



Research Article



Phytochemical Markers of *Cydonia oblonga* Mill. Cultivars of Ukrainian Breeding


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Quince (*Cydonia oblonga* Mill.), one of the earliest domesticated fruit crops, combines high adaptability with stable productivity, making it a promising source of bioactive compounds. This study aimed to compare three Ukrainian quince cultivars (Maria, Darunok Onuku, and Kharkivska) with respect to their total flavonoid content and antioxidant activity in fruit extracts. The plants were grown in 2024 at the M.M. Gryshko National Botanical Garden of the National Academy of Sciences of Ukraine (Kyiv). Total flavonoid content was determined spectrophotometrically using the reaction with $AlCl_3$. The antioxidant activity of the extracts was determined by the 2,2-diphenyl-1-picrylhydrazyl free radical assay. Significant differences in total flavonoid content were observed among the studied cultivars, ranging from 1.19 ± 0.08 to 2.48 ± 0.07 mg RE·g⁻¹ fresh weight, with the highest values recorded in cv. Maria. Antioxidant activity, assessed using EC_{50} values, also varied among cultivars and followed a similar pattern. The lowest EC_{50} value (18.49 ± 1.6 mg) was observed for cv. Maria, indicating the highest antioxidant capacity, whereas higher values were obtained for cv. Kharkivska (20.59 ± 1.8 mg) and cv. Darunok Onuku (23.68 ± 1.8 mg). A clear relationship between flavonoid content and antioxidant activity was observed. Since all cultivars were grown under identical conditions, the detected differences can be attributed primarily to genotypic variation. The results highlight the potential of the studied cultivars, particularly cv. Maria is a promising source of natural antioxidants for use in food and nutraceutical applications.

Keywords: *Cydonia oblonga*, cultivars, pomological characteristics, flavonoids, antioxidant activity

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Introduction

Natural antioxidants derived from plant sources play a crucial role in protecting biological systems against oxidative stress and are increasingly valued for their potential applications in human health and food preservation (Middleton et al., 2000; Pham-Huy et al., 2008; Colunga Biancatelli et al., 2020; Hrelia et al., 2020; Akbari et al., 2022). Among these compounds, flavonoids represent a major class of plant secondary metabolites with well-documented antioxidant activity (Panche et al., 2016). The identification of plant genotypes with enhanced flavonoid profiles and antioxidant capacity is therefore of particular importance for breeding programs, nutritional evaluation, and the development of functional food products.

Quince (*Cydonia oblonga* Mill.) is one of the earliest domesticated fruit species, with cultivation dating back several millennia. The species is believed to have originated in the Caucasus and the Middle East, including Mesopotamia, where quince was cultivated between 5000 and 4000 years ago (Khoshbakht and Hammer, 2006; Abdollahi, 2019; Ľorbová et al., 2024). Approximately 2500 years ago, quince was introduced from Persia into China and subsequently established in Xinjiang Province (Xie et al., 2023).

Today, quince is cultivated across a broad range of regions worldwide, including Western and Eastern Europe, Middle and Central Asia, as well as North, Central, and South America, Africa, Australia, and New Zealand (Kafkas et al., 2018; Hussain et al., 2021; Xie et al., 2023). Turkey is currently the leading producer of quince globally (Kafkas et al., 2018; Abdollahi, 2019). In more northern regions (e.g., Ukraine, Baltic states), quince is less common but still cultivated – often in gardens, botanical collections, and experimental plots rather than large commercial orchards. Phenological studies in Ukraine indicate that quince completes its growth cycle successfully under local climatic conditions. Quince thrives in temperate and warm-temperate climates, requiring a distinct cool season for proper flowering and fruit set. Breeding efforts in Eastern Europe, the Baltic states, and other regions focus on selecting winter-hardy genotypes and utilizing quince as ornamental or rootstock material (Kafkas et al., 2018).

The fruits of *C. oblonga* contain polyphenols (phenolic, flavonols, and small amounts of anthocyanins depending on cultivar), tannins/proanthocyanidins, organic acids, sugars, dietary fiber/pectin (polysaccharides) (Silva et al., 2005; Rop et al., 2011; Oliveira et al., 2012; Wojdyło et al., 2013; Ashraf et al., 2016; Blanda et al., 2020; Kostecka-Gugała et al., 2024).

