MACRO AND MICRO ELEMENTS IN SPONTANEOUS FLORA MUSHROOMS FROM THE TRANSYLVANIAN REGION

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Abstract. *The use of edible mushrooms from the spontaneous flora can help complete food diets being considered important sources of micronutrients with positive effects on human health. The identification of the nutritional status of the mushrooms from the Transylvanian area involves identification of species, environmental factors, and qualitative and quantitative physico-chemical mushrooms' traits. The purpose of the research is to determine Ca and K macroelements and As, Cu, Fe, Mn, and Zn microelements occurence in mushrooms from a specific area, to provide a picture of their macro-and microelemental nutritional status. The samples considered for the analysis consisted of two species of mushrooms Boletus edulis Bull. (boletus) and Cantharellus cibarius Fr. (chanterelle mushrooms) and determinations of mineral elements were performed using an ElvaX Mobile - a portable Energy Dispersive - X-Ray Fluorescence (ED-XRF) analyzer. The results of the study revealed that potassium was the most abundant macro element (in average concentration of 25.92 g/kg) in Boletus edulis Bull. followed by calcium. The same trend was recorded in the case of Cantharellus cibarius Fr. samples. Among the microelements, Fe tended to be most abundant in both mushrooms' species. The main idea derived from the research carried out is that wild-grown mushrooms are natural food resources, which must be valued due to their flavor and taste on one hand and to their high mineral content on the other hand.*

***Keywords**: Boletus edulis Bull., Cantharellus cibarius Fr., nutritional status*

INTRODUCTION

Utilizing edible mushrooms from the natural environment can contribute to enhancing dietary diversity, as these mushrooms are recognized as valuable sources of micronutrients that positively impact human health (Bal, 2018; Siwulski et al., 2014). It is well known that edible mushrooms are nutritional sources rich in proteins, and for this reasons higly appreciated as food. These mushrooms have gained recognition as a valuable and healthful dietary choice, thanks to their substantial nutritional content comprising proteins, vitamins, and minerals. This has contributed to their growing global consumption. Furthermore, mushrooms are prized for their bioactive compounds, demonstrating potential in the prevention and treatment of serious diseases (Grangeia et al., 2011: Kele; et al., 2011).

The pollutants stemming from human activities disrupt the ecological balance, affecting the homeostasis of the ecosystem, affecting the plants in general, and mushrooms in particular (Huang et al., 2015; Murati et al., 2019). The accumulation of heavy metals in mushrooms is influenced by two primary factors: environmental factors and those associated with fungi intrinsec structure (GEBEYEHU et al., 2016; Liu et al., 2015; Semreen and Aboul-Enein, 2011). Various elements contribute to the concentration of heavy metals in mushrooms, such as changes in the physiology of different mushroom types, the sample's location, the mineral composition of the soil, metal uptake, the distance from the contamination source, etc. (Yildiz et al., 2019).

Assessing the nutritional composition of mushrooms in the Transylvanian region requires examining species identification, environmental factors, and various physico-chemical traits of mushrooms, both qualitatively and quantitatively (Sarikurkcu et al., 2020). The research aims to ascertain the presence of macroelements such as calcium (Ca) and potassium

(K), and microelements represented by arsenic (As), copper (Cu), iron (Fe), manganese (Mn), and zinc (Zn) in mushrooms specific to the area, to offer insights into the macro- and microelemental nutritional profile of these mushrooms in the designated region.

MATERIAL AND METHODS

The research was carried on during the fall of 2023 (September, October). The limitroph area of forest from souroundings of Figa location (47°08'23''N; 24°12'39"E), Bitrița-Năsăud County, located in proximity of local roads, was the sampling site. Two mushroom species from the spontaneous flora were identified and collected, *Boletus edulis* Bull. (boletus) and *Cantharellus cibarius* Fr. (chanterelle mushrooms), respectively. The samples were conditioned in the Laboratory of the Environmental Protection and Climatic Changes of UASVM Cluj-Napoca. Dry matter (DM) determination was done using the gravimetric method (Șara and Odagiu, 2005), with Radwak (UK) analytical balance, and furnace (Nabertherm, Germany). Macroelements (Ca and K), and microelements were quantified from mushroom matrices using the X-ray fluorescence methodology, using Elvatech (Ukraina) ElvaX Mobile - portable Energy Dispersive - X-Ray Fluorescence (ED-XRF) spectrometer. Ten replicates were useed for each analysis. Statistical interpretation was performed using STATISTICA for Windows v.8.0. Basic statistics, Pearson simple correlations, response area graphics, and multiple correlations algoritms were used.

