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TESTING THE MACRONUTRITIONAL POTENTIAL OF SOME WILD BERRY SPECIES IN RELATIONSHIP WITH CLIMATIC CONDITIONS

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Abstract. *It is well known that wild berries are valuable sources of nutrients, and their consumption has positive effects on human health status. They are considered as sources of phytonutrients that are thought to have, mainly to their antioxidant activity, both curative and preventive effects against a wide range of diseases. This study was conducted for quantifying the macronutrients content of four species of wild berries: Rubus idaeus L., Ribes nigrum L., Vaccinium vitis-idaea L. and Vaccinium myrtillus L., and for identifying the influence of specific climatic conditions of the harvesting area on their dry matter content. Fruits were colected from Sovata area, Cluj County, Romania, and analysis were performed in the Laboratory of the Department of Environmental Engineering and Protection, of UASVM Cluj-Napoca. Our study shows that in concerned area black currant and bilberry have the highest nutritional content in crude protein (1.18% and 1.22%, respectively), non-nitrogen compounds (15.06%, and 8.06%, respectively), and dry matter content (17.24%, and 14.9%, respectively). The multivariate analysis show that only environmental temperature and precipitation has an influence upon fruits dry matter. The above-mentioned climatic factors influence in different extent the dry matter. Thus, in black currant (R = 0.395), raspberry (R = 0.635), and bilberry (R = 0.671) their influence is lower compared with lingonberry (R = 0.940). Our study also suggests that* black currant *and bilberry species emphasize strong nutritional potential, and they are less influenced by the climatic conditions compared with other wild berry species.*

Keywords*: crude chemical composition, multiple correlations, precipitations, temperature*

INTRODUCTION

The potential benefits of eating fruit in general and berries are traditionally recognized around the world. Studies over time have shown that many species of berries are valuable sources of phytonutrients that are thought to have preventive effects against a wide range of chronic diseases, many of which are related to age (HARRIS et al., 2014; PAREDES-LÓPEZ et al., 2010). Research in the field, both in humans and at the cellular level, has led to results that suggest that a constant consumption of berries is a dietary habit that can be associated with a lower risk of cardiovascular disease, diabetes, and reducing the risk of associated complications, cancer, and neurodegenerative diseases, etc. (BASU et al., 2010; JOSEPH et al., 2003; LEE et al., 2008; SEERAM, 2008). In addition to being a valuable source of vitamins, minerals and dietary fiber, they contain a variety of secondary metabolites, mostly phenolic, which have complex biological activity, mainly antioxidant (SCHELL et al., 2019; SZAJDEK and BOROWSKA, 2008). This is the context in which there is a growing global interest in the consumption of berries worldwide. This has helped to refocus attention on promoting the use of non-timber forest products as part of regional and rural development activities, employment and income generation projects or general nutrition and health education policies (SAASTAMOINEN et al., 2000; ZHANGA et al., 2019).

For this reason, in last decade an increasing interest concerning the use of berries as raw material in producing food supplements is reported. The use of food supplements is ubiquitous and can provide substantial amounts of valuable micronutrients to those who use them (SCHELL et al., 2019). Food supplements can be consumed daily or episodically and can provide either low/very low doses or high/very high doses of nutrients that are not limited by energy intake (HUI, 2007; DOMÍNGUEZ DÍAZ et al., 2020). In this context, it should be emphasized that when characterizing the dietary intake of nutrients administered as supplements, in addition to their description, their method of production is also essential (DiPERSIO et al., 2006; FELLOWS, 2000; GEORGE et al., 2004; GRABOWSKI et al., 2003). Ourdays, the know-how on the best methods of evaluating dietary supplements, as well as the structure of the measurement error in reporting the results related to them, is not sufficiently exhaustive. Several characteristics of the nutrients that are part of food supplements have certain peculiarities when compared to those in consumer foods (DOMÍNGUEZ DÍAZ et al., 2020). The results of food supplements administration on health depend on the contributions made by their way of administration. To improve the health of the organisms that consume them, a description of their level of inadequacy/excess is needed, and an evaluation of the relationships between them and other nutrients (CORDAIN et al., 2000).

