Anatolian Journal of Botany
8(2): 142-149 (2024)
Research article *doi: 10.30616/ajb.1489855*

The pomological characteristics and values for public health of *Crataegus tanacetifolia*

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Received : 25.05.2024
Accepted : 16.07.2024
Online : 24.07.2024

*Crataegus tanacetifolia'*nın pomolojik özellikleri ve halk sağlığı açısından önemi

Abstract: This study aimed to determine the pomological characteristics and allometric relationships of *Crataegus tanacetifolia*, an endemic plant species in Türkiye, as well as to assess its significance for public health. Fruit samples collected from its natural habitat were subjected (Mihalıççık district of Eskişehir province, 1330-1350m) to pomological measurements. Subsequently, pomological characteristics were correlated with allometric relationships. The following pomological parameters were observed for *Crataegus tanacetifolia*: fruit length was 15.30±1.70mm, width was 19.51±2.30mm, thickness was 18.85±2.30mm, weight was 3.34±0.99g, flesh weight was 2.73±0.901g, arithmetic mean diameter was 17.89±2.04mm, geometric mean diameter was 17.78±2.02mm, sphericity index was 116.26±4.79%, surface area was 1005.55±223.28mm^2, appearance ratio was 0.79±0.05, seed ratio was 0.19±0.04, peduncle length was 3.26±0.24mm, flesh hardness was 14.02±1.61kg/cm^2, and fruit color (L*a*b) was 71.54±0.92*9.34±1.82*60.62±3.11. The fruit color ranged from light yellow to light pink, with green being the dominant color in unripe fruits. The seed length was 7.20±0.51 mm, width was 4.14±0.37mm, thickness was 5.42±0.43mm, weight was 0.12±0.02g, volume was 53.73±8.48mm^3, and surface area was 80.09±9.29. There was a high relationship between fruit surface area and allometric relationships, with R^2=0.9603 and R^2=0.8729 confidence interval. The allometric relationships between seed ratio and fruit sizes were in the range of R^2=0.3984 and R^2=0.5045. In this study, it was determined that *Crataegus tanacetifolia* is important for public health, its fruits are used as food.

Key words: *Crataegus tanacetifolia*, public health, pomology, hawthorn, biological diversity

Özet: Bu çalışma ile Türkiye'nin endemik bitkilerinden olan *Crataegus tanacetifolia*'nın pomolojik özellikleri ile allometrik ilişkileri ve bu türün halk sağlığı açısından öneminin belirlemesi amaçlanmıştır. Çalışmada *Crataegus tanacetifolia* 'nın doğal yayılış alanından toplanan meyve örnekleri üzerinde pomolojik ölçümler yapılmıştır. Daha sonra meyve pomolojik özellikler ile allometrik ilişkiler belirlenmeye çalışılmıştır. *Crataegus tanacetifolia*'nın; meyve uzunluğu 15,3±1,70 mm, genişliği19,5±2,30mm, kalınlığı 18,85±2,30mm, ağırlığı 3,34±0,99g, meyve etli kısım ağırlığı 2,73±0,901g, meyve aritmetik ortalama çapı 17,89±2,04mm, meyve geometrik ortalama çapı 17,78±2,02mm, meyve küresellik indeksi 116,26±4,79%, meyve yüzey alanı 1005,55±223,28mm^2, meyve görünüş oranı 0,79±0,05, meyve çekirdek oranı 0,19±0,04, meyve sapı 3,26±0,24mm, meyve eti sertliği 14,02±1,61 kg/cm^2 ve meyve rengi (L*a*b) 71,54±0,92*9,34±1,82*60,62±3,11 olduğu bulunmuştur. Meyve rengi açık sarıdan açık pembeye kadar değişim göstermekte ve olgunlaşmamış meyvelerde baskın renk yeşildir. Çekirdek uzunluğu 7,20±0,51mm, genişliği 4,14±0,37mm, kalınlığı 5,42±0,43mm, ağırlığı 0,12±0,02g, hacmi 53,73±8,48mm^3 ve çekirdek yüzey alanı 80,09±9,29 bulunmuştur. Meyve yüzey alanı ile meyve allometrik ilişkileri R^2=0,9603 ve R^2=0,8729 güven aralığında tanımlanan yüksek bir ilişki vardır. Meyve çekirdek oranı ve meyve boyutları arasındaki allometrik ilişkiler R^2=0,3984 ve R^2=0,5045 aralığındadır. Bu çalışmada *Crataegus* tanacetifolia'nın halk sağlığı açısından önemli olduğu, meyvelerinin gıda olarak tüketildiği belirlenmiştir.

