

Total phenolic content in ten potato cultivars with different resistance to potato virus S(PVS)

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ABSTRACT

Being one of the most consumed vegetables across the world, potato is a highly nutritious crop, constituting an important source of essential compounds for human health. The present study evaluated the total content of phenolic compounds (TPC) in the skin and flesh of several Romanian potato cultivars with different resistance to potato virus S (PVS) grown in Brasov, over two years. Significant differences were observed across the cultivars. Lower levels of TPC were found in the flesh than in the skin of the tubers. Blue genotype "Blue Purple of Galanesti" and Romanian cultivar 'Foresta' had the highest values for TPC in skin and flesh. This study contains information regarding the content of valuable micronutrients of several new Romanian potato cultivars with good nutritional quality and different resistance to PVS.

Keywords: potato, total phenolic content, potato virus S.

INTRODUCTION

Potatoes make a significant contribution to the dietary intake of some functional compounds and valuable nutrients. So many articles on potato composition revealed that there is much more in potatoes than starch (Ezekiel *et al.*, 2013). Phenolic compounds have a large array of health-beneficial characteristics. Based on their concentration and frequency of consumption, potato is considered the third most important source of phenols after apples and oranges (Ezekiel *et al.*, 2013). It is a valuable source of important nutrients (starch, fibers, amino acids, vitamins, minerals), potato tubers representing a complex matrix in the human diet, having potential health benefits.

Some of the reasons that led the choice of this subject (study polyphenol content of potato tubers) were: the special bioavailability of this plant, economic considerations (lower price compared to other sources of antioxidants), the content of anthocyanin and the presence of valuable polyphenols (chlorogenic acid, quercetin and kaempferol glycosylated with rutinose significant amounts of catechin, usually acylated glycosides of rutinose and glucose) (Andre *et al.*, 2006; Ezekiel *et al.*, 2013). In particular, potato antioxidants have been shown to have favorable impacts on several measures of cardio-metabolic health, including lowering blood pressure, improving lipid profiles and decreasing markers of inflammation (Pryia *et al.*, 2023; Salma *et al.*, 2020; Valcarcel *et al.*, 2015; Wang *et al.*, 1999). Tubers with increased levels of polyphenols could have an impact on human health, because these compounds possess antioxidant, antiglycemic, antiviral and anti-inflammatory activities (Duthie *et al.*, 2000; Wang *et al.*, 1999). This impact could be strong, especially for

people where potato is the most important food crop and therefore would be of interest to consumers and producers (Valcarcel *et al.*, 2015).

Potato virus S (PVS) is transmitted mechanically and by aphids in a non-persistent manner (Cojocaru N., 1987, Loebenstein G., 2008). The damage caused by these pathogens is qualitative (commercial depreciation of tubers) and quantitative (reduction of production). Under favorable conditions, in case of sensitive potato cultivars, the financial losses can be important, for consumption (production unmarketable) and for seed potatoes (possibly of downgrading) (Bădărău *et al.* 2012).

The main objective of this work was to evaluate the amount of total polyphenols content of ten Romanian potato cultivars with different resistance to potato virus S grown in Brasov over two years with different climatic conditions.

MATERIALS AND METHODS

The experiment was conducted during 2023–2024 at the National Institute of Research and Development for Potato and Sugar Beet, Braşov, Romania, using ten Romanian potato cultivars with different resistance to Potato Virus S (PVS): ‘Darilena’, ‘Foresta’, ‘Christian’, ‘Cezarina’, ‘Sevastia’, ‘Marvis’, ‘Castrum’, ‘Brasovia’, ‘Cosiana’ (new Romanian cultivars) and ‘Albastru Violet de Galanesti’ (‘Blue Purple of Galanesti’)(with strong pigmentation in the flesh).

Seed tubers were planted in May in three biological replicates under uniform fertilization and crop management practices. Mature tubers were harvested 148–160 days after planting, and medium-sized, healthy tubers were selected, washed and stored at 4°C until 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–Ciocâlţeu 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).

The PVS infection status of the cultivars was verified using ELISA according to Clark and Adams (1977). Statistical analyses were performed using ANOVA followed by Duncan’s multiple range test, with significance set at $p < 0.05$.

