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FRUIT QUALITY AND BIOACTIVE COMPOUND ACCUMULATION IN ROMANIAN PEPPER CULTIVARS

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Abstract

This study, conducted in 2023 and 2024, explored the phenotypic diversity of five Romanian pepper cultivars from VRDS Buzău (Roial, Decebal, Cantemir, Regal, L-50), focusing on fruit quality traits and yield. Fruit quality was assessed by analyzing dry matter content, fruit firmness, total soluble solids, titratable acidity, ascorbic acid, lycopene, and β-carotene at different ripening stages. Results showed a significant increase in bioactive compounds at full ripeness. L-50 exhibited the highest total soluble solids (9.53°Brix) and β-carotene (8.71 mg·100 g^{-1} F.W.) levels, making it nutritionally valuable. Roial stood out for its high vitamin C content (232.8 mg·100 g^{-1} F.W.), while Cantemir demonstrated superior firmness (11.42 N), enhancing post-harvest durability. All genotypes exhibited antioxidant properties, suggesting their potential contribution to functional foods These findings highlight the diversity and nutritional attributes of the studied Romanian pepper cultivars, though further research is needed to confirm their broader applicability.

Key words*: Capsicum spp., carotenoids, nutritional profile, vitamin C.*

INTRODUCTION

Capsicum peppers, part of the Solanaceae family, include 44 identified species, of which five are domesticated: *C. annuum*, *C. frutescens*, *C. chinense*, *C. baccatum*, and *C. pubescens* (Barbosa et al., 2002; Agapie et al., 2024). Among them, *C. annuum* is the most widely cultivated and consumed in Romania due to its distinctive taste and pungency.

Globally, peppers are valued for their culinary versatility and rich nutritional profile, containing bioactive compounds with strong antioxidant properties (Bogusz et al., 2018).

Their consumption offers health benefits, including reduced risks of cardiovascular disease, diabetes, and neurodegenerative disorders. Additionally, they support brain function by preventing lipid oxidation in brain cells (Arimbor et al., 2015).

In 2021, global Capsicum production reached 38 million tons fresh and 5,8 million tons dry (FAO, 2023). In Romania, peppers rank fourth among vegetables, with 9,510 hectares cultivated, yielding 104,560 tons (FAO, 2023).

The Vegetable Research and Development Station (VRDS) Buzău plays a key role in breeding and preserving Capsicum germplasm, registering 11 pepper cultivars in the Official Catalogue of Species and Varieties of Cultivated Crops in Romania, including bell peppers, long peppers, pimiento peppers, and hot peppers.

In recent years, plant breeding efforts have increasingly focused on developing genotypes with high antioxidant content, recognizing the strong correlation between diet and human health (Brezeanu et al., 2022).

This study investigates the phenotypic diversity of five Romanian pepper cultivars, assessing key fruit quality traits and yield performance. The findings aim to highlight their potential applications while raising consumer awareness of their nutritional and health benefits.

MATERIALS AND METHODS

Five pepper varieties bred at VRDS Buzau were analyzed: two sweet peppers: Cantemir, Regal, two hot peppers: Roial, Decebal, and one pimiento accession L50 (Figure 1).

The experiment was conducted in the years 2023 and 2024 at the experimental research plot of the VRDS Buzău.

The crop technology applied for pepper cultivation followed the recommendations from the specialized literature (Barcanu et al., 2021).

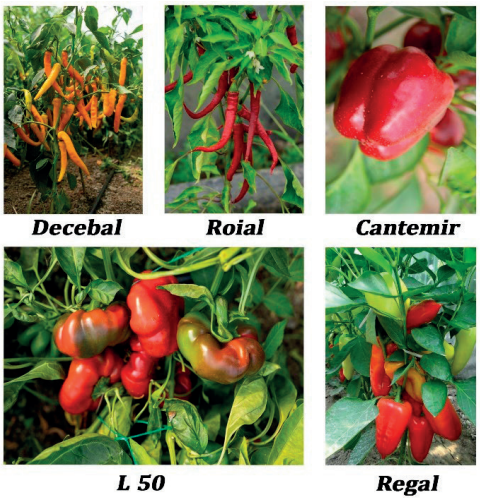

Figure 1. Pepper fruit varieties taken into study

Pepper fruits were harvested at two distinct ripening stages to assess fruit quality traits: harvest maturity (HM) and physiological maturity (PM). Fruits collected at the green stage (HM) were noted as Cantemir I, Regal I, Roial I, Decebal I, and L50 I, while fully ripe fruits at physiological maturity (PM) were noted as Cantemir M, Regal M, Roial M, Decebal M, and L50 M.