The aim of the present study is to highlight the nutrient content of four species of wild berries (*Rubus idaeus* L., *Ribes nigrum* L., *Vaccinium vitis-idaea* L. and *Vaccinium myrtillus* L.) and to identify the influence of specific climatic conditions of the harvesting area on their dry matter content, being known the direct proportionality between above mentioned trait and the nutritional value of the plant.

MATERIAL AND METHODS

Four species of spontaneous culture wild berries (raspberry - *Rubus idaeus* L., balck currants - *Ribes nigrum* L., lingonberries - *Vaccinium vitis-idaea* L. and bilberries - *Vaccinium myrtillus* L.) from Sovata area, Mureș County, Romania. 30 samples of fruits belonging to each species were analyzed. The harvesting period was August and September 2020. The analyze of the macronutrients of the fruits belonging to the above-mentioned wild berry species, crude chemical composition, respectively was developed according to Weende pattern (ȘARA and ODAGIU, 2015) in the Laboratory of the Department of Environmental Engineering and Protection, of the University of Agricultural Sciences and Veterinary Medicine (UASVM) Cluj-Napoca

The meteorological data, which characterize the zonal climatic conditions during the vegetation period of berries, April - September 2020, come from a specialized database (https://www.meteoblue.com/). The climatic indicators taken into account are: environmental temperature (°C), atmospheric pressure (mmHg), relative atmospheric humidity (%) and precipitation (mm).

In order to identify the climatic factors/climate factor that has the potential to influence the dry matter content of the studied berry species, the interaction between all four stated climate indicators was initially tested using multivariate analysis. STATISTICA v.8.0 for Windows was used for statistical data processing. Basic statistics, test of least significant differences, and multivariate analysis were used.

RESULTS AND DISCUSSIONS

Following the determinations carried out on the raspberry species (*Rubus idaeus* L.), a mean water content of 86.30% was quantified, which corresponds to a dry matter content of 13.90%. In terms of nutrient content, crude protein content of 1.08%, crude cellulose content of 6.32% and crude ash content of 0.46% are reported. Regarding the content of non-nitrogenous extractive substances, their mean content in the analyzed samples is 6.04% (Table 1).

The crude chemical analysis carried out on black currants (*Ribes nigrum* L.) led to an average water content of 82.76%, which corresponds to a dry matter content of 17.24%. In terms of nutrient content, crude protein content of 1.18%, crude cellulose content of 0.40% and crude ash content of 0.60% are emphasized. Concerning the content of non-nitrogenous extractive substances, one may find that their average content in the analyzed samples is 15.06% (Table 2).

Table 1

The basic statistics for the crude chemical composition identified in raspberry (% of dry matter)

Issue	n	X	Min.	Max.	s	CV(%)
Water	30	86.30	85.00	88.00	1.30	1.51
DM	30	13.90	12.00	15.00	1.34	9.65
CP	30	1.08	1.00	1.30	0.13	12.07
CC	30	6.32	6.00	6.80	0.31	4.93
CA	30	0.46	0.30	0.60	0.11	24.79
SEN	30	6.04	4.20	7.50	1.30	21.45

DM – dry matter; CP – crude protein; CC – crude cellulose; CA – crude ash; SEN – non nitrogen extractives; N – number of samples; X – mean; Min. – minimum value; Max – maximum value; s – standard deviation; CV(%) – coefficient of variation.

Table 2

The basic statistics for the crude chemical composition identified in black currants (% of dry matter)

Issue	n	X	Min.	Max.	s	CV(%)
Water	30	82.76	81.00	84.00	1.09	1.32
DM	30	17.24	16.00	19.00	1.09	6.32
CP	30	1.18	1.00	1.30	0.13	11.05
CC	30	0.40	0.30	0.60	0.12	30.62
CA	30	0.60	0.50	0.70	0.10	16.67
SEN	30	15.06	14.00	16.60	0.95	6.33

DM – dry matter; CP – crude protein; CC – crude cellulose; CA – crude ash; SEN – non nitrogen extractives; N – number of samples; X – mean; Min. – minimum value; Max – maximum value; s – standard deviation; CV(%) – coefficient of variation.

