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PHENOLIC COMPOSITION OF WILD BLUEBERRIES AND WILD CRANBERRIES HARVESTED IN ROMANIA

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Abstract

Wild berries from spontaneous flora represent valuable plant resources due to their high content of phenolic compounds. The objective of this study was to determine the total phenolic content of wild blueberries (Vaccinium myrtillus L.) and cranberries (Vaccinium vitis-idaea L.) collected from different natural habitats in Romania, Cluj County. Total phenolic content was evaluated using spectrophotometric methods and expressed as mg gallic acid equivalents. The results revealed distinct differences between the two species. Blueberries showed the highest phenolic levels, with maximum concentrations of approximately 1154 mg GAE/100 g of plant material, whereas cranberries presented lower maximum values, reaching about 624 mg GAE/100 g. The findings underline the importance of Romanian wild blueberries and cranberries as natural sources of phenolic compounds and support their potential use in agriculture, food, and nutraceutical applications.

Key words*: wild berries, Vaccinium myrtillus, Vaccinium vitis-idaea, total phenolic content, antioxidant activity.*

INTRODUCTION

Wild berries from spontaneous flora have attracted increasing scientific interest due to their high content of bioactive compounds and their associated health benefits (Nowak et al., 2022; Nemzer et al., 2022; Giovanelli et al., 2009). Among these, species of the genus *Vaccinium*, including *Vaccinium myrtillus* L. (wild blueberry) and *Vaccinium vitis-idaea* L. (wild cranberry), are recognized as important sources of polyphenolic compounds with strong antioxidant properties (Ștefănescu et al., 2020).
Polyphenols represent a diverse class of secondary metabolites involved in plant defense mechanisms against environmental stress factors such as ultraviolet radiation, pathogens, and oxidative stress. These compounds are widely studied due to their antioxidant capacity and their role in reducing oxidative stress and inflammation in biological systems (Bernal-Gallardo et al., 2022; Goławska et al., 2023).
Both wild blueberries (*Vaccinium myrtillus* L.) and cranberries (*Vaccinium vitis-idaea* L.) are characterized by a complex phytochemical composition, being rich in phenolic acids, flavonoids, and anthocyanins (Neuenfeldt et al., 2022; Nowak et al., 2022). Wild blueberries (*Vaccinium myrtillus* L.) are particularly known for their high anthocyanin content, which contributes to their strong antioxidant activity and potential health benefits, including cardiovascular and neuroprotective effects (Bunea et al., 2011; Hein et al., 2021). In contrast, cranberries (*Vaccinium vitis-idaea* L.) have a different phenolic profile, characterized by higher levels of proanthocyanidins and phenolic acids, which also contribute to their biological activity (Heiss et al., 2022; Gudžinskaitė et al., 2020; Šedbarė et al., 2022).
The phenolic composition of these berries is influenced by multiple factors, including geographical origin, environmental conditions, altitude, and genetic variability. Consequently, significant differences may occur in both the qualitative and quantitative profiles of polyphenols, even within the same species (Ciulca et al., 2021; Dyukaryeva & Mallik, 2023; Aliman et al., 2020).

Although both blueberries and cranberries have been extensively studied individually, comparative analyses of their phenolic content, especially in relation to specific geographical regions, remain limited. This highlights the importance of investigating these species together in order to better understand their phytochemical variability and potential applications.

Romania represents a favorable environment for the growth of wild *Vaccinium* species due to its diverse climatic and geographical conditions, particularly in mountainous and subalpine regions. Previous studies have shown that wild berries collected from Romanian habitats exhibit significant variability in phenolic content and antioxidant activity depending on environmental conditions and location (Ciulca et al., 2021; Ștefănescu et al., 2020; Bunea et al., 2011; Brad et al., 2025).

However, despite the abundance of wild berry resources, data regarding the comparative phenolic composition of wild blueberries and cranberries from Romanian natural habitats remain limited. Therefore, the evaluation of total phenolic content in these species is of significant scientific and practical interest (Brad et al., 2025).

The aim of the present study is to determine and compare the total phenolic content of wild blueberries (*Vaccinium myrtillus* L.) and wild cranberries (*Vaccinium vitis-idaea* L.) collected from natural habitats in Romania and to assess their potential as sources of bioactive compounds.

