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FOOD THERAPY AND EDUCATION NEXUS AGRONOMIC FRAMEWORK. EVIDENCE FROM MOUNTAIN BERRIES

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Abstract. Background: Berries from mountainous regions, essential members of the *Plantae* kingdom, play a vital role in the present health and medical context during the ongoing pandemic, particularly in establishing the framework for natural therapy. Researchers have extensively investigated berry-derived extracts to evaluate their potential in inhibiting infectious diseases. The authors delved into specialized literature, formulating agronomic engineering strategies aimed at augmenting the behavior consumption of mountain berries. Methods: In this study, the authors delve into nutritional information, encompassing calories, fats, carbohydrates, fibres, and proteins, comparing values for regular berries (based on USDA values) and mountain berries (derived from their own research). The investigation reveals that mountain berries boast superior nutritional values, emphasizing their potential health benefits over standard berries as per USDA guidelines. Results: Berries sourced from mountainous regions, including *Hippophae rhamnoides* (sea buckthorn) from the *Elaeagnaceae* family, *Vaccinium vitis-idaea* (blueberry) from the *Ericaceae* family, *Ribes uva-crispa* (gooseberries), and *Ribes nigrum* (currants) from the *Grossulariaceae* family, as well as *Aronia melanocarpa* (chokeberry), *Rubus fruticosus Rosales: Rosaceae* (European blackberry), and *Rubus idaeus* (raspberry) from the *Rosaceae* family, play a pivotal role in both preventing and combatting various infectious diseases. Conclusion: This manuscript succinctly underscores the significance of specific mountain plants aligning with the attributes of biologically produced products to fortify health-promoting behaviors. The research findings underscore that mountain berries exhibit qualitative values that surpass standard berries, as outlined by the USDA.

Keywords: food education and behavior, infectious disease, mountain berries, natural therapy, nutritional security and safety, wellness-oriented conduct.

Introduction. Formulation of the problem

In a world increasingly polarized from a nutritional point of view, where some suffer from overfeeding – obesity and others from underfeeding – hunger, the need to establish macro-nutritional standards becomes imperative. Thus, at the global level, the World Health Organization requires the association of the most important macro-nutritional elements with the foods sold. In this context, the authors realized the need to present some macro-nutritional elements for some berries, respectively calories, fats, carbohydrates, fibers, proteins. According to the Harris-Benedict Equation for Basal Energy Expenditure (the most used in calories nutrition), the daily caloric intake should be around 1900 calories, which is confirmed by the World Health Organization to be approximately 2000 calories per day. Regarding protein and fat levels, the American Dietetic Association recommends approximately 61-76 grams of protein per day and 53 grams of fat per day. The United States Department of Agriculture (USDA) recommends that about 45-65% of total calories should come from carbohydrates. Thus, with a daily intake of 2000 calories, 1200 of these should come from carbohydrates. Dietary macro-nutritional elements come from cereals, fruits and vegetables, berries being among the most important fruits for nutrition balance [1].

The paper study the importance of calories, fats, carbohydrates, fibers, and proteins, using in nutrition balance *Hippophae rhamnoides* (sea buckthorn) from the *Elaeagnaceae* family, *Vaccinium vitis-idaea* (blueberry) from the *Ericaceae* family, *Ribes uva-crispa* (gooseberries), and *Ribes nigrum* (currants) from the *Grossulariaceae* family, as well as *Aronia melanocarpa* (chokeberry), *Rubus fruticosus Rosales: Rosaceae* (European blackberry), and *Rubus idaeus* (raspberry) from the *Rosaceae* family. Additionally, the paper proposes agronomic remedies for these berries in order to be healthier.

Studies suggest that constituents found in berry fruits can impede the replication of the infectious diseases through both direct and indirect mechanisms [2-6].

Comprehensive analyses and experiments conducted by the authors and fellow researchers reveal that mountain biological products exhibit qualitatively superior attributes when compared to their lowland counterparts. The authors seek to sensitize consumers of berries to the significance of the origin of these products and advocate for the biological and agronomic optimization of these crops. Furthermore, the authors advocate for the cultivation of behaviors that reinforce the consumption of mountain food cultivated within a biological system. This emphasis is particularly noteworthy due to the inherent character of these biological mountain food, which play a pivotal role as agricultural products with natural therapy properties. The biological mountain berries under consideration hail from the European Carpathians, specifically the Maramures and Neamt areas.

