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POTATO –„POWERHOUSE" FOR SEVERAL MICRONUTRIENTS

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ABSTRACT

Despite its traditional reputation as an inexpensive and commonplace dietary staple, the potato (Solanum tuberosum L.*) constitutes a nutritionally crop characterized by high levels of carbohydrates, vitamins and essential minerals. Current literature increasingly suggests that the bioactive constituents of potatoes yield favorable outcomes for cardio-metabolic health, including improved lipid profiles and diminished inflammatory biomarkers. The present study investigates the functional characteristics of some Romanian potato cultivars, with a particular emphasis on key antioxidants such as vitamin C and polyphenols. These data deliver preliminary yet insightful benchmarks for researchers and producers seeking to advance the functional prospects of potato-based nutrition.*

INTRODUCTION

Potato ranks as the third most consumed food globally, following maize and rice. Its tubers are well-known as excellent sources of carbohydrates, potassium, phosphorus, magnesium and vitamins (B1, B3 and B6). Although potatoes have only a moderate iron content, their high levels of L-ascorbic acid significantly enhance iron absorption. Additionally, potatoes contain essential amino acids, folate, pantothenic acid and riboflavin.

Recent nutritional studies reveal that potato composition extends far beyond starch. In fact, potatoes contain crucial phytochemicals that may help prevent cardiovascular diseases, diabetes and certain types of cancer. Specifically, potato antioxidants have demonstrated favorable impacts on cardio-metabolic health by improving lipid profiles, lowering blood pressure and reducing inflammatory markers (Valcarcel et al. 2015, Wang et al. 1999). Consequently, tubers with elevated levels of polyphenols, carotenoids, or vitamin C could significantly improve human health due to their properties (Duthie et al. 2000, Wang et al. 1999). This benefit is particularly vital for populations where the potato serves as a primary staple crop, making it a subject of great interest for both consumers and producers (Valcarcel et al. 2015).

Deeply pigmented purple-fleshed potatoes represent a good source of polyphenols (such as chlorogenic acid and anthocyanin pigments). Globally, this resource remains underutilized, and in Romania, it has been almost entirely unexploited until recently. Although many plant species produce polyphenols, commercial exploitation has been restricted to only a few due to the high costs and limited availability of specific plant materials. Chemically, red-fleshed potatoes

contain acylated glucosides of pelargonidin, whereas purple varieties also include acylated glucosides of petunidin, malvidin and delphinidin, all these compound having antioxidant properties. Therefore,potatoes should be classified as vegetables with high antioxidant capacity, highly dependent on their flesh composition.

Furthermore, research has identified various phenolic acids in potatoes (caffeic, ferulic, p-coumaric, and vanillic acids), alongside catechin and the flavonols us rutin and kaempferol-3-O-rutinoside. White-fleshed potatoes contain approximately 30 µg of flavonoids (predominantly catechin and epicatechin) per 100 g of fresh weight (FW), whereas red- and purple-fleshed varieties contain roughly twice that amount (Valcarcel et al. 2015)

Vitamin C serves as a potent antioxidant that stimulates the production of collagen - a primary component of muscle tissue - and enhances iron absorption. Additionally, it supports digestive efficiency, cardiovascular health, and blood pressure regulation, while playing a role in preventing scurvy, the common cold, and potentially certain types of cancer. Previous studies (Love et al. 2004, Beals 2019, Kondo et al. 2012, Pryia & Saiprasad 2023) have shown that vitamin C content ranges between 18 and 35 mg/100 g across various potato cultivars. Consequently, potatoes are recognized as an excellent source of this nutrient, capable of fulfilling 30 % to 58 % of the daily requirement (60 mg/day). Furthermore, the year-round availability of potatoes and their frequent consumption across all age groups position them as a major dietary contributor of this vitamin. Vitamin C is the most abundant vitamin in potatoes; it is estimated that potatoes provide approximately 18 % of the recommended daily allowance (RDA) in Australia and 21 % in the UK (Camire et al. 2009, Cahill et al. 2009). Three main biological functions have been identified for vitamin C (L-ascorbic acid): acting as an enzyme cofactor, serving as a free radical scavenger, and operating as an electron donor/acceptor at the plasma membrane. Humans have lost the ability to synthesize vitamin C, they must rely on dietary sources to maintain optimal health. Vitamin C deficiency causes scurvy, a disease characterized by skin spots, spongy gums, and mucosal bleeding, which stems from impaired collagen synthesis due to the absence of vitamin C (L ascorbic acid) as a cofactor (Camire et al. 2009, Cahill et al. 2009, Schleicher et al. 2009). Although scurvy is considered rare in modern developed nations, a significant portion of these populations may still have a vitamin C intake below the RDA, which is set at 80 mg/day in the European Union (EC 2008). Certain human group, such as smokers, pregnant women, and individuals of low socioeconomic status, face a heightened risk of L-ascorbic acid deficiency. This vitamin is particularly crucial because it counters the chelating effect of phytic acid on iron, thereby increasing iron bioavailability (Camire et al. 2009). Therefore, tubers with elevated levels of polyphenols or vitamin C can profoundly benefit human health through their antioxidant, anti-inflammatory and antiviral activities. This impact is especially significant for populations reliant on potato as a staple crop, making these traits highly valuable to both consumers and producers.