MATERIALS AND METHODS

Sampling collection

Wild blueberries (*Vaccinium myrtillus* L.) and wild cranberries (*Vaccinium vitis-idaea* L.) were collected from five natural locations in Romania, Cluj County: Vlădeasa Mountain, Boaică (B), Pârâul Leucii (PL) and Poiana Horea (PH). In the case of Vlădeasa Mountain, two distinct sampling points were selected, corresponding to different altitudinal zones, namely Vlădeasa Răzoare (VR) and Vlădeasa Sus (VS). The sampling locations map is described in Figure 1.

The sampling sites were located at altitudes ranging between 700 and 1400 m. Fully ripened fruits were manually harvested, as shown in Figure 2, during the harvesting seasons of 2024 and 2025.



Figure 1. Map of sampling locations



Figure 2. Manual collection of wild cranberry and wild blueberry samples

After collection, the samples were placed in clean containers and transported to the laboratory under refrigerated conditions to minimize biochemical degradation. Prior to analysis, the samples were processed immediately or stored at 4°C for a short period. The samples were coded as described in Table 1.

Table 1. Coding of the collected samples

Sample	Meaning
MVSA24	Cranberry samples collected from Vlădeasa Sus in August 2024
MVSS24	Cranberry samples collected from Vlădeasa Sus in September 2024
MVRA24	Cranberry samples collected from Vlădeasa Răzoare in August 2024
MVRS24	Cranberry samples collected from Vlădeasa Răzoare in September 2024
MB24	Cranberry samples collected from Boaică in 2024
MPL25	Cranberry samples collected from Pârâul Leucii in 2025
MVS25	Cranberry samples collected from Vlădeasa Sus in 2025
MVR25	Cranberry samples collected from Vlădeasa Răzoare in 2025
AB24	Blueberry samples collected from Boaică in 2024
AV24	Blueberry samples collected from Vlădeasa in 2024
AVR25	Blueberry samples collected from Vlădeasa Răzoare in 2025
AVS25	Blueberry samples collected from Vlădeasa Sus in 2025
APH25	Blueberry samples collected from Poiana Horea in 2025

Total Phenolic Content Determination

Total phenolic content (TPC) in wild blueberries (*Vaccinium myrtillus* L.) and wild cranberries (*Vaccinium vitis-idaea* L.) was determined using a modified Folin-Ciocalteu colorimetric method.

Fresh berry samples were collected from natural habitats and manually homogenized using a mortar and pestle prior to analysis.

For phenolic extraction, approximately 1 g of fresh homogenized sample was mixed with 10 mL of 60% ethanol. The mixture was subjected to maceration for 24 h, followed by incubation in a water bath for 3 h. The extracts were then cooled, filtered, and stored at 4°C until further analysis.

Subsequently, the extracts were centrifuged at 4000 rpm for 10 min, and the supernatants were collected for analysis.

An aliquot of 0.1 mL of extract was mixed with 1.4 mL of distilled water and 0.1 mL of Folin-Ciocalteu reagent. After 3 min of incubation, 0.4 mL of sodium carbonate (Na_2CO_3) solution was added. The reaction mixture was then incubated for 60 min at 25°C in the dark to allow color development.

The absorbance was measured at 765 nm using a UV-Vis spectrophotometer (Predescu et al., 2016).

Total phenolic content was calculated using a calibration curve based on gallic acid and expressed as mg gallic acid equivalents per gram of fresh weight (mg GAE g^{-1} FW) (Figure 3).

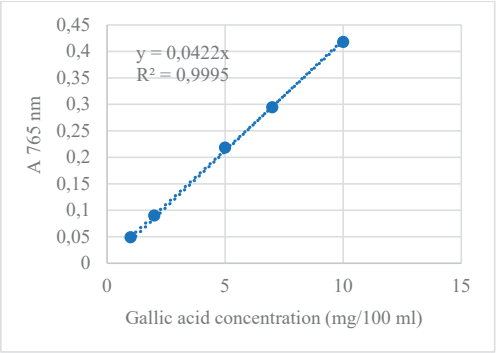

Figure 3. Gallic acid calibration curve used for the determination of the total phenolic content