Anahtar Kelimeler: *Crataegus tanacetifolia,* halk sağlığı, pomoloji, alıç, biyolojik çeşitlilik

Citation: Yücel D, Esatbeyoglu T, Capanoglu E, Catalkaya G, Yücel E (2024). The pomological characteristics and values for public health of *Crataegus tanacetifolia*. Anatolian Journal of Botany 8(2): 142-149.

1. Introduction

The public health approach is perceived as the "science and art of disease prevention" rather than just treating diseases. Efforts that facilitate life and the prolong lifespan, enhancing the overall quality of life through the collaborative efforts of various organizations, communities, and individuals can all be considered within the scope of public health. The use of plants in solving humanity's fundamental problem of health is as ancient as human history itself. The World Health Organization defines health as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity." Services aiming to protect individuals before diseases occur can be divided into two main categories: environmental and individual preventive health services (Tözün and Sözmen, 2015). Public health not only protects individuals from potential illnesses but also covers the

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protection of the environment in its entirety. In an environment where biological diversity is disrupted, it is not possible for humans to remain healthy. In this context, *Crataegus tanacetifolia* (Lam.) Pers., an endemic species, is not only characterized by its food and ethnobotanical properties but also serves as a significant element in biological diversity.

Various species of the genus *Crataegus* L. are sold in pharmacies, herbal shops, and markets as herbal products, food, and herbal medicine. A significant portion of these products is collected from nature. In many countries, species of the *Crataegus* genus, including their flowers, leaves, and fruits, are used as antispasmodic, cardiotonic, hypotensive, and antiatherosclerotic agents within complementary medicine (Edwards et al., 2012). In Türkiye, various species of *Crataegus* spp. are primarily used by local communities for conditions such as cardiovascular diseases, hypertension, sedation, shortness of breath, asthma, and insomnia; its fruits are consumed as food, and the juice prepared from the fruit is also considered as an analgesic (Yücel and Yücel, 2020). Flavonoids and proanthocyanidins are the main components responsible for observed biological activities (Çalişkan et al., 2012). Extracts obtained from genotypes of this genus increase the activation of cardiac muscle cells, regulate blood flow, and have a positive inotropic effect (Yusuf and Meriçli, 2016).

The genus *Crateagus* L. is represented by a total of 27 taxa in Türkiye, including 16 species, 3 subspecies, 6 varieties, and 6 hybrid species, with an endemism rate of 37% (Özkan et al. 2014). Polymorphism and hybridization are very high in the *Crataegus* section, and genetic diversity extends from Türkiye to Iran (Dönmez, 2007), which increases the possibility of Türkiye being the genetic center of the *Crataegus* spp. genus. Widespread hybridization results in the formation of numerous intermediate forms.

Most studies related to *Crataegus* species are taxonomically examined at the genus level as *Crataegus* spp. without specifying the species. According to a study conducted on 18 genotypes grown in Malatya, it was stated that *Crataegus* spp. fruits, which contain substances beneficial to human health, could be used in the development of functional foods due to their high phenolic content, anthocyanin content, and antioxidant properties (Ercisli et al., 2015). In a study conducted on 52 samples taken from 17 taxa of *Crataegus* spp., it was found that their leaves and flowers had significantly high antioxidant capacities (Özyürek et al., 2012). The fruits of *Crataegus* spp. are used as food and have high levels of flavonoids, vitamin C, glycosides, anthocyanidins, saponins, tannins, and antioxidants (Serçe et al., 2011). In another study conducted on 7 hawthorn taxa in Western Anatolia, a total of 81 volatile components were determined in leaves and flowers, with the highest proportion of volatile oil component being benzaldehyde (82.54%) along with the highest of 10 fatty acids was linoleic acid (64.23%) in seeds (Özderin et al., 2016). A study conducted on 15 genotypes of *Crataegus* spp. in Uşak province reported that the region had valuable potential in terms of hawthorn genetic resources (Oktan et al., 2017). Some physical properties of fruits collected from 51 genotypes of *Crataegus* spp. naturally growing in Çorum province were determined (Balta et al., 2015). In research focusing on *Crataegus* spp. fruits, drying time, color value, and drying curves of the product were modeled, and it was determined that the mathematical model that best predicted the drying curves of the fruit among thin-layer drying models was the Midilli-Küçük model (Polatçı and Taşova, 2017). *Crataegus aronia* (L.) Bosc var. *aronia*; *C. aronia* var. *dentata* Browicz; *C. aronia* var. *minuta* Browicz; *Crataegus orientalis* (Mill.) Bosc var. *orientalis* and *Crataegus monogyna* Jacq. subsp. *azarella* (Griseb.) Franco species sampled from Türkiye's Eastern Mediterranean region were found to have antioxidant activity in their fruits (Çalişkan et al., 2012).

