (Anonymous, 2024f).

Figure 8. Ornaments and tamgas of walnut canes (Anonymous, 2024h).

The fruit of the walnut tree is consumed as a snack. The green shell of the fruit is used as a dye in weaving. Thanks to their high tannin content, walnut leaves, green clove, branch, and root barks have constipation-relieving, appetite-increasing, and hemorrhagic properties. It is also known that dried walnut leaves are beneficial against diabetes because they lower blood sugar.

The areas of use of walnut trees in the wood industry include the heartwood part, furniture and veneer production, solid wood production, rifle stocks and mounts, frame production, aircraft propeller production, turning, carving, sculpture, and musical instrument production (Figure 9).

Figure 9. Raw materials for the rifle stock are made of walnut timber (Anonymous, 2024i)

8. SWEET CHERRY

The natural distribution areas of sweet cherry are Europe, Caucasus, Türkiye, and North Africa. While it is found scattered in the forests in the Black Sea region, it is generally grown in gardens in Türkiye. The tree can grow up to 15-20 meters. In our country, it is found naturally in mixed-leaved forests, especially in Northern Anatolia, in Demirköy, Belgrade Forest, Düzce-Akçakoca, oak-beech forests around Sinop-Boyabat, in the highlands of Artvin (1600 m), and between Kütahya-İnönü at an altitude of 900 m. In addition, cherries have been grown in various regions of Türkiye (Giresun, Sapanca, Yarımca, Kütahya, Tekirdağ) for many years.

American sweet cherry (0.58 gr/cm^3) and Japanese cherry (0.63 gr/cm^3) are evaluated similarly in areas where sweet cherry trees are used, with their densities. The usable trunk length of this tree is 6-8 meters, its diameter is around 0.6-0.8 meters, and it has a cylindrical shape. The sapwood is 2.5-5 cm wide and is yellowish to reddish-white. The heartwood is slightly darker in its fresh state, ranging from yellowish to light reddish brown, and darkens over time. In its fresh state, the steamed material turns reddish brown and takes on a color similar to mahogany.

The texture is delicate and homogeneous, and the fibers are regular, finely needle-striated, shiny, and decorative. Annual ring borders and pith rays can be observed with the naked eye; the vessels are visible under the microscope. In a radial section, the naked eye can distinguish pith ray platelets.

The smooth-fibrous material is workable, easy to glue and nail, and reasonable in coloring. Its capacity to accept varnish is excellent. Although it is prone to warping, it can dry quite quickly. Its stability in the place of use is moderate. The sapwood is sensitive to anobiums but resistant to lyctus. The heartwood is moderately durable, but difficult to impregnate. It can be found in the market as lumber and veneer. This tree is included in the group of trees with heartwood, and its outer wood is narrow. It has a scattered pore structure; the pores are large in spring texture and thin in autumn texture. Annual ring boundaries are visible. It forms straight-lined or wavy vein patterns. The heart rays form groups and give the surface shine. This tree has a delicate and tight texture, a complicated structure, complex to split, comfortable, and easy to process. Its planed surface is weakly resistant to physical effects and offers a smooth and shiny appearance. It works pretty hard while drying and can be polished well. Its air-dry specific gravity is an average of 0.60 gr/cm^3.

Sweet cherry wood has a wide range of uses in furniture and interior architecture, both solid and veneered. It is also a preferred material in the lathe and carving works, in the production of musical instruments and scientific instruments, in the Bitlis/Ahlat region in Türkiye, in the production of walking sticks, and in model making. However, it is recommended not to use the heartwood of the cherry in quality works. Sweet cherry wood is widely used in paneling, decorative carpentry works, decorative cut veneer panels, doors, wall coverings, and furniture making.

The sweet cherry tree has often been a source of inspiration for its flower's aesthetic visuality and fruit's benefits and for composing songs, writing poetry, and creating kimono patterns. In addition, the trunk bark of the sweet cherry tree is also used in dyeing processes (Figure 10).

Figure 10. A table made of sweet cherry wood (Anonymous, 2024j).

9. HAZELNUT

Hazelnut wood, obtained by cleaning the bottom shoots and rejuvenating branches after harvest, provides a large portion of the fuel the producer needs during the winter months.

In the spring, young branches cut from hazelnut groves make chairs, fences, different hand tools, walking sticks, corn drying equipment (çöten), and various baskets. Some hazelnut species are grown as ornamental plants in parks and gardens. Hazelnut leaves and fruit husks are used as fertilizer.

Hazelnut wood obtained through pruning produces herek (hangal, pole) for various vegetables.

Surplus hazelnuts are used as oil. Hazelnut crude oil is refined and used as cooking oil, and hazelnut meal is used as an additive in the feed industry. It has positive effects on health.

10. BASKETS AND BASKETRY

A basket is a tool for carrying different geometric shapes (oval, round, conical) woven with a lower and upper weave system using plant branches and grain stalks. Basketry is a weaving and handicraft made from the thin shoots of trees and the non-lignified stems of plants. This art is as old as human history and is a critical tradition contributing to societies' cultural heritage.

Basketry is an aesthetic handicraft and reflects the inner worlds of those who practice this art. The elegance, colors, textures, patterns, and shapes in basket weaving express the artists' mood. Since basketry is generally a handicraft, it is applied in different ways and styles in each region. The purpose for which the basket will be used directly affects the material and shape used in its weaving. For example, a basket that carries grain or liquid must be tightly woven, and additional materials must be placed between them. On the other hand, baskets that will serve functions such as cages, nets, or traps must have a perforated structure.

There are many different basket-weaving technologies today. Two of these techniques organize all basket preparation methods. The first is weaving rolls made of a single fiber by sewing them on top of each other. The second is the lattice or ready-made weaving method. In addition, basket weaving styles are sometimes imitated with more complex processes, such as metal or porcelain, to obtain similar aesthetic and functional features.

The art of basketry, although a tradition that dates back to ancient times, has somewhat declined today with the advancement of packaging technology. While in the past, the transportation and marketing of products, mainly agricultural, garden, vineyard, and fishing products, were done entirely with baskets, the modern packaging industry has primarily eliminated this need. Despite this, the field of luxury basketry, which requires fine artistry, continues to develop. This tradition also manifests itself in areas such as chair and armchair production in furniture (Figures 11,12).

Figure 11. Making a basket from hazelnut branches and bottom shoots (Anonymous, 2024k)

Figure 12. Making a basket from hazelnut branches and bottom shoots (Anonymous, 2024l).

This tree species is widespread in Europe, Türkiye, and Western Asia. It has mature characteristics, and there is no significant color difference between sapwood and heartwood. The wood color varies from yellowish to light reddish brown. It is prone to warping, and the drying process is slow; the best drying method is oven drying. It can also be easily impregnated.

This moderately complex wood can be turned perfectly, has good nail and screw-holding properties, and can be glued successfully. The coloring and polishing processes also give excellent results.

Black can give it an ebony-like appearance, and steaming can also give it a reddish-brown color. Logs obtained from pear trees should be processed by the end of May. This wood should not be stacked in an airy environment, as there is a risk of cracking in the cut sections.

It is widely used in carving and obtaining turned material that offers an aesthetically pleasing appearance. It produces brush handles, umbrella handles, measuring instruments, ruler sets, and T-rules. In addition, the parts painted black are used to make violins, guitars, block flutes, and pianos. Logs with appropriate diameters and lengths can be evaluated to produce decorative cut coating sheets. It is also preferred in pipe making due to its heat-proof properties and is used in hot molds in bottle factories (Figure 13).

Figure 13. A table made of pearwood (Anonymous, 2024m).

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MORPHOLOGICAL CHARACTERIZATION OF ROSEHIP (*Rosa canina* L.) GENOTYPES IN BAKLAN DISTRICT OF DENIZLI PROVINCE

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1. INTRODUCTION

Rosehip (*Rosa canina* L.), classified in the Rosaideae subfamily of the Rosaceae family, is a perennial plant species (Vasić et al., 2023). This plant, also known as wild rose or rose apple in local culture, is a shrub that can grow 1-3 meters tall, attracts attention with its thorny structure and has high adaptability to harsh environmental conditions. Its white and pink flowers, which appear before fruit development, have chromatic features that attract insects and are aesthetically valuable (Jian et al., 2024). The flower axis fleshes into a fruit, which contains numerous hairy, hard seeds. Thanks to its adaptability, it can live in habitats with harsh ecological conditions (Yamankaradeniz, 1982).

It is a valuable raw material for the food and pharmaceutical industries in European countries such as Germany, Russia, Turkic Republics, Switzerland, Poland and

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Finland (Yamankaradeniz, 1983). In these countries, it is widely used in the production of baby food, fruit juice, jelly and tea. In Turkey, the industrial use of rose hips is not very old and it is used in pulp, nectar, marmalade, tea and beverage production. It is also used in the preparation of various local products (Dölek, 2013).

Rosehip, which grows naturally in every region of Anatolia, is an important part of traditional nutrition culture. According to Davis (1972), there are 24 Rosa species, one of which is endemic, 5 subspecies, 2 varieties and 15 hybrids in Turkey. The researcher determined that R. pulverulenta and R. canina are widespread throughout the country, while other species are concentrated in certain regions. For example, *R. villosa* L., *R. pisiformis*, *R. jundzilli* Besser, *R. foetida*, in Erzincan and *R. foetida*, *R. hemisphaerica*, *R. pimpinellifolia* in Gümüşhane.

The importance of rose hips, a valuable member of Turkey's natural flora, is increasingly recognized. In this context, various selection studies have been carried out and continue in regions with dense populations (Mısırlı et al., 1999; Kazankaya et al., 1999; Kızılcı, 2005; Dölek, 2008; Duran and Kılıç, 2023; Yiğit, 2019; Kasun, 2017). Especially with the selection studies carried out in Tokat and Erzincan, important steps have been taken for the registration of promising genotypes.

Morphological characterization and evaluation processes, which form the basis of plant breeding studies, play a vital role in designing and guiding future breeding programs (Mehmood et al. 2014; Ganopoulos et al. 2015). This methodological approach allows researchers to optimize available genetic resources and develop sustainable conservation plans. Systematic documentation of the characteristics of different plant species and genotypes is an effective tool for identifying duplicates and potential errors in genebanks, while optimizing identification processes (Dangi et al. 2021). Morphological characterization is still the primary method for the identification and classification of genetic resources, and when integrated with multivariate analysis techniques, it becomes an even more effective tool for the evaluation of plant collections (Badenes et al. 2000; Rakonjac et al. 2010; Kırca and Aygün, 2024).

The aim of this study was to determine the potential of rosehip plant, whose traditional use and economic value is increasing, in Denizli province, which is one of the important distribution areas in the Aegean Region, and to reveal morphological characterization data that will form the basis for future breeding programs.