Antioxidants such as carotenoids (especially lutein and zeaxanthin) are present across all potato varieties. These compounds exhibit several health-promoting effects; notably, lutein and zeaxanthin play a critical role in preserving ocular health by reducing the risk of age-related macular degeneration, confering valuable functional properties to this vegetable (Andre et al. 2007, Camire et al. 2009, Chucair et al. 2007).

In this study, ten popular Romanian cultivars, highly favored by both

consumers and producers, were evaluated over a two-year planting period for their antioxidant profiles, specifically focusing on total polyphenols and vitamin C content. The findings of this research provide interesting data regarding micronutrient concentrations in potato cultivars optimized for enhanced nutritional quality.

MATERIAL AND METHODS

Biological material. Ten Romanian potato cultivars (with moderately resistance to the main potato viruses) evaluated in this study were the following: 'Darilena', 'Foresta', 'Christian', 'Cezarina', 'Sevastia', 'Marvis', 'Castrum', 'Brasovia', 'Cosiana' and Albastru Violet de Galanesti ('Blue Purple of Galanesti') (strong colour in the flesh). Biological material was planted in May in a greenhouse from National Insitute of Research and Development for Potato and Sugar Beet Brasov in 2024 and 2025, with three replicates. Similar chemical inputs were used in all experiments realised in greenhouse under uniform conditions. Mature potato tubers were harvested 165 days after planting in 2024 and 152 days in the next year. After harvest, tubers (medium size, free of defects or damage) were selected and stored at 6-8 ^{o}C until the sample preparation.

Total phenolic content (TPC) analysis. Phenolic compounds were extracted using 80 % (v/v) ethanol according to Valcarcel et al. (2015) with minor adjustments, and total phenolic content (TPC) was determined using the Folin–Ciocâlteu method (Singleton et al., 1999), with absorbance recorded at 725 nm. Results were expressed as mg gallic acid equivalents (GAE) per gram dry weight (DW) (Bădărău et al. 2025).

Vitamin C analysis. Dry matter (thermoventilated oven at 105 ^{o}C), vitamin C (spectrophotometric method, L ascorbic acid test kit, Megazyme, Bioreba) were determined on tissue from tubers stored at 6-8 ^{o}C. We choosed a representative sample of tubers. The sample for these analysis were choosed from each 3 tubers (3 tubers/sample). The characteristics determination was made in 3 repetitions.

Statistical interpretation. Analysis of variance (ANOVA) and Duncan's multiple range test were used.

RESULTS AND DISCUSSIONS

The experiments made in Brasov show that cultivar 'Blue Purple of Galanesti' (AVG) had the highest mean TPC value in skin and flesh tissue, in the years 2024 and 2025. The sample with the lowest TPC values was from the variety Darilena in both years for both tissues flesh and skin, respectively (table 1).

The levels of TPC were from 0.69 to 3.47 mg GAE/ g DW (in the flesh) and 2.82 to 11.05 mg GAE/ g DW (in the skin), the tissue poliphenol contents showing a significant difference between the cultivars (table 1). On average, the potato skin contained 4.78 and 3.93 times more total phenolic compounds (TPC) than the flesh in 2024 and 2025, respectively (table 1). In both tissues (skin and flesh), TPC was positively correlated with tissue pigmentation, yielding Pearson correlation coefficients of 0.823 ($p < 0.01$) for the skin and 0.598 ($p < 0.01$) for the flesh.

