RESEARCH ARTICLE

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Morphological, biochemical and health promoting properties in seed propagated quince fruits found in Çoruh Valley in Türkiye

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Abstract
Pome fruits including apples and pears widely recognized species and shows rich morphological and biochemical properties. However, the studies on the other pome fruits including quince are scarce in literature. Quince is one of the most diverse specie in the pome fruits and, in particular, its fruits are rich in bioactive compounds. Türkiye, China and Uzbekistan are leading country for world quince production. Due to self-pollination characteristics, it is possible to obtain high quality quince genotypes from seeds. In this study, some important fruit properties of ten seed propagated quince genotypes naturally found in Aras valley, located in the eastern Anatolia region of Türkiye were investigated. The genotypes differed each other for most of the morphological, biochemical and human health promoting properties. Fruit weight were in range of 205-389 g among genotypes. Seven genotypes were found pear-shaped (pyriformis) and the rest of the genotypes were apple-shaped (maliformis). Fruit firmness ranged from 5.12 kg/cm^2 to 8.30 kg/cm^2, respectively. Fruit skin Chroma and Hue values were found between 47.34-65.67 and 71.98-89.17, respectively. SSC (Soluble Solid Content), Vitamin C and total phenolic content of the genotypes ranged from 9.7-13.4%, 4.2-11.2 mg per 100 g FW (fresh weight), 290–432 mg gallic acid equivalent per 100 g FW, respectively. This work constitutes an important step in the conservation of quince genetic resources in the eastern Anatolia.
Keywords: Genetic resources, Characterization, Diversity, Quince

INTRODUCTION

More recently there is an increasing interest to exotic fruits, including quinces that have distinctive taste and aroma. The characteristic flavor of exotic fruits is one of their most attractive attributes to consumers. They are found in general as semi wild in nature and are an important employment and income sources for rural peoples. In addition, these fruits are often inexpensive and rich in vitamins and human health promoting substances and can be used in a wide range of food products. Nowadays, food industries are looking at how to use these exotic fruits to obtain new products (Lee et al., 2020; Garcia-Vallejo et al., 2023).

The origin of the quince (*Cydonia vulgaris* Pers.), which is among the temperate climate fruit species, is North West Iran, North Caucasus, Caspian Sea and North Anatolia. Quince cultivation in the world has been known since ancient times. It is reported that quince passed from Anatolia to Greece and Rome in the years before Christ and was cultivated in Greece in 650 years (Abdollahi, 2019).

According to FAO data, quince is grown in about 50 countries in the world. Türkiye ranks first with 199.311 tons of production and followed by China with a production of 112.000 tons. Uzbekistan placed in the third with a production of 96.200 tons (FAO, 2022).

In Türkiye, due to the increase in quince usage areas and consumption in recent years, significant increases are evident in the quince production area and production amount. When the quince production amounts and production areas of Türkiye for the last five years are examined, it is understood that this increase is more especially in 2017 and 2018. In these years, the production area has increased 1.5 times and the production amount has doubled compared to previous years (TUIK, 2022). Quince is a species whose table consumption as a fruit has been limited. The fruit features play an important role for restricting table consumption. In accordance with this situation, studies on quince are few in literature.

Considering the fruit shape, quinces shows apple-shaped (maliformis) and pear-shaped (pyriformis). In the world, most of the quinces grown are in pear shaped (Ercisli et al., 2015; Abdollahi, 2019). There are some structural differences between pear-shaped quince and apple-shaped quince. In pear-shaped quinces, the fruit flesh is soft and there are fewer stone cells. On the other hand, the most distinctive feature of apple-shaped quinces is that their fruits are dry, their flesh is hard and are more aromatic than those in the form of pear-shaped (Velickovic et al., 2001; Rodríguez-Guisado et al., 2009; Pinar et al., 2016).

Compared to apples and pears, the number of cultivars in quince is very limited throughout world. The main reason for this is that the quince is self-fertile. For example, in Türkiye, the number of quince cultivars around 30, while this number is around 400 for apples and 350 for pears. Another reason is that quince fruits not easily consumed as fresh and in general processed into jams, jellies, marmalades, fruit juices and preserves (Patel et al., 2011; Najman et al., 2023). However, more recently its commercial importance and popularity among consumers has continued to expand to markets in Türkiye (Yildiz et al., 2019; Gunes and Poyrazoglu, 2022; Sonmez and Sahin, 2023).