2. MATERIAL AND METHOD

This study was conducted in the Baklan district of Denizli province, located in Turkey's Aegean Region. The altitude of the research area varies between 920-950 m. Sixteen naturally grown rosehip genotypes (G1, G2 ...., G16) were selected from the Baklan Plain. Ten fruit samples were selected from each genotype for evaluation. Measurements were made on these genotypes including fruit and seed weight (g), fruit width and length (mm), fruit shape, fruit flesh and peel color (L*, a*, b*, Chroma, Hue°), number of seeds, seed length and width (mm), fruit inner hairiness, and fruit flesh weight (g) (Güneş and Şen, 2001). Fruit color measurements were obtained using a colorimeter (PCE Instruments Colorimeter, model PCE-CSM 1, Manchester, UK) at 2 different points on the fruit peel surface (Table 3 Supplementary).

3. STATISTICAL ANALYSIS

The basic statistical parameters were calculated for fruit characteristics, including mean values, lowest and highest measurements, standard deviation, and coefficient of variation (%). Statistical analyses were conducted using the mean values of phenotypic data. Variance was analyzed for all characteristics, and Pearson correlation coefficient was calculated using R Studio 2024.09.1 (© 2009–2022 RStudio, PBC) statistical software to determine correlations between characteristics (Wickham, 2016). Principal Component Analysis Biplot (PCA) was used to determine relationships between genotypes based on the covariance matrix of coefficients using JMP Pro 17 (Trial) software (Kırca and Aygün, 2024).

4. RESULTS AND DISCUSSION

The descriptive statistical data of the characteristics examined in rosehip genotypes are given in Table 1. Fruit weight varies between 0.60-1.33 g, with an average of 0.93±0.18 g and has a coefficient of variation of 19.47%. In similar studies, Dölek (2008) reported fruit weight as 1.37-4.01 g in their study conducted in 2006-2007; Akkuş (2016) reported 1.29-4.69 g; Sağır (2010) 1.65-2.78g; Uçaral (2017) 0.77-3.14 g; and Encu (2015) reported 0.95-1.99 g.

Fruit width varies between 9.80-12.45 mm, with an average of 10.93±0.84 mm and has a coefficient of variation of 7.73%. Fruit length varies between 12.89-22.37 mm, with an average of 17.40±2.68 mm and has a coefficient of variation of 15.41%. In similar studies, fruit width and length were reported respectively as 11.18-17.79 mm and 18.84-28.02 mm (Dölek, 2008), 12.06-19.49 mm and 18.09-28.85 mm (Akkuş, 2016), 12.41-15.97 mm and 16.19-25.85 mm (Sağır, 2010), 10.21-15.78 mm and 16.67-29.64 mm (Uçaral, 2017), 10.78-14.53 mm and 15.46-25.29 mm (Encu, 2015).

For fruit flesh color values, L* varies between 16.56-24.29 with an average of 19.72±2.25 and has a coefficient of variation of 11.40%; a* value varies between 38.87-82.41 with an average of 49.71±9.49 and has a coefficient of variation of 19.09%; b* value varies between 28.54-41.33 with an average of 33.83±3.46 and has a coefficient of variation of 10.23%. Fruit flesh color Chroma varies between 55.66-63.18 with an average of 58.92±2.23 and has a coefficient of variation of 3.79%. Fruit flesh color Hue° varies between 29.82-48.41 with an average of 36.07±5.13 and has a coefficient of variation of 14.22%. For fruit peel color values, L* varies between 13.95-24.56 with an average of 18.15±2.55 and has a coefficient of variation of 14.04%; a* value varies between 44.66-50.13 with an average of 47.71±1.76 and has a coefficient of variation of 3.69%; b* value varies between 22.11-64.96 with an average of 32.22±9.37 and has a coefficient of variation of 29.09%. Fruit flesh color Chroma varies between 52.62-60.66 with an average of 57.04±2.32 and has a coefficient of variation of 4.06%. Fruit flesh color Hue° varies between 27.45-38.01 with an average of 32.36±3.00 and has a coefficient of variation of 9.26%. In similar studies, Parlar (2015) reported L* 20.4067-33.9233, a* 25.8200-34.8467, b* 17.3133-27.6133, chroma 31.2533-39.6133, Hue° 30.5167-38.0533. Similarly, Uçaral (2017) reported L* 29.86-47.91, a* 27.13-41.20, and b* value as 10.61-27.70.

Seed weight ranges between 0.18-0.55 g, with an average of 0.33±0.09 and a coefficient of variation of 25.90%. Dölek (2008) reported individual seed weight as 0.019-0.090 g; Akkuş (2016) reported total seed weight as 0.36-1.75 g; Sağır (2010) reported individual seed weight as 0.014-0.020 g; Uçaral (2017) reported individual seed weight as 0.006-0.072 g; Encu (2015) reported total seed weight varying between 0.10-0.91 g.

Number of seeds varies between 9.10-28.00, with an average of 20.33±5.04 and has a coefficient of variation of 24.81%. In similar studies, Dölek (2008) reported seed numbers as 2-42; Akkuş (2016) 14-41; Sağır (2010) 20-32; Uçaral (2017) 2.23-41.07; Encu (2015) reported 3-33 seeds.

Seed length ranges between 4.25-6.00 mm, with CV% of 7.85. Seed width ranges between 2.27-4.60 mm, with an average of 2.80±0.57 mm and CV% of 20.45. Encu (2015) reported seed length varying between 4.73-5.98 mm and width between 2.04-2.85 mm.

Fruit flesh weight varies between 0.34-0.88 g, with a coefficient of variation of 27.46. Encu (2015) reported fruit flesh weight varying between 0.80-1.86 g in the rosehip genotypes studied.

Fruit flesh ratio varies between 40-74%, with an average of 55±10% and has a coefficient of variation of 17.61%. In previous studies, among rosehip genotypes, Dölek (2008) reported fruit flesh ratio between 45.82-93.93%; Akkuş (2016) 60-79%; Sağır (2010) 63.89-75.01% and Uçaral (2017) reported 60.98-94.96%.

Fruit shape index varies between 1.24-2.28, with an average of 1.60±0.27 and has a coefficient of variation of 17.11%. In studies examining pomological characteristics of rosehip genotypes, Dölek (2008) reported fruit shape index as 0.72-2.17; Akkuş (2016) 1.13-2.03; Sağır (2010) 1.12-2.08 and Uçaral (2017) reported 1.26-2.30.

Of the examined genotypes, 2 are oval, 5 are conical, 2 are truncated conical, 1 is flat round, 2 are flat oval, 2 are cylindrical, 1 is elliptical, and the last one is long elliptical. Dölek (2008) reported that 35 genotypes were conical, 25 were oval, 25 were cylindrical, and 5 were round; Sağır (2010) reported 6 oval, 1 cylindrical, 1 round, and 1 flat round; Uçaral (2017) reported 12 conical, 12 truncated conical, 5 elliptical, 1 long elliptical, 2 oval, and 17 cylindrical shaped genotypes.

Regarding fruit inner hairiness, 5 genotypes were determined as having few hairs, 9 genotypes as medium, and 2 genotypes as very hairy. Our findings indicate high genetic diversity particularly in fruit size characteristics, while color parameters appear to be more stable. Dölek (2008) reported that in 2006, 42 genotypes were medium, 41 were very hairy, and 7 were few hairy, while in 2007, 2 were few hairy, 1 was very hairy, and others were medium; Uçaral (2017) reported that among the genotypes examined, 8 were very hairy, 39 were medium, and 2 were few hairy.

Table 1. Descriptive statistics of pomological characteristics of rosehip genotypes.

Characteristics	**Abbreviation**	**Min.**	**Max.**	**Mean**	**±SD**	**CV%**
Fruit weight (g)	FWe	0.60	1.33	0.93	0.18	19.47
Fruit width (mm)	FWi	9.80	12.45	10.93	0.84	7.73
Fruit length (mm)	FL	12.89	22.37	17.40	2.68	15.41
Fruit flesh color L*	FFL*	16.56	24.29	19.72	2.25	11.40
Fruit flesh color a*	FFa*	38.87	82.41	49.71	9.49	19.09
Fruit flesh color b*	FFb*	28.54	41.33	33.83	3.46	10.23
Fruit flesh color Chroma	FFCh	55.66	63.18	58.92	2.23	3.79
Fruit flesh color Hue^o	FFHue	29.82	48.41	36.07	5.13	14.22
Fruit peel color L*	FPL*	13.95	24.56	18.15	2.55	14.04
Fruit peel color a*	FPa*	44.66	50.13	47.71	1.76	3.69
Fruit peel color b*	FPb*	22.11	64.96	32.22	9.37	29.09
Fruit peel color Chroma	FPCh	52.62	60.66	57.04	2.32	4.06
Fruit peel color Hue^o	FPHue	27.45	38.01	32.36	3.00	9.26
Seed weight (g)	SWe	0.18	0.55	0.33	0.09	25.90
Number of seeds	NuSe	9.10	28.00	20.33	5.04	24.81
Seed length (mm)	SL	4.25	6.00	5.07	0.40	7.85
Seed width (mm)	SWi	2.27	4.60	2.80	0.57	20.45
Fruit flesh weight (g)	FFWe	0.34	0.88	0.52	0.14	27.46
Fruit flesh ratio (%)	FFR	0.40	0.74	0.55	0.10	17.61
Fruit shape index	FSI	1.24	2.28	1.60	0.27	17.11
Fruit shape	FS	oval=2, conical=5, truncated conical=2, flat round=1, flat oval= 2, cylindrical=2, elliptical=1, long elliptical=1				
Fruit inner hairiness	FIH	few=5, medium=9, very=2				

The PCA Biplot analysis showing the relationships between genotypes and examined fruit characteristics is presented in Figure 1. According to PCA analysis results, it was determined that the first five principal components explained 81.03% of the total variance (Table 2). Of the first two principal components, PC1 explained 24.2% of the total variance, PC2 explained 19.5%, and together (PC1+PC2) they explained 43.7% (Figure 1).

According to PCA analysis, on the PC1 (24.19%) axis, characteristics such as fruit weight (FWi), fruit width (FWe), fruit length (FL), seed weight (SWe), number of seeds (NuSe), and fruit flesh weight (FFWe) stand out in the positive direction, while color characteristics such as fruit flesh color L* (FFL*), fruit flesh color b* (FFb*), fruit peel color a* (FPa*), fruit peel color Chroma (FPCh), and fruit peel color Hue° (FPHue) are prominent in the negative direction. On the PC2 (19.46%) axis, fruit shape index (FSI), fruit peel color b* (FPb*), fruit peel color Hue° (FPHue), fruit peel color L* (FPL*), and fruit flesh color a* (FFa*) stand out in the positive direction, while characteristics such as fruit width (FWe) and fruit peel color a* (FPa*) are notable in the negative direction. Regarding genotypes, G2 and G14 genotypes stand out in the positive direction of PC2 with fruit shape index (FSI) and fruit peel color characteristics, while G11 genotype is associated with dimensional characteristics such as fruit weight (FWi), fruit width (FWe), and fruit length (FL) in the positive direction of PC1. G7 genotype stands out with number of seeds (NuSe) and fruit flesh weight (FFWe) in the positive direction of PC1 and negative direction of PC2, while G5 and G4 genotypes are characterized by fruit peel color a* (FPa*) and b* (FPb*) in the negative direction of PC1. G6 and G10 genotypes are associated with fruit peel color a* (FPa*) and fruit width (FWe) in the negative direction of PC2. These analysis results indicate that fruit color parameters and physical characteristics explain the majority of the variation, while seed characteristics are represented by lower variance ratios. Particularly fruit color characteristics and size parameters stand out as the most determining characters in the differentiation of genotypes.