In lingonberry (*Vaccinium vitis-idaea* L.), the crude chemical analyzes carried out resulted in a mean water content of 87.60%, which corresponds to a mean dry matter content of 12.40%. Concerning the other macronutrients content, crude protein is equal to 0.66%, crude cellulose equal to 4.36% and crude ash equal to 0.72%. The non-nitrogenous extractive substances recorded a mean content of 6.66% (Table 3).

Table 3

The basic statistics for the crude chemical composition identified in lingonberry (% of dry matter)

Issue	n	X	Min.	Max.	s	CV(%)
Water	30	87.60	86.00	89.00	1.14	1.30
DM	30	12.40	11.00	14.00	1.14	9.19
CP	30	0.66	0.40	0.90	0.21	31.42
CC	30	4.36	3.80	5.00	0.52	11.87
CA	30	0.72	0.50	0.95	0.18	24.36
SEN	30	6.66	6.15	7.70	0.64	9.55

DM – dry matter; CP – crude protein; CC – crude cellulose; CA – crude ash; SEN – non nitrogen extractives; N – number of samples; X – mean; Min. – minimum value; Max – maximum value; s – standard deviation; CV(%) – coefficient of variation.

In bilberry (*Vaccinium myrtillus* L.) the determinations carried out showed an average water content of 85.10%, while the dry matter content is 14.90%. In terms of nutrient content, the crude protein content is equal to 1.22%, while the crude cellulose is 4.98% and a crude ash content of 0.64%. As regards the content of non-nitrogenous extractive substances, their mean content in the samples analyzed is 8.06%. (Tabelul 4).

Table 4

The basic statistics for the crude chemical composition identified in bilberry (% of dry matter)

Issue	n	X	Min.	Max.	s	CV(%)
Water	30	85.10	84.00	86.00	0.89	1.05
DM	30	14.90	14.00	16.00	0.89	6.00
CP	30	1.22	1.10	1.30	0.08	6.86
CC	30	4.98	4.20	6.00	0.76	15.19
CA	30	0.64	0.50	0.80	0.11	17.82
SEN	30	8.06	6.80	9.50	1.14	14.14

DM – dry matter; CP – crude protein; CC – crude cellulose; CA – crude ash; SEN – non nitrogen extractives; N – number of samples; X – mean; Min. – minimum value; Max – maximum value; s – standard deviation; CV(%) – coefficient of variation.

For all the species studied, harvested from the Sovata area (Mureș County), the values of water, dry matter and nutrient content have a normal distribution, highlighted by the values of the standard deviation. According to the resulting variability highlighted by the values of the coefficients of variation, the averages are in all cases characterized by homogeneity, which is very good in the case of crude protein, dry matter and non-nitrogenous extractive substances and average in the case of water, cellulose and crude ash (Tables 1 - 4).

In the studied area, the highest content in dry matter is reported in black currant species (17.24%), followed by bilberry (14.9%), raspberry (13.9%), and lingonberry (12.4%). The highest content in crude protein is reported in bilberry (1.22%), followed by black currant (1.18%), raspberry (1.08%), and lingonberry (0.66%). The highest content in crude cellulose is reported in raspberry (6.32%), followed by bilberry (4.98%), lingonberry (4.36%), and black currant (0.4%). The highest ash content is reported in lingonberry (0.72%), followed by bilberry (0.64%), black currant (0.6%), and raspberry (0.46%). The highest non-nitrogen compounds content is reported in black currant (15.06%), followed by bilberry (8.06%), lingonberry (6.66%), and raspberry (6.04%).