RESULTS AND DISCUSSIONS

The climatic conditions (mean temperature and rainfall) in the growing season of the experimental years 2023 and 2024 are presented in Table 1. As can be seen in this table, compared with 2023, the year 2024 was slightly warmer, especially during June–August (mean/sum 17.7°C/106.2°C in the vegetation months of the year 2024, mean/sum 16.2 °C/ 97°C in the same period of the year 2023, respectively).

Also, the level of rainfall in May and June was lower in 2024 (42.7 mm in May, 54.5 mm in June, compared with 77.5 mm, 111.1 mm in the same months of the year 2023). The temperature and precipitation regime for the year 2024 indicated a year with poor precipitations distributions in May and June, compared with 2023.

During these months the potato plants are susceptible to the pathogens attack (Hu *et al.* 2012). At the same time, in this period, the accumulation of biological compounds in the plants is important for their metabolic activities (Hu *et al.* 2012).

Results showed that cultivar ‘Blue Purple of Galanesti’ recorded the highest mean TPC in both skin and flesh in both experimental years, while ‘Darilena’ presented the lowest values (Table 2). The TPC ranged from 0.62 to 3.39 mg GAE g⁻¹ DW in the flesh and from 2.76 to 10.43 mg GAE g⁻¹ DW in the skin, respectively, statistically significant difference among the cultivars as revealed by ANOVA followed by Duncan’s multiple range test ($p < 0.05$) (Table 2). Overall, skin samples contained on average 4.51-fold higher TPC than flesh samples in

2023, and 4.05-fold higher in 2024 (Table 2). Differences between cultivars were also influenced by tuber color, with intensely pigmented cultivars showing higher TPC values.

Table 1. Climatic conditions in the experimental years

Month	Year	Mean temperature (° C)	Rainfall (mm)
April	2023	7.3	83.1
	2024	12.2	43.5
May	2023	13.8	77.5
	2024	13.6	42.7
June	2023	17.6	111.1
	2024	21.1	54.5
July	2023	20.5	59.1
	2024	22.2	79.4
August	2023	20.9	77.5
	2024	21.2	65.0
September	2023	16.9	11.0
	2024	15.9	48.7
Average / Sum	2023	16.2/ 97.0	69.9/ 419.3
	2024	17.7/ 106.2	55.6/ 333.8

Table 2. Total polyphenol content (mg GAE/g DW) of potato samples (Brasov, 2023-2024)

Cultivars /resistance to PVS	Flesh / Skin colour	Year 2023		Year 2024	
		Flesh	Skin	Flesh	Skin
Darilena/r	W / LY	0.62±0.152 (g)*	2.88±0.121(h)	0.84±0.121(f)	2.76±0.168(i)
Foresta/mr	DY / R	0.75±0.089(ef)	7.80±0.057(b)	0.90±0.057(ef)	8.26±0.203(b)
AVG/ nr	B/B	3.17±0.309(a)	9.48±0.090(a)	3.39±0.090(a)	10.43±0.101(a)
Brasovia/r	WY / Y	0.90±0.068(d)	3.34±0.079±(f)	1.07±0.079(e)	3.94±0.139(gh)
Castrum/r	LY / Y	1.14±0.110(c)	4.03±0.185(e)	1.42±0.185(c)	4.47±0.208(f)
Azaria/mr	Y / R	1.33±0.178(c)	6.57±0.090(cd)	1.53±0.090(c)	6.88±0.239(d)
Cosiana/mr	WY / R	0.77±0.139(ef)	7.14±0.121(bc)	1.07±0.121(e)	7.61±0.262(c)
Marvis/r	WY / Y	0.73±0.101(ef)	4.45±0.125(de)	0.91±0.125(ef)	4.63±0.271(f)
Cezarina/r	Y / Y	0.87±0.080(de)	3.18±0.146(g)	1.22±0.146(d)	3.56±0.060(g)
Sevastia/r	DY / Y	1.67±0.255(b)	5.02±0.121(d)	1.96±0.121(b)	5.70±0.297(e)
Mean		1.191	5.370	1.439	5.827

*Means with different letters are significantly different at $p<0.05$ in each column. Values reported are the mean of three filed replicates. Abbreviations: GAE Gallic Acid Equivalents; DW dry weight; AVG Albastru Violet de Galanesti (Blue Purple of Galanesti). Abbreviations for the type of PVS resistance of the cultivars: r resistant; mr medium resistant; nr no resistant. Abbreviations for the colours:W white; WY white yellow; C cream; LY light yellow; Y yellow; DY dark yellow; R red; B blue.