There are around 30 quince cultivars in Turkey, but there are numerous seed propagated quince genotypes in every region. Especially in the central, northern and eastern Anatolian regions, quince populations consist of promising genotypes that have completely grown from seeds. Traditionally, farmers have retained genotypes at field or orchards that emerge from seed which have good fruit characteristics. The seed propagated quince genotypes from the Aras valley shows great variability from an agro-morphological point of view. Many of them, despite being practically unknown in the scientific literature, presented very interesting productive characters.

Opposite to cultivars, seed propagated quinces more resistant to adverse soil and climatic conditions. Most seed propagated quinces may have high content of phytochemicals that vital for human health compared with cultivated one (Pinar et al., 2016). They have rich gene combinations that could be important for breeding new commercial quince cultivars with improved aroma and resistance to biotic and abiotic stressors.

More recently there were an increasing interest in nutraceuticals and functional foods which had better organoleptic properties and high human health promoting content. Exotic and less known fruits including quince are rich sources of nutraceuticals and studies concentrated on their quality and bioactivity (Muzykiewicz et al., 2018; Sonmez and Sahin, 2023). Exotic fruits exhibit rich morphological and biochemical diversity and all those traits can be influenced by environmental conditions and genotypes (Najman et al., 2023). Thus, genotype selection is important task for appropriate cultivar development and this is more important for species which had less number of cultivars. Therefore, it is crucial to make detailed comparative studies on quince genotypes related to important plant traits and phytochemical content.

In the literature, there was limited information about the comparison of morphological, biochemical and human health promoting substances in quinces, in particular seed propagated ones. Thus, in this study, we aimed to determine and compare some important morphological, biochemical and human health promoting features of ten seed propagated quince genotypes, naturally growing in Aras valley in Türkiye.

MATERIALS AND METHODS

Plant material

The fruits of 10 genotypes and cv. Ekmek were sampled at full commercially maturation stage in Aras valley (Kagizman district) located northeastern Anatolia region of Turkey during October in 2021 and 2022. A total of 40 health fruits per genotype and cultivar were randomly harvested from different parts of trees and quickly transferred to the laboratory in cold chain for morphological measurements, biochemical and human health content analysis.

Morphological measurements

The harvest time was determined when the pubescence of fruit skin can be easily removed by hand in genotypes had pubescence on fruit skin. However, for the other genotypes, which had no pubescence, it was determined when green skin color turns to yellow. Fruit weight (g) was measured with a digital scale sensitive to 0.01 g (Scaltec SPB31). Fruit firmness was determined with non-destructive Acoustic Firmness Sensor (Aweta B.V., The Netherlands) expressed as kg/cm^2. Fruit shape index (SI) was calculated with the following equation (Ercisli et al., 2009)

$$SI = \frac{W+T}{2L}$$ where W: Width, T: Thickness and L: Length

Fruit dimensions (length, width) were determined by digital caliper. The pubescence of fruit skin was determined by observation and expressed as low, medium and high. Shape index were determined by using fruit width and length.

The color of the fresh harvested quince fruits was assessed on both sides of the fruits by using a handheld tri-stimulus colorimeter (Minolta Chroma Meter CR-400) and a CIE standard illuminant C to determine the CIE color space co-ordinates, *L**, *a**, *b**, C, and hue° (*h*°) values. C was the color intensity of the skin, and the *h*° distinguishes one color from another and is described using common color names such as green, blue, red, yellow, etc. Hue value refers also to the lightness or darkness of a color. It defines a color in terms of how close it is to white or black. The colorimeter was calibrated against a standard and the results are expressed as the mean of three replications (Mc Lellan et al., 1995).

Biochemical Composition

Sample Preparation and Extraction

To conduct biochemical analyses, the harvested quince fruits from genotypes and cv. Ekmek was immediately frozen and stored at −80 °C. For doing analysis, the frozen quince fruits were taken and thawed to 24–25 °C. A blender was used to homogenise the fruit samples (100 g lots of fruits per genotype) and a single extraction procedure (3 g aliquots put inside tubes and extracted for 1 h with 20 mL buffer including acetone, water (deionized), and acetic acid (70:29.5:0.5 *v/v*) was used for total phenolic content analysis.