Multiple studies and reviews report high total phenolic content (TPC) in quince fruit and by-products; values vary with cultivar, part (peel > pulp > seed in some assays), maturity, and extraction method. Reported individual phenolics frequently include chlorogenic (3-O-caffeoylquinic) acid, other caffeoylquinic isomers, catechin, and coumaric derivatives (Herrera-Rocha et al., 2022). Quince extracts have demonstrated antioxidant (Costa et al., 2009; Wojdyło et al., 2013; Umar et al., 2015; Kostecka-Gugała et al., 2024), anti-inflammatory (Herrera-Rocha et al., 2022), antidiabetic (Abed et al., 2022; Chi et al., 2022), and anticancer (Khan et al., 2021) activities. Several reports document the antibacterial or antifungal effects of quince extracts or essential/volatile fractions against certain microorganisms, although activity depends on extract type and concentration. Due to the specific content of different compounds, quince is used for jams, jellies, purees, vinegars, and as a pectin source. Processing often increases palatability and may concentrate certain bioactive compounds. Quince by-products, such as peel and seeds, are promising sources of antioxidants or pectin for their practical use (Romero et al., 2024).

The present study aimed to compare three Ukrainian quince cultivars – Maria, Darunok Onuku, and Kharkivska – with respect to their total flavonoid content and antioxidant activity in fruit extracts. The results contribute to assessing their potential value as raw materials rich in bioactive compounds for further use in the food industry and related fields, including the development of functional products.

Material and Methodology

Plant material

Fruits of three quince cultivars (Maria, Darunok Onuku, and Kharkivska) were collected at full physiological maturity in 2024 from the collection of the Department of Fruit Plants Acclimatization, M.M. Gryshko National Botanical Garden of the National Academy of Sciences of Ukraine (Kyiv, Ukraine). The experimental plots are located in the Zvirynets district of Kyiv (50° 27' N, 30° 31' E) at an altitude of approximately 197 m above sea level. The region has a temperate continental climate characterized by moderately warm summers and relatively mild winters.

Preparation of fruit extracts

Fresh fruits were homogenized, and 10 g of sample material was extracted with 50 mL of 70% ethanol. Extraction was performed for 24 h at 28 °C under

constant shaking (180 rpm) using a Clim-J-Shake System (Kühner IRC-1-U). The extracts were then centrifuged at 10,000 rpm for 10 min (Eppendorf Centrifuge 5415C), and the supernatants were collected for further analysis.

Determination of total flavonoid content

Total flavonoid content was determined spectrophotometrically according to the method of Pękal and Pyrzyńska (2014) with slight modifications. Briefly, 0.25 mL of extract was mixed with 1.0 mL of deionized water and 0.075 mL of 5% NaNO₂ solution. After 5 min, 0.075 mL of 10% AlCl₃ solution was added. After an additional 5 min incubation, 0.5 mL of 1 M NaOH and 0.6 mL of deionized water were added. Absorbance was measured at 510 nm using a spectrophotometer. Total flavonoid content was expressed as milligrams of rutin equivalents per gram of dry weight (mg RE·g⁻¹ DW).

DPPH radical scavenging assay

The antioxidant activity of the extracts was determined using 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical assay, according to Brand-Williams et al. (1995). Radical scavenging activity (RSA) was initially expressed as inhibition percentage, calculated using the formula:

$$\%RSA = 100 \left(\frac{OD_{\text{control}} - OD_{\text{sample}}}{OD_{\text{control}}} \right)$$

RSA values were used to construct dose–response curves. The primary measure of activity was the half-maximal effective concentration (EC₅₀), defined as the amount of wet fruit weight required to scavenge 50% of DPPH radicals, expressed in mg WW. EC₅₀ values were determined using linear regression on the linear portion of the RSA curve.

Statistical analysis

All measurements were performed in triplicate, and results are presented as mean ± standard error (SE). Linear regression analysis was used to generate calibration curves for rutin and to estimate EC₅₀ values. Statistical analysis and data visualization were performed using RStudio (version 2026.01.1) with R version 4.4.2.