RESULTS AND DISCUSSIONS

The potassium average amounts are almost three times higher in *Cantharellus cibarius* Fr. (chanterelle mushrooms) compared with *Boletus edulis* Bull. (boletus), while calcium are two folds bigger (Table 1).

Arsenic was identfied only in boletus (4.18 mg/kg), but Cu, Fe, Mn, and Zn were identified in both analyzed species. Significant differences are reported between Cu, Mn and Zn contents identified in boletus and chanterelle mushrooms, while between Fe contents, no significant differences are observed. Fe and Zn are present in higher amounts in boletus, while Cu, and Mn in chanterelle mushrooms. Both mushrooms species present homogenous macro and microlemental content (CV<30%).

Table 1

The basic statistics for macro-elements (Ca and K) and microelements content in *Boletus edulis* Bull. and *Cantharellus cibarius* Fr.

Issue	*Boletus edulis* Bull.			*Cantharellus cibarius* Fr.			Limits	References
	n	$X \pm s_X$	CV%	n	$X \pm s_X$	CV%		
DM, %	10	12.17±1.13	4.36	10	7.35±0.99	5.32	-	-
Ca, g/kg	10	0.52a±0.06	25.07	10	1.10b±0.96	19.55	-	-
K, g/kg	10	25.92d±9.65	8.33	10	67.12e±2.88	9.60	-	-
As, mg/kg	10	4.18c±0.45	24.07	10	-	-	0,1 mg/kg	WHO, 1989
Cu, mg/kg	10	75.80e±4.03	11.89	10	87.60f±0.51	1.30	73,30 mg/kg	WHO, 1989
Fe, mg/kg	10	289.80g±21.34	16.47	10	287.40g±3.94	3.07	425,50 mg/kg	WHO, 1989
Mn, mg/kg	10	26.80±2.08	17.38	10	34.40±1.97	12.77	500 mg/kg	GEBEYEHU and BAYISSA, 2020
Zn, mg/kg	10	162.20i±2.97	4.10	10	136.40j±2.04	3.34	99,40 g/kg	WHO, 1989

Values over admitted limits are observed for arsenic. Cu and Zn contents over admitted limits are seen in both species. Similar concentration of Fe are reported by Gebrelibanos et al., 2016 in Pleurotus sp. (220.87 mg/kg, and 243.92 g/kg, respectively), while other researches show lower concentrations in the same species. Yadav et al. (2020) identified 88,24 mg/kg, and 84,84 mg/kg respectively, and Tuzen et al. (1998) found a content of 48.60 mg/kg. In the same species Gebrelibanos et al., 2016 identified lower Cu and Zn concentrations (53.56 mg/kg, and 89.68 mg/kg, respectively), but higher mg content (47.55 mg/kg). An et al. (2020) identified in a study performed in Korea, in ten mushroom species, lower As contents (which ranged between 0.006 mg/kg to 3.9 mg/kg dry weight) compared with the content we reported in our study in boletus. Lower Cu (48.09 mg/kg), Fe (59.76 mg/kg), and Zn (130.43 mg/kg) concentrations in different mushroom species are reported by Dowlati et al. (2021) as result of a bibliographical study, compared to results of our research.

Simple positive correlation of average intensity (R = 0.411) is observed between calcium and potassium contents in boletus, representative in proportion of 16.80%, described by the regression line (Fig. 1). In chanterelle mushrooms, also positive moderate correlation is observed between potassium and calcium, but of lower intesity (R = 0.355) compared to the one reported in boletus (Fig. 2).