Soluble Solid Content (SSC)

SSC of fruits were determined by a hand refractometer (Kyoto 250 RH, Japan). A single drop of juice from each sample was mounted on the prism of dry refractometer and data was recorded in percent.

Titratable Acidity (TA)

Titratable acidity of quince samples obtained from 10 genotypes and cv. Ekmek was done by titration method. For analysis, 5 g fruit pulp was homogenized and followed by mixing with 20 ml of distilled water and then filtered to obtain pure extract. The pure extract (5 ml) was titrated with sodium hydroxide solution and phenolphthalein. This titration continues until end point reaches light pink color. Results expressed as %.

Vitamin C

Assessment of vitamin C in each sample was determined by using RQflex (Merck, Germany). Vitamin C was expressed as mg of vitamin C per 100 g fresh weight.

Total Phenolic Contents

Folin–Ciocalteu method according to Singleton and Rossi (1965) was used for determination of total phenolic content (TPC) of the samples. The TPC results was expressed as mg of gallic acid equivalents (GAE) per 100 g of fresh sample.

Statistical Analysis

The data of both years were pooled because there were no differences between years. SPSS software and procedures used for analysis and Least Significant Difference (LSD) method at $p < 0.05$ was used to analyze of variance tables.

RESULTS AND DISCUSSION

Morphological traits

Table 1 presents average fruit weight, shape index, color indices (chroma and hue), fruit firmness, pubescence, stone cell situation and shape of 10 seed propagated quince genotypes and cv. Ekmek. There were statistically significant differences among genotypes and cv. Ekmek in terms of fruit weight, shape index, color indices (chroma and hue) and fruit firmness at $p<0.01$ level (Table 1).

We found a wide variation in fruit weight. The genotype AV7 gave the highest fruit weight as 396 g and followed by AV9 as 386 g, AV4 as 378 g, respectively. The lowest fruit weight was obtained from AV1 as 233 g. The cultivar Ekmek gave fruit weight as 298 g. Six genotypes gave the higher fruit weight than cv. Ekmek and rest of the 4 genotypes gave fruit weight close to cv. Ekmek or lower values than cv. Ekmek (Table 1). Quince is an interesting self-pollinated fruit species that shows great variation among cultivars in terms of fruit weight. Ercisli et al. (2009) reported fruit weight between 255-530 g among local quince cultivars. It could be interesting to use AV7, AV9 and AV4 with higher fruit weight in future quince breeding programs. Tok (2020) reported fruit weight between 96-362 g among 60 local quince genotypes sampled in western Anatolia. Bak et al. (2015) investigated fruit weight on a number of quince genotypes and found between 188 and 345 g. Yilmaz (2007) also reported a great variation among local quince genotypes (between 240-597 g) in Türkiye. Gungor (1989) also found a wide variation among local quince genotypes in Türkiye between 164-595 g. Ercisli et al. (2015) found fruit weight 175-329 g among 4 quince cultivars in Türkiye.

With respect to shape index, most of the genotypes had shape index over 1.0 indicating the majority of genotypes had pyriformis fruit shape. The AV6 genotype with 1.20 shape index value showed more elongated fruits than the others. Previously Ercisli et al. (2009) reported shape index between 0.88-1.21 and indicating most of the quince genotypes had pyriformis fruit shape which shows similarities with our results. They also reported shape index as 0.88 for cv. Ekmek which shows great similarities with our result on cv. Ekmek. Bak et al. (2015), Ercisli et al. (2015) and Tok (2020) also reported shape index over 1.0 in fruits of among a large number of quince genotypes indicating similarities with our present results.

Quince genotypes showed great variations on fruit skin color indices (Chroma and Hue values). The Chroma value of genotypes and cv. Ekmek were between 47.34-65.67 and hue value ranged from 71.98 to 89.17 (Table 1). Tok (2020) reported Chroma and Hue value between 46-61 and 73-89 among a large number of quince genotypes sampled from Bolu region in Turkey. Ercisli et al. (2015) also reported chroma and hue values between 56.83-65.22 and 92.70-96.47 among 4 quince cultivars. Our results on Chroma and Hue are good agreement with Ercisli et al. (2015) and Tok (2020). The results are also indicating that color saturation of some genotypes are better than cv. Ekmek indicating their fruits attractiveness.