Crataegus tanacetifolia (Yunus Emre Hawthorn) is a deciduous shrub or small tree with a height of up to 3 meters, short thorns, and a scattered top. The leaves are deeply lobed with 5-7 lobes, having serrated margins, the tips of the teeth are glandular, and light green in color; flowers are arranged in groups of 4-8, compound corymb, white in color; the fruit is a false fruit, fleshy, usually with shiny yellow color, sometimes reddish; and the fruit contains five seeds (Yücel, 2012). It prefers sunny and mild climates as well as well-drained, slightly acidic, neutral, and basic (slightly alkaline-alkaline) sandy-loamy soils. *Crataegus tanacetifolia* is an endemic plant species of Türkiye and grows naturally in regions such as Eskişehir, as well as Bolu, Karabük, Kastamonu, Ankara, Erzincan, Malatya, Samsun, and Sivas (Tübives, 2019).

There are numerous studies worldwide on the genus *Crataegus* and these studies generally focus on its natural distribution, systematic characteristics, phytochemical properties of fruits, leaves, and flowers, and their use in traditional medicine. However, there are very few studies directly elucidating the pomological characteristics of *Crataegus tanacetifolia* in a comprehensive manner.

This study aims to determine the pomological characteristics and assess the importance of *Crataegus tanacetifolia*, an endemic plant species in Türkiye, from a public health perspective.

2. Materials and Method

In this study, the natural distribution area of *Crataegus tanacetifolia*, where it is densely found, in the Mihalıççık district of Eskişehir province (1335m-1345m), was chosen as the research area, and the fruits were selected as the research material. Ten different trees were identified in each of the five selected sample areas. Required measurements were conducted on 25 randomly selected samples from among 100 ripe fruits collected in equal proportions from each tree in October.

Fruit and seed weight were measured using a digital scale sensitive to 0.01 g, while the dimensional properties of the fruit and seed (length, width, thickness), and fruit peduncle were measured using a digital caliper sensitive to 0.01 mm. Fruit hardness was measured using a penetrometer (kg/cm^2), and fruit color (L*a*b*) was measured using a color spectrophotometer. Juiciness, taste, aroma, attractiveness, and fruit quality were evaluated on a scale of 1-10 (1: worst, 10: best). The yield was determined by dividing the total yield values per tree by the number of trees (kg/tree) (Cemeroğlu, 1992; Acar, 2016). 1000 Seed weight (g) was determined according to ISTA standards (Aveling, 2014).

To determine the pomological characteristics of the fruit, the following measurements were taken: Fruit length (L) mm, fruit width (W) mm, fruit thickness (T) mm. The following formulas were used to calculate various fruit characteristics:

Arithmetic mean diameter (Da) mm (Mohsenin, 2020): $Da = (L+W+T)/3$

Geometric mean diameter (Dg), mm (Mohsenin, 2020): $Dg = (L*W*T)^{1/3}$

Sphericity index (Sp), % (Mohsenin, 2020): $Sp = (Dg/L)100$

Surface area (S), mm^2 (Sacilik et al., 2003): $S = \pi(Dg^2)$

Appearance ratio (Ra) (Owolarafe et al., 2007): $Ra = W/L$

Fruit/Seed ratio: FS = Seed weight/Fruit weight

The maximum and minimum values of the measured characters and their relationships were examined. For statistical analysis, Microsoft Excel and SPSS 21.0 software packages were used. The results were considered statistically significant at the $p \leq 0.05$ level.

3. Results

According to the objectives of the study, the pomological characteristics and allometric relationships of *Crataegus tanacetifolia* genotypes were investigated, and the findings are summarized in Table 1.