Statistical Analysis

Statistical analysis was performed using MedCalc® statistical software version 23.4.9 (MedCalc Software Ltd., Ostend, Belgium). All measurements were carried out in triplicate, and the results are expressed as mean ± standard deviation. The normality of data distribution was assessed using the Shapiro-Wilk test, while the homogeneity of variances was evaluated using Levene's test. Since the assumptions for parametric analysis were not met ($P < 0.05$), non-parametric tests were applied. Differences between multiple samples were evaluated using the Kruskal–Wallis test followed by Conover post-hoc comparisons. Differences between wild blueberry and wild cranberry samples were assessed using the Mann-Whitney U test. Statistical significance was considered at $P < 0.05$.

RESULTS AND DISCUSSIONS

Total Phenolic Content of Wild Blueberry and Wild Cranberry

Assessing the phytochemical profile of wild berries is essential for understanding their biological activity and potential applications. Among the various bioactive constituents, phenolic compounds are of particular interest due to their strong antioxidant properties. In this context, the total phenolic content (TPC) of wild blueberries (*Vaccinium myrtillus* L.) and wild cranberries (*Vaccinium vitis-idaea* L.) was determined to provide a comparative evaluation of their antioxidant-related characteristics.

Using the Folin-Ciocalteu method, the total phenolic content (TPC) of wild blueberries (*Vaccinium myrtillus* L.) and wild cranberries

was determined and expressed as mg GAE/100 g fresh weight.

The mean phenolic concentrations of wild cranberry samples ranged from 382.99 to 546.02 mg GAE/100 g, while wild blueberry samples ranged from 491.67 to 1047.45 mg GAE/100 g. In wild cranberries, the lowest mean value was recorded for MVSS24 samples (382.99 ± 2.53 mg GAE/100 g), while the highest phenolic content was observed in MPL25 samples (546.02 ± 3.89 mg GAE/100 g). In wild blueberries, the lowest value was observed in AVS25 samples (491.67 ± 3.30 mg GAE/100 g), while the highest concentration was recorded for AB24 samples (1047.45 ± 7.16 mg GAE/100 g).

Table 2. Mean concentration and standard deviation for total phenolic content (mg GAE g^{-1}) of wild cranberries (*Vaccinium vitis-idaea* L.) samples

Cranberry Samples	Mean TPC (mg GAE /100 g fruit)
MVSA24	419.96bc+2.69
MVSS24	382.99c+2.53
MVRA24	412.16bc+2.67
MVRS24	457.71bc+3.21
MB24	439.18c+2.69
MPL25	546.02a+3.89
MVS25	475.32bc+3.26
MVR25	473.87b+3.22

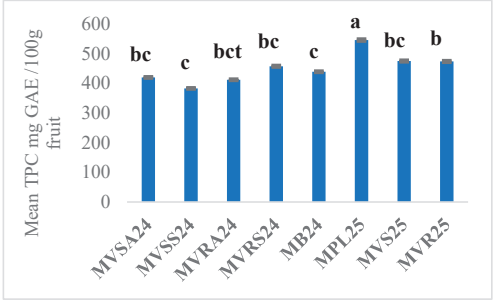

Figure 4. Total polyphenol concentrations in fresh cranberries (*Vaccinium vitis-idaea* L.)

Statistical analysis was performed using MedCalc software. The distribution of the data was assessed using the Shapiro-Wilk test, which indicated a deviation from normality ($P<0.05$), while Levene's test showed heterogeneity of variances ($P<0.001$). Therefore, non-parametric tests were applied.

For wild cranberries, significant differences in total phenolic content were observed depending on location, as indicated by the Kruskal-Wallis test ($P=0.000002$). Post-hoc analysis revealed that certain samples exhibited significantly higher phenolic concentrations, suggesting a strong influence of environmental conditions.

Table 3. Mean concentration and standard deviation for total phenolic content (mg GAE g^{-1}) of wild blueberries samples (*Vaccinium myrtillus* L.)