For fruit quality analysis, randomly mixed samples were prepared for each genotype, with all parameters assessed in triplicate on the harvest day. These included Total Dry Matter (%, AOAC 930.04), Total Soluble Solids (TSS - °Brix, AOAC 932.12), and Titratable Acidity (TA% citric acid, AOAC 942.15), using standardized methods.

The fruit firmness was tested using the electronic penetrometer TR Turoni 53205 equipped with a 3 mm piston and the results were expressed in Newton.

The quantification of lycopene and β-carotene was conducted according to the method developed by Nagata and Yamashita (1992) and the vitamin C content was determined using a modified iodine titration method (0.01 M) based on Sheeba and Shalini (2021). For juice preparation, 10 g of each sample was finely chopped, blended with 50 ml of distilled water, and filtered. The filtrate was transferred to a 100 ml volumetric flask and diluted to volume. A 20 ml aliquot was mixed with 150 ml of distilled water in a 200 ml Erlenmeyer flask, then titrated against iodine solution using an automatic TitroLine Easy. Results were expressed as mg/100 g fresh weight (FW).

Statistical analyses were performed using analysis of variance (ANOVA). In the case of a significant F-value, the means were compared using Duncan test.

RESULTS AND DISCUSSIONS

Hot peppers generally weigh less than sweet peppers. In this study, yield/plant ranged from 2.15 kg in Roial to 3.35 kg in L50 (Figure 2).

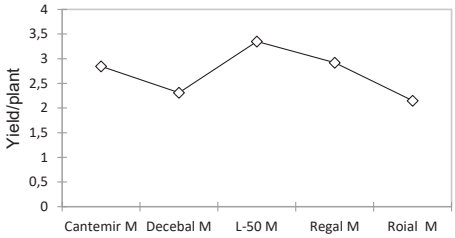

Figure 2. The mean values of yield/plant for studied varieties

Dry matter content (DM%) at harvest maturity ranged from 5.25% (Decebal) to 9.21% (Roial), increasing significantly during ripening, with Roial reaching the highest value (14.72%) and Regal the lowest (4.87%) (Figure 3). This trait is essential for chili powder production (Ribes-Moya et al., 2018).

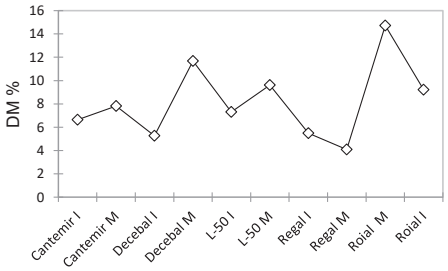

Figure 3. The mean values of DM content of studied varieties

Previous studies reported DM values between 4.83%-17.78% (Brezeanu et al., 2022) and 11.9%-16.5% (Stan et al., 2021), with the present study's range (4.87%-14.08%) falling within these intervals.

Cell wall structure is a key quality attribute influencing consumer preference and a primary selection criterion in breeding programs (Perez-Grajales et al., 2019). In this study, fruit firmness increased during ripening, peaking at 11.42 N in Cantemir at physiological maturity (Figure 4). High firmness enhances suitability for fresh consumption and extends shelf life (Barcanu et al., 2021), which is crucial for long-distance transport (Flores-Velázquez et al., 2022). Firmness values reported for bell peppers vary, ranging from 12.64N-21.60N (Figueroa et al., 2015) to lower values of 6.39N-7.0N (Palacio & Sánchez, 2015).

