PhD THESIS

The valorization of berries from Bistrița-Năsăud County based on a qualitative and quantitative assessment methodology of their nutritional curative potential

SUMMARY OF THE Ph.D THESIS

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INTRODUCTION

The identification and mapping of forest fruit production areas in general, regardless of the area of origin, is carried out by evaluating the prevailing soil types, climate and reliefs (BURDUHOS MARIA DANIELA ET AL., 2020). Carrying out laboratory analyzes to determine the content of nutrients, antioxidants, vitamins and minerals in forest fruits (BURDUHOS (TRIPON) DANIELA ET AL., 2021).

1. Aspects concerning the study of the berries

Berries have remedial effects on several diseases, and these health-promoting effects are associated with their phenolic compounds, which may vary depending on the type and variety of the fruit, along with other factors such as climate, agricultural conditions, etc. (CIANCIOSI ET AL., 2019). Most berries have remarkable beneficial roles in many systems of the human body. In addition, they are effective in some metabolic disorders and in several types of cancer. A number of health-promoting effects of bioactive compounds in berries are known (VENDRAME ET AL., 2016).

2. The bioactivity of berries

Berries contain powerful antioxidants, potential allergens, and other bioactive compounds. Genetics and environmental factors affect the production and storage of such important berry compounds, of which anthocyanins (water-soluble plant pigments) have important functions in plant physiology as well as health effects (WU ET AL., 2006).

3. Research objectives

The following objectives were pursued: the characterization of the climatic regime of the experimental area of provenance of the berry species studied; the study of the nutritional status of forest fruits from the spontaneous flora of Bistrita-Năsăud county, Colibița area; testing the possibility of valorizing berries from the spontaneous flora of the Colibița area and developing a methodology for estimating the nutritional/healing potential of berries.

4. Environmental peculiarities of the experimental site

Colibița, Bistrița-Năsăud County (47°10'14''N, 24°53'17''E) in the area where the activities of monitoring climate factors and harvesting forest fruits were carried out, it is located in the central part of the country. The Colibița area, located in the Bistrița-

Năsăud county in Romania, has an orography characteristic of the mountain and submontane regions of the Eastern Carpathians. This area is in a mountainous area surrounded by the beautiful Călimani Mountains and the Rodnei Mountains, which gives the landscape a spectacular appearance. The hydrology of the Colibița area, located in the Bistrița-Năsăud county in Romania, is influenced by the presence of the Colibița reservoir, the Bistrița river, as well as the hydrological characteristics of the Călimani Mountains and the Rodnei Mountains in the surroundings. Lake Colibița is an important reservoir located in this region. This lake was created by building a dam on the Bistrita River and is mainly used for hydroelectric power production. It has a generous area and is surrounded by forests and hills. The hydrology of the lake involves the regulation of water levels according to energy production requirements as well as downstream irrigation needs. The Bistrița River is an important river that crosses this area.

5. Material and method

The methodology provides for the consultation of specialized literature, a presentation of the Colibița region in Bistrița-Năsăud county and the importance of forest fruits in this area. Added to this is a detailed analysis of the chemical composition of different berry species and their health benefits, the presentation of the results of chemical and nutritional analyzes for different berry species, the analysis of the correlations between the chemical composition of the fruits and their nutritional characteristics and curatives, explaining the significance of the results obtained and their impact on the utilization of berries in the area, comparing with similar studies from other regions and discussing how this methodology can be used to guide growers, the food industry and consumers in the utilization of berries. In order to complete the doctoral thesis, four species were studied (raspberries - *Rubus idaeus* L., black currants - *Ribes nigrum* L., lingonberries - *Vaccinium vitis-idaea* L. and bilberries - *Vaccinium myrtillus* L.), depending on climatic conditions specific to the harvesting area, in order to identify their influence on their dry matter content. The preliminary activities for the experimental research consist in the study of the specialized literature, based on which the research methodology is developed, the species of forest fruits that will be studied are selected. The experimental activities complementary to the laboratory activities are represented by: the choice of the sampling sites of forest fruits, both from the spontaneous flora and from the plantations of the profile vegetable farms, the recording of the climatic data corresponding to the sampling sites, the conditioning carried out by drying /dehydration as well as from the compilation of databases containing the raw data obtained from experimentation.