Analysis of recent research and publications

In the current pandemic context, *Plantae* berries are recognized as vital sources of natural therapy. As a result, there is a need to impart education to individuals regarding healthy behaviors. In the specific context of this paper, individuals have the opportunity to enhance and modify their consumption behaviors for the betterment of their well-being.

The *Elaeagnaceae* family, specifically the species *Hippophae rhamnoides* (sea buckthorn), exhibits a diverse array of characteristics, notably its anti-inflammatory properties. Sea buckthorn contains a distinctive blend of bioactive constituents, encompassing flavonoids, phenolic acids, proanthocyanidins, carotenoids, fatty acids, triterpenoids, vitamins, and phytosterols, highlighting the remarkable medicinal value of this fruit [7].

In a comprehensive study on sea buckthorn, researchers conducted both in vitro and in vivo experiments, spanning from cell lines to animal models, as well as involving human patients and healthy volunteers. The findings underscore the fruit's multifaceted biological activities, including anti-inflammatory and immunomodulatory effects, antioxidant properties, anticancer activities, hepatic protection, cardiovascular protection, neuroprotection, radioprotection, skin protection effects, antiaging properties, and benefits for eye and gastrointestinal disorders. Notably, toxicological assessments revealed the non-toxic nature of both the fruits and seeds of sea buckthorn. Biological mountain berries hailing from the *Ericaceae* family, specifically the species *Vaccinium vitis-idaea* (blueberry), contribute significantly to fortifying the immunodeficiency aspect of the organism. Blueberries demonstrate robust antioxidant activity, characterized by a substantial content of polyphenols and essential mineral elements. This content encompasses diverse phenolic compounds, including anthocyanins, flavanols, quercetin, hydroxycinnamic acids, hydroxybenzoic acids, vitamin C (ascorbic acid), vitamin A, essential minerals, tannins, and dietary fibres such as cellulose, hemicellulose, including soluble fibres like pectins. Additionally, blueberries contain sugars such as glucose and fructose [8].

Biological mountain berries belonging to the *Grossulariaceae* family, specifically the species *Ribes uva-crispa* (gooseberries) and *Ribes nigrum* (currants), exhibit various qualities that enhance the antioxidant capacities of the immune system. Gooseberries, comprising carbohydrates, flavonoids, alkaloids, glycosides, anthocyanosides, and phenols, exert potent reducing effects and are recognized as stabilizing and protective agents for immunity. They have demonstrated efficacy against pathogens such as *E-coli* and *Staphylococcus* aureus [9]. Currants, particularly *Ribes nigrum*, are acknowledged for their significant levels of vitamin C and polyphenolic compounds [10].

Belonging to the *Rosaceae* family, the species *Aronia melanocarpa* (chokeberry), *Rubus fruticosus Rosales: Rosaceae* (blackberry), and *Rubus idaeus* (raspberry) actively support the anti-infection mechanisms of the immunomodulatory system. Chokeberry, *Aronia melanocarpa*, is characterized by a significant content of phenolic components, including procyanidins, anthocyanins, flavonols, as well as organic acids, vitamins, calcium, magnesium, iron, zinc, sodium, potassium, and iodine [11]. European blackberries, *Rubus fruticosus Rosales: Rosaceae*, are particularly noteworthy for their potent antioxidant properties, attributed to high levels of anthocyanins [12]. Blackberry's impact on various diseases necessitates comprehensive investigation by contemporary scientists [13]. Raspberries, *Rubus idaeus*, are integral to the diet due to their abundance in essential nutrients and phytochemicals [14].

Fruits from the genus *Rubus*, within the family *Rosaceae* – subfamily *Rosoideae*, encompassing raspberries, blackberries, and similar fruits, confer substantial health benefits. These fruits contain water, carbohydrates, fats, proteins, cellulose, sodium, potassium, calcium, iron, vitamins A, B1, B2, B6, malic acid, citric acid, glucose, fructose, sucrose, and invert sugar [15]. *Aronia melanocarpa* (chokeberry), *Ribes uva-crispa* (gooseberries), *Hippophae rhamnoides* (sea

buckthorn), and *Ribes nigrum* (currants) cultivated in mountainous regions exert potent inhibitory effects on cancer cell proliferation, with additional antimutagenic, hepatic-protective, cardioprotective, antimicrobial, and antidiabetic benefits [16-17].