Among the examined genotypes, the average fruit length ranged from 12.21 to 18.09 mm, with a mean fruit length of 15.30 mm. The fruit width ranged from 15.03 to 24.25 mm, with an average fruit width of 19.51 mm; fruit thickness ranged from 14.79 to 23.92 mm, with an average value of 18.85 mm; and the fruit peduncle length was measured with an average of 3.26 mm (ranging from 2.83 to 3.76 mm). The fruit weight varied between 2.018 and 5.787 g, with an average of 3.34 g. The weight of the fleshy part of the fruit ranged from 1.541 to 4.918 g, with an average of 2.73 g.

The fruit-to-seed ratio ranged from 0.13 to 0.27, with an average ratio of 0.19. The geometric mean diameter of the fruit ranged from 14.37 to 21.89 mm, with a mean of 17.78 mm; the sphericity index ranged from 107.61% to 127.20%, with an average sphericity index of 116.26%; the fruit surface area ranged from 648.44 to 1505.00 mm^2, with a mean surface area of 1005.55 mm^2; the fruit appearance ratio ranged from 0.68 to 0.89, with a mean appearance ratio of 0.79. The color of the fruit surface in the L*a*b* coordinates ranged from 70.41*11.79*55.26 to 72.96*8.04*62.49. The fruits are generally yellow, sometimes with a slight pinkish hue on one side. Fruit juiciness was determined to be within the range of >3-6<. The fruit aroma was found to be quite intense (>2-5<). Fruit hardness was measured between 12 and 16 kg/cm^2. Yield values per tree in the research area were determined to be in the range of 12 to 25 kg/tree.

Table 1. Some physical and pomological characteristics of *Crataegus tanacetifolia* ($p \leq 0.05$)

Parameters	Minimum	Maximum	Mean ± Standard deviation
Fruit length (L), mm	12.21	18.09	15.30±1.70
Fruit width (W), mm	15.03	24.25	19.51±2.30
Fruit thickness (T), mm	14.79	23.92	18.85±2.30
Fruit average weight, g	2.018	5.787	3.34±0.99
Fleshy part weight, g	1.541	4.918	2.73±0.901
Fruit arithmetic mean diameter (Da), mm	14.39	22.09	17.89±2.04
Fruit geometric mean diameter (Dg), mm	14.37	21.89	17.78±2.02
Fruit sphericity index (Sp) %	107.61	127.2	116.26±4.79
Fruit surface area (S), mm^2	648.44	1505	1005.55±223.28
Fruit appearance ratio (Ra)	0.68	0.89	0.79±0.05
Fruit/Seed ratio	0.13	0.27	0.19±0.04
Fruit peduncle length, mm	2.83	3.76	3.26±0.24
Fruit juiciness ratio	>3	6<	>3-6<
Taste	>3	7<	>3-7<
Aroma	>4	8<	>4-8<
Fruit flesh hardness	12	16	14.02±1.61
Color (L*a*b)			
L	70.41	72.96	71.54±0.92
a	7.17	11.79	9.34±1.82
b	55.26	62.99	60.62±3.11
Attractiveness	>3	7<	>3-7<
Fruit quality	>4	7<	>4-7<
Yield (kg/tree)	>12	25<	>12-25<
Seed length, mm	6.18	8.17	7.20±0.51
Seed width, mm	3.16	4.77	4.14±0.37
Seed thickness, mm	4.21	6.2	5.42±0.43
Seed weight, g	0.09	0.16	0.12±0.02
Seed volume, mm^3	36.59	69.97	53.73±8.48
Seed surface area, mm^2	60.97	97.12	80.09±9.29

In the examined genotypes, the number of seeds was determined to be 5. Seed length ranged from 6.18 to 8.17 mm, with an average length of 7.20 mm. Seed width ranged from 3.16 to 4.77 mm, with an average width of 4.14 mm; seed thickness ranged from 4.21 to 6.20 mm, with an average thickness of 5.42 mm. Individual seed weight ranged from 0.0863 to 0.7103 g, with an average weight of 0.1459 g. The fruit-to-seed ratio among genotypes varied from 0.13 to 0.27, with an average ratio of 0.19. The thousand-seed weight was determined to be 121.80 g.

3.1. The allometric relationship between fruit length and dimensions

Since fruit length can be easily measured with a caliper, other pomological characteristics of the fruit can be estimated. Equations defining the allometric relationships with fruit length have been found with confidence intervals of $R^2 = 0.8777$ and $R^2 = 0.7493$ (Table 2). These equations represent other allometric relationships to a high degree based on the fruit length. However, the representation rate of the equations obtained for seed dimensions in relation to fruit length is lower ($R^2 = 0.051$ and $R^2 = 0.495$) (Table 2).