The laboratory activities consist of the physico-chemical analyzes that provide for the analysis of the nutritional content (through determinations of crude protein,

crude fat, crude cellulose, crude ash and non-nitrogenous extractive substances) and the content in vitamin C, total polyphenolic compounds, resveratrol and pH determination -, both before and after the drying/dehydrating conditioning process. The processing and interpretation of experimental data activities presuppose the use of previously prepared databases. The "XLSTAT" program was used.

6. The characterization of the climatic regimen of the experimental area where rignated the studied berries species

The relationship between the average temperature and the precipitation regime in Colibița is complex and variable, but it has a significant impact on the environment and daily life (Fig. 6.1).

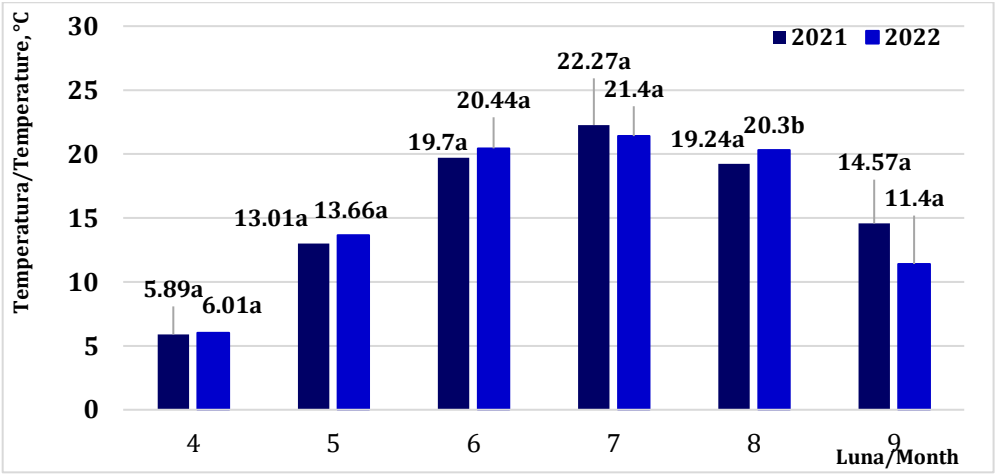

Figure 6.1. The thermic regimen of Colibița area during vegetation period of berries, in 2021 and 2022 (°C)

In the context of global climate change, it is essential to monitor and understand these correlations in order to manage resources and protect the environment. For the atmospheric temperature, the minimum value was recorded in April of 2021, which corresponds to the median equal to 5.89°C, and the maximum in July of 2022, which corresponds to the average of 22.27°C (Fig. 6.1). In the experimental periods corresponding to the years 2021 and 2022, averages equal to 15.43°C and 15.54°C are recorded, respectively, with a minimum daily value corresponding to both experimental years and equal to 1°C and a daily maximum equal to 27 .90°C corresponding to the year 2022. Over the entire experimental period, an average equal to 15.48°C is reported for the average air temperature.

7. The study of the nutritional status of berries from the spontaneous flora of Bistrita-Năsăud County, Colibița area

Applying the least significant difference test at the 5% significance level (LSD5%) to berries shows that the differences are highly statistically significant for most parameters of the crude chemical composition, being only significant in the case of crude fat and crude ash (Tables 7.9, 7.18 and 7.27).

Table 7.9.