Plantae berries, particularly from mountainous regions, contribute significantly to fostering health-promoting behaviors compared to other vegetable and animal resources. These berries exhibit robust free radical scavenging, antioxidant, anti-inflammatory, anti-aging, anti-cancer, and immunodeficiency properties.

Nutritional education assumes a pivotal role in enlightening individuals about the paramount importance of fostering a health-conscious lifestyle through the consumption of nutrient-rich foods.

The authors **aim** comparative studies using data from USDA for regular berries and from own researches for mountain berries.

Research materials and methods

The article examines a nutritional comparison between simple berries and mountain berries, proposing agronomic treatments for mountain berries so that they could be healthier and easily marketable.

The study adopted a comprehensive approach to investigate the potential of mountain berries as a source of natural therapy. The research focused on evaluating the macro-nutritional composition, nutritional values, biological activities, and agronomical approaches of berries sourced from mountainous regions.

The nutritional content of mountain berries was analyzed, including calories, fats, carbohydrates, fibers, and proteins. Values for regular berries were sourced from the USDA, while data for mountain berries were obtained through independent research.

Berries from various mountainous regions, including *Hippophae rhamnoides* (sea buckthorn), *Vaccinium vitis-idaea* (blueberry), *Ribes uva-crispa* (gooseberries), *Ribes nigrum* (currants), *Aronia melanocarpa* (chokeberry), *Rubus fruticosus* (European blackberry), and *Rubus idaeus* (raspberry), were selected for the study.

The authors conducted a thorough review of specialized literature to gather information on the biological activities, health benefits, nutritional constituents, and agronomical remedies of the selected mountain berries.

Nutritional values of mountain berries were compared with those of regular berries based on USDA values. The aim was to highlight the superior nutritional profile of mountain berries.

The study delved into agronomic engineering strategies to optimize the cultivation of mountain berries. This involved analyzing experiments and comprehensive analyses conducted by the authors and fellow researchers.

Specific examinations were conducted on individual berry species, such as sea buckthorn, blueberry, gooseberries, currants, chokeberry, European blackberry, and raspberry.

In the period May 2021 – May 2023, the authors processed laboratory and proximate nutritional analysis from Eat and Track for mountain berries, and from USDA for simple berries. Specific mountain berries (500 grams each) were analyzed by Eat and Track, respectively chokeberry, gooseberries, currants from European Carpathians Maramures and sea buckthorn, blueberry, European blackberry, raspberry from European Carpathians Neamt. Laboratory analysis methods for fats was Soxhlet, and for protein Kjeldahl. Proximate analysis was used for calories, fibers, and carbohydrates. Error interval for the data was ± 0.1.

Regarding agronomic research, between 1988-2023, some authors tested different agricultural remedies for healthier berries. These agronomic remedies were developed in results, discussion and solutions sections, as output for the paper.

The results were presented in a tabulated format, comparing nutritional values of regular and mountain berries.

Results of the research and their discussion

Various researchers posit that mountain berries exhibit superior qualitative characteristics compared to low-land or conventional agricultural products [18-19]. Consistent with this assertion, the authors conducted a study on berries sourced from the European Carpathians, the Romanian mountain range, affirming the previously stated hypothesis. Consequently, mountain berries boast qualitative attributes pertaining to calories, fats, carbohydrates, fibers, and proteins (Table 1). In contrast to standard berries outlined by the USDA, mountain berries offer nutritionally superior values, positioning them as potential food with natural therapeutic properties.

As outlined in Table 1, mountain berries display low caloric density, with *Hippophae rhamnoides* (sea buckthorn) at 0.52 kcal/g, *Vaccinium vitis-idaea* (blueberry) at 0.57 kcal/g, *Ribes uva-crispa* (gooseberries) at 0.34 kcal/g, *Ribes nigrum* (currants) at 0.44 kcal/g, *Aronia melanocarpa* (chokeberry) at 0.47 kcal/g, *Rubus fruticosus Rosales: Rosaceae* (European blackberry) at 0.43 kcal/g, and *Rubus idaeus* (raspberry) at 0.52 kcal/g [18-22]. The significance of mountain berries positions them as crucial food with natural therapeutic properties, underscoring the imperative for their qualitative and quantitative enhancement. Consequently, the authors present specific biological and agronomic elements for the optimization of mountain berries.