The results obtained are comparable to those previously in the literature, where TPC ranged between 1.56 to 12.9 and 0.54 to 3.59 mg GAE g-1 DW for skin and flesh respectively (Valcarcel *et al.*, 2015), 1.4 to 2.4 mg GAE g-1 DW for flesh (Cornacchia *et al.*, 2011),0.92 to

12.37mg GAE g⁻¹ DW for whole tubers (Andre et al., 2006; Xu *et al.*, 2009) and 1.00 to 4.3 mg GAE g⁻¹ DW for skin (Kahkonen *et al.*, 1999; Makris *et al.*, 2007).

Although some other vegetables have higher TPC than potatoes, in many countries the potatoes are consumed in higher quantities making them an important contributor to daily dietary intake of phenolic compounds. A study in USA reported that potatoes the third major source of phenolics in the diet, after oranges and apples, with an average consumption of 171 g day⁻¹ Chun *et al.*, 2005).

Results concerning the influence of tuber pigmentation on TPC are presented in Figure 1.

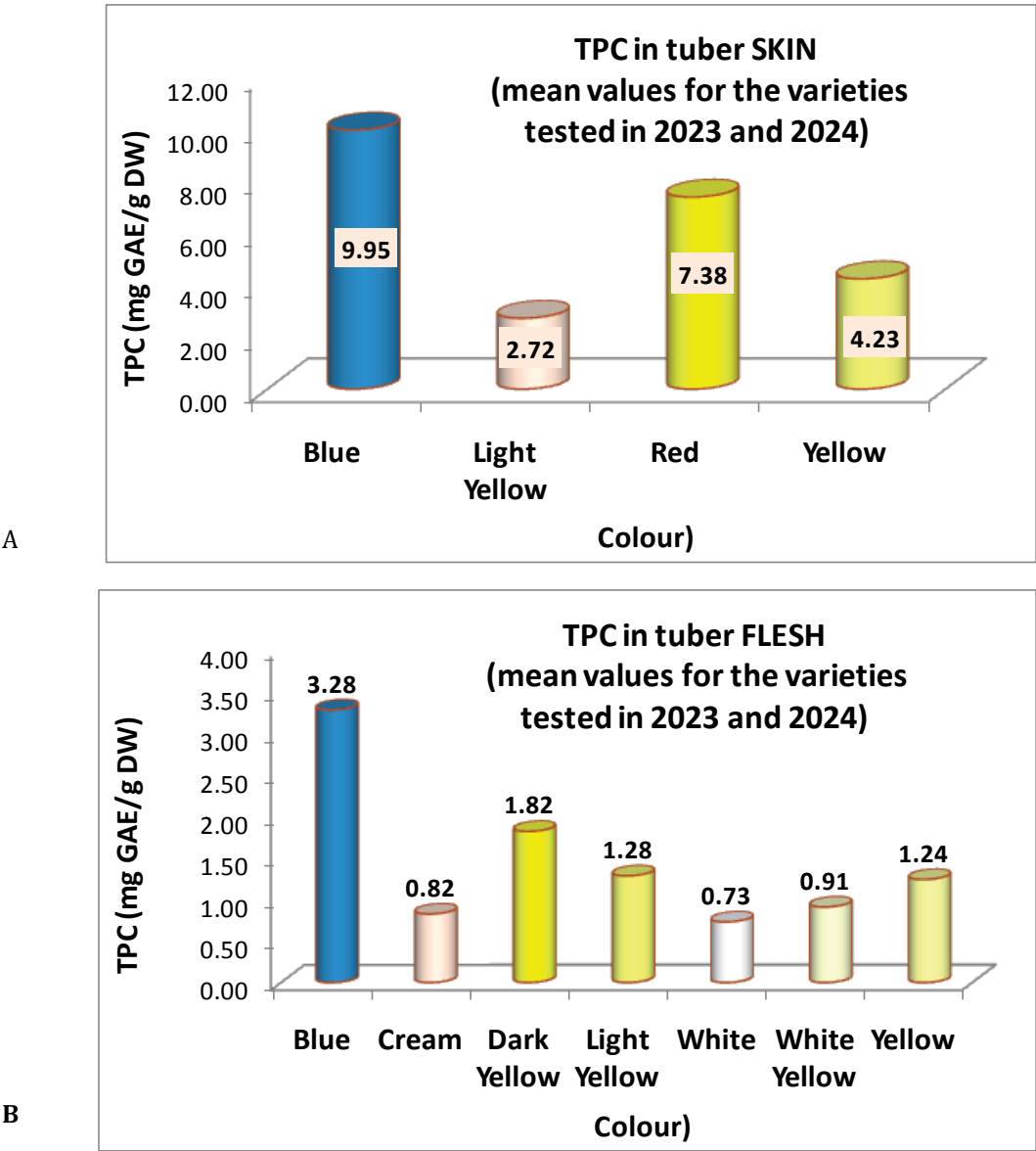


Figure 1. Mean total phenolic content (TPC) in relation to tuber skin colour (A) and flesh colour (B), based on mean values of samples collected in 2023 and 2024.

