CHAENOMELES JAPONICA (THUNB.) LINDL. - FRUIT CROP IN THE CONTEXT OF CLIMATE CHANGE: CULTURAL AND ECOSYSTEM SERVICES

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Abstract: *Chaenomeles japonica* (Thunb.) Lindl. has gained attention over the past decade as a new fruit crop.The research was based on the hypothesis that there are genotypes adapted to climate change, producing high-quality fruits that provide both cultural and ecosystem services, while also being significant for commercial production. Therefore, in this study, the biochemical composition and antioxidant capacity of fresh fruit juicy parts were analysed at the genotype level using an official protocol with two analytical-grade reagents: ethanol and distilled water. The results highlight ethanol as a more efficient solvent for extracting bioactive compounds, enhancing their potential for neutralizing free radicals. Additionally, the findings confirm significant concentrations of phenolic compounds, tannins, flavonoids, anthocyanins, and vitamin C, as well as antioxidant activity. These results could have important implications for the practical use value of the selected genotype, demonstrating its sustainability under climate change conditions.

Key words: Japanese Quince, bioactive compounds, antioxidant activity, selection, semi-urban ecosystems

1. INTRODUCTION

Under the conditions of intense climate change, scientific institutions face the research task of developing resilient genotypes with desirable traits through individual selection and breeding programs [1]. When organising this process, it is particularly important to determine the key biological characteristics of non-traditional plants found in semi-urban territories [2,3]. In this context, taxa of the genus *Chaenomeles* Lindl. (Rosaceae) have been promising since the 18th century, when they were introduced into European gardens [4], particularly the domesticated *Chaenomeles japonica* (Thunb.) Lindl.

From an ecological perspective, Japanese Quince is significant in the function of windbreaks and crop protection belts, as well as serving as a natural barrier in agroforestry ecotones and agricultural land [5]. Given its sustainability on low-quality soils and resistance to diseases [3], as well as its resilience under climate change conditions [6], Japanese Quince is an attractive ornamental and fruit-bearing species that is not destroyed during fruit harvesting, making it a renewable resource. In terms of biochemical composition, the fruits of Japanese Quince are rich in vitamins and biologically active substances. According to Zhang et al. [7], fresh fruits contain higher levels of vitamin C than the published values for apples, pears, peaches, lemons, and other fruits, highlighting its potential since vitamin C has antiscorbutic effect and helps metabolic transformations and boosts immunity [8]. Numerous experimental studies have confirmed the antioxidant, antimicrobial, anti-inflammatory, cytotoxic, and anti-metastatic potential of *Ch. japonica* fruits [9-11].

Considering that, to our knowledge, the content of bioactive compounds and antioxidant activity in the fruits of Japanese Quince at the genotype level is still less understood, the main objectives of the research are: conservation of *in situ* sustainable genotypes in the semi-urban zone of Belgrade, and investigation of the content of total phenols, tannins, anthocyanins, flavonoids, vitamin C, and antioxidant properties of fresh fruit extracts, in order to determine the significance of cultural and ecosystem services

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2. ANALYSIS OF BIOACTIVE COMPONENTS IN FRUITS

2.1. Study area

Based on the assessment and analysis of the presence of Japanese Quince in the semi-urban areas of Belgrade, a location was selected at the edge of residential blocks in New Belgrade, on a non-exposed area, 939.5 meters from the left bank of the Sava River and 6,500 meters from the main meteorological station (MMS) in Surčin (Figure 1). Considering the flowering phenophase duration, based on previous research conducted between 2007 and 2024 (Petrov et al., 2024), and the yield abundance over 18 consecutive years, a genotype was selected for breeding that would be both adaptable and applicable for ornamental purposes, as well as a nutritionally significant fruit for cultural and ecosystem services.

Figure 1 – Semi-urban zone with georeferenced selected genotype of Japanese Quince (CHJA) and MMS Surčin

The elevation of the selected genotype is 76 meters, while the MMS Surčin is at 99 meters. The soil is of the anthropogenized Luvisol Chernozem type [12]. According to data from MMS Surčin (φ44º47'54.44"N and λ20º27'53.35"E, https://www.hidmet.gov.rs/ciril/meteorologija/klimatologija_godisnjaci.php and https://www.ogimet.com/synopsc.phtml.en, accessed on January 6, 2025), the annual precipitation totals range from 351.6 to 937.3 mm (average 626.4 mm), while the mean annual air temperature varies from 10.8 to 13.9°C (average 12.5°C) in the reference period of 1991-2020. The total precipitation for 2024 was lower by 25.7 mm, while the mean annual temperature was 2.6°C higher than the 1991-2020 average.