Results and Discussion

Some pomological characteristics

The *Cydonia oblonga* germplasm preserved at the National Botanical Garden (NBG) encompasses

a broad diversity of cultivars originating from multiple regions. The collection consists predominantly of genotypes bred within NBG programs, alongside cultivars developed at the Nikita Botanical Garden and accessions introduced from Middle Asian and other geographical sources (Klymenko and Ilyinska, 2019; Ilyinska and Klymenko, 2024).

Evidence accumulated over many years of observation indicates that *C. oblonga* exhibits substantial ecological flexibility combined with strong adaptive and reproductive performance (Klymenko, 1993, 2009, 2011; Ilyinska and Klymenko, 2024). This biological resilience enables the species to tolerate fluctuating environmental conditions and underpins its potential for widening the geographical range of quince cultivation in Ukraine. In the context of ongoing climate change, particularly the rising incidence of extreme heat events, these attributes become increasingly valuable. As a result, *C. oblonga* can be considered a promising crop for the development of commercial orchards in regions experiencing climatic stress.

The cultivar Maria (Figure 1), derived from Crimean quince seedlings, is characterized by high productivity, early fruiting, and good winter hardiness (Klymenko and Ilyinska, 2019). Among the studied genotypes, it produced the largest fruits. Under standard conditions, fruit weight is reported to range from 360 to 380 g, while in the present study, it exceeded these values by approximately 1.5-fold. Mean fruit diameter reached about 10.3 cm, with fruit length around 9.5 cm. This cultivar also showed the highest variability in fruit mass (CV ≈ 30%), indicating considerable heterogeneity in fruit development.

The cultivar Darunok Onuku, obtained through synthetic breeding, is characterized by an oval-cylindrical fruit shape with a smooth surface lacking pronounced ribs. It demonstrates stable productivity, early bearing, and satisfactory winter hardiness. The mean fruit mass ranges from 250 to 295 g, exceeding previously reported values by 10–20%. Fruit length reaches approximately 99 mm, while diameter varies from 83 to over 100 mm, indicating moderate variability (CV ≈ 22%) (Klymenko and Ilyinska, 2019).

The cultivar Kharkivska is a locally bred selection characterized by stable fruiting, high productivity, and good adaptation to continental climatic conditions. It is mainly used for processing purposes. Fruit weight ranges from 330 to 360 g, exceeding reference values by approximately 1.2–1.4 times. Mean fruit length is 9.0–9.3 cm, while diameter ranges from 9.8 to 10.1 cm, corresponding to a broadly rounded fruit shape with



Figure 1 Cultivars of *Cydonia oblonga* Mill. bred at the M.M. Gryshko National Botanical Garden, National Academy of Sciences of Ukraine

slight ribbing. Variability in fruit mass is moderate (CV \approx 22–25%), indicating relatively uniform fruit development.

Previous studies have demonstrated considerable variation in fruit weight among quince cultivars. Ercisli et al. (2015) described pomological characteristics of 36 quince cultivars and genotypes. In particular, fruits differed in shape, and fruit weight varied from 257.4 g to 514.1 g. A study of 10 quince cultivars grown in Brazil also reported variability in fruit weight (68.6–175.1 g) (Leonel et al., 2016). Fruit size is an important factor affecting fruit quality and is an important economic trait. Larger fruits with greater weight are often associated with enhanced marketability, making cultivars with such traits particularly attractive for commercial production.

Plants of the three cultivars, according to long-term observations, have demonstrated sufficient winter hardiness while exhibiting clear genotypic differences in morphological traits. These differences may also be reflected in secondary metabolism. Therefore, flavonoid synthesis was investigated, as flavonoids are key secondary metabolites involved in plant stress responses and adaptation to adverse environmental conditions (Heim et al., 2002; Kumar and Pandey, 2013; Panche et al., 2016). In addition to their ecological functions, flavonoids possess strong antioxidant properties (Pietta, 2000), which support the potential use of quince fruits in the food industry and as

nutraceuticals for disease prevention (Middleton et al., 2000; Panche et al., 2016).

Total flavonoid content and antioxidant capacity

The total flavonoid content varied significantly among the three *C. oblonga* cultivars (Darunok Onuku, Maria, and Kharkivska), ranging from 1.19 ± 0.08 to 2.48 ± 0.07 mg RE·g⁻¹ WW (Figure 2). The highest flavonoid content was observed in the cultivar Maria. Consistently, this cultivar also demonstrated the strongest antioxidant activity, corresponding to its elevated flavonoid levels.