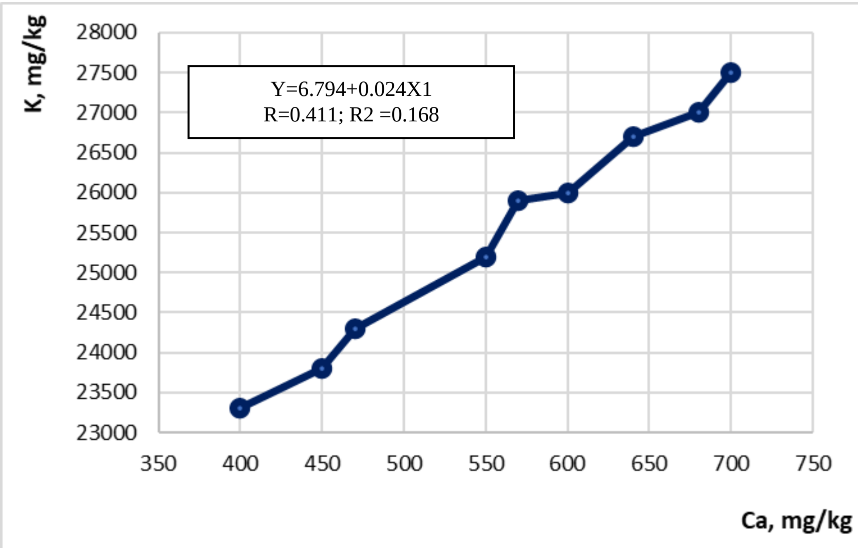


Figure 1.The simplecorrelation between Ca and K content in *Boletus edulis* Bull.

The multiple correlations between macroelements (Ca and K) content on one side and identified microelements on the other side are of different intensities. A moderate multiple correlation (R=0.700) is observed between Ca, K, and As.The biggest As content of 5.30 mg/kg is observed in boletus when Ca content increases from 350 mg/kg to 750 mg/kg, and K content decrease from 29,000 mg/kg to 27,000 mg/kg (Fig. 3a). Moderate multiple correlations may be observed between Ca, K, Cu (Fig.3b, R=0.473), and Zn (Fig. 3e, R=0.490). The highest Cu content in boletus (86 mg/kg) is reported when Ca concentration increases from 550 mg/kg to 750 mg/kg, and K concentration decrease from 29,000 mg/kg to 25,500 mg/kg (Fig. 3b), while the Zn conntent records the highest value (170 mg/kg), when Ca content increases from 600 mg/kg to 750 mg/kg, and K content decreases from 29,000 mg/kg to 23,000 mg/kg (Fig. 3e).

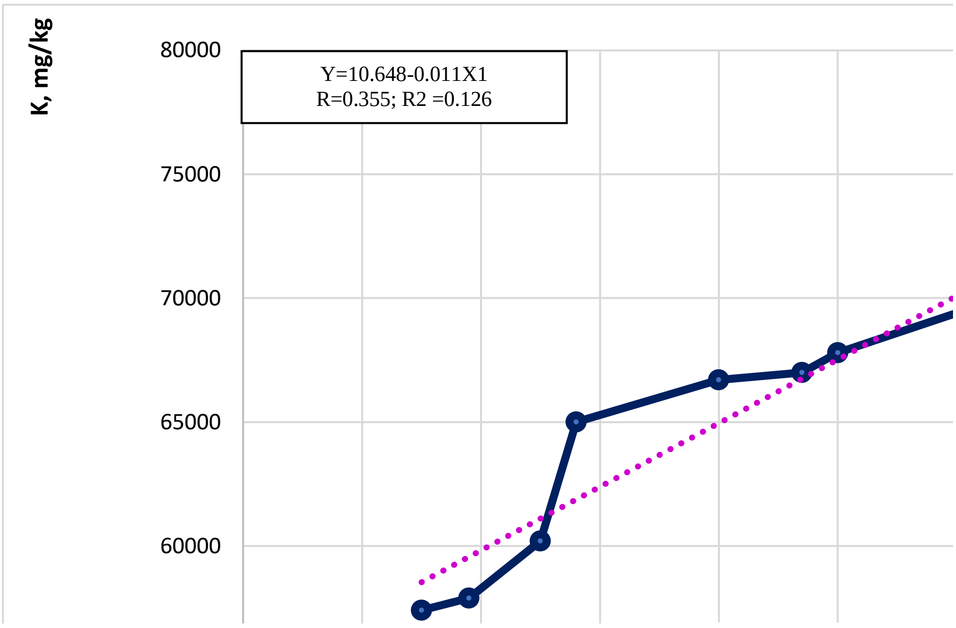
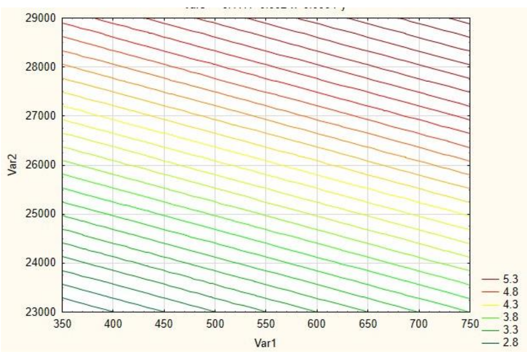
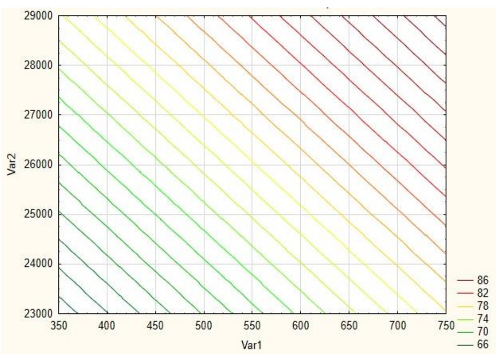


Figure 2.The simple correlation between Ca and K content in *Cantharellus cibarius* Fr.