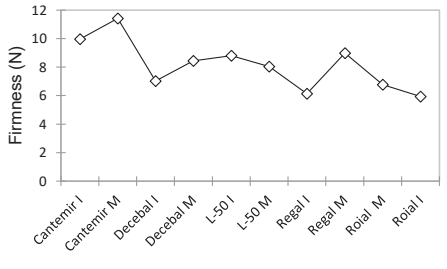

Figure 4. The mean values of firmness of studied varieties

TSS, comprising sugars and organic acids, is a key indicator of pepper maturity and sensory quality (Martínez et al., 2007). Similar to DM content, TSS increased during ripening, (Rahman et al., 2017). This rise enhances fruit sweetness due to hexose sugar accumulation (Nielsen et al., 1991).

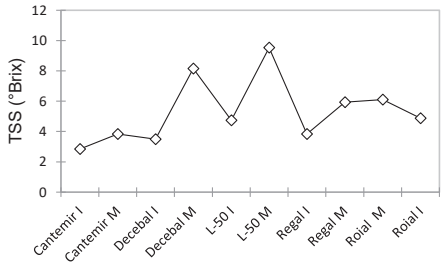

Figure 5. The mean values of TSS content of studied varieties

Our results (Figure 5) shown that TSS values varied across maturity stages but showed no statistical differences among genotypes. The highest TSS at harvest maturity was recorded in Roial, with 4.88°Brix, while at physiological maturity L50 shown the highest value, 9.33°Brix The recorded values (3.49-9.33°Brix) align with literature reports of 3.5-7°Brix (Soare et al., 2017) and 5.20-8.85°Brix (Flores-Velázquez et al., 2022).

Titratable acidity (TA) and the TSS/TA ratio serve as critical indicators of fruit ripening, reflecting the concentration of organic acids (Martínez et al., 2007). In this study, TA exhibited a significant increase during ripening (Figure 6), a trend consistent with the findings of Ghasemnezhad et al. (2011). At harvest maturity, the highest TA value was recorded in the Roial cultivar (0.18 g citric acid·100 g^{-1} FW), while the lowest was observed in the Decebal cultivar (0.09 g citric acid·100 g^{-1} FW). Notably, at physiological maturity, the Decebal variety demonstrated the most substantial increase in TA, reaching almost he highest content (0.27 g citric acid·100 g^{-1} FW).

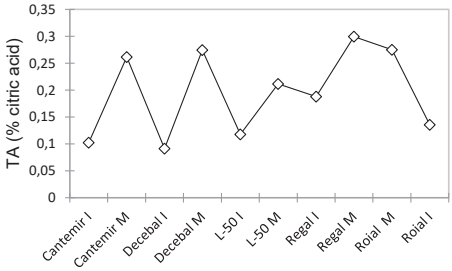

Figure 6.The mean values of TA content of studied varieties

The increasing interest in carotenoids stems from their potential health benefits, as peppers serve as a valuable source of lycopene and β-carotene (Brezeanu et al., 2022; Igbokwe et al., 2013). Lycopene has been associated with antioxidant, anti-inflammatory, and chemoprotective effects in cardiovascular and neurodegenerative diseases, as well as certain cancers (Cruz et al., 2013). Meanwhile, β-carotene, a precursor of vitamin A, exhibits strong free radical scavenging properties (Deepa et al., 2006).

Statistical analysis revealed significant differences in lycopene and β-carotene content among the studied cultivars. The highest lycopene concentration was recorded in the L50 variety (6.17 mg·100 g^{-1} F.W) (Figure 7), also

L50 accession exhibited the highest β-carotene content (8.71 mg·100 g^{-1} F.W) (Figure 8). In contrast, the Decebal cultivar, characterized by orange-colored fruits, had undetectable lycopene levels. Lycopene and β-carotene content in pepper (*Capsicum annuum*) genotypes is strongly influenced by genetic factors, with yellow and orange cultivars typically lacking lycopene due to mutations affecting carotenoid biosynthesis (Agarwal & Rao, 2000). These colour variations are primarily linked to differential gene expression regulating the conversion of β-carotene to downstream carotenoids, such as capsanthin and capsorubin, which are characteristic of red peppers (Rodríguez-Burruezo et al., 2011; Naresh et al., 2020).