Th evolution of the proximate analysisi in studied wild berries species from Colibița area, Bistrița-Năsăud County (% of DM)

Issue	Parameter						
	Water	DM	CP	CF	CF	CA	NFM
Raspberry	86.91a	13.09c	9.58e	51.14g	3.94k	4.50m	30.84o
Bilberry	83.87b	16.13d	8.40e	4.89h	4.42k	4.45m	80.15p
Lingonberry	82.10b	17.90d	7.91e	19.39i	7.04l	7.30n	65.64q
Currants	82.79b	17.21d	22.22f	34.95j	3.54k	4.35m	38.03r
Mean	83.92b	16.08d	-	-	-	5.15m	-
Median	-	-	8.99	27.17	4.18	-	51.84
CV(%)	2.53	13,21	56.80	72.22	33.33	27.86	43.17
$LSD_{5\%}$	19.25	1.17	0.51	0.17		1.09	1.25
F	2,853	12.678*	16.764*	44.789***		12.964*	38,580**

DM –dry matter; CP –crude protein; CF –crude fiber; CA –crude ash; NFM –nitrogen free matter; n – număr de probe/number of samples; CV – coefficient of variation; %, $LSD_{5\%}$ – Least Significant Differences; the differences between any two variants are significant, if their values are followed by letters, or groups of different letters.

Table 7.18.

The evolution of the Ca, K, P, Fe, and Zn content in studied berries from Colibița area, Bistrița-Năsăud County, 2021 – 2022 (mg/100 g)

Issue	Parameter				
	Ca	K	P	Fe	Zn
Raspberry	42.10a	75.10e	699.90j	1.99k	0.63n
Bilberry	128.30b	107.60f	415.20h	1.60k	0.76n
Lingonberry	26.43c	250.40g	25.20c	14.17m	4.69l
Currants	35.78d	32.20d	171.70i	3.88l	0.74n
Mean	-	-	-	-	-
Median	38.94	91.35	293.45	2.94	0.75
CV(%)	81.19	81.30	90.11	109.51	116.76
$LSD_{5\%}$	1.27	1.12	0.53	0.19	0.14
F	17,933***	13.196**	38.593***	30.943***	25.461**

CV – coefficient of variation; %, $LSD_{5\%}$ – Least Significant Differences; the differences between any two variants are significant, if their values are followed by letters, or groups of different letters.

Table 7.27.

The evolution of the pH and bioactive compounds content in studied berries from Colibița area, Bistrița-Năsăud County, 2021 – 2022

Issue	Parameter			
	pH	VitaminC, mg/100 g	TPC, mg GAE/g	Resveratrol, mg/100 g
Raspberry	3.11a	3.35b	4.50b	3.40b
Bilberry	3.12a	36.1c	29.22f	4.87b
Lingonberry	2.41a	12.25d	29.78f	19.88g
Currants	2.92a	212.30e	29.30f	1.59h
Mean	2.89	-	-	-
Median	-	66.00	23.20	7.44
CV(%)	11.52	149.26	53.75	113.04
$LSD_{5\%}$	17.22	0.12	0.47	0.25
F	$1{,}450^{ns}$	52.196^{***}	38.369^{***}	39.869^{***}

CV – coefficient of variation; %, $LSD_{5\%}$ – Least Significant Differences; the differences between any two variants are significant, if their values are followed by letters, or groups of different letters.

8. Identifying the interrelationships between the nutrients quantified in berries and climate conditions of the harvesting area

In order to develop a methodology for the superior valorization of forest fruits from the spontaneous flora of the Colibița area, Bistrița-Năsăud County, the interrelationships between the dry matter of the four species of forest fruits taken in the study, harvested from the mentioned area, in the years 2021 and 2022, as well as the recorded climatic conditions represented by: atmospheric temperature, precipitation regime, atmospheric pressure and wind speed. As a result of the fact that multiple positive, strong, very strong and significant correlations were obtained between all analyzed nutrients and the dry matter content of all four berry species studied, the analysis of the interrelationship between environmental factors and nutrient composition of fruits started from the premise that it is sufficient to take into account only the dry substance in the numerical analyzes carried out.