C. oblonga is recognized as a fruit species with a rich profile of phenolic compounds, including flavonoids, which significantly contribute to antioxidant activity and potential health benefits (Al-Zughbi and Krayem, 2022). Numerous studies have shown that *C. oblonga* is rich in phenolic acids and flavonoids with strong antioxidant properties (Silva et al., 2005; Fattouch et al., 2007; Oliveira et al., 2007). Considerable variation in flavonoid and polyphenol content has been reported across cultivars and genotypes. For example, a comparative analysis of 13 quince varieties and five genotypes revealed total polyphenol levels ranging from 17.09 mg·g⁻¹ DW (genotype 'S1') to 34.36 mg·g⁻¹ DW (cultivar Leskovac), with flavan-3-ols representing 78–94% of total polyphenols (Wojdyło et al., 2013). Similarly, studies on Turkish cultivars confirmed significant differences in total phenolic

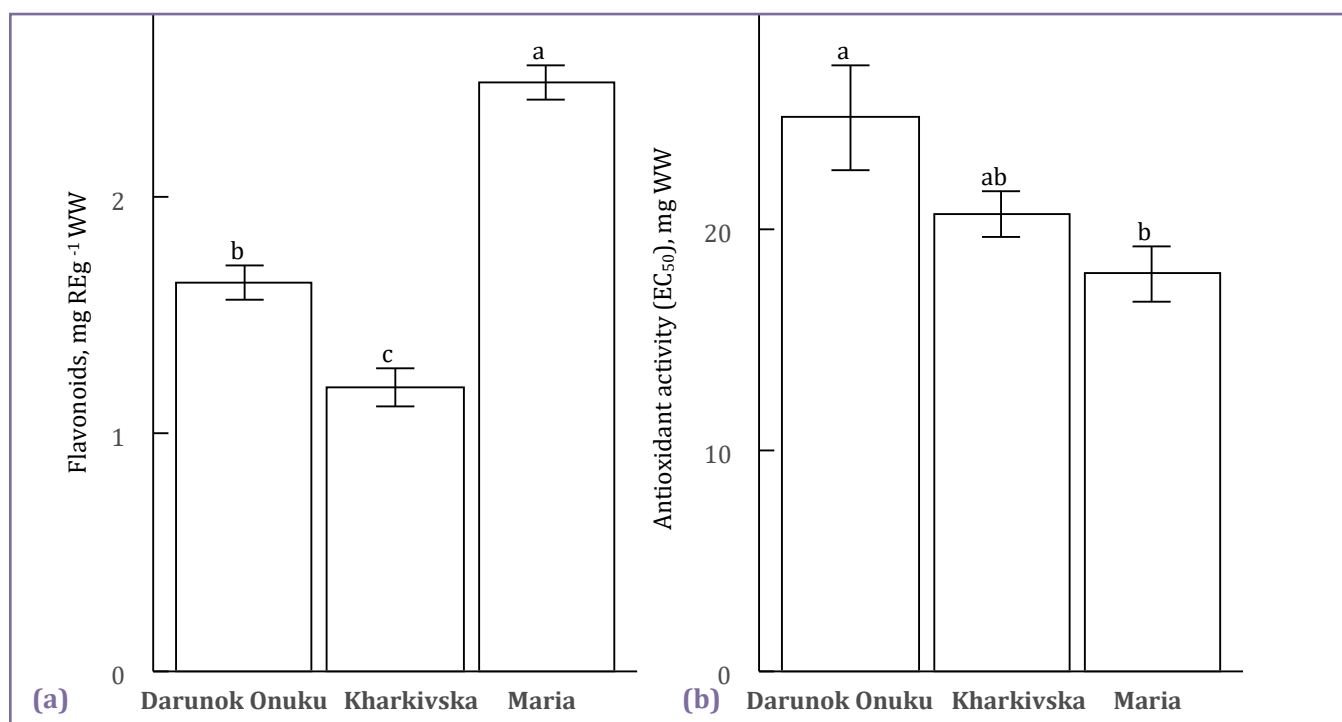


Figure 2 Total flavonoid content (a) in fruits of *Cydonia oblonga* cultivars of Ukrainian breeding (Darunok Onuku, Maria, and Kharkivska) and antioxidant activity (b) of ethanol fruit extracts from the same cultivars

content and antioxidant capacity among genotypes, with a strong correlation between phenolic content and antioxidant activity (İmrak et al., 2025).