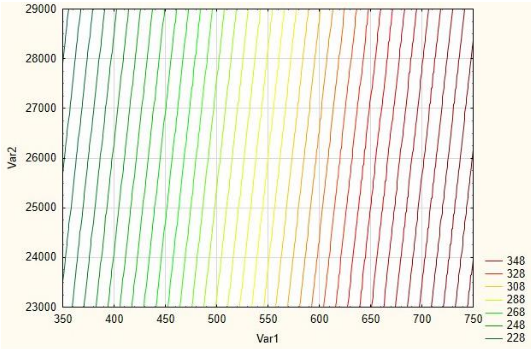
Very strong multiple correlations are observed between macroelements (Ca and K), Fe (Fig.3c, R=0.972), and Mn (Fig. 3d, R=0.993). According to our study, the highest Fe and Mn contents (348 mg/kg, and 37 mg/kg, respectively) are observed when Ca content increase from 600 mg/kg to 750 mg/kg, while K content increase from 67.000 mg/kg to 70,000 mg/kg (Fig. 3c, and Fig. 3d, respectively).



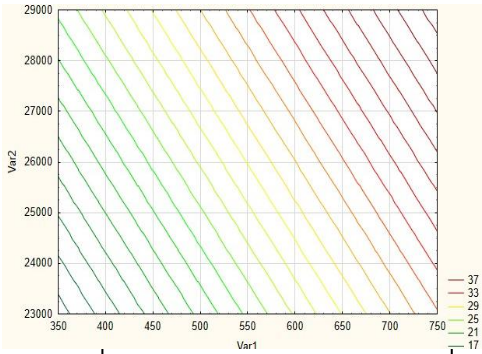


a.Y1=6.111+0.260X1-0.765X2
R=0.700; R^2 =0.490

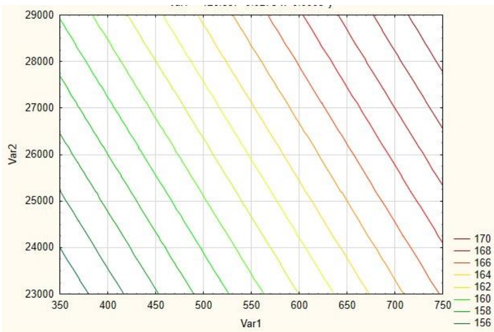
b.Y2=14.263+0.4520X1-0.418X2
R=0.473; R^2 =0.224



c.Y3=159.107+0.932X1+0.082X2
R=0.972; R^2 =0.944



d.Y4=-26.522+1.075X1-0.596X2
R=0.993; R^2 =0.986

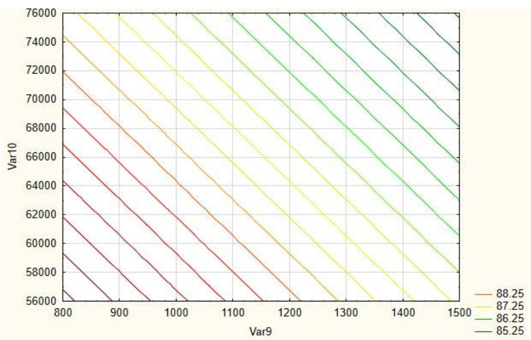


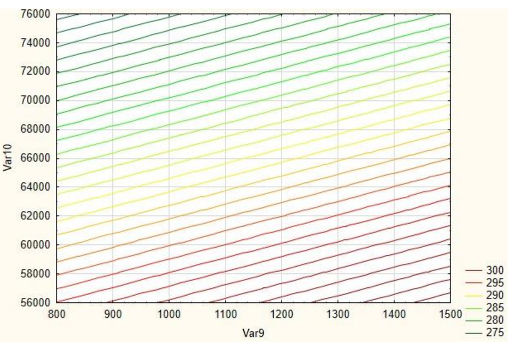
e.Y5=126.887+0.535X1-0.264X2
R=0.490; R^2 =0.241

X1, Var 1-Ca content; X2, Var 2-K content; Y1-multiple correlation between Ca, K and As; Y2-multiple correlation between Ca, K and Cu; Y3-multiple correlation between Ca, K and Fe; Y4-multiple correlation between Ca, K and Mn; Y5-multiple correlation between Ca, K and Zn; R-coefficient of correlation; R^2-coefficient of determination.