2.2. Nutrition Constituents

A 500g sample of Japanese Quince fruits was collected on September 1, 2024, for the purpose of extracting fresh pulp and analyzing phenols, tannins, flavonoids, anthocyanins, vitamin C, and antioxidant capacity. The extraction was performed following official analytical protocols and methods [13] using 70% ethanol and distilled water (10ml) in a 1:50 ratio: 1) Total phenols and tannins were determined using the Folin-Ciocalteu reagent, with absorbance read at λ=730nm, expressed in mg quercetin equivalents per gram of fresh weight, according to Nagavani & Raghava Rao [14]; 2)Total tannin content (mg quercetin equivalents per gram of fresh weight) was calculated by subtracting non-tannin phenols from the total phenols; 3)Total flavonoids were quantified by complex formation with Al^{3+}, with absorbance measured at λ=430nm, and results expressed in mg quercetin equivalents per gram of fresh weight, as per Markham [15]; 4)Total anthocyanins were determined by pH differential, using pH 1 and pH 4.5 for measuring absorbance at λ=520nm and λ=700nm, and results were expressed as mg cyanidin-3-glucoside per gram of fresh weight. The total reduction capacity of the samples was measured using the FRAP method, with absorbance read at λ=593nm, and the result was expressed as mg Trolox equivalents per gram of fresh weight [16]. To assess the antioxidant capacity of the plant extracts, the radical scavenging activity of the samples was determined using the $ABTS^{\cdot}$+ method, measuring absorbance at λ=734nm [17]. The transformation of DPPH radicals was measured using the DPPH method [18], with absorbance read at λ=517nm, and the efficacy of natural antioxidants in the samples was expressed in mg Trolox equivalents per gram of fresh weight. Vitamin C content was determined using the 2,4-dinitrophenylhydrazine (DNP) method, as described by Al-Ani [19]. A calibration curve was obtained using solutions with varying concentrations of ascorbic acid (vitamin C). The results were expressed as mg ascorbic acid equivalents per gram of raw fruit.

3. RESULTS AND DISCUSSION

Analysis of the bioactive components in Japanese Quince fruits indicates significant differences in the concentrations of phenolic compounds, tannins, flavonoids, and anthocyanins, as well as in antioxidant activity, which may have important implications for human nutrition and other potential applications. The results show that 70% ethanol as a solvent (Table 1) significantly better extracts the total phenol content from Japanese Quince fruits (8.6 mg quercetin equivalents per gram) compared to distilled water (3.21 mg quercetin equivalents per gram).

Table 1 –Polyphenolic Composition and Antioxidant Activity of Fresh Japanese Quince Fruits

	Total phenols[1]	**Total tannins**[1]	**Total flavonoids**[1]	**Total anthocyanins**[2]	**FRAP**[3]	**ABTS**[3]	**DPPH**[3]
Distilled water	3.21 ± 0.59	2.64 ± 0.21	0.18 ± 0.05	0.13 ± 0.01	6.83 ± 0.78	6.02 ± 0.36	11.38 ± 0.94
70% ethanol	8.6 ± 0.65	6.17 ± 0.52	1.63 ± 0.31	1.75 ± 0.18	15.88 ± 0.71	17.94 ± 0.51	29.09 ± 0.57

[1]Expressed as mg quercetin equivalents per gram of fresh weight
[2]Expressed as mg cyanidin-3-glucoside per gram of fresh weight
[3]Expressed as mg Trolox equivalents per gram of fresh weight

This increase can be attributed to the better extraction properties of ethanol, which more efficiently releases polyphenols, known for their antioxidant, anti-inflammatory, and anticancer properties. A similar trend is observed with tannins (6.17 mg/g for ethanol compared to 2.64 mg/g for water) and flavonoids (1.63 mg/g for ethanol compared to 0.18 mg/g for water), further confirming the effectiveness of ethanol as a solvent (Table 1). Anthocyanins (Table 1), expressed as mg cyanidin-3-glucoside per gram, also show a significant increase in the ethanol extract (1.75 mg/g) compared to water (0.13 mg/g). These pigments contribute to the color of the fruit, but are also associated with numerous health benefits, including protection against oxidative stress and reduced risk of chronic diseases such as cardiovascular diseases and diabetes. Regarding antioxidant activity (Table 1), the results for the FRAP, ABTS, and DPPH methods clearly show that the ethanol extract of Japanese Quince fruits exhibits significantly higher activity (15.88 mg, 17.94 mg, and 29.09 mg Trolox equivalents per gram) compared to water (6.83 mg, 6.02 mg, and 11.38 mg Trolox equivalents per gram). These results suggest that ethanol not only more efficiently extracts bioactive components but also enhances their potential for neutralizing free radicals, which could be crucial for health preservation [11].

In addition to the content of polyphenolic compounds and antioxidant capacity, the vitamin C content in the fruits of the selected genotype was also determined. The average vitamin C value was 3.89 mg per gram of fresh fruit. Our findings are consistent with studies by Hellin et al. [20] and Ros et al. [21] in Lithuania, where vitamin C content varies by genotype from 2.0 to 11.2 mg/g, but are lower compared to the findings of Bieniasz et al. [22] in Poland, who report values ranging from 7.1 to 24.3 mg/g and 7.3 to 17.2 mg/g depending on genotype and year of research. However, the conclusion is the same: in fresh Japanese Quince fruits, vitamin C content is determined by genotype and season. Due to the specific nature of Japanese Quince fruits and the necessity for their processing, it is important to perform selection and identify genotypes with high vitamin C content and other bioactive compounds.

4. CONCLUSION

In the local semi-urban community, considering its adaptability to climate change, the selected genotype contributes to the landscape's aesthetics and is also significant for nutrition. Specifically, the cultural and ecosystem services of Japanese Quince derive from the bioactive compounds present in its fruits, which are a source of bioenergy and contribute to human health. Notably, the presence of vitamin C and polyphenolic compounds, known for their antioxidant activity, stands out, which is why the selected genotype is recommended for breeding and selection programs, as well as for the promotion of a new commercial variety for fruit production in Serbia under altered moderate continental climate conditions. The diverse cultural and ecosystem services provided by the selected genotype of Japanese Quince make it a candidate for commercialization and contribute to local economic development based on cultural, economic, and ecological criteria. As such, a strategy for cultivating Japanese Quince could be based on future crossing tests and progeny trials in well-designed field studies.

5. REFERNCES

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