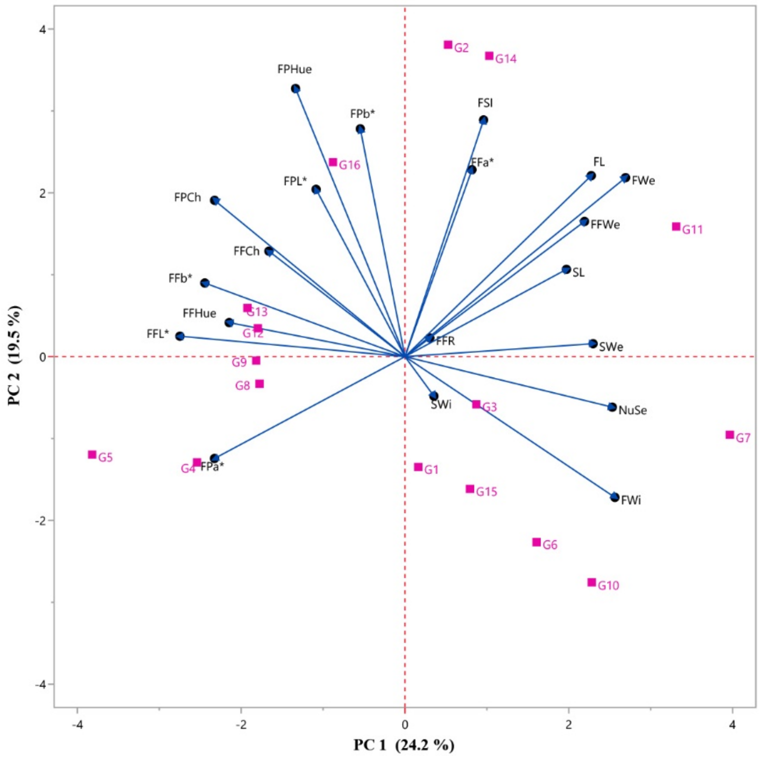

Figure 1. PCA analysis showing the relationship between genotypes.

In the analysis results, the most notable strong positive correlations were observed between fruit flesh color b* and fruit flesh color L* ($r=0.950$, $p<0.001$), between fruit flesh color Hue° and fruit flesh color b* ($r=0.885$, $p<0.001$), and between fruit peel color b* and fruit flesh color a* ($r=0.884$, $p<0.001$).

These relationships are statistically highly significant. Additionally, strong positive correlations were detected between fruit flesh color Hue° and fruit flesh color L* ($r=0.837$, $p<0.001$)

and between fruit peel color Chroma and fruit flesh color Chroma ($r=0.804$, $p<0.001$).

Table 2. Eigenvalues, total variance proportions, and eigenvectors of principal components for the Rosehip genotypes studied

Characters	PC1	PC2	PC3	PC4	PC5
Fruit weight	0.309	0.279	0.077	0.202	-0.000
Fruit width	0.294	-0.220	-0.009	0.128	-0.015
Fruit length	0.261	0.282	0.025	0.266	-0.107
Fruit flesh color L*	-0.315	0.032	-0.084	0.388	-0.198
Fruit flesh color a*	0.094	0.292	-0.150	-0.377	0.014
Fruit flesh color b*	-0.280	0.115	-0.156	0.367	-0.223
Fruit flesh color Chroma	-0.190	0.165	0.435	0.064	0.142
Fruit flesh color Hue°	-0.246	0.053	-0.335	0.224	-0.295
Fruit peel color L*	-0.124	0.261	-0.122	-0.010	0.204
Fruit peel color a*	-0.267	-0.159	0.289	0.032	0.186
Fruit peel color b*	-0.062	0.355	-0.261	-0.278	-0.003
Fruit peel color Chroma	-0.266	0.244	0.211	-0.012	0.356
Fruit peel color Hue°	-0.153	0.418	-0.096	-0.151	0.108
Seed weight	0.263	0.020	-0.202	0.179	0.380
Number of seeds	0.290	-0.079	-0.289	-0.077	-0.012
Seed length	0.226	0.136	0.229	0.346	0.094
Seed width	0.041	-0.062	-0.071	0.209	0.472
Fruit flesh weight	0.251	0.211	0.302	-0.002	-0.275
Fruit flesh ratio	0.035	0.029	0.380	-0.236	-0.345
Fruit shape index	0.110	0.369	0.027	0.177	-0.085
Eigenvalue	4.84	3.89	3.07	2.65	1.75
% of Variance	24.19	19.46	15.37	13.24	8.77
Cumulative %	24.19	43.65	59.02	72.26	81.03

When examining moderately significant correlations, it is observed that the number of seeds parameter shows negative correlations with several variables. Particularly, moderate negative correlations exist between number of seeds and fruit peel color a* ($r=-0.626$, $p=0.009$), between number of seeds and fruit flesh color Chroma ($r=-0.622$, $p=0.010$), and between number of seeds and fruit peel color Chroma ($r=-0.619$, $p=0.010$). A moderate positive correlation was observed between fruit length and seed length (r=0.609, p=0.012).

The FPHue parameter showed significant positive correlations with both fruit peel color b* (r=0.771, p<0.001) and fruit peel color L* (r=0.631, p=0.009). Notably, the fruit flesh weight parameter exhibited moderate positive correlations with fruit length (r=0.525, p=0.037) and seed length (r=0.522, p=0.038).

The correlation between fruit characteristics examined in rosehip genotypes is presented in Figure 2. A very high positive correlation was observed between fruit length and fruit weight (r=0.795, p=0.000). Similarly, a strong positive relationship exists between seed length and fruit length (r=0.609, p=0.036). A significant positive correlation between fruit flesh weight and fruit weight (r=0.739, p=0.001) is also notable. Additionally, a very strong positive relationship was found between fruit shape index and fruit length (r=0.885, p=0.000). Regarding color characteristics, a very high positive correlation was observed between fruit flesh color b* and fruit flesh color L* (r=0.950, p=0.000), and a strong relationship between fruit flesh color Hue° and fruit flesh color b* (r=0.885, p=0.000). Moreover, a significant positive relationship exists between fruit peel color Chroma and fruit peel color Hue° (r=0.635, p=0.008). These results indicate strong positive relationships between fruit weight, length, and color characteristics.

Looking at negative correlations, some notable relationships are found. A significant negative correlation was observed between fruit peel color Hue° and fruit width (r=-0.563, p=0.023). Similarly, a significant negative relationship exists between fruit peel color Chroma and fruit width (r=-0.537, p=0.032). A significant negative correlation between fruit peel color a* and number of seeds (r=-0.621, p=0.010) is also notable.

Regarding color characteristics, a significant negative relationship was found between fruit flesh color a* and fruit peel color a* (r=-0.373, p=0.041). Additionally, a significant negative correlation was observed between fruit flesh color Chroma and number of seeds (r=-0.622, p=0.010). These results indicate some negative relationships particularly between fruit width, number of seeds, and color characteristics.

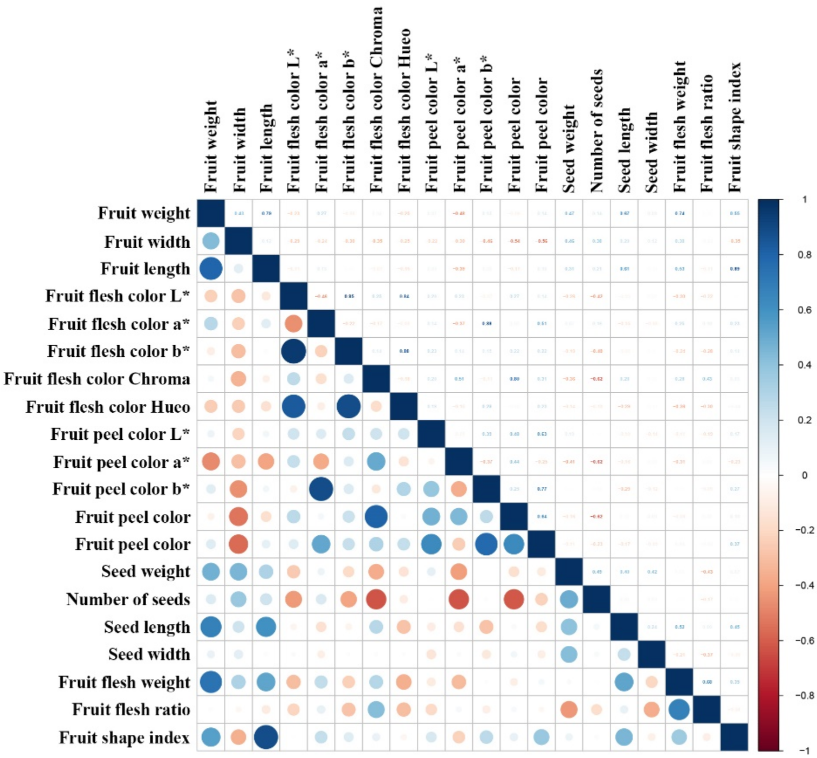

Figure 2. Correlation analysis between the examined fruit traits (p<0.05).

5. CONCLUSION

In this study, which aimed to characterize the morphological characteristics of natural rosehip (*Rosa canina* L.) genotypes in the Baklan district of Denizli province, significant morphological differences were identified among the examined rosehip genotypes. Particularly, the G11 genotype showed superior characteristics in terms of fruit size, having the highest value with 1.33 g fruit weight. The G7 genotype possessed the highest number of seeds with 28 pieces and good fruit flesh weight values. Regarding fruit characteristics, fruit weight varied between 0.60-1.33 g (average 0.93±0.18 g), fruit width between 9.80-12.45 mm (average 10.93±0.84 mm), and fruit length between 12.89-22.37 mm (average 17.40±2.68 mm). The fruit flesh ratio varied between 40-74%, with an average seed number of 20.33±5.04. According to PCA analysis results, the first five principal components explained 81.03% of the total variance. Particularly fruit color parameters and physical characteristics constituted the majority of the variation. For future breeding studies, it is recommended to evaluate especially G11 and G7 genotypes, introduce these genotypes to commercial production through vegetative propagation, and test their adaptation capabilities under different ecological conditions. Additionally, the identified high genetic diversity constitutes a valuable gene pool for future breeding programs.