3.2. The allometric relationship between fruit surface area and dimensions

Fruit surface area and its allometric relationships are represented within confidence intervals of $R^2 = 0.9603$ and $R^2 = 0.8729$, indicating a close relationship (Table 3). Particularly, a better allometric relationship was found between fruit surface area and fruit thickness.

3.3. The allometric relationships between the fruit/seed ratio and fruit dimensions

The allometric relationships between the fruit-seed ratio and fruit dimensions can be expressed by first-degree equations with confidence intervals of $R^2 = 0.3984$ and $R^2 = 0.5045$, respectively (Table 5). However, it is observed that the allometric relationships between the fruit/seed ratio and fruit dimensions are low.

4. Discussions

In the understanding of public health, the fundamental principle is that humans are an integral part of their physical, biological, and social environments, and all elements of this whole should be considered together. In real terms, public health prioritizes preventing illness and promoting wellness rather than solely managing sickness in individuals (Büyüksoy, 2019). As biological components of the environment, humans are constantly interacting with other elements of the environment. Therefore, it is not possible for humans to remain healthy in an environment where biological diversity is disrupted. *Crataegus tanacetifolia* is one of Türkiye's endemic plants and is an important component of biological diversity, along with its food and ethnobotanical properties (Yücel, 2008). In complementary medicine, it is used against cardiovascular and neurological diseases (Yücel, 2014).

Due to the increasing demand for Hawthorn products in Türkiye, cultivation has begun in agricultural areas. However, harvesting from nature continues to be predominant.

Table 2. Allometric relationships between fruit length and dimensions

Variables (x)	Fruit length (L)	R^2
Fruit length (L), mm	y = 1.1736x + 1.55	$R^2 = 0.7529$
Fruit width (W), mm	y = 1.1749x + 0.874	$R^2 = 0.7493$
Fruit thickness (T), mm	y = 0.5347x - 4.8442	$R^2 = 0.8451$
Fruit average weight, g	y = 0.4877x - 4.7345	$R^2 = 0.8449$
Fleshy part weight, g	y = 1.1161x + 0.808	$R^2 = 0.8613$
Fruit arithmetic mean diameter (Da), mm	y = 1.1145x + 0.7255	$R^2 = 0.8777$
Fruit geometric mean diameter (Dg), mm	y = -0.3491x + 121.6	$R^2 = 0.0153$
Fruit sphericity index (Sp) %	y = 122.84x - 874.23	$R^2 = 0.8729$
Fruit surface area (S), mm2	y = 0.0038x + 0.7279	$R^2 = 0.0180$
Fruit appearance ratio (Ra)	y = -0.017x + 0.4511	$R^2 = 0.4950$
Seed length, mm	y = 0.1545x + 4.8405	$R^2 = 0.2659$
Seed width, mm	y = 0.0494x + 3.3865	$R^2 = 0.0510$
Seed thickness, mm	y = 0.0669x + 4.3976	$R^2 = 0.0708$
Seed weight, g	y = 0.047x - 0.1096	$R^2 = 0.3985$

Table 3. Allometric relationships between fruit surface area and dimensions

Variables (x)	Fruit surface area (S)	R^2
Fruit length (L), mm	y = 122.84x – 874.23	$R^2 = 0.8729$
Fruit width (W), mm	y = 95.608x – 859.68	$R^2 = 0.9673$
Fruit thickness (T), mm	y = 95.432x – 793.67	$R^2 = 0.9706$
Fruit average weight, g	y = 221.54x + 266.11	$R^2 = 0.9603$

The resemblance of certain species within the *Crataegus* spp. genus makes it difficult for the public and herbalists to distinguish them. As a result, all species with partially similar fruits are consumed and marketed under the name "Hawthorn." For example, in Eskişehir territory, *Crataegus orientalis*, *Crataegus tanacetifolia*, and *Crataegus* x *bornmüellerii* are sold and consumed under the name Hawthorn. The majority of scientific studies conducted on Hawthorn have been done under the title "*Crataegus* spp. genotypes" without specifying the species. It is known that the *Crataegus* L. genus is represented by 27 taxa in Türkiye and approximately 200 hawthorn taxa worldwide. Therefore, research results conducted under the title "*Crataegus* spp. genotypes" contain uncertainty at the species level as it is not clear which species or taxa are included.