**Cultivars included resistant, medium-resistant and non-resistant variants to Potato Virus S (PVS). Abbreviations: TPC = total phenolic content; DW = dry weight.*

The tubers with blue skin had the highest TPC values. These values were significantly different compared to all other colors except red-skinned cultivars. Similarly, cultivars with blue flesh recorded the highest TPC values, significantly higher than those of all other flesh

color groups. The increased TPC values in blue and red tissues can be attributed to the presence of anthocyanins (Andre *et al.*, 2008), pigments known for their strong antioxidant potential. Previous studies also reported strong associations between phenolic composition and antioxidant activity in coloured potato cultivars (Andre *et al.*, 2006; Hu *et al.*, 2012; Reyes *et al.*, 2005; Valcarcel *et al.*, 2015), highlighting phenolic and flavonoid compounds as major contributors to antioxidant capacity.

Various reserchers have reported variation in total phenolic content in 297 potato cultivars ranging from 0.2 to 580 mg/FW, wich provides breeders a huge opportunity to incorporate this beneficial treit into popularly consumed cultivars (Pryia *et al.*, 2023). In the same time, enhancing the concentration of chlorogenic acid (the major phenolic compound in potatoes) becomes important in lowering the glicemic index value of potatoes (Salma *et al.*, 2020) wich is a major concern in their consumption.