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Table 3. Data and values of rosehip genotypes and pomological characteristics examined

Genotypes	FWe	FWi	FL	FFL*	FFa*	FFb*	FFCh	FFHue	FPL*	FPa*	FPb*	FPCh	FPHue	SWe	NuSe	SL	SWi	FFWe	FFR	FSI	FS	FIH
G1	0.90	11.99	14.98	16.83	50.69	29.00	58.41	29.82	18.29	47.98	31.55	57.70	33.56	0.30	18.20	4.25	2.34	0.50	0.55	1.25	oval	few
G2	1.03	10.10	18.11	18.17	82.41	34.72	55.86	41.45	19.77	44.66	64.96	56.33	38.01	0.35	24.30	4.64	2.50	0.55	0.53	1.79	conical	medium
G3	0.95	11.94	17.85	20.09	44.24	34.60	56.78	37.89	24.56	47.26	28.61	55.36	31.16	0.42	28.00	5.03	2.51	0.45	0.47	1.50	truncated conical	few
G4	0.86	10.79	17.59	23.97	40.76	41.33	58.37	44.23	16.04	49.86	27.63	56.16	29.45	0.29	16.10	4.90	2.65	0.35	0.40	1.63	conical	medium
G5	0.60	10.36	12.89	24.29	38.87	38.87	58.90	48.41	18.84	46.23	32.47	57.33	34.60	0.26	21.20	4.55	2.74	0.34	0.57	1.24	flat round	medium
G6	0.91	11.57	17.01	18.71	47.82	32.24	56.29	35.56	15.66	47.22	27.05	54.50	29.71	0.41	25.00	5.08	4.60	0.38	0.42	1.47	conical	medium
G7	1.19	12.45	20.37	18.77	47.66	32.36	58.18	34.32	13.95	46.31	22.11	52.62	27.45	0.30	25.10	5.46	2.27	0.88	0.74	1.64	cylindrical	few
G8	9.40	10.13	16.87	21.19	44.48	35.83	57.87	37.97	17.96	49.43	30.92	58.35	32.04	0.36	16.10	5.00	2.48	0.40	0.51	1.67	oval	medium
G9	0.76	10.11	14.51	19.08	52.28	31.94	63.18	31.79	18.77	50.13	32.20	60.66	32.69	0.27	20.80	5.00	2.76	0.51	0.67	1.43	conical	very
G10	0.76	11.10	16.98	16.56	47.55	28.54	55.66	30.94	14.29	46.52	24.60	52.65	27.81	0.30	24.50	5.08	2.27	0.46	0.62	1.53	flat oval	medium
G11	1.33	12.15	20.27	19.30	48.90	33.27	59.53	34.08	18.33	44.93	31.59	58.39	33.10	0.55	22.70	6.00	3.27	0.63	0.47	1.67	truncated conical	medium
G12	0.94	10.91	14.94	20.90	50.23	36.03	62.13	36.34	18.46	49.56	31.78	59.02	32.70	0.30	9.10	5.19	3.20	0.67	0.72	1.37	flat oval	few
G13	0.89	11.42	15.79	19.95	50.04	33.39	61.29	34.14	19.12	49.13	32.94	59.20	33.86	0.18	14.20	5.28	2.52	0.50	0.56	1.54	elliptical	few
G14	1.11	9.80	22.37	19.14	50.69	33.00	60.68	33.11	20.31	46.47	35.01	58.31	36.97	0.33	21.50	5.40	2.65	0.67	0.60	2.28	long elliptical	very
G15	0.81	10.76	15.99	17.12	50.79	29.50	58.76	30.11	16.65	49.34	28.69	57.08	30.04	0.41	23.10	5.09	3.12	0.42	0.52	1.49	conical	medium
G16	1.04	10.47	21.81	21.39	47.90	36.73	60.77	37.02	19.41	48.53	33.46	58.97	34.58	0.27	15.30	5.24	2.96	0.54	0.52	2.08	cylindrical	medium

FWe: fruit weight, FWi: fruit width, FL: fruit length, FFL*: fruit flesh color L*, FFa*: fruit flesh color a*, FFb*: fruit flesh color b*, FFCh: fruit flesh color chroma, FFHue: fruit flesh color Heu°, FPL*: fruit peel color L*, FPa*: fruit peel color a*, FPb*: fruit peel color b*, FPCh: fruit peel color chroma, FPHue: fruit peel color Heu°, SWe: seed weight, NuSe: number of seeds, SL: seed length, SWi: seed width, FFWe: fruit flesh weight, FS: fruit shape, FIH: fruit inner hairiness

MORPHOMETRIC AND PHYTOCHEMICAL CHARACTERISTICS OF PROMISING WILD PEAR GENOTYPE

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1. INTRODUCTION

Türkiye offers a unique genetic resource for fruit breeding with its richness of species and varieties. This broad genetic range has excellent potential in breeding efforts to improve essential traits of fruit species such as yield, quality, disease and pest tolerance, and resistance to environmental stresses. Identifying genotypes with superior performance in terms of certain fruit traits within existing populations by selection not only ensures the efficient use of genetic resources but also contributes to the conservation of diversity. In this context, breeding processes increase agricultural productivity and conserve genetic resources. This is vital for evaluating genotypes' adaptation potential, preserving genetic diversity, and preparing the ground for future brendin research (Ünver, 2023).

Wild fruit species contribute significantly to biodiversity. Both wild animals and humans value them as food sources.

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Moreover, wild fruits often contain essential bioactive compounds that can prevent or cure medical conditions and diseases (Vidaković and Poljak, 2024). Research has revealed that several biologically active secondary metabolites, especially phenolic compounds and flavonoids, contained in the genus *Pyrus* have positive physiological effects on the human body (Kayhan et al., 2024). Wild edible fruits are a good source of natural antioxidants and antimicrobial agents (Sagdic et al., 2022). However, the literature contains limited research on wild pear (*P. elaeagnifolia*), one of the wild grown fruits. The peel and flesh of pear varieties within the same species as wild pear contain remarkable compounds such as chlorogenic acid, arbutin, ursolic acid, oleanolic acid, epicatechin, and rutin (Li et al., 2014). *P. elaeagnifolia* fruit extract is known to have low inhibition (53.62%) of total phenolic compounds and flavonoids (Kayhan et al., 2024). *Pyrus* is recognized as a rich source of natural antioxidants (Sagbas et al., 2021). In recent years, due to their potential health benefits, wild fruits have received more attention, especially in nutrition and health, and are increasingly valued as an essential foodstuff (Kayhan et al., 2024). Phenolic compounds offer various biochemical properties and neutralize and render free radicals harmless. These compounds are rich in powerful antioxidants that reduce oxidative stress. Therefore, they show a protective effect on health by preventing oxidative damage at the cellular level (Karadeniz et al., 2022). Anatolia harbors a wide genetic diversity in terms of wild fruit species and has strategic importance as a geographical area where they naturally spread (Gerçekcioğlu and Yiğithanoğlu, 2023). Pomological research in these areas reveals valuable fruits with many new characteristics (Çorumlu, 2010). It can potentially evaluate existing genotypes, be used in future breeding studies, and form the basis for variety development. Selection breeding studies have been conducted in different regions, with many fruit species growing naturally in the country. New studies are still being carried out with varying fruit species today (Ünver, 2023). Today, there are increased risks to conserving genetic resources at increased risk. Rapid urbanization, uncontrolled harvesting of plants from nature, and forest fires (Ünver, 2023), combined with human-induced habitat loss and fragmentation, are alarmingly causing natural populations to disappear. The loss of diversity of wild fruit species has negative impacts (Vidaković and Poljak, 2024). Conserving genetic diversity is critical (Ünver, 2023).Wild pear (*Pyrus elaeagnifolia* Pall.) is included in the genus *Pyrus* in the subfamily Pomoideae of Rosaceae in the order Rosales in botanical classification (Davis, 1970). It is known as a wild pear because it resembles a pear. In Turkish, wild pear is called "ahlat" (Ercisli, 2004). Although it varies according to the region, it is known by wild pear, aklap, argun, çötür, and kerte (Karadeniz, 2004). Wild pear is a fruit species resistant to chlorosis and drought and has a significant genetic diversity that can be used in rootstock development (Yiğit, 2017; Kırca and Aygün, 2018). The origin of *P. elaeagnifolia* is known to be Anatolia (Dumanoğlu et al., 1999). In Anatolia, it is possible to see wild pear trees on rocky slopes, mountain passes, riversides, and forests in many areas, from vast plains to mountain peaks (Özer, 2019).

Although much research has been carried out on the conservation of genetic material of apple, pear, and quince species, which are among the pome fruit species, and the evaluation of the potential of this material, scientific studies on this subject are minimal. Wild pear is an essential genetic resource among these species, but the number of studies on it is insufficient (Sagbas et al., 2021).

In the country, there are wild pear plantations in Kütahya, Denizli, Uşak, Afyonkarahisar, Ankara, Eskişehir, Kayseri, Sivas, Antalya, İstanbul, Kastamonu, and Bolu provinces. Today, although there are large plantations, there are no wild pear orchards (Aygün and Kırca, 2023). In this context, it is possible to reveal genotypes with superior characteristics, protect existing gene resources, and maintain plant diversity through selection studies. This study was carried out to examine the selected promising wild pear genotype in terms of fruit characteristics and to provide a basis for future studies. At the same time, it aimed to protect the existing genotype to preserve plant diversity and introduce this genotype to fruit growing in the country.

2. MATERIALS AND METHODS

2.1. Plant material

The material of this study was a wild pear genotype with remarkable characteristics in terms of fruit weight. The wild pear genotype was selected in the Beypazari district of Ankara province, and morphometric and phytochemical analyses were performed on this genotype for two years. The genotype was not subjected to cultural practices such as irrigation, fertilization, and pruning.

2.2. Measurements and analysis

In this research, fruit weight, fruit length, fruit width, fruit shape index, seed weight, seed length, seed width, number of seeds, length of eye basin and width of eye basin, stalk length, stalk thickness, soluble solids content (SSC), pH, titratable acidity (TA), fruit skin and flesh color, phenolic acids, and flavonoids were used as descriptors.

Fruit (g) and seed (g) weights were measured on a precision balance; fruit length and width, seed length and width, length of eye basin and width of eye basin, stalk length and thickness were measured using a digital caliper with a precision of 0.01 mm. The number of seeds was determined in number. Shape index was obtained by dividing fruit length by fruit width.

A digital handheld refractometer recorded soluble solids content in homogeneous juice in %. pH was determined with a digital pH meter, and the titratable acid content (%, malic acid) was determined using the titration method. Fruit skin and flesh color were measured as L* (brightness), a* (redness), b* (blueness), Chroma, and Hue^{o} with a handheld colorimeter.

Phenolic compounds in the wild pear genotype used in the study were determined by Shimadzu CTO-20A HPLC device according to the method of Pehluvan et al. (2015). In wild pear genotype, 5 g of fruit was homogenized with 10 ml of solvent and centrifuged at 15,000 rpm for 15 minutes. Chlorogenic acid, caffeic acid, rutin, *p*-coumaric acid, myricetin, *q*-coumaric acid, syringic acid, gallic acid, quercetin, and catechin standards were used. Readings were made in the wavelength range of 190-800 nm.

Descriptive statistics were used to determine the general characteristics of the wild pear genotype (Table 1).