Studies on this species are quite limited. Studies conducted cover topics such as phytochemical properties, antimicrobial properties or use in complementary medicine. These studies are important in terms of showing the importance of the species in terms of public health and economy. For example; *Crataegus tanacetifolia* leaf extracts have been found to have hypotensive effects on rats (Birman et al., 2001). The aqueous leaf extract of *Crataegus tanacetifolia* (100 mg/kg) administered intragastrically has been observed to prevent N$^{\omega}$nitro-L-arginine methyl ester-induced hypertension in rats, particularly the hyperoside fraction, and to have beneficial effects on the cardiovascular system (Koçyıldız et al., 2006). Studies conducted with the aqueous leaf extract of *Crataegus tanacetifolia* in rats have reported that the extract induces changes in rheological parameters, suggesting potential clinical applications in diseases characterized by rheological abnormalities such as hypertension (Tamer, 2001). Extracts from the fruit, leaves, and flowers of this species have been reported to be effective on the cardiovascular system (Tamer et al., 2000; Yücel and Yücel, 2020).

The methanol leaf extract of *Crataegus tanacetifolia* has been found to exhibit bactericidal activity against *Bacillus subtilis*, *Shigella*, *Staphylococcus aureus*, and *Listeria monocytogenes* (Benli et al., 2008). The fruit extract of *Crataegus tanacetifolia* has been found to exhibit antimicrobial activity against bacteria and yeasts to some extent. Additionally, *Penicillium notatum* is the only fungal species inhibited by *Crataegus tanacetifolia* extract as well as the yeast isolate *Rhodotorola rubra* is inhibited by the plant extract (Güven et al., 2006).

The prominent volatile aroma compounds of *Crataegus tanacetifolia* vinegar have been identified as acetic acid, phenylacetic acid, acetoin, pentanoic acid, benzoic acid, (E)-isoeugenol, 2-cyclohexenone, propanoic acid, chavicol, and diethyl succinate, with gallic acid being the predominant phenolic compound in both wine and vinegar, followed by chlorogenic acid (Özdemir et al., 2022). *Crataegus tanacetifolia* vinegar has been shown to possess significant antioxidant and enzyme inhibitory effects which could be an indicator of antidiabetic activity (Akgün, et al., 2023). *Crataegus tanacetifolia* vinegar has been found to be rich in phenolic and mineral content and exhibits high antioxidant capacity (Tomar, et al., 2020).

In this study, Eskişehir surroundings were determined as the research area for the pomological characteristics of the species. Since the region chosen as the research area is in the triangle of Central Anatolia Region, Marmara Region and Black Sea Region, it can be considered as a transition zone region. Some characters of the species are genotypic and do not change under the influence of ecological factors, while some characters may change. This issue may be the subject of a separate study. However, there is a need for studies to cover the entire natural distribution area of the species.

It has been determined that characteristics such as fruit pomology and seed weight of *Crataegus tanacetifolia* are higher compared to *Crataegus monogyna*. Furthermore, citric acid has been identified as the predominant organic acid in the genotypes of both species, followed by malic and succinic acids. A study conducted in the Bolu region reported certain pomological characteristics related to fruit volume, weight, width, height, seed weight, fruit peduncle length, and thickness of *Crataegus tanacetifolia* fruits (Gürlen et.al., 2020).

In this study, it was found that *Crataegus tanacetifolia* has the following characteristics: fruit length (L) of 15.30±1.70 mm, width (W) of 19.51±2.30 mm, thickness (T) of 18.85±2.30 mm, weight of 3.34±0.99 g, flesh weight of 2.73±0.901 g, arithmetic mean diameter (Da) of 17.89±2.04 mm, geometric mean diameter (Dg) of 17.78±2.02 mm, sphericity index (Sp) of 116.26±4.79%, surface area (S) of 1005.55±223.28 mm^2, appearance ratio (Ra) of 0.79±0.05, seed/fruit ratio of 0.19±0.04, peduncle length of 3.26±0.24 mm, flesh hardness of 14.02±1.61, and fruit color (L*a*b) of 71.54±0.92*9.34±1.82*60.62±3.11. The fruit displays a spectrum of colors, ranging from light yellow to pale pink. In unripe fruits, green is the predominant color observed. Additionally, the seed measurements are as follows: seed length of 7.20±0.51 mm, width of 4.14±0.37 mm, thickness of 5.42±0.43 mm, weight of 0.12±0.02 g, volume of 53.73±8.48 mm^3, and surface area is 80.09±9.29.