In order to capitalize on the production of forest fruits in Bistrița-Năsăud county, we believe that a methodological approach is necessary that includes qualitative and quantitative estimation of the nutritional and curative potential of these fruits. For this purpose, based on the study carried out, we propose a methodology aimed at satisfying both the needs of the market of fresh consumption of forest fruits and the food supplements industry, based on the qualitative and quantitative estimation of their nutritional/healing potential. The proposed methodology includes three main stages related to: field analysis, laboratory analysis and market analysis (Fig. 8.13).

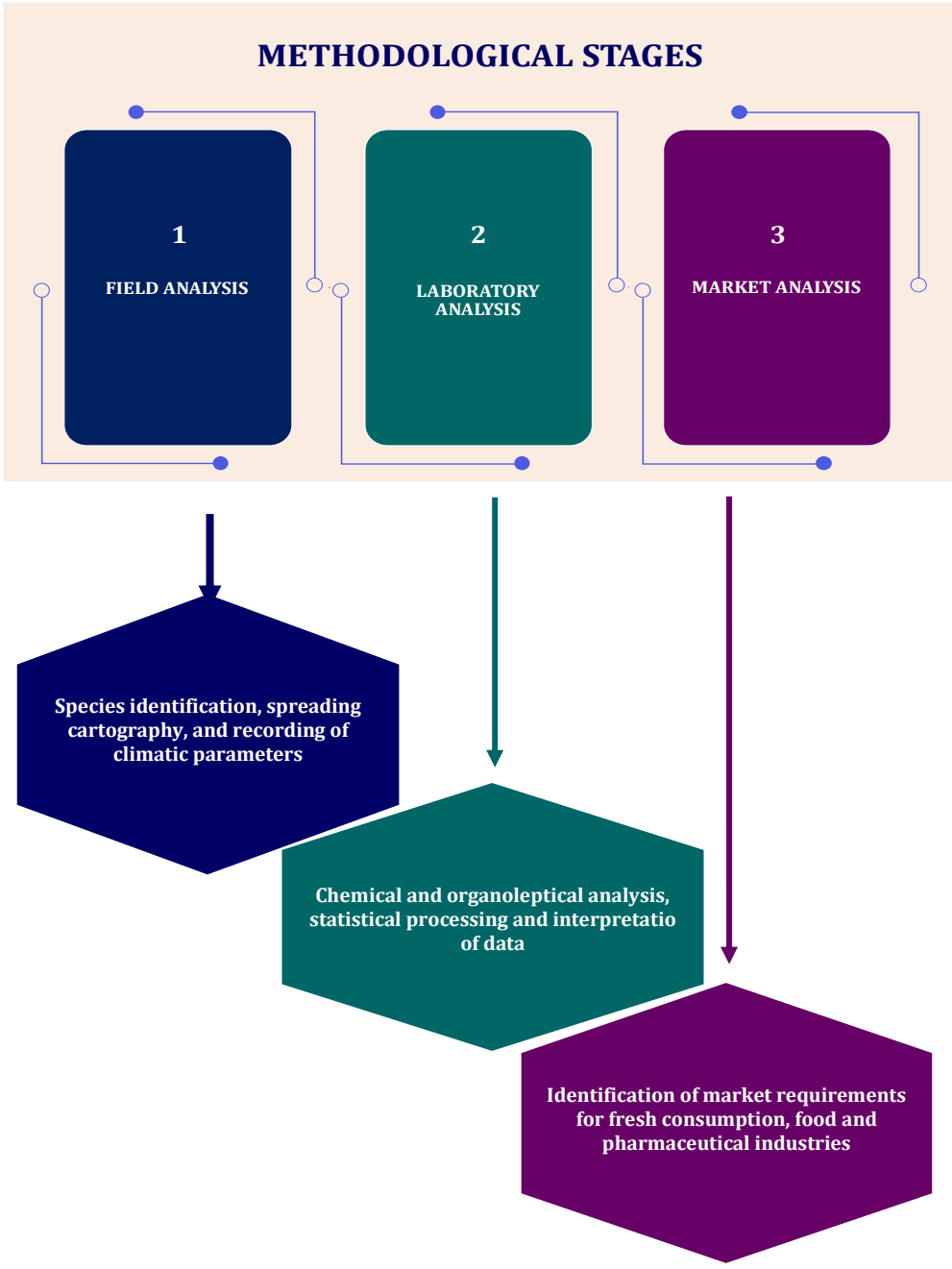

Fig. 8.13. Proposed methodology for valorization of the production of the wild berries fom Bistrița – Năsăud County