3. RESULTS AND DISCUSSION

Some pomological characteristics of the wild pear genotype are given in Table 1. It was determined that the fruit weight of that genotype was between 55.73-68.41 g, fruit length was between 38.53-52.65 mm, and fruit width was between 38.71-56.39 mm. Fruit shape index was determined to be between 0.72-1.36. The seed weight ranged between 0.18-1.50 g, and the number of seeds ranged between 1-5. The length of the eye basin and width of the eye basin values were between 15.67-21.44 mm and 17.05-23.39 mm, and the stalk length and thickness values were between 4.32-15.25 mm and 2.44-4.69 mm, respectively. In terms of fruit weight, this research findings gave high results compared with the conclusions of Keçeci (2017), Yilmaz et al. (2015), Uzun et al. (2018), Alp and Söylemez (2020), Bozhüyük

(2021), Gercekcioglu et al. (2016) and Karatas and Ercisli (2021). Şahiner Öylek (2022) reported that fruit weight was 70.62 g, fruit length was 45.08 mm, and fruit width was 51.03 mm in the wild pear genotype in Diyarbakır conditions in 2021. It is seen that the fruit weight (63.96 g) of the wild pear genotype evaluated in this study is very close to the value reported by the researcher in 2021. In study, the coefficient of variation of the fruit weight of the wild pear genotype was determined to be 6.45%. A low coefficient of variation may be an indicator of ecological differences. However, environmental and genotypic differences affect fruit characteristics. Fruit weight and size are among the main factors determining consumers' fruit choices (Muradoğlu et al., 2021). The selected wild pear genotype will be able to gain an essential place in the market with its remarkable fruit weight.

In this research, seed weight and number were lower than Şahiner Öylek (2022) and Keçeci (2017). Uzun et al. (2018) reported that seed numbers showed wide variation. In selection studies, genotypes can occur in a wide range under the influence of various factors (Karadeniz et al., 2021).

Table 1. Some pomological characteristics of selected wild pear genotype

Characteristics	Unit	Min.	Max.	Mean	SD	CV(%)
Fruit weight	g	55.73	68.41	63.96	4.13	6.45
Fruit length	mm	38.53	52.65	44.71	4.25	9.50
Fruit width	mm	38.71	56.39	49.60	4.27	8.60
Shape index	-	0.72	1.36	0.91	0.17	18.13
Seed length	mm	8.54	10.19	9.41	0.56	6.00
Seed width	mm	4.38	6.31	5.36	0.54	10.12
Seed weight	g	0.18	1.50	0.51	0.42	82.95
Number of seeds	piece	1.00	5.00	2.64	1.21	45.75
Stalk length	mm	4.32	15.25	10.31	3.40	33.04
Stalk thickness	mm	2.44	4.69	3.17	0.57	17.96
Length of eye basin	mm	15.67	21.44	18.74	1.90	10.12
Width of eye basin	mm	17.05	23.39	20.65	1.97	9.54

Fruit skin color L* value was 62.33 on average, while a* and b* values were 11.68 and 36.59, respectively. Chroma* and Hue° values were 40.15 and 73.07, respectively. In flesh color, L, a*, b*, Chroma*, and Hue° values were 68.56, 4.57, 19.83, 20.43, and 77.26, respectively. The value in fruit flesh showed a high variation (97.14%) (Table 2). Özlük (2015) reported that the fruit flesh color was cream, Alp and Söylemez (2020) reported that the fruit skin color was yellowish on green and the fruit flesh color was yellowish. Şahiner Öylek (2022) reported that the yellow color was generally dominant in the selected wild pear genotypes in the study, and the genotypes measured in 2019 were greener than in 2020. The differences between the color parameters in the researchers' findings may be due to differences between ecological and harvest times. Unlike apples and pears, wild pears have two different maturity stages: actual eating and consumption maturity, and the fruit should be consumed when the flesh turns brown (Özlük, 2015).

Table 2. Fruit skin and flesh color of selected wild pear genotypes

Characteristics		**Min.**	**Max.**	**Mean**	**SD**	**CV (%)**
Fruit Skin Color	L*	45.33	76.18	62.33	11.12	17.84
	a*	-3.38	25.09	11.68	11.34	97.14
	b*	29.28	41.09	36.59	3.56	9.72
	Chroma*	38.27	43.68	40.15	1.57	3.92
	Hue°	49.90	94.97	73.07	17.89	24.49
Fruit Flesh Color	L*	54.15	77.13	68.56	6.59	9.61
	a*	1.94	7.92	4.57	1.83	39.96
	b*	17.50	22.65	19.83	1.43	7.23
	Chroma*	18.10	23.46	20.43	1.59	7.76
	Hue°	68.56	83.88	77.26	4.75	6.15

SSC is a vital fruit characteristic that provides taste and suitability for fresh consumption. The selected wild pear genotypes were 18.00-22.00% of SSC, pH 4.00-5.00, and TA values 0.54-0.87 (Table 3). Chemical analyses were partially similar to the findings of other researchers (Yilmaz et al., 2015;

Özlük, 2015; Şahiner Öylek, 2022). The research results on wild pear genotypes were higher than the SSC values of Keçeci (2017). Uzun et al. (2018) reported a wide variation in SSC values, while Alp and Söylemez (2020) reported that wild pears with an astringent and grittiness texture could be consumed.

Table 3. Some chemical properties of the studied genotype

Characteristics	Unit	Min.	Max.	Mean	SD	CV (%)
SSC	%	18.00	22.00	20.00	1.41	7.07
pH	-	4.00	5.00	4.31	0.38	8.83
TA	%	0.54	0.87	0.71	0.23	32.84

This research, six different phenolic compounds (gallic, chlorogenic, caffeic, syringic, *p*-coumaric, and *q*-coumaric) and four flavonoids (catechin, myricetin, quercetin, and rutin) were determined by HPCL in wild pear genotype. The most striking result from phenolic acids was gallic acid, with 3.36 mg/100 ml FW. Similarly, the highest results from flavoids were 7.72 mg/100 ml FW myricetin and 5.57 mg/100 ml FW catechin. In addition, chlorogenic acid showed a high variation rate (95.55%) (Figure 1, Appendix 1). Phenolic compounds play a critical role in forming the unique characteristics of fruits and are essential in terms of biochemical properties in this context. These compounds provide sensory properties such as distinct taste, bitterness, and astringency to fruits and have a decisive effect on the formation of the aroma profile of fruits. In this respect, phenolic compounds stand out as an essential component in defining fruit quality. Güdücü (2014) determined the total phenolic content by the FCR method as 49.81 µg GAE/mg extract for acetone extract and 28.91 µg GAE/mg extract for methanol extract. Şahiner Öylek (2022) determined that the total phenolic content was 67.82-133.82 mg GAE /100 g, and the total antioxidant capacity was 0.70-2.07 mmol TR/100 g in promising genotypes. Wild pear is a rich source of total phenolics (Yilmaz et al., 2015). Kayhan et al. (2024) detected gentisic acid (9.3 mg/100 g DW), vanillic acid

(0.6 mg/100 g DW), and protocatechuic acid (3.5 mg/100 g DW) with HCl extract in a study they conducted. The researcher detected high levels of quercetin in the fruits. Tüysüz et al. (2021) reported that sinapic acid was the most dominant phenolic acid in wild pear fruits. In this research, the most dominant flavonoids were myricetin and catechin; phenolic compounds were gallic and chlorogenic acid. The ecological factors and genotypic differences in which the fruits are grown may produce different results in the biochemical properties of the fruits.

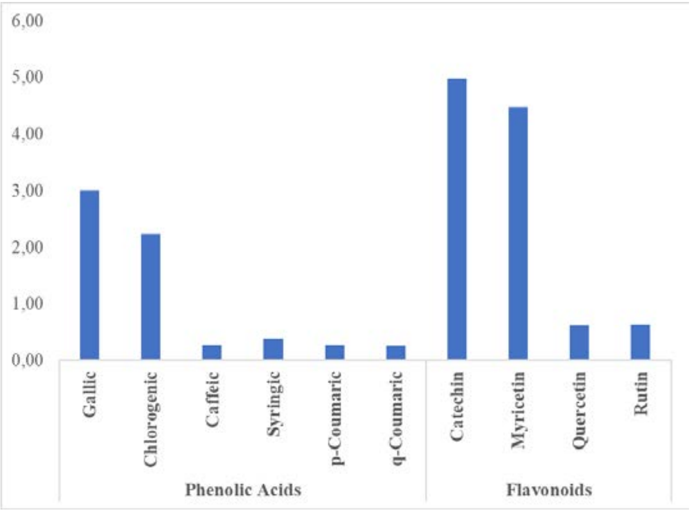

Figure 1. Phenolic contents of the researched promising wild pear genotype (mg/100 ml FW)

4. CONCLUSIONS

Consequently, increasing fruit genetic diversity, conserving local genetic resources, and strengthening their adaptability are critical for improving yield and quality. Advanced breeding enriches the genetic diversity of local species, enabling the development of more resilient and productive genotypes. This process will contribute to increasing global competitiveness and sustainable agricultural practices.

The literature contains limited studies on the morphometric characteristics and phytochemical constituents of wild pear fruit, which prevents a comprehensive evaluation of this fruit's potential. This research provides the basis for further studies to explore the genetic diversity of wild pear and the potential of this genotype. The selected wild pear genotype is remarkable for its fruit weight and SSC values. Gallic acid content, myricetin, and catechin values of the wild pear genotype show attractive values compared to other phenolic compounds. Considering that Anatolia is rich in wild pear, it is seen that this fruit has been neglected in terms of scientific studies. In this context, It is essential to identify and comprehensively examine wild pear genotype in terms of genetic diversity and phytochemical content, especially phenolic compounds, flavonoids, and other bioactive compounds, and to fill the gap in the literature. However, more comprehensive studies on fruit genetic diversity and phytochemical content will provide the opportunity to examine the health effects of local fruit species, especially their antioxidant properties, in more detail. Research on the biochemical properties and health benefits of neglected local fruit species will allow for significant progress in agricultural production.

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Appendix 1. Phenolic contents of the studied promising in wild pear genotype (mg/100 ml FW)

	mg/100 g FW	Min.	Max.	Mean	SD	CV (%)
Phenolic Acids	Gallic	2.60	3.36	3.00	0.41	13.84
	Chlorogenic	0.39	4.09	2.24	2.14	95.55
	Caffeic	0.24	0.31	0.27	0.04	15.05
	Syringic	0.28	0.49	0.39	0.11	29.59
	p-Coumaric	0.24	0.30	0.27	0.30	11.92
	q-Coumaric	0.13	0.42	0.26	0.15	58.49
Flavonoids	Catechin	4.57	5.57	4.98	0.46	9.13
	Myricetin	1.23	7.72	4.48	3.74	83.56
	Quercetin	0.54	0.69	0.61	0.08	13.21
	Rutin	0.52	0.75	0.63	0.12	19.37

SWOT ANALYSIS IN EVALUATION OF APRICOT GROWTH: ÇİVRİL DISTRICT

Berna DOĞRU ÇOKRAN[1]

1. INTRODUCTION

The genetic diversity of apricot in the world is classified into three main gene center levels, considering wild apricot forms and existing cultivars. The First-Degree Gene Center covers China, Kashmir, Afghanistan, Tajikistan and Uzbekistan. The Second-Degree Gene Center includes Northern and Eastern Iran, Türkiye, the Caucasus and Turkmenistan. The Third-Degree Gene Center covers Southwestern, Southern and Southeastern Europe (Ruiz et al., 2011).