Table 1

Total polyphenol content (mg GAE/g DW) of potato samples (Brasov, 2024-2025)

No	Cultivars / genotypes	Flesh / Skin colour	Year 2024		Year 2025	
			Flesh	Skin	Flesh	Skin
1	Darilena	W / LY	0.69±0.012 *(g)**	2. 82±0.298 (*h*)	0.94±0.118 (*f*)	2.93±0.174 (*i*)
2	Azaria	C / R	0.87±0.136 ef)	8.03±0.894 *(b)*	0.95±0.120 (*ef*)	8.87±0.305 *(b*)
3	AVG	B/B	3.23±0.214 (*a*)	9.62±1.245 *(a)*	3.47±0.373 *(a)*	11.05±1.110 (*a*)
4	Brasovia	WY / Y	0.11±0.072 (*d)*	3.47±0.104*(f*)	1.13±0.149 *(e)*	4.06±0.108 (*gh)*
5	Castrum	LY / Y	1.22±0.108 (*c)*	3.97±0.218*(e)*	1.62± 0.246(*c*)	4.93±0.152 *(j*)
6	Cosiana	WY / R	0.73±0.019 (*ef)*	7.46±0.278 *(bc)*	1.32±0.203 (*e*)	7.84±0.322 (c)
7	Marvis	WY / Y	0.85±0.042 (*ef)*	4.89±0.235 *(de)*	0.99±0.213 (ef)	5.07± 0.250*(f)*
8	Christian	Y / R	1.19± 0.063(*c)*	6.83 ±0.314*(cd)*	1.77± 0.042(*c*)	7.05±0.116 (*d)*
9	Roclas	Y / Y	0.93±0.194 (*de)*	3.52± 0.132*(g)*	1.46±0.182 (d)	3.93±0.714(*g*)
10	Sevastia	DY / Y	1.83±0.117 (*b)*	5.18± 0.109(*d)*	2.04±0.121 (*b*)	5.84±0.127 (*e)*

*Mean values ± standard deviation. Means with different letters are significantly different at p<0.05 in each column. Values reported are the mean of three replicates. Abbreviations: GAE Gallic Acid Equivalents; DW dry weight; AVG Albastru Violet de Galanesti (Blue Purple of Galanesti); W white; WY white yellow; C cream; LY light yellow; Y yellow; DY dark yellow; R red; B blue; C. Cream.

Table 2

Dry matter and vitamin C content of the biological material (Brasov, 2024-2025)

No	Cultivars / genotypes	Year 2024		Year 2025	
		Dry matter (% FW)	Vitamin C (mg/100 g DW) ±SD	Dry matter (% FW)	Vitamin C (mg/ 100 g DW) ±SD
1	Darilena	25.2±0.050	18.000±4.206 (f)**	22.3±0.055	17.014±2.653 (e)**
2	Azaria	24.8± 0.138	23.290±3.205(ef)	23.2± 0.133	23.667±1.248(f)
3	AVG	25.1±0.075	25.340±2.104 (ef)	24.9±0.058	24.666±1.853(f)
4	Brasovia	21.8±0.080	31.667±3.859 (de)	20.8±0.024	28.333± 0.558 (e)
5	Castrum	24.8±0.010	34.667±5.075 (d)	22.7±0.015	29.666± 1.111 (e)
6	Cosiana	23.6±0.084	43.340±1.278 (c)	21.7±0.098	39.667±2.773 (d)
7	Marvis	24.2±0.128	64.337±0.357 (b)	22.6±0.143	58.008±0.270 (bc)
8	Christian	23.8±0.020	64.333±0.595(b)	21.0±0.408	59.067±1.055 (bc)
9	Roclas	23.4±0.142	65.3433±1.856 (b)	21.8±0.122	60.333±1.633 (b)
10	Sevastia	24.0±0.086	76.533±43.634(a)	21.3±0.090	71.666±1.186 (a)

* Values not followed by the same letter are significantly different (p<0.05) according to Duncan's test. Abbreviation: FW= fresh weight; DW = dry weight; SD=standard deviation.