Fruit firmness ranged from 5.12 kg/cm^2 to 8.30 kg/cm^2, the genotypes with the softest and the hardest being cv. Ekmek and AV7 genotype, respectively. It is also important to point out the relevant differences recorded for this parameter between the ten genotypes and cv. Ekmek. Tok (2020) reported fruit firmness between 4.80-6.46 kg/cm^2 among a large number of quince genotypes sampled from Bolu region in Turkey. Bolat and Ikinci (2015) found fruit firmness as 7.73 kg/cm^2 in Esme quince cultivar in Turkey. Quince cultivars and genotypes show great variation in terms of fruit weight as well as fruit firmness (Ercisli et al., 2009; Tok, 2020)

With respect to pubescence on fruit skin, 5 genotypes had high, 3 genotypes had low and 2 genotypes had medium pubescence. The cv. Ekmek had medium pubescence on its fruit skin (Table 1). The 4 genotypes had low, 3 genotypes had medium and rest of 3 genotypes had high stone cell in its fruits. Thus AV1, AV4, AV5 and AV9 genotypes also recorded low values of stone cell. This tendency to produce only a stone cell free well-formed fruit is a highly desirable cultivar trait in quince and even in pears. Previous studies described variability in pubescence and stone cell formation of Quince cultivars and ecotypes (Ercisli et al., 2009; Guney et al., 2019). These promising ecotypes can be considered for future research on the quince cultivar development.

The obtained diversity on most of the searched morphological parameters on quince genotypes may have important because quince is self-pollinated species and thus obtained greater gene diversity could increase crop genetic diversity.

Biochemical Traits

ANOVA test shows significant differences between the quince samples including ten genotypes and cv. Ekmek (p<0.01) in vitamin C, SSC, titratable acidity, and total phenolic content (Table 2)

AV4, AV9 genotypes and cv. Ekmek had the lowest vitamin C content (4.2, 5.0 and 5.8 mg/100 g, respectively). In contrast, vitamin C in fruits of AV1, AV2 and AV6 genotypes were much more abundant (11.2, 10.9 and 10.4 mg/100 g, respectively). The other genotypes AV3, AV7, AV8, AV10 and AV5 had vitamin C content as 9.4, 8.9, 8.2, 7.2 and 6.2 mg/100 g, respectively. Previous studies reported that the concentration of vitamin C in quince cultivars are relatively low change between 3-24 mg/100 g (Ercisli et al., 2009; Wojdylo et al., 2013; Rasheed et al., 2018). The studies also indicated that vitamin C in quince fruits can vary according to cultivars and genotypes, the fruits ripening degree and growing conditions (Rasheed et al. 2018).

The genotypes affected significantly the amounts of SSC. The highest SSC content was obtained from AV10 genotype (13.4%), and followed by AV7 (13.1%) and AV1(11.2%), respectively (Table 2). The AV9 genotype had the lowest SSC content (9.7%). Tok (2020) found SSC content on a large number of Quince genotypes between 9.46-13.68% indicating similarities with our present results on SSC. Ercisli et al. (2009) reported SSC content between 11.80-16.00% in a number of local quince cultivars in Northeastern Anatolia. Bak et al. (2015) found SSC in quince genotypes between 8.18-11.80% also indicating similarities with present findings. SSC along with acidity is important quality and harvest criteria for most of the fruit species and in particular used for harvest time determination.

Titratable acidity of quince samples were between 0.90-1.25% (Table 2). Previous studies are also indicated that quince genotypes shows differences on titratable acidity. Ercisli et al. (2009) found titratable acidity between 0.54-1.51% on quince samples. Tok (2020) reported titratable acidity between 0.90-1.19% on a large number of quince genotypes. Bolat ve Ikinci (2014) found titratable acidity as 0.63 on Esme quince cultivar. Calhan and Koyuncu (2018) found SSC and titratable acidity as 13.40% and 0.88% in quince fruit. Our SSC and titratable acidity results were in agreement with previous reports and titratable acidity is also affected by environmental conditions, genetic background of used plant materials, harvest time etc. (Ercisli, 2009; Bolat and Ikinci, 2014).