The cultivation of apricots dates back to approximately 5000 years ago. This fruit was brought to Anatolia during the campaigns of Alexander the Great in the 4th century BC. Since Anatolia has a climate and soil conditions that are extremely suitable for the cultivation of apricots, apricots spread rapidly here and became a "second orjin". During this period, apricots began to spread rapidly in the fertile lands of Anatolia and became one of the important agricultural products of the region (Asma, 2000).

Apricot production in Türkiye is divided into seven different regions in terms of geographical features, production processes and evaluation methods. These regions differ in terms of apricot cultivation intensity and diversity. These are; Malatya region, Elazığ-Erzincan-Sivas region, Mediterranean region,

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Kars-Iğdır region, Aegean region, Central Anatolia region and Marmara region. Of these regions, Malatya production share accounts for more than half of Türkiye apricot production (Asma and Kan, 2004; Asma, 2011).

In Türkiye, which is the leader in fresh and dried apricot production worldwide, apricot production varies according to the varieties in different regions. Malatya stands out in terms of dried apricot production and is considered the most important production center of our country in this field. The Aegean and Mediterranean regions and Iğdır province have great potential in the production of table and especially early harvested apricot varieties (Doğru Çokran and Karadeniz, 2019; Karadeniz and Doğru Çokran, 2020). Apricots produced in these regions are generally offered to the market for fresh consumption (Öztürk et al., 2011).

The amount of apricots produced in the world is 3.932.659 tons, while in Türkiye it is 803.000 tons. Türkiye, which meets 20.4% of the world's apricot production, ranks first (FAO, 2024). Denizli apricot production amount is 2.123 tons (TUİK, 2024). Çivril district share in Denizli apricot production amount is 51.3% (Figure 1).

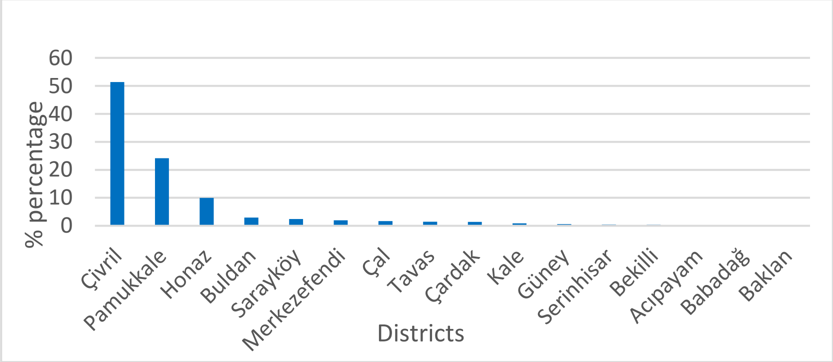

Figure 1. Denizli Apricot Production Quantities by Districts in 2023 (tons)

Apricot production ranks fifth in Çivril fruit growing. Although there has been an increase in apricot production areas and production amounts in the district, decreases have been observed in certain periods (Table 1). These changes are due to the fact that agricultural production is largely dependent on weather conditions, climate changes and other natural factors, as well as farmers turning to different products to adapt to these conditions. Despite these fluctuations, Çivril is a district that meets more than half of the apricot production of Denizli province. For this purpose, Çivril district was selected as a sample area and was aimed to be analyzed with the SWOT method.

Table 1. Apricot production, planted areas and yield in Çivril District

	Number of Fruiting Trees (number)	Number of Non-Fruiting Trees (number)	Area of All Orchards (decare)	Production Quantity (tons)	Verim (Yield (kg/number of fruiting trees)
2004	15 130	12 250	860	227	15
2005	17 150	12 730	1 020	343	20
2006	23 180	13 700	1 306	1 159	50
2007	26 850	16 030	1 546	237	9
2008	29 880	16 050	1 666	896	30
2009	34 895	15 405	1 840	1 396	40
2010	37 705	15 610	1 960	377	10
2011	40 950	15 855	2 110	819	20
2012	44 160	15 665	2 230	1 457	33
2013	47 150	22 325	2 198	680	14
2014	45 950	17 890	2 000	919	20
2015	43 750	14 090	1 800	438	10
2016	37 450	11 285	1 500	1 408	38
2017	39 550	9 080	1 479	3 072	78
2018	35 300	7 270	1 300	2 433	69
2019	36 510	6 075	1 300	2 373	65
2020	31 720	4 865	1 100	1 903	60
2021	26 525	6 310	975	1 194	45
2022	27 310	7 025	1 025	2 463	90
2023	28 720	16 880	1 400	1 090	38

(TUİK, 2024)

Table 2. Çivril 2023 Fruit Production Quantity and Fruit Production Area

Fruits Grown in Çivril	Production Amount (tons)	Production Area (decare)
Apple	161 102	52 500
Peach	73 110	25 000
Nectarine	2 918	5 250
Pear	2 361	1 100
Apricot	1 090	1 400
Plum	944	600
Walnut	888	7 200
Cherry	840	3 000
Quince	771	460
Sour Cherry	456	700
Almond	240	1 650
Jujube	211	200
Table Grapes, Seedled	210	1 000
Table Grapes, Seedless	165	1 500
Cornelian cherry	98	30
Wine Grapes	93	1 000
Dried Grapes, Seedled	42	200
Dried Grapes, Seedless	28	250
Pistachio (Pistachio)	4	120
Oleaster	0	0
Mulberry	0	0
Total	245 571	103 160

(TUİK, 2024)

1.1. Climatic Characteristics of Çivril District

Çivril is the largest district of Denizli province with a surface area of 1499 km², and is located on the Denizli - Uşak State Highway and 840 meters above sea level. It borders Sandıklı and Dinar (Afyon) to the east, Karahallı (Uşak), Bekilli, Çal and Baklan (Denizli) to the west, Sivaslı (Uşak) and Sandıklı (Afyon) to the north, and Dazkırı, Evciler (Afyon) and Baklan (Denizli) to the south (Anonymous, 2024a).

Çivril has a climate that is transitional between the Mediterranean climate of the Aegean Region and the continental climate of the Central Anatolia Region. Summers are hot and dry, and winters are cold and rainy. The district has large agricultural areas covered with fertile soil and is quite suitable for agriculture due to the combination of mountainous and plain lands. Çivril Plain consists of alluvial layers and joins the Dinar Plain in the southeast and the Baklan Plain in the southwest. The Büyük Menderes River, which is the most important water source in the region, flows through the Çivril Plain and irrigates the plain lands (Anonymous, 2024b).

Çivril is a very rich region in terms of agriculture, and in addition to various fruits such as apple, peach, nectarine, pear, apricot, plum, walnut, cherry, quince, sour cherry, almond, grape, jujube (Table 2), corn, sugar beet, clover (green grass), corn, barley, wheat, animal beet, poppy, pea, sunflower, clover are also grown (TUİK, 2024). Apricot is one of the important agricultural products of Çivril. Apricot cultivation in the district constitutes both the livelihood of the local people and an important part of the economic activity in the region.

2. SWOT ANALYSIS OF APRICOT CULTIVATION

SWOT analysis is a method used in the strategic planning process to evaluate the internal situation of a region or any sector and the external factors around it (Özen and Gül, 2020). This method consists of four basic components. The subject or area to be addressed is evaluated according to these four perspectives: strengths (S), weaknesses (W), opportunities (O) and threats (T). Examinations made on these four components regarding the subjects enable quantitative and qualitative analyzes, and a strategic view can emerge as a result of these analyzes (Çelik and Sarıaltın, 2019). It is an easy-to-understand, simple diagram and does not require any mathematical knowledge. SWOT can be applied to different depths (Sarsby, 2016). Strengths and weaknesses are considered as internal factors since they arise from the internal potential of the area. Opportunities and threats are considered external factors because they originate from the external environment or factors outside the field (Taş, 2011).

For the SWOT analysis of apricot cultivation in Çivril district, producers and agricultural engineers were interviewed. In the light of this information, the strengths and weaknesses of apricot production in Çivril district, opportunities and threats were determined. In this way, the potential of the district in apricot production and the difficulties it faces will be understood more clearly.

2.1. Strengths

Among the horticultural products grown in our country, fruits have great importance with their diversity, production values, cultivation areas, importance in terms of human health and share in exports. Apricot, which is among the hard-core fruits among the fruit species (Hormaza et al., 2007), is among the important fruit species due to its diversity of genetic resources, cultivation in wide areas in terms of climate conditions, high production amount and various consumption patterns. Table apricots are mostly grown in the Aegean region. In Çivril, production with different apricot varieties and establishment of gardens with different varieties spreads the harvest times to a wide period. Apricot varieties such as Roksana, Şalak (Iğdır Apricot), Şekerpare, Alyanak, Milord are widely grown in the region. This situation provides advantages in terms of products supplied to domestic and foreign markets. The suitability of Çivril climate and soil structure, the ability to obtain quality fruit, high income, and lower chemical pesticide costs in terms of combating diseases and pests compared to other fruit species commonly grown in the region constitute its strengths.

2.2. Weaknesses

Lack of variety stability, difficulty in finding workers for practices such as pruning, thinning, and harvesting, low fruit set and low yield due to not using pollinator varieties in the orchards established at the beginning, farmers' distant approach to the product due to this situation, and insufficient agricultural insurance constitute the weaknesses.

2.3. Opportunities

Contributing to the region as an alternative product in terms of being an important fruit type, not having sales problems due to proximity to the market, not feeling strange in switching to apricot cultivation due to years of fruit cultivation and having a high number of conscious farmers in terms of fruit cultivation, intensive production of products such as apples, peaches, nectarines, walnuts, cherries in the region and the abundance of cold storage facilities for post-harvest storage, providing a solution to the storage need for apricots, not having another region in the region that can compete with Çivril in terms of apricots, having a lot of agricultural land that allows for increased production, low out-migration due to high agricultural income and a high number of young people working in agriculture are opportunities.

2.4. Threats

In terms of climatic factors, since apricot is one of the early flowering fruit species, the biggest threat is late spring frosts. It threatens the sustainability of production to a great extent and leads to price instability. At the same time, due to the fact that many different fruit gardens are adjacent to each other, diseases and pests are intense, sometimes full, and water resources are limited, posing a threat to apricot cultivation.

Demirtaş and Gül (2003) found that more than 70% of farmers in a study they conducted in Mersin were exposed to frost damage in spring. Since it does not have a high winter dormancy requirement, blooms immediately after almonds among stone fruit species, and is heavily damaged by late spring frosts, apricot production has been limited both in the world and in our country. In our country, except for the Mediterranean and Southern Aegean coasts, other regions are under the threat of late spring frosts (Güleryüz and Bolat, 1992; Baktır et al., 1992).