For Sovata area, Mureș County, the application of the test of the least significant differences, (LSD5%) to harvested berries shows that the differences are statistically very significant for most of the parameters of the raw chemical composition. In the case of crude cellulose and non-nitrogenous extractive substances, the values of the variability exceed the threshold of 30% (CV_{CC} = 63.39% and CV_{SEN} = 46.41%). Due to the lack of representativeness of the means, in these cases the medians are calculated (4.67% CC and 7.36% SEN). For the dry matter, crude protein and crude ash contents, the variability being below the threshold value equal to 30%, the averages are representative (Table 5).

The basic statistics applied to the climatic factors taken into account corresponding to the vegetation period of the studied berry species show that the variability is below the 30% threshold for most of them, except for precipitation, which confirms the representativeness of the averages in terms of temperature, pressure, and relative humidity (Table 6). The mean temperature is 15.96 °C and the mean atmospheric pressure is 761.91 mmHg. The atmospheric humidity had a mean value equal to 69.07%. Due to the fact that the reported variability for the pluviometric regime exceeds the threshold of 30%, for this climatic indicator the median equal to 14.27 mm is presented (Table 6). Testing the influence of climatic factors, taken into account, on the dry matter content of the studied berries species results that there are very weak multiple correlations between them (Table 7).

Table 5

The evolution of the crude chemical analysis parameters in studied wild berry species (%)

Species	Parameter				
	DM	CP	CC	CA	SEN
Raspberry	13.90dcb	1.08adc	6.32d	0.46cd	6.04da
Black currant	17.24d	1.18ad	0.40d	0.60cba	15.06d
Lingonberry	12.40cd	0.66dd	4.36da	0.72db	6.66adc
Bilberry	14.90bda	1.22cad	4.98da	0.64cab	8.06bdc
Mean	14.61bda	1.03ad	-	0.60	-
Median	-	-	4.67	-	7.36
CV(%)	13.91	24.81	63.39	17.98	46.41
$LSD_{5\%}$	1.25	0.16	0.51	0.17	1.09
F	$16{,}230^{***}$	15.704^{***}	136.074^{***}	3.538^{*}	80.374^{***}

DM – dry matter; CP – crude protein; CC – crude cellulose; CA – crude ash; SEN – non nitrogen extractives; CV – coefficient of variation; LSD – the lowest significant differences; F – Fisher coefficient.
Different letters correspond to significant differences at $p < 0.05\%$

Table 6

The basic statistics for the climatic parameters recorded in fruits harvesting area

Issue	n	X	Min.	Max.	s	CV(%)
Temperature)°C)	183	15.96	17.39	8.46	20.39	4.55
Atmospheric pressure mmHg	183	761.91	758.27	764.64	2.20	0.29
Relative humidity, %	183	69.07	70.52	54.02	77.18	8.05
Precipitations, mm	183	14.27	10.80	85.60	10.00	25.20

N – number of samples; X – mean; Min. – minimum value; Max – maximum value; s – standard deviation; CV(%) – coefficient of variation.

A very low multiple correlation between analyzed climatic factors and raspberry dry matter content is reported (0.067). According to the regression line (Y = 15.844-0.582X1-12.937X2 + 14.192X3 + 7.448X4), in the climatic conditions specific to the harvest area, a positive influence on the dry matter content of raspberry is reported as being the result of the increase of atmospheric humidity, in a greater extent, and slightly less to an increase of the precipitation level. In back currants, the multiple correlation is also very weak (R = 0.093), with a low representativeness, respectively 0.9%. According to the regression line (Y = 15,093-1.123X1-13.868X2 + 16.346X3 + 7.346X4), to a greater extent the increase in atmospheric humidity and to a lesser extent an increase in the level of precipitation have positive influence on the dry matter content. Concerning lingonberry, also a very weak multiple correlation is reported (R = 0.088), with a low representativeness (0.8%). The regression line (Y = 12,225-0.651X1-5.805X2 + 6.579X3 + 3,659X4), shows that the increase of atmospheric humidity, in a greater extent, and slightly less to an increase of the precipitation level determine the increase of the dry matter content. In bilberry, a multiple correlation expressed by the coefficient of correlation of R = 0.091 is reported. It has a very low representativeness (0.8%). According to the regression line (Y = 12.662-0.941X1-8.869X2 + 8.980X3 + 4.336X4), to a greater extent the increase in atmospheric humidity and to a lesser extent an increase in the level of precipitation have a positive influence on the dry matter content. Thus, it is found that only atmospheric temperature and precipitation have a mean influence in fruits dry matter (Table 7).