Blueberry Samples	Mean TPC (mg GAE /100 g fruit)
AB24	1047.45a+7.16
AV24	963.58a+7.23
AVR25	609.92b+4.06
AVS25	491.67b+3.3
APH25	581.01b+4.47

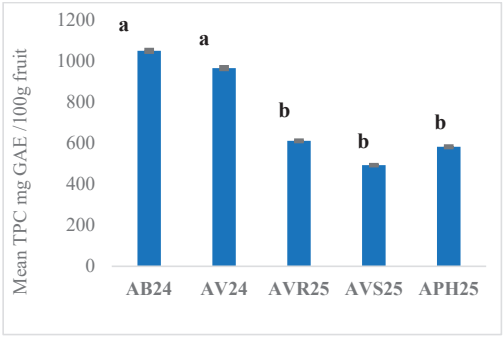

Figure 5. Means for total phenolic content in 100 g fresh blueberries (*Vaccinium myrtillus* L.)

Similarly, in wild blueberries, the Kruskal-Wallis test showed significant differences between samples collected from different locations ($P=0.000856$), confirming variability in phenolic content depending on habitat.

When comparing the two species, the Mann–Whitney U test revealed a statistically significant difference in total phenolic content ($P < 0.0001$), with wild blueberry (*Vaccinium myrtillus* L.) samples exhibiting higher phenolic concentrations than wild cranberry samples.

These findings indicate that both species and environmental conditions significantly influence phenolic accumulation. The higher phenolic content observed in wild blueberries (*Vaccinium myrtillus* L.). may be associated with species-specific metabolic characteristics and their enhanced capacity for phenolic biosynthesis.

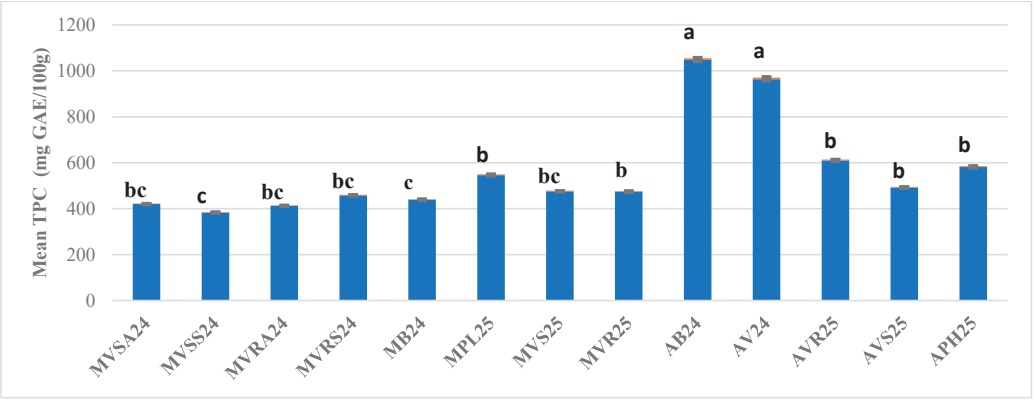

Figure 6. Means for total phenolic content in 100g fresh weight cranberries (*Vaccinium vitis-idaea* L.), respectively wild blueberries (*Vaccinium myrtillus* L.)

CONCLUSIONS

The present study demonstrated that both wild blueberries (*Vaccinium myrtillus* L.) and wild cranberries (*Vaccinium vitis-idaea* L.) represent valuable natural sources of phenolic compounds. However, clear differences in total phenolic content were observed between the two species as well as between sampling locations.

Wild blueberry samples exhibited higher total phenolic concentrations, ranging from 491.67 to 1047.45 mg GAE/100 g, while wild cranberry samples showed lower values, ranging from 382.99 to 546.02 mg GAE/100 g. These results confirm that wild blueberries have a greater capacity for phenolic accumulation compared to wild cranberries.

Significant variability in phenolic content was observed among samples collected from different locations, indicating that environmental factors such as altitude and habitat conditions play an important role in influencing phenolic concentration.

Statistical analysis confirmed the presence of significant differences both between samples from different locations and between the two species ($P < 0.05$), highlighting the impact of both species-specific characteristics and environmental conditions on phenolic accumulation.

Overall, the findings emphasize the importance of wild *Vaccinium* species as natural sources of phenolic compounds and support their potential use in food, agricultural, and nutraceutical applications.

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