3. CONCLUSION

Apricot cultivation in Çivril has a strong potential with the economic contributions it provides and the efficient agricultural conditions. It is particularly suitable for table varieties. However, difficulties such as late spring frosts, hail damage, limited water resources, diseases and pests cause fluctuations in apricot production. This situation is one of the main factors that directly affect the sustainability and productivity of agricultural activities. Therefore, irregularities in apricot production in Çivril are directly related not only to local agricultural strategies but also to environmental conditions. For this, gardens should be established with later flowering varieties and suitable pollinator varieties in areas with air flow and without depressions. Therefore, when selecting apricot varieties suitable for the ecological conditions in the region, attention should be paid to the yield and quality of the fruit as well as the characteristics of the varieties such as resistance to cold and frost.

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POST HARVEST FRUIT LOSS; A PERSPECTIVE

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1. INTRODUCTION

1.1. Importance of Post-Harvest Crop Losses

The issue of post-harvest product losses is a critical concern that profoundly affects food security, farmer livelihoods, and the overall efficiency of the global food system. These losses occur at various stages along the food supply chain, encompassing the period from harvesting through to consumption (Parfitt et al., 2010; Kumar & Kalita, 2017; Krishna et al., 2022; McNamara & Tata, 2015). The multifaceted nature of these losses can be attributed to a variety of factors, including improper harvesting techniques, inadequate infrastructure, limited access to markets, poor storage and handling practices, and outdated post-harvest technologies (Parfitt et al., 2010; Tadesse et al., 2018; Hengsdijk & Boer, 2017; Onkware et al., 2021; Anyoha et al., 2023; Kharel, 2022).

The magnitude of post-harvest losses varies significantly across different crops, geographic regions, and economic contexts (Kumar & Kalita, 2017; Krishna et al., 2022; Chimaobi, 2023;

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Baidya et al., 2020). In particular, developing countries experience particularly high levels of post-harvest losses, which can range from 5% to 20% for grains and soar to as much as 60% for tubers, fruits, and vegetables (Chimaobi, 2023; Zhang et al., 2021; Agarwal et al., 2021). Such significant losses have dire implications for food security and farmer incomes (Tadesse et al., 2018; McNamara & Tata, 2015). Additional contributing factors include geographical remoteness from markets, inadequate infrastructure, and environmental conditions such as low rainfall, all of which can exacerbate post-harvest losses (Hengsdijk & Boer, 2017; Akpa et al., 2022). Furthermore, the use of inappropriate packaging materials and negligent handling practices during transportation are major contributors to product damage and subsequent losses (Onkware et al., 2021; Anyoha et al., 2023).

Addressing post-harvest losses demands a comprehensive and multifaceted approach that includes the introduction of culturally specific innovations and technologies, enhanced post-harvest management practices, and substantial investments in infrastructure and market access (Parfitt et al., 2010; Onkware et al., 2021; OK, 2023; Manandhar et al., 2018). In addition, education and capacity-building efforts for farmers play a crucial role in equipping them with the knowledge and skills required to effectively minimize post-harvest losses (Akpa et al., 2022; Lelea et al., 2022). The efforts to mitigate these losses are essential for improving food security, increasing farmer incomes, and enhancing the efficiency of the global food system (Tadesse et al., 2018; McNamara & Tata, 2015; Lelea et al., 2022). A collaborative approach involving a wide range of stakeholders, including policymakers, researchers, and farmers, is necessary to implement sustainable solutions for this pressing issue.

1.2. The Economic Dimension of the Fruit Sector

The economic dimension of the fruit sector is profoundly influenced by post-harvest product losses, which have significant implications for the entire supply chain. Various studies highlight the substantial economic losses associated with fruit and vegetable waste. Post-harvest losses of citrus fruits can reach as high as 14-15% in developed countries such as the United States, representing a considerable waste of investment that diminishes the economic well-being of all actors involved in the supply chain (Hanif & Ashari, 2021). Globally, losses and waste in fruits and vegetables may account for up to 60% of total production, making it the highest among all food categories (Sagar et al., 2018). Processing operations often generate 25-30% waste in the form of by-products like peels, pomace, and seeds. These by-products contain a wealth of bioactive compounds, including dietary fiber, flavonoids, phenolic compounds, antioxidants, and other health-promoting nutrients, and effectively utilizing them can help mitigate economic losses while aligning with sustainable development goals (Nirmal et al., 2023; Villacís-Chiriboga et al., 2020; Kumar et al., 2020).

Current technologies present opportunities to valorize fruit and vegetable waste as valuable ingredients, food bioactive compounds, and biofuels (Zhu et al., 2023). In developing countries, many small and micro-scale industries struggle with managing the fruit waste generated during their operations, leading to economic and environmental challenges (Kamaraj et al., 2019). Valorizing these by-products can provide a practical solution to the waste problem while fostering sustainable economic growth within a bio-economy framework.

The fruit and vegetable sector also plays a crucial role in the socio-economic development of rural and urban populations in developing countries. For example, the mango production chain in Kenya significantly contributes to agricultural GDP and foreign exchange earnings, thereby supporting local economies (Torres-León et al., 2018). By diversifying the production chain through the valorization of by-products, additional income can be generated, and employment opportunities can be created for local communities.

Overall, the economic losses associated with post-harvest fruit and vegetable waste are substantial, potentially reaching as high as 60% on a global scale. The effective utilization of these by-products through various valorization techniques not only reduces economic losses but also fosters sustainable economic growth and supports the socio-economic development of communities, particularly in developing countries.

1.3. Environmental and Social Impacts of Fruit Losses

The environmental and social impacts of fruit losses are significant and multifaceted, as highlighted in various studies. From an environmental perspective, substantial fruit and vegetable waste generated throughout the supply chain poses serious ecological concerns. The fruit and vegetable industry produces millions of tons of residues, leading to considerable economic losses and environmental issues (Zhu et al., 2023). Effective utilization of these fruit wastes can help reduce the carbon footprint and greenhouse gas emissions, thereby supporting sustainable development goals (Nirmal et al., 2023).

The nutritional and food security implications of fruit losses are also noteworthy. Tropical fruits, dairy, and fish are important commercial food and crop enterprises that play a crucial role in the socio-economic development of rural and urban populations in developing countries (Torres-León et al., 2018). For instance, the mango production chain in Kenya contributes significantly to agricultural GDP and foreign exchange earnings, directly benefiting local economies (Torres-León et al., 2018). By diversifying the production chain with the valorization of by-products, additional income can be generated, and employment opportunities can be created for residents, which ultimately support impoverished communities (Torres-León et al., 2018).

Moreover, substantial economic losses are associated with post-harvest fruit and vegetable waste, potentially reaching as high as 60% globally (Sagar et al., 2018). These losses represent a wasted investment, adversely impacting the economic well-being of all actors in the supply chain (Hanif & Ashari, 2021). Effective utilization of these by-products through various valorization techniques can not only mitigate economic losses but also foster sustainable economic growth and contribute to the socio-economic development of communities, particularly in developing countries (Villacís-Chiriboga et al., 2020; Torres-León et al., 2018).

2. DEFINITION AND CAUSES OF POST-HARVEST LOSSES

Post-harvest losses of fruits and vegetables can be substantial, varying between 5-35% in developed countries and reaching as high as 20-50% in developing countries (Aguilar-Ayala & Herrera-Rojas, 2023). Sagar et al. (2018) estimate that global losses and waste in fruits and vegetables may account for up to 60% of total production, making it one of the highest rates among all food categories. These losses arise from a variety of factors, including improper harvesting, handling, packaging, transportation, and storage methods (Rokaya et al., 2016; Jain, 2023; Hussain et al., 2021).

Post-harvest losses can manifest in both quantitative and qualitative forms. Quantitative losses refer to the measurable reduction in the physical quantity of the produce, while qualitative losses involve the deterioration of the produce's quality, including the loss of nutritional value, acceptability, and edibility (Rokaya et al., 2016; Jain, 2023; Hussain et al., 2021; Kaya et al., 2024). Various methods have been employed to measure post-harvest losses in the fruit sector. Direct measurement techniques, such as monitoring the number of fruits lost or damaged at different stages of the supply chain, are commonly used (Opara et al., 2021). For example, a study documented the direct counting of individual pieces of fruit with defects discarded in the "waste bins" of a pomegranate farm (Opara et al., 2021).

In addition to direct methods, indirect approaches such as surveys and interviews with value chain actors have been utilized to estimate post-harvest losses (Ludwig-Ohm et al., 2019). These indirect methods are valuable for identifying the main reasons for food losses and for assessing effective measures for their reduction. Understanding the physiological and biochemical changes that occur in fruits during the post-harvest period is crucial, as these changes can significantly contribute to losses (Baidya et al., 2020; Rana & Siddiqui, 2018). Monitoring these changes and applying appropriate post-harvest treatments—such as the use of growth regulators, calcium, and essential oils—can help prolong shelf life and mitigate losses (Aguilar-Ayala & Herrera-Rojas, 2023; Rana & Siddiqui, 2018; Kumar, 2023).

2.1. Physiological Causes: Respiration, Water Loss, Maturation

2.1.1. Respiration: Respiration is a major contributor to post-harvest fruit losses, causing a reduction in weight due to loss of water (Kozlu & Elmacı, 2020; Freitas & Mitcham, 2013). As fruits ripen, their respiration rates increase, leading to higher rates of weight loss and subsequent quality deterioration (Weber et al., 2016; Xing et al., 2015). Treatments that can reduce respiration rates, such as applying ethanol and chitosan coatings, have been shown to help extend the shelf life of fruits (Weber et al., 2016; Xing et al., 2015; Yan et al., 2012).

2.1.2. Dehydration: Dehydration is another key factor contributing to post-harvest fruit losses. As fruits lose moisture through transpiration and respiration, they may experience wilting, shriveling, and softening, which adversely affects their appearance and overall quality (Hussain et al., 2021; Oliveira et al., 2021). Various factors, including storage temperature and packaging, can significantly influence the rate of dehydration and weight loss in fruits (Freitas & Mitcham, 2013; Yan & Yinzhe, 2013).

2.1.3. Maturation: The stage of fruit maturity at harvest also plays a significant role in determining post-harvest losses. Less mature fruits are more susceptible to physiological disorders and environmental stresses, resulting in higher rates of weight loss and quality deterioration compared to more mature fruits (Grigio et al., 2016; Ambuko et al., 2017; Álvarez-Herrera et al., 2021). Enzymatic changes that occur during ripening can further contribute to softening and loss of firmness in mature fruits (Álvarez-Herrera et al., 2021; Yao et al., 2012).

2.2. Biological Causes: Microorganisms (Fungi, Bacteria) and Pests

The biological causes of post-harvest fruit losses can primarily be attributed to microorganisms such as fungi and bacteria, as well as pests.