Table 7

The influence of the climatic factors (temperature, atmospheric pressure, relative humidity, precipitations) on dry matter content of studied wild berries from Sovata area, Mureș County

Issue	R	R^2	Regression line
Raspberry	0.067	0.004	Y = 15.844-0.582X1-12.937X2+14.192X3+7.448X4
Black currant	0.093	0.009	Y = 15.093-1.123X1-13.868X2+16.346X3+7.346X4
Lingonberry	0.088	0.008	Y = 12.225-0.651X1-5.805X2+6.579X3+3.659X4
Bilberry	0.091	0.008	Y = 12.662-0.941X1-8.869X2+8.980X3+4.336X4

Y – dry matter; X1 – environmental temperature (°C); X2 – environmental pressure (mmHg); X3 – relative atmospheric humidity (%); X4 – precipitations (mm); R – coefficient of multiple correlation; R^2 – coefficient of determination.

Multiple correlations of different degrees of intensity were identified between the dry matter content of wild berries species and climatic factors environmental temperature, and precipitations. The highest representativeness (88.4%) is reported in lingonberry, wile the lowest (39.5%) in black currant. The dependence between dry matter, and climatic factors is described by the regression lines (Table 8).

Table 8

The influence of the climatic factors (temperature, atmospheric pressure, relative humidity, precipitations) on dry matter content of studied wild berries from Sovata area, Mureș County

Issue	R	R^2	Regression line
Raspberry	0.635	0.403	Y = 16.699-0.321X1-0.479X2
Black currant	0.395	0.153	Y = 16.258+0.003X1+0.349X2
Lingonberry	0.940	0.884	Y = 10.351+0.925X1-0.481X2
Bilberry	0.671	0.450	Y = 12.805+0.560X1+0.263X2

Y – dry matter; X1 – environmental temperature (°C); X2 – precipitations (mm); R – coefficient of multiple correlation; R^2 – coefficient of determination.

For raspberries and blueberries, average to strong correlations were calculated, respectively, R = 0.635 (with a representation equal to 40.30%) and R = 0.671 (with a representation equal to 45%). For cranberries a very strong correlation is reported (R = 0.940 with a representation equal to 88.40%), and for currants an average correlation equal to R = 0.395 with a representation equal to 15.30% (Table 8).

CONCLUSIONS

Considering the results of the crude chemical analysis reported in the four wild berries species analyzed in this study, we identify black currant and bilberry as having the highest nutritional content concerning crude protein (1.18% and 1.22%, respectively), and non-nitrogen compounds (15.06%, and 8.06%, respectively). The highest dry matter content is also reported in black currant (17.24%), and bilberry (14.9%). According to $LSD_{5\%}$ test, significant and very significant differences ($p < 0.05\%$) are reported between the macronutrients identified, function of species.

The analysis of the influence of the climatic factors upon the dry matter content in studied species emphasizes that only environmental temperature and precipitation has an influence. The coefficients of multiple correlation between the two above mentioned climatic factors and dry matter content in studied wild berries species, which are low or medium, show that black currant ($R = 0.395$), raspberry ($R = 0.635$), and bilberry ($R = 0.671$), are less influenced by them, compared with lingonberry ($R = 0.940$).

Thus, from the point of views of macronutrients composition, and influence of climatic conditions upon their dry matter content, black currant and bilberry species emphasize a strong nutritional potential, both for fresh consumption or as raw material in food supplements industry.

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