Producers cultivating *Aronia melanocarpa* (chokeberry), *Ribes uva-crispa* (gooseberries), *Hippophae rhamnoides* (sea buckthorn), and *Ribes nigrum* (currants) in mountainous regions encounter challenges related to sunlight exposure and soil conditions in their cultivation areas.

Table 1 – Nutritional values of the mountain versus standard berries [18-22]

Berry types / 100 g nutrition information	Calories	Fats	Carbohydrates	Fibers	Proteins
Elaeagnaceae family					
Hippophae rhamnoides (sea buckthorn)	52 kcal (218 kJ)	2.5 g	10.2 g		0.9 g
	52 kcal (218 kJ)	5.0 g	2.5 g		0.9 g
Ericaceae family					
Vaccinium vitis-idaea (blueberry)	57 kcal (238 kJ)	0.3 g	14 g	2.4 g	0.7 g
	57 kcal (240 kJ)	0.33 g	14.5 g	2.4 g	0.74 g
Grossulariaceae family					
Ribes uva-crispa (gooseberries)	34 kcal (142 kJ)	0 g	7 g	4.3 g	0.6 g
	44 kcal (184 kJ)	0.58 g	10.2 g	4.3 g	0.88 g
Ribes nigrum (currants)	44 kcal (184 kJ)	0.6 g	10.2 g	4.3 g	0.9 g
	56 kcal (234 kJ)	0.2 g	13.8 g	4.3 g	1.4 g
Rosaceae family					
Aronia melanocarpa (chokeberry)	47 kcal (197 kJ)	0.5 g	9.6 g	5.3 g	1.4 g
	375 kcal	0 g	83.3 g	25 g	0 g
Rubus fruticosus Rosales: Rosaceae (European blackberry)	43 kcal (180 kJ)	0.5 g	9.6 g	5.3 g	1.4 g
	43 kcal (181 kJ)	0.49 g	9.61 g	5.3 g	1.39 g
Rubus idaeus (raspberry)	52 kcal (218 kJ)	0.7 g	11.9 g	6.5 g	1.2 g
	52 kcal (220 kJ)	0.65 g	11.9 g	6.5 g	1.2 g

Mountain berries from Carpathians area
Standard berries from USDA sources

Authors and Dordevic et al. [23] propose enhanced protection for *Aronia melanocarpa* (chokeberry) against excessive sunlight exposure, considering that mountainous areas often experience extreme conditions than other regions (Fig. 1). The authors implemented remedial biological and agronomic measures, as suggested by Dordevic et al. [23], for crops in the European Carpathians within the Maramures region.

A study focusing on the remedial agronomy of *Ribes uva-crispa* (gooseberries) and *Ribes nigrum* (currants) [24] reveals that crops cultivated under covers in mountainous areas exhibit superior performance compared to those in other settings.

For the European Carpathians Maramures gooseberries (Fig. 2) and currants (Fig. 3), a mountain producer engaged in remedial agronomy utilized various coatings, both organic and inorganic, including plastic coverings. The adoption of cover crops and controlled agriculture demonstrated benefits such as nitrogen fixation from the atmosphere and the suppression of invasive plants with detrimental effects during the initial stages of crop development.

Hippophae rhamnoides (sea buckthorn), extensively cultivated in arid and semi-arid regions or challenging agricultural terrains such as the mountainous areas of the European Carpathians, encounters natural reproduction challenges (Fig. 4) [7].

In the mountainous cultivation of *Vaccinium vitis-idaea* (blueberry), soil drainage emerges as a significant issue, especially for the European Carpathians Maramures fruits (Fig. 5).