9. Conclusions and recommendations

Correlations between climatic factors in the areas of origin of the studied berry populations, it is observed that they are average. These correlations emphasize the complexity of the climate in the Colibița area and the need to carefully monitor climate change in order to develop adaptation strategies.

Black currants and cranberries have the highest dry matter averages with values of 17.90% and 17.21% respectively. Blackcurrants have the highest crude protein content (22.22%), raspberries the highest crude cellulose content (51.14%), lingonberries the highest crude fat content (7.04%) and crude ash (7.30%), and bilberries have the highest content of nitrogen free extracts (NFE), with 80.15%. Potassium and trace elements showed the largest variations, indicating considerable variability in the mineral composition of the berries. Bilberries and raspberries are relatively high in calcium and phosphorus, suggesting a high nutritional potential. Lingonberries are notable for their high potassium, iron and zinc content, which gives them a distinct mineral profile. Black currants are low in calcium, potassium, iron and zinc. Lingonberries have the highest acidity (pH = 2.41 pH units). Among the berry species analyzed, cranberries, black currants and bilberries (29.78 mg GAEg, 29.30 mg GAE/g and 29.22 mg GAE/g) rich in total polyphenolic compounds and lingonberries the richest in resveratrol (19.88 mg/100 g). Bilberries have the lowest acidity, respectively the highest average pH (3.12 pH units), although this still falls into the high acidity category. Black currants are the richest in vitamin C among the berry species analyzed, resulting in differences in the bioactive content of the berries.

The studies undertaken as part of the doctoral thesis highlight the fact that in the case of raspberry and blueberry fruits, the precipitation regime has a major influence on the accumulation of dry matter, as well as on the synthesis of most nutrients, except for ash and fat in the case of raspberry and protein and fat in the case of blueberries, which are less influenced by climate. For lingonberries and black currants fruits, the thermal regime and the precipitation regime influence the accumulation of dry matter as well as the synthesis of most of the crude chemical components, minerals, bioactive compounds and pH. The exception is fat in the case of lingonberries, fat, ash, and TPC in the case of black currants.

In order to capitalize on the production of wild berries in Bistrița-Năsăud County, a methodological approach is proposed that includes the qualitative and quantitative estimation of the nutritional and curative potential of these fruits. The proposed methodology focuses on meeting the needs of the fresh berry consumption market and the food supplement industry and includes three main stages: field, laboratory, and market analysis. We believe that the proposed methodological plan will allow an efficient and sustainable exploitation of forest fruits from Bistrita-Năsăud county, maximizing both the economic and nutritional and curative benefits of these valuable natural resources.

Following the studies, we believe that the following recommendations can be formulated: ▶it is necessary to monitor the climatic conditions to assess and forecast the

nutritional quality of the studied wild berry species, which come from the populations present in the spontaneous flora. It is also recommended to include details of the exact location of the berry's area of origin, such as geographical coordinates and altitude. This can provide a clearer picture of the geographical context of the study; ▶ taking into account the complex interactions between different nutrients in the case of each of the raspberry, bilberry, lingonberry and black currant fruit species studied, it is recommended to constantly monitor their nutritional composition with a view to a higher utilization, based on research and innovation. We believe that this approach can contribute to the optimization of the production and utilization of forest fruits in a sustainable and efficient way, while contributing to the sustainable development of the relevant industries and to satisfying the demands of consumers in the market; ▶ implementation of a methodology for the valorization of berry production, which includes field analysis, laboratory analyzes and market analysis, to qualitatively and quantitatively assess the nutritive and healing potential of berries.

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