2.2.1. Fungi: Several studies emphasize the role of fungal pathogens in causing post-harvest fruit losses. *Monilinia* species, which are responsible for brown rot, are a significant concern for cherries and other stone fruits (Larena et al., 2021; Bellamy et al., 2022). *Colletotrichum* species, which trigger anthracnose, pose substantial problems for mangoes, avocados, and other tropical fruits (Tovar-Pedraza et al., 2020; Sharma et al., 2017). Other fungi, such as *Rhizopus* and *Botrytis*, can also lead to post-harvest decay in various fruits (Agyare et al., 2020). These fungal pathogens can infect fruits during the pre-harvest stage and remain latent until fruit ripening, when they switch to a necrotrophic lifestyle and cause significant post-harvest losses (Galsurker et al., 2018; Galsurker et al., 2020). Factors like improper handling, storage conditions, and the maturity stage of the fruit can influence susceptibility to fungal infections (Larena et al., 2021; Agyare et al., 2020).

2.2.2. Bacteria: While the focus is more on fungal pathogens, bacterial infections can also contribute to post-harvest fruit losses. Bacterial soft rots, caused by species such as *Erwinia* and *Pseudomonas*, can lead to the deterioration of fruits during storage and transportation (Adhikari & Aarati, 2021).

2.2.3. Pests: In addition to microbial pathogens, pests including insects and mites can cause significant post-harvest losses. For example, the yellow tea thrips (*Scirtothrips dorsalis*) can infest and damage mangoes during storage and transportation (Kim et al., 2023). Implementing proper pest management strategies, including fumigation techniques, can help mitigate these losses.

2.3. Physical Causes: Damage, Injury, Improper Storage

Mechanical damage and physical injury significantly contribute to post-harvest fruit losses. The maturity stage of tomatoes at harvest, alongside pre- and post-harvest handling, are essential factors in ensuring fruit quality and minimizing losses (Machado et al., 2018). Post-harvest deterioration of plant products during storage can lead to significant losses, potentially up to 50% worldwide, underscoring the importance of understanding physiological changes during post-harvest storage to reduce losses due to over-ripening and shriveling (Kesanakurti et al., 2012).

Proper storage conditions are critical in maintaining fruit quality and minimizing post-harvest losses. Chilling injury in summer squash fruits during storage can lead to changes in cell membrane lipids and loss of membrane integrity, ultimately impacting fruit quality (Kannaujia et al., 2019). Grafted watermelon fruits show higher firmness compared to control fruits during storage, indicating the importance of storage conditions in preserving fruit quality (Çandir et al., 2021).

Physiological changes occurring in fruits during post-harvest handling and storage also contribute to physical losses. Physical, chemical, and physicochemical transformations are the main contributors to quality loss during storage, and using appropriate post-harvest technologies is crucial for preserving fruit quality (Nobre et al., 2018). Higher weight loss in avocado fruits is associated with faster ripening, leading to physical deterioration of fruit quality (Vallejo-Pérez et al., 2015).

Environmental factors such as temperature and humidity significantly influence post-harvest fruit losses. Cold storage and prolonged storage periods can lead to chilling injury and loss of ascorbic acid in oranges, causing substantial financial losses (Hussain et al., 2017). Mango fruits are particularly sensitive to low-temperature storage, which can induce chilling injury and reduce fruit quality (Sivankalyani et al., 2017).

2.4. Chemical Causes: Pesticide Residues, Toxin Formation

Pesticide residues in fruits are a significant contributor to post-harvest losses. Residues can persist in different parts of cherry tomatoes, even after household rinsing, impacting the quality and safety of the produce (Shimshoni et al., 2019). Handling methods, including washing, peeling, and cooking, can either increase or decrease the concentration of pesticide residues in fruits and vegetables (Ssemugabo et al., 2022). The health risks associated with pesticide residues in fruits are also a major concern; the use of pesticides during production often leads to their presence in fruits, posing risks to consumer health (Jawale, 2023). Additionally, concerns regarding pesticide residues in fresh foods, particularly fruits and vegetables, have been highlighted (Fothergill & Abdelghani, 2013). Various classes of pesticides, such as organophosphates, triazines-triazoles-conazoles, and carbamates, are commonly detected in fruit samples, with apples and pears identified as among the most contaminated (Chen et al., 2011; Christia et al., 2015).

In addition to pesticide residues, the formation of toxins represents another chemical cause of post-harvest fruit losses. Various post-harvest practices, such as irradiation and chemical fungicides, can control post-harvest decay and improve the market value of fruits; however, these practices might also lead to the formation of contaminants and toxins that negatively impact the quality and safety of the produce (Geetanjli, 2017). There is a growing emphasis on using alternative, non-chemical methods to manage post-harvest diseases. For instance, using biocontrol agents and natural compounds as alternatives to chemical fungicides can help manage post-harvest diseases such as anthracnose in mango fruits (Nisansala et al., 2016; Luo et al., 2015).

Environmental conditions play a significant role in influencing post-harvest fruit losses. Cold storage and prolonged storage periods can lead to chilling injury and loss of ascorbic acid in oranges, resulting in significant financial losses (Hussain et al., 2017). Mango fruits are sensitive to low-temperature storage, which can induce chilling injury and reduce fruit quality (Sivankalyani et al., 2017). High ambient temperatures and relative humidity also increase the susceptibility of fruits to microbial spoilage during the post-harvest period (Tm, 2013). The indiscriminate exposure of fruits to the environment at farms and markets, combined with their high nutritional content, can lead to increased contamination by microorganisms (Akpoka et al., 2020).

Microbial contamination is a major factor in post-harvest fruit losses. Various fungal species, including Penicillium and Colletotrichum, are associated with post-harvest spoilage of fruits (Serag et al., 2022; Mailafia et al., 2016). Fruits can become contaminated by microorganisms at the time of harvest due to their contact with water, soil, and other environmental factors (Akpoka et al., 2020; Kifle, 2024).

Pre-harvest factors are crucial in determining the susceptibility of fruits to post-harvest losses. Agronomic practices and soil-climate conditions can influence the physiological and pathological components of fruit quality, which in turn affect their vulnerability to post-harvest diseases (Ewané et al., 2013). High temperatures and increased solar radiation at the end of the harvest season may cause fruit weight losses (Pehluvan, et al., 2018).

Harvesting and handling practices also significantly impact fruit losses. Mechanical damage and physical injury during harvesting, handling, and transportation contribute to post-harvest deterioration and quality losses (Machado et al., 2018; Kesanakurti et al., 2012; Kırca et al., 2023).

3. POST-HARVEST LOSSES ACCORDING TO FRUIT TYPES

Significant post-harvest losses are observed in citrus fruits, particularly oranges. Cold storage and prolonged storage periods can lead to chilling injury and loss of ascorbic acid in oranges, resulting in substantial financial losses (Hussain et al., 2017). The use of chitosan and essential oils has been discussed as a method to control fungal decay and extend the shelf life of oranges during storage (Cháfer et al., 2012).

Tropical fruits, such as mangoes, avocados, and passion fruits, face their own set of post-harvest challenges. Mango fruits are particularly sensitive to low-temperature storage, which can induce chilling injury and degrade fruit quality (Sivankalyani et al., 2017). The impact of Colletotrichum species, which cause anthracnose, has been noted as a significant factor contributing to post-harvest losses in mangoes and avocados (Tovar-Pedraza et al., 2020; Sharma et al., 2017). Changes in quality attributes during the ripening of passion fruits can also affect overall fruit quality (Gomes et al., 2021).

While the references do not specifically highlight post-harvest losses in nuts, insights can be drawn from the discussions of other fruit groups. Proper handling, storage conditions, and the application of post-harvest treatments are essential for mitigating losses in various fruit crops, including nuts, which may suffer from physical damage, microbial contamination, and physiological changes during the post-harvest period.

Overall, the literature emphasizes substantial post-harvest losses across different fruit groups, with a particular focus on citrus and tropical fruits. These losses are attributed to a combination of factors, including environmental conditions, microbial contamination, physical damage, and physiological changes during handling and storage. Effective post-harvest management strategies, such as control of temperature and humidity, microbial management, and the use of coatings and treatments, are crucial to minimize these losses and ensure fruit quality and shelf life.

4. LOSSES DURING HARVESTING AND TRANSPORTATION

Mechanical damage and physical injury during harvesting, handling, and transportation are major contributors to post-harvest fruit losses. Improper harvesting techniques, such as rough handling or using inappropriate tools, can lead to bruising, cuts, and other physical damage to fruits, making them more susceptible to microbial spoilage and quality deterioration (Singh et al., 2022).

The maturity stage of the fruit at the time of harvest significantly impacts post-harvest losses. Less mature fruits are more susceptible to physiological disorders and environmental stresses, resulting in higher rates of weight loss and quality deterioration compared to more mature fruits (Samaradiwakara et al., 2019). Harvesting at the optimal maturity stage is crucial to ensure better post-harvest quality and shelf life.

Proper harvesting practices, including careful handling, the use of appropriate tools, and avoiding over-ripening or over-maturity, are essential for minimizing post-harvest losses (Kharel, 2022; Hengsdijk & De Boer, 2022). Adopting suitable harvesting methods, such as hand-picking or using specialized harvesting equipment, can help reduce mechanical damage and physical injury to the fruits (Kharel, 2022).

Transportation and post-harvest handling also significantly impact fruit losses. Factors such as the mode of transportation, distance to markets, and handling practices during loading, unloading, and distribution contribute to post-harvest losses (Hengsdijk & Boer, 2017; Muroyiwa et al., 2020). Improving transportation infrastructure, handling techniques, and storage facilities can help mitigate these losses (Hengsdijk & Boer, 2017; Muroyiwa et al., 2020).

5. THE ROLE OF TRANSPORTATION CONDITIONS

Improper handling and transportation can lead to mechanical damage and physical injury to fruits, increasing their susceptibility to microbial spoilage and quality deterioration (Silapeux et al., 2021; Kumari et al., 2019). Factors such as the mode of transportation, distance to markets, and handling practices during loading, unloading, and distribution significantly contribute to post-harvest losses (Hengsdijk & Boer, 2017).

Maintaining appropriate environmental conditions, including temperature and humidity, during transportation is crucial for minimizing post-harvest losses (Krishna et al., 2022). Exposure to unfavorable environmental conditions can result in physiological disorders, increased respiration rates, and heightened susceptibility to microbial contamination, all of which contribute to post-harvest losses (Krishna et al., 2022).

Poor transport conditions, including inadequate temperature and humidity control, can lead to increased microbial contamination and spoilage of fruits during transportation (Silapeux et al., 2021; Krishna et al., 2022). Improper handling and storage practices during transportation can cause cross-contamination, further exacerbating post-harvest losses (Silapeux et al., 2021).

Lack of proper transportation infrastructure and limited access to markets significantly contribute to post-harvest losses, especially in developing countries (Hengsdijk & Boer, 2017). Households located further away from markets and main roads tend to experience higher post-harvest losses, underscoring the need for improved transportation and market access (Hengsdijk & Boer, 2017).

To mitigate transport-related losses, adopting appropriate post-harvest handling practices, such as proper packaging, temperature and humidity control, and efficient transportation methods, is recommended (Dawad & Karki, 2022; Chhetri, 2023). Investments in transportation infrastructure, logistics, and supply chain management are crucial for reducing post-harvest losses, particularly in developing countries (Hengsdijk & Boer, 2017; Muroyiwa et al., 2020; Pillai et al., 2022).

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