Figure 3.The interaction between maco- and microelements content in *Boletus edulis* Bull.

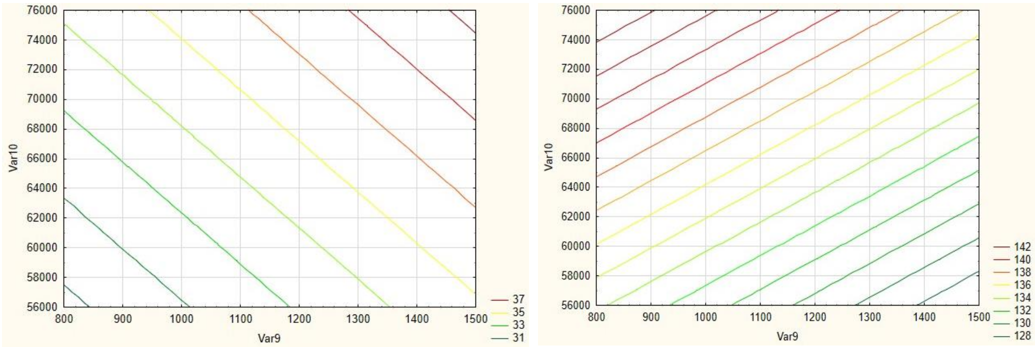
Strong multiple correlations are identified in chanterelle mushrooms between macroelements (Ca and K) contents on one side and Cu (Fig. 4a, R=0.730), Fe (Fig. 4a, R=0.914), and Zn (Fig. 4d, R=0.860) on the other hand. The biggest Cu content of 88.25 mg/kg is observed in boletus when Ca content increases from 800 mg/kg to 1150 mg/kg, and K content decrease from 70,000 mg/kg to 66,000 mg/kg (Fig. 4a). The biggest Fe content in chanterelle mushrooms (300 mg/kg) is reported when Ca concentration increases from 800 mg/kg to 1,500 mg/kg, and K concentration decrease from 66,000 mg/kg to 56,000 mg/kg (Fig. 4b), while the Zn conntent records the highest value (142 mg/kg), when Ca content increases from 800 mg/kg to 1,150 mg/kg, and K content increases from 67,000 mg/kg to 70,000 mg/kg (Fig. 4d). A weak to moderate correlation is seen between Ca, K and Mn contents (Fig. 4, R=0.309). The highest Mn content (37mg/kg) seen when Ca content increase from 800 mg/kg to 1,500 mg/kg, while K content decrease from 76.000 mg/kg to 69,000 mg/kg (Fig. 4c).





Y=98.390-0.708X1-0.60X2
R=0.730; R^2 =0.534

Y=347.317+0.268X1-0.783X2
R=0.914; R^2 =0.835



Y=16.491+0.287X1+0.251X2
R=0.307; R^2 =0.094

Y=116.732-0.417X1+0.618X2
R=0.860; R^2 =0.740

X1, Var 9-Ca content; X2, Var 10-K content; Y1-multiple correlation between Ca, K and Cu; Y2-multiple correlation between Ca, K and Fe; Y3-multiple correlation between Ca, K and Mn; Y4-multiple correlation between Ca, K and Zn; R-coefficient of correlation; R^2-coefficient of determination.

Figure 4.The interaction between maco- and microelements content in *Cantharellus cibarius* Fr.

CONCLUSIONS

The analysis of potassium and calcium content in chanterelle and boletus mushrooms reveals differences between the two species. Chanterelle mushrooms exhibit potassium levels nearly three times higher and calcium levels twice as large compared to boletus. Furthermore, arsenic is exclusive to boletus, while Cu, Fe, Mn, and Zn are identified in both species. Significant variations are observed in the levels of Cu, Mn, and Zn between both mushrooms, while no significant differences are noted in Fe content. In both mushroom species ca and k area moderately correlated.

Differences are reported between analyzed mushrooms species concerning the multiple correlations between Ca and K on one hand, and studied microelements on the other hand. Our study underscores the distinct mineral profiles of these mushrooms, providing valuable insights into their nutritional composition and potential dietary benefits.

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