Original Article

Relative Nutrient Indices As A Tool To Assess Wild Edible Plant's Nutrients Content For Future Food Security

Ram Chand Bhatti[1,2], Sabir Hussain[2], Rupinder Kaur[3], Abhishek Kumar[4], VineyKumar[5], SirilSingh[6], Pardeep Kumar[7], SheenuSharma[8], ChongthamNirmala[9], Anand NarainSingh[10*]

[1,2]Smt. Aruna Asaf Ali Govt. Post Graduate College, Kalka (Panchkula), Haryana, INDIA
[2,3,4,5,7,8,10*]Soil Ecosystem and Restoration Ecology Lab, Department of Botany, Panjab University, Chandigarh 160014, INDIA
[6]Department of Environment Studies, Panjab University, Chandigarh 160014, INDIA
[9]Department of Botany, Panjab University, Chandigarh 160014, INDIA

[*]Corresponding Author: - Anand NarainSingh

*Soil Ecosystem and Restoration Ecology Lab, Department of Botany, Panjab University, Chandigarh 160014, INDIA, E-mail:dranand1212@gmail.com
DOI: 10.47750/pnr.2023.14.S02.248

Abstract

Wild edible plants have gained attention due to growing concerns for global food security.Nutrient contents are frequently determined for wild edible plants identified from ethnobotanical surveys.In this article, we conducted an ethnobotanical survey at the study site and collected twenty-one wild plants for evaluating their relative nutrient indices. Our results suggested that the tubers of *Colocasia esculenta* hadthe highest macronutrients, fruits of *Spondias pinnata* had high vitamins, the leaves of *Colocasia esculenta* and *Chenopodium giganteum* had high dietary fibres, and leaves of *Digera muricata*were rich in minerals. Thus, these plants can offer a basis for developing dietary supplements and nutraceuticals on a commercial scale, which may help in achievingthe sustainable development goal of zero hunger.

Keywords: Future food, Wild edible plant, Nutrient component, Relative nutrientindices

INTRODUCTION

Globally, the number of individuals affected by hunger and malnutrition has continued to rise. The number of people suffering from hunger or malnutrition reached about 700-800 million in 2020 after the covid-19 pandemic(FAO 2021). In India, 190 million women of reproductive age are undernourished or anaemic, among the total 210 million people suffering from hunger or malnutrition (FAO 2021). Concerning the severity of the issue,the United Nations sustainable development goal 2 (SDG-2) aims to end hunger and all forms of malnutrition by 2030. Although we were already struggling to achieve this challenging goal, the covid-19 pandemic further exacerbatedthe issue by forcing more than 100 million people into a state of hunger and malnutrition.Further, the continued population expansion, unaffordability, and ongoing environmental change are expected to lead toa global food crisis. One option to address these challenges is to diversify our food systems, which can be achieved by identifying newer, cheaper, and more nutritious food sources (Ulian et al. 2020).

Although more than 7,000 species of plants are known to be edible, only 400 of them are domesticated as food crops (Antonelli et al. 2020). Among these 400 domesticated food crops, only three crops (rice, maise and wheat) are staples for more than half of the global human population.Edible plants that grow and sustain in a wild environment without being cultivated are considered wild edible plants (WEPs).In India, about 1,400 edible plants are consumed for energy intake, and almost half of them are found in the Himalayas (Ray et al. 2020). Many WEPs have higher nutrient contents than commercialised domesticated food staples (Maikhuri et al. 2021; Bhatti et al. 2022). These underutilised wild plants have other multipurpose uses ranging from food and medicinal to economic benefits (Ulian et al. 2020, Hussain et al., 2022). Good nutrition is associated with health benefits, and many WEPs are also traditionally used for medicinal purposes (Kumar et al. 2020). The bioactive secondary compounds in the WEPs promote good health and protect against many diseases (Nirmala et al. 2014; Santosh et al. 2019). Thus, an inventory of wild food resources and nutrient analysis for scientific validation can establish the substitute crops for the domestic and cultivated species, which will help select important and valuable wild plant species (Wong et al. 2013). Given the higher nutrients, health benefits, and affordability of WEPs, their inclusion in mainstream agriculture can help us achieve zero hunger and food security.

Ethnobotanical surveys aim to identify the potential plant species