Total phenolic content varied from 290 mg GAE to 432 mg GAE per 100 g in ten samples. Quince fruits is accepted one of the richest source of phenolic content (Rop et al., 2011). Phenolic content of quince fruits was the highest on skin (peel) and followed by flesh (Karakaya and Balta, 2021). Previously total phenolic content was reported as 282 mg Esme quince cultivar grown in central Anatolia (Karadeniz et al., 2005). In Spain it was determined as 40-100 mg GAE in flesh and 200-430 in peel on 9 quince cultivars. (Legua ve ark., 2013). Several factors including genetic background, harvest period, cultural treatments may have affact phenolic content (Legua et rk., 2013; Wojdylo ve ark., 2013; Blanda ve ark., 2020).

Table 1. Morphological traits of 10 quince genotypes

Genotypes	Fruit weight (g)	Shape index	Chroma	Hue	Fruit firmness (kg/cm²)	Pubescence	Stone cell	Shape
AV1	233 ± 11.3	1.12± 0.08	47.34± 2.1	73.44± 3.1	6.45± 0.81	Low	Low	Pyriformis
AV2	304 ± 14.2	1.07± 0.11	55.03± 2.7	85.23± 4.0	6.90± 0.77	High	Medium	Pyriformis
AV3	286 ± 10.0	0.91± 0.07	49.67± 2.0	75.56± 3.6	8.11± 0.60	Medium	High	Maliformis
AV4	378 ± 12.2	1.10± 0.14	60.08± 3.2	71.98± 3.2	6.10± 0.73	Medium	Low	Pyriformis
AV5	290 ± 13.1	1.16± 0.11	54.37± 2.7	83.08± 4.1	5.85± 0.66	Low	Low	Pyriformis
AV6	341 ± 14.4	1.20± 0.13	65.67± 4.0	77.20± 4.3	7.11± 0.59	High	Medium	Pyriformis
AV7	396 ± 15.7	0.96± 0.05	63.11± 4.2	80.65± 3.8	8.30± 0.84	High	High	Maliformis
AV8	255 ± 12.0	0.88± 0.10	61.44± 3.9	87.48± 3.6	7.74± 0.45	High	High	Maliformis
AV9	386 ± 20.1	1.15± 0.07	58.98± 3.5	89.17± 3.4	5.78± 0.38	Low	Low	Pyriformis
AV10	314 ± 141	1.06± 0.08	52.20± 2.6	75.30± 4.2	7.30± 0.65	High	Medium	Pyriformis
Ekmek	298 ± 13.1	0.90± 0.05	62.11± 2.9	82.80± 4.4	5.12± 0.47	Medium	Low	Maliformis
Significance	**	**	**	**	**			
LSD5%	12.5	0.10	4.2	6.8	1.43			

***:p<0.01*

Table 2. Biochemical traits of 10 quince genotypes

Genotypes	Vitamin C (mg/100 g)	SSC (%)	Titratable acidity (%)	Total phenolic content (mg GAE/100 g)
AV1	11.2 ± 0.4	12.7± 0.4	1.02± 0.05	345±17
AV2	10.9± 0.4	11.0± 0.3	0.95± 0.06	325±11
AV3	9.4± 0.3	12.7± 0.4	1.16± 0.09	407±19
AV4	4.2± 0.2	10.5± 0.4	1.25± 0.08	290±12
AV5	6.2± 0.2	12.0± 0.3	1.10± 0.05	390±15
AV6	10.4± 0.5	11.5± 0.3	0.90± 0.10	382±18
AV7	8.9± 0.3	13.1± 0.4	1.14± 0.07	298±9
AV8	8.2± 0.4	10.6± 0.4	1.10± 0.06	432±20
AV9	5.0± 0.2	9.7± 0.2	0.98± 0.10	307±15
AV10	7.2± 0.3	13.4± 0.4	1.06± 0.10	333±16
Ekmek	5.8± 0.2	10.7± 0.2	0.90± 0.05	358±18

CONCLUSION

As a conclusion of the study, there were enough variability among local quince genotypes in Aras valley and some genotypes was found promising for future breeding activities to use them in cross breeding studies.

COMPLIANCE WITH ETHICAL STANDARDS

Peer-review

Externally peer-reviewed.

Conflict of interest

Author declare that they have no conflicts of interest

Ethics committee approval

Ethics committee approval is not required. This article does not contain any studies with human participants or animals performed by any of the authors.

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Data availability

Not applicable.

Consent for publication

Not applicable.

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