These findings are comparable to values reported by other researchers, which range from 1.56 to 12.9 mg GAE/g DW in the skin and 0.54 to 3.59 mg GAE/g DW in the flesh (Valcarcel et al. 2015)

Certain other vegetable sources exhibit higher TPC concentrations than potatoes, but the high volume of potato consumption in many countries makes this crop a major contributor to the daily intake of phenolic compounds. For instance, a study conducted in the USA estimated that potatoes were the third highest dietary contributor to daily phenolic compound intake -surpassed only by oranges and apples - based on an average consumption rate of 171 g/day (Chun et al. 2005). These nutritional benefits could be further amplified if cultivars with high TPC levels gain wider public popularity. Unfortunately, the 'Albastru-Violet de Gălănești' cultivar (which exhibited the highest TPC levels in both flesh and skin in this study) faces low consumer acceptance due to its small, elongated tubers and deep eyes. Future potato breeding programs may address these unfavorable quality parameters to develop new cultivars that combine superior agronomic traits with functional food characteristics.

In our study, the reported values for vitamin C were generally lower than those found in the literature (Hamouz et al.2010, Mazurczyk 2001, Kolbe et al. 1997, Han et al. 2004), a discrepancy that may be attributed to cultivation conditions, particularly soil composition. Supporting this hypothesis, a previous study noted higher vitamin C levels in potatoes cultivated in basic soils (Burgos et al. 2009). The experiments conducted in Brașov during 2024 and 2025 revealed that the 'Sevastia' cultivar achieved the highest mean vitamin C values. Conversely, the lowest concentrations were quantified in 'Darilena', 'Azaria', and 'Albastru-Violet de Gălănești' in both 2024 and 2025 (table 2). Vitamin C levels ranged from negligible amounts to (76.533±43.633 and 71.000±1.187 mg/100g DW in the tuber flesh, with flesh content showing a statistically significant difference between both years (Table 2). These data align with existing literature; previous studies have reported that vitamin C content varies between 18 and 35 mg/100 g fresh weight among different potato cultivars (Love et al. 2004, Beals 2019, Kondo et al. 2012, Pryia & Saiprasad 2023), which equates to approximately 72–145 mg/100g DW assuming a 75 % moisture content in fresh samples. Finally, the vitamin C values of the biological material tested in our study demonstrated a very weak positive correlation with total phenolic compounds, showing a Pearson coefficient of 0.301 ($p < 0.001$) (data not shown).

Nutrient loss in potatoes is heavily influenced by the harvest type, storage conditions, and processing methods, with vitamin C being the most susceptible component. Depending on the genotype, cold storage conditions can lead to a 20% to 60 % reduction in vitamin C content (Dale et al., 2003). Furthermore, a study by Tosun and Yücecan (2008) demonstrated a 51 % loss of this nutrient during the processing stages prior to freeze-drying (Pryia & Saiprasad 2023). Consequently, freeze-drying techniques must be minimally destructive to mitigate such substantial losses. Research by Navarre et al. (2009, 2010) indicated that cooking methods such as microwaving, baking, boiling, and steaming unpeeled, freeze-dried potatoes result in minimal vitamin C loss. A primary factor driving this preservation is the absence or limited involvement of water in several of these culinary techniques, preventing nutrient leaching. A bioavailability study conducted by Kondo et al. (2012) revealed that vitamin C derived from potatoes is more effectively absorbed by the human body than readily available commercial supplements (Pryia & Saiprasad 2023).

Given that potato consumption plays a vital role in human nutrition, this study provides data for researchers and producers regarding the concentrations of vitamin C and polyphenols. Ultimately, these findings highlight the valuable functional antioxidants that remain "hidden in a common vegetable" like the potato.

CONCLUSIONS

The exploration of the "hidden" antioxidants within potato tubers was driven by the crop's good bioavailability, economic advantages (offering a lower-cost alternative to other antioxidant sources), the vitamin C content and the presence of valuable polyphenols. To evaluate these properties, ten Romanian potato genotypes exhibiting diverse skin and flesh pigmentation were cultivated in Brașov over a two years period and analyzed for total phenolic compounds (TPC) and vitamin C levels.

The results demonstrated that while the TPC values aligned closely with ranges reported in the literature, the vitamin C content was generally lower than published benchmarks, a discrepancy potentially caused by environmental and cultivation factors, specifically soil composition. Statistical analysis revealed significant differences in both vitamin C and TPC among the tested cultivars. Notably, deeply pigmented tubers possessed significantly higher polyphenol concentrations than their white-fleshed counterparts, suggesting that visual traits could serve as a reliable practical metric for selecting nutrient-dense varieties. Among the evaluated genotypes, the blue-skinned and blue-fleshed cultivar 'Albastru-Violet de Gălănești' exhibited the highest TPC levels, whereas the dark-yellow-fleshed cultivar 'Sevastia' achieved the highest vitamin C concentrations

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