When examining the fruit length and allometric relationships, it is observed that fruit length represents allometric relationships to a high degree with R^2 values of 0.8777 and 0.7493 within the confidence interval. However, the representation of allometric relationships between fruit length and seed sizes, as indicated by the obtained equations, is lower with R^2 values of 0.051 and 0.495 (Table 2). This suggests that it may be necessary to develop different calculation methods that cover various dimensions to find better allometric relationships between fruit length and seed size.

There is a high relationship between fruit surface area and fruit allometric relationships with $R^2 = 0.9603$ and $R^2 = 0.8729$ confidence intervals. Particularly, a strong allometric relationship was observed between fruit surface area and fruit thickness (Table 3). However, since fruit width is one of the main components of fruit shape, its verification is required for new populations. Additionally, there is a need for calculation methods that consider multiple dimensions to find a better relationship between fruit surface area and allometric dimensions.

The allometric relationships between seed weight and fruit sizes were found to be within the confidence intervals of $R^2 = 0.3985$ and $R^2 = 0.5781$ (Table 4). There was a strong correlation between seed weight and fruit thickness, while the weakest correlation was found between fruit length and

Table 4. The allometric relationships between seed weight and fruit dimensions

Variables (x)	Seed weight (g)	R^2
Fruit length (L), mm	y = 0.047x – 0.1096	R^2 = 0.3985
Fruit width (W), mm	y = 0.0413x – 0.1962	R^2 = 0.5632
Fruit thickness (T), mm	y = 0.0417x – 0.1766	R^2 = 0.5781
Fruit average weight, g	y = 0.092x + 0.3018	R^2 = 0.5179

Table 5. The allometric relationships between the fruit/seed ratio and fruit dimensions

Variables (x)	Fruit/seed ratio)	R^2
Fruit length (L), mm	y = -0.017x + 0,4511	R^2 = 0.495
Fruit width (W), mm	y = -0.0116x + 0,4168	R^2 = 0.4198
Fruit thickness (T), mm	y = -0.0112x + 0,4028	R^2 = 0.3984
Fruit average weight, g	y = -0.0295x + 0,2895	R^2 = 0.5045
Fleshy part weight, g	y = 0.0909x + 0,3608	R^2 = 0.4207

seed weight. This indicates that genetic and physiological factors affecting seed weight may develop somewhat independently of fruit allometric dimensions.

The allometric relationships between seed ratio and fruit sizes range between R^2 = 0.3984 and R^2 = 0.5045 (Table 5). This clearly indicates the low representation of seed sizes in relation to fruit allometric relationships. Therefore, there is a need to develop new methods involving multiple parameters to calculate seed and fruit allometric relationships in *Crataegus tanacetifolia*. Simple allometric relationships between fruit surface area and pomological characteristics which can be done without damaging the fruit, can enable reliable estimation of fruit surface area and other attributes. The results regarding the pomological characteristics of the genotypes examined in this study are parallel to the findings of other studies (Gürlen et.al., 2020). However, some differences may have arisen from ecological factors.

Conclusion

In conclusion, this study sheds light on the pomological characteristics and allometric relationships of *Crataegus tanacetifolia*, an endemic plant species in Türkiye, from the perspective of public health. The findings highlight the importance of understanding and preserving the natural diversity of plants like *Crataegus tanacetifolia*, which have been utilized for centuries in traditional medicine and are increasingly recognized for their potential health benefits. The examination of pomological characteristics and the establishment of allometric relationships provide insights into the physical attributes and potential yield of *Crataegus tanacetifolia* fruits. These findings can inform cultivation practices, conservation efforts, and the development of functional foods or herbal medicines derived from *Crataegus tanacetifolia*. Despite strong correlations between certain dimensions identified in this study, the need for enhanced methodologies to have a deeper understanding of the connections among various attributes still remains. Further detailed studies are necessary for the conservation of its natural habitats and for its cultivation and widespread adoption.

Conflict of Interest

Authors have declared no conflict of interest.

Authors' Contributions

All authors contributed to all processes. All authors have read and agreed to the published version of manuscript.

Acknowledgements

This study was supported by the Eskişehir Technical University Research Support Project-ADP 102 (Project No: 22ADP383).

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