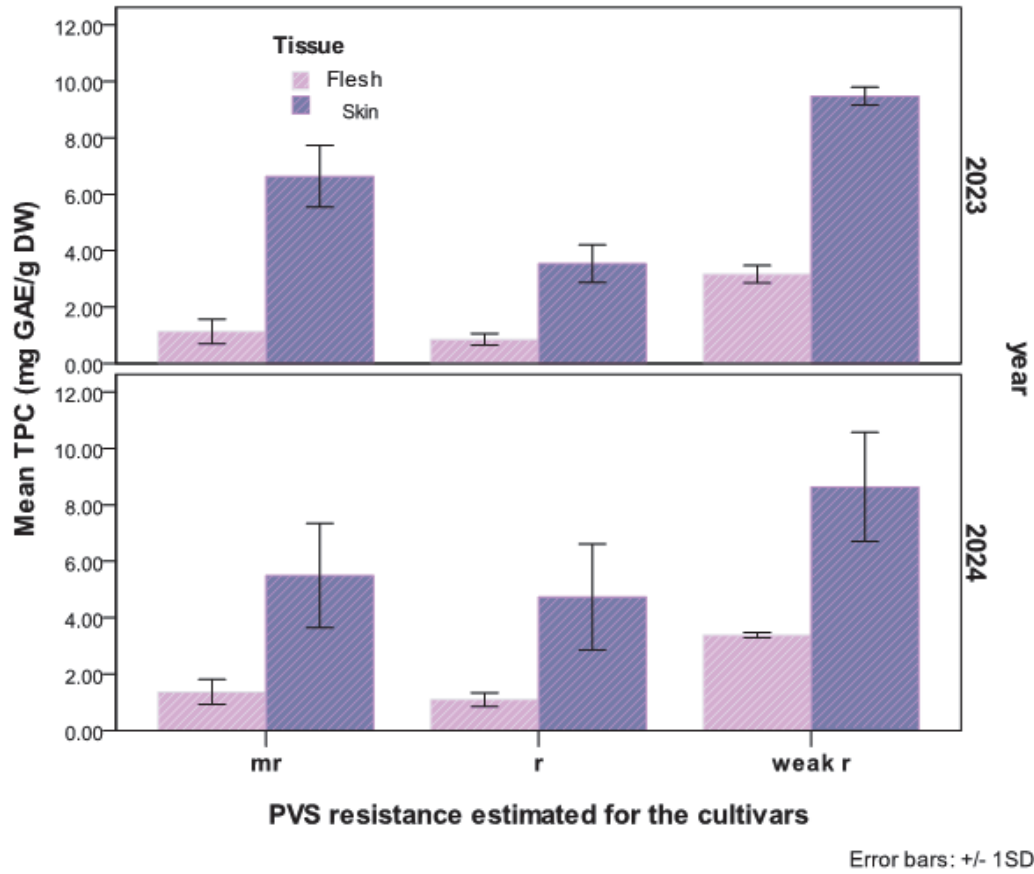


Figure 2. Mean total polyphenols content (TPC) according to the PVS resistance estimated for the cultivars tested. Abbreviations: PVS = Potato Virus S; mr = medium-resistant; r = resistant; weak r = non-resistant.

The nutritional relevance of potatoes could be further enhanced if cultivars with naturally higher. TPC level become more widely adopted by consumers. However, the cv. ‘Blue Purple of Galanesti’-which reported the higher TPC value in both skin and flesh in the present study, is less preferred due to its small, elongated tubers with deep eye. Future breeding programs may address these morphological limitations to combine improved nutritional potential with desirable consumer traits.

Tubers grown in Brasov in 2024 showed higher average TPC than those grown in 2023. Similar to previous reports, potato skin proved to be a rich source of polyphenol, as nearly

50% of phenolic these compounds are located in the peel and adjacent tissues (Albishi *et al.*, 2013; Al-Weshahy *et al.*, 2009).

The mean TPC was generally higher in tubers collected in 2024 compared to 2023. Based on climatic conditions recorded during the growing seasons (Table 1), 2024 was slightly warmer, particularly in June–August, which may have influenced phenolic accumulation, as early tuber development stages are considered critical for biosynthesis. In the present study, deeply pigmented cultivars displayed high TPC values; however, most of these were classified as medium-resistant to PVS (Foresta, Azaria, Cosiana) or non-resistant (AVG), as shown in Table 2 and Figure 2.

Significant interactions between year and cultivar and tissue were also found (Table 3).

Table 3. Effects of the tested factors and their interactions on TPC

Variables /Interactions between variables	ANOVA p values
Year	< 0.01
Cultivar	0.169
Tissue	0.205
Replicate (year)	0.269
<i>Year x cultivar</i>	< 0.01
Year x tissue	0.504
<i>Cultivar x tissue</i>	< 0.01

This suggests that evaluation of TPC across years may be more important than evaluation across PVS resistance of the cultivar, which should be confirmed by further field trials considering a wider cultivar of cultivars and over more than 2 years. A cultivar of factors can influence variation of TPC between the structure to climatic conditions or pressure from pests or pathogens.

CONCLUSIONS

Ten Romanian potato cultivars with different resistance to potato virus S, cultivars with different color of the skin and flesh tissue (grown in Brasov two years) were analyzed for estimation their total polyphenols content. The results obtained were in the range of values reported in the literature.

Significant differences between the different cultivars tested were observed for TPC. Higher contents of antioxidants (polyphenols) were found in intense colored fleshed tubers than in white counterparts, which should allow visual selection of cultivars with enhanced levels of these compounds.

So, the genotype “Blue Purple of Galanesti” with blue skin and flesh had higher values of total polyphenols content, but this cultivar is non-resistant to PVS.

Potato consumption has a great importance in population’s food and this study offers preliminary information to researchers and producers on the level of some phytochemicals such polyphenols, antioxidants with functional properties.

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