Fig. 1. *Rosaceae* family – species *Aronia melanocarpa* (chokeberry) from European Carpathians Maramures

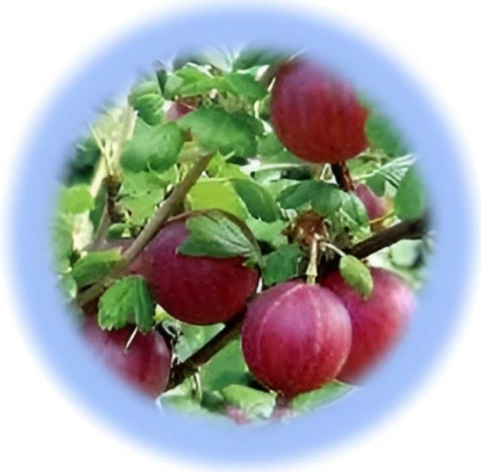

Fig. 2. *Grossulariaceae* family – species *Ribes uva-crispa* (gooseberries) from European Carpathians Maramures

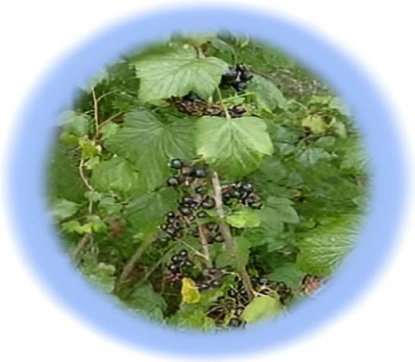

Fig. 3. *Grossulariaceae* family – species *Ribes nigrum* (currants) from European Carpathians Maramures

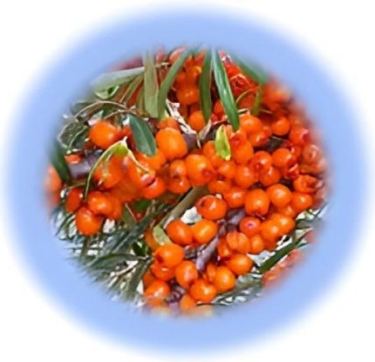

Fig. 4. *Elaeagnaceae* family – species *Hippophae rhamnoides* (sea buckthorn) from European Carpathians Neamt

Fig. 5. *Ericaceae* family – species *Vaccinium vitisidaea* (blueberry) from European Carpathians Neamt

Fig. 6. *Rosaceae* family – species *Rubus fruticosus Rosales: Rosaceae* (European blackberry) from European Carpathians Neamt

In addressing this concern, Prodorutti et al. [25] present solutions for enhancing productivity.

The mountain producer involved in implementing biological and agronomic remedies operates in the European Carpathians Maramures region.

To optimize productivity in the mountainous terrain, blueberries necessitate favourable growing conditions with well-drained soils maintaining an optimal acidity level within the pH range of 4.5 to 4.8.

Given the shallow root system of blueberries, particularly below 60 cm in depth, the mountainous soils, including those in Maramures, underwent mulching with a deep layer of organic material (at least 10 cm) such as bark, sawdust, and leaves.

This mulching practice increased organic matter in the soil, preserved soil moisture, shielded roots from heat, and aided in weed control.

Rubus fruticosus Rosales: Rosaceae (European blackberry) stands out as one of the most extensively cultivated shrubs in mountainous regions (Fig. 6).

As highlighted by Pereira et al. [26], the productivity of blackberries is intricately linked to fertilization treatments.

The authors observed that these treatments exert positive influences on various parameters such as stem density, cut dry mass, chlorophyll index, yield, number of fruits, and nutritional provision, encompassing leaf composition with respect to nitrogen, potassium, calcium, magnesium, and sodium.

Rubus idaeus (raspberry), along with blueberries, represents one of the most emblematic fruits of the European Carpathians Mountain region.

The mountain producer under consideration operates with raspberries from European Carpathians Neamt (Fig. 7).

Fig. 7. *Rosaceae* family – species *Rubus idaeus* (raspberry) from European Carpathians Neamt

For raspberry cultivation in the mountainous terrain, the producer adheres to the recommendations outlined in the paper by Lepaja et al. [27], which emphasizes more abundant irrigation compared to other crops, along with the practice of mulching.

Nutritional parameters for chokeberry exhibited improved performance when the plants were shielded from intense sunlight using polyethylene nets. Pomological characteristics of this shrub in the European Carpathian Mountain area were optimized through treatments, care practices, and predominantly organic fertilization, resulting in enhanced productivity of clusters and berries. The application of higher fertilizer rates and the use of dark netting demonstrated substantial positive effects on total phenolic content. Agriculture practices for upland crops are increasingly aligning with strategies that maximize yield and judiciously utilize natural resources. In the European Carpathians Mountain region, the adoption of various soil covers or controlled agriculture practices creates a favorable environment for optimal plant development.