Additional compositional analyses have identified specific flavonoids in quince fruits. *In situ* measurements in fresh fruit revealed total polyphenolic content of approximately 246.98 ± 6.76 mg GAE·100 g⁻¹, along with individual compounds such as catechin (3.33 ± 0.09 mg·100 g⁻¹), epigallocatechin (8.04 ± 0.05 mg·100 g⁻¹), quercetin-3-O-rutinoside (4.60 ± 0.26 mg·100 g⁻¹), and quercetin (0.95 ± 0.01 mg·100 g⁻¹), all of which are recognized as potent natural antioxidants (Najman et al., 2023).

The antioxidant activity of fruit extracts from the three studied *C. oblonga* cultivars showed clear variability. Fruits of cv. Maria exhibited the highest antioxidant activity, consistent with their elevated flavonoid content. Specifically, the effective concentration (EC₅₀) for cv. Maria was 18.49 ± 1.6 mg, whereas the corresponding values for cv. Kharkivska and cv. Darunok Onuku were 20.59 ± 1.8 mg and 23.68 ± 1.8 mg, respectively. Lower EC₅₀ values indicate higher antioxidant activity. Previous comparative studies on eight quince cultivars grown in Türkiye reported significant differences in antioxidant capacity among genotypes (İmrak et al., 2025). Using the DPPH assay, inhibition values ranged from 87.13% in cv. Altınayva to 97.60% in cv. Ekmek and cv. Bardacık. These cultivars also exhibited the highest antioxidant activity in juice samples (97.14 and 96.80%, respectively). A strong positive correlation between total phenolic content and antioxidant activity was observed, confirming the role of phenolic compounds in antioxidative potential (İmrak et al., 2025).

A broader evaluation of 36 quince cultivars and genotypes from the Yalova Atatürk Horticultural Central Research Institute also found significant differences in antioxidant activity measured by DPPH, FRAP, ABTS, and CUPRAC assays among cultivars, reflecting genotype-dependent variability (Göksel, 2024). The values of antioxidant activity (by DPPH scavenging activity) in four quince fruit samples in another study were in the range from 26.90 ± 0.61 to $49.14 \pm 0.38\%$ (Bystrická et al., 2017).

As highlighted above, genotype (cultivar) significantly influences flavonoid content and antioxidant activity in quince fruits. In our study, three *C. oblonga* cultivars grown in Ukraine also differed in this parameter. Variation in polyphenol and flavonoid levels, together with corresponding antioxidant activity, reflects complex interactions among genetic, environmental, and agronomic factors. Environmental conditions,

including light intensity, temperature, and water availability, modulate phenolic accumulation by influencing enzyme activity in flavonoid biosynthesis and by inducing stress-responsive secondary metabolite production (Baroni et al., 2022; İmrak et al., 2025). Since all plants in our study were cultivated under identical conditions and harvested at the same phenological stage, the observed differences can be attributed primarily to genotypic variation. Allelic diversity in key enzymes of the phenylpropanoid pathway influences both qualitative and quantitative profiles of flavonoids and other polyphenols (Wojdyło et al., 2013). Thus, the observed variations in flavonoid content and antioxidant activity in cultivars Maria, Darunok Onuku, and Kharkivska may result from genetic specificity and correspondingly different activity of specific genes involved in polyphenol biosynthesis.

Conclusions

The present study demonstrates pronounced cultivar-dependent differences in total flavonoid content and antioxidant activity among fruits of *Cydonia oblonga* cultivars bred in Ukraine. The cv. Maria was distinguished by both superior fruit size and the highest flavonoid concentration, which corresponded with enhanced antioxidant activity. These results emphasize the value of targeted cultivar selection for improving the nutritional and functional quality of quince fruits. Owing to its high biochemical potential and favorable agronomic traits, the cv. Maria represents a promising genetic resource for breeding programs, functional food development, and the production of natural antioxidant-rich products, particularly under conditions of ongoing climatic change.

Conflict of interest

The authors declare no conflict of interest.

Ethical statement

This article does not contain any studies that would require an ethical statement.

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