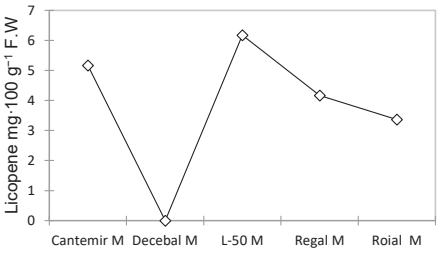

Figure 7. The mean values of licopene content of studied varieties

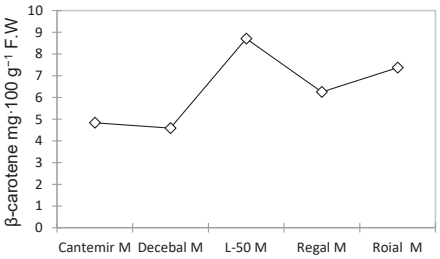

Figure 8.The mean values of β-carotene content of studied varieties

Carotenoid accumulation is closely linked to fruit ripening, as lycopene levels increase while chlorophyll degrades, leading to the transition from green to red pigmentation (Flores-Velázquez et al., 2022). Consequently, we analyze lycopene and β-carotene only at physiological maturity.

Peppers contain bioactive compounds with applications in animal feed, nutraceuticals, cosmeceuticals, and functional foods (Razola-Diaz et al., 2022). Epidemiological studies have consistently linked fruit and vegetable consumption to reduced mortality rates from cancer, cardiovascular diseases, degenerative disorders, and aging-related conditions (Chávez-Mendoza et al., 2015).

Vitamin C is among the most significant bioactive compounds in peppers, playing a crucial role in collagen biosynthesis and acting as a co-factor in essential hydroxylation reactions. Additionally, ascorbate supplementation has been associated with a reduced risk of Alzheimer's disease, while its antioxidant properties help mitigate cellular damage (Grosso et al., 2013). Since humans cannot synthesize vitamin C due to mutations in the gluconolactone oxidase gene, dietary sources of this nutrient are essential.

In this study, vitamin C content varied significantly among genotypes and increased during ripening (Figure 9). At physiological maturity, Roial exhibited the highest concentration (232.80 mg/100 g FW), while Regal and L50 showed the lowest levels (94.93-106.73 mg·100 g^{-1} F.W). Considerable variation in ascorbic acid content has been reported in previous studies (Dinu et al., 2013; Soare et al., 2017), influenced by cultivar response, sampling variability, and environmental factors (Kouassi et al., 2012).

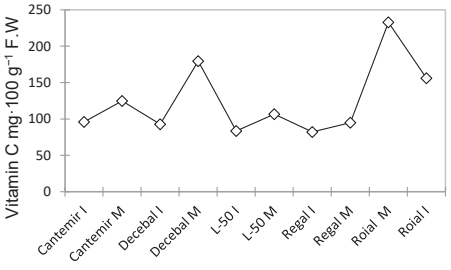

Figure 9.The mean values of Vitamin C content of studied varieties

All analyzed pepper varieties proved to be excellent sources of vitamin C, surpassing the recommended daily dose (RDD) of 60 mg/ 100 g. On average, Regal contributed 158% of the RDD, while Roial provided 348%. These findings align with previous studies suggesting that bell peppers (*Capsicum annuum*) can

provide between 25% and 218% of the recommended daily dietary intake (RDD) of vitamin C, depending on factors such as genotype, ripening stage, and cultivation conditions (Chávez-Mendoza et al., 2015).

CONCLUSIONS

The study provides insights into the physical attributes, bioactive compound composition, and yield potential of five Romanian pepper (*Capsicum annuum*) cultivars. Among the evaluated genotypes, L-50 exhibited the highest total soluble solids and β-carotene content, suggesting its potential nutritional value. Roial demonstrated elevated vitamin C levels, while Cantemir displayed notable fruit firmness, which may contribute to improved postharvest storage and transportability.

These findings contribute to a broader understanding of the phytochemical profile of these pepper cultivars. The studied varieties show promising characteristics for direct market use, though additional investigations on consumer preference and postharvest behaviour would support their commercial recommendations.

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