For gooseberries and currants, in the mountainous areas of the European Carpathians Maramures, treatments involving white plastic covers and straw (derived from wheat, hemp, and millet) proved to be effective, yielding superior results compared to alternative treatments. These treatments led to enhanced agronomic performance, evidenced by increased plant height, fruit and leaf numbers, and consequently, a higher yield of plant biomass. The mountain producer in question specifically employed white plastic wrap and wheat straw, resulting in an observable increase in the number of fruits and leaves. Shrub growers in mountainous regions should aspire to achieve harmonious development within the existing mountain ecosystem, giving due consideration to factors such as water, soil, light, and nutrients.

According to the authors model, enhancing the productivity of sea buckthorn in various mountainous regions involves improving the wild form of this shrub through reproduction assisted by molecular markers and genetic interventions for continuous enhancement. This approach positions sea buckthorn as a viable mountain product.

In Romanian mountainous areas, most blueberry plantations require annual nitrogen applications, with other nutrients applied selectively as needed. Ammonium sulphate, chosen for nitrogen application, is particularly beneficial in areas with relatively high soil pH, as it tends to lower the pH level. The mountain producer, though not implementing nitrogen applications presently, intends to follow these agronomic recommendations in the future. Blueberry pollination, characterized by self-pollination, signifies that the flowers are self-fertile. Disease management in blueberry crops, as practiced by the mountain grower, involves minimal pesticide use and adheres to strict phytosanitary measures to prevent plant diseases during the developmental stages of plant material.

Notably, fertilization treatments for European blackberry significantly impacted the growth, yield, and nutrient composition of both fruits and leaves. This observation aligns with the findings of a mountain producer from the European Carpathians Neamt area, who implemented fertilization treatments, resulting in a noteworthy increase in plant growth and individual plate yield. Furthermore, nitrogen maintenance fertilization contributes to the overall vegetative enhancement of blackberries, favoring linear growth.

Water scarcity in specific mountain areas, including the location where raspberries are planted, presents a distinct challenge in different European Carpathians regions, contingent on the unique characteristics of each mountain ecosystem and variety. Post-irrigation and mulching treatments for raspberries demonstrated significant alterations in parameters such as number/area/leaf area index, shoot length, fruit number/diameter/length/weight, and total yield. Specifically, irrigation induced notable changes in these parameters, while mulching impacted leaf number/area, shoot length, and fruit weight. The outcomes affirmed that moderate water stress hinders vegetative growth, emphasizing the indispensability of abundant irrigation for achieving enhanced raspberry productivity.

The realm of food with natural therapeutic properties, particularly mountain berries, unfolds a plethora of health-promoting possibilities in a world marked by pandemics and instability. The cultivation of mountain food with natural therapeutic properties addresses numerous challenges in current food security and safety. Expanding agricultural production in mountainous regions, where land is underutilized, holds the potential to alleviate a portion of the global hunger crisis. Enhancing agricultural output in mountain areas, through the implementation of diverse biological and agronomic interventions outlined in this paper, stands as a solution for fortifying immune systems. *Healthier people, safer world* should be the focal point of our current educational and policy food aspirations.

Conclusion

The study provides valuable insights into the potential of mountain berries as a source of natural therapy, more than simple berries. Through a comprehensive examination of the nutritional composition and biological activities of these berries, the research demonstrates their promising therapeutic properties.

The identified compounds within mountain berries exhibit significant antiviral, antibacterial, antimicrobial, and antifungal activities, suggesting a potential role as natural therapy. The macro-nutritional constituents in these berries presents a compelling natural framework for the development of health therapy. Furthermore, the study highlights the importance of considering agricultural factors in understanding the nexus therapeutic mountain berries in producing these beneficial fruits.

The findings of this research contribute to the growing body of knowledge on alternative sources of natural therapy, emphasizing the importance of exploring mountain nature's resources for novel therapeutic agents. As it was faced challenges such as antibiotic resistance, the exploration of macro-nutritional compounds, especially those derived from mountain berries, offers a sustainable and ecologically conscious approach to healthy food discovery.

In conclusion, the study underscores the potential of mountain berries as an agronomic promising nexus for natural therapy. Further research and development in this area could lead to the discovery of natural therapeutic agents that are not only effective against infectious disease but also environmentally sustainable. This research opens avenues for future investigations into harnessing the therapeutic potential of mountain natural resources to address the global health challenges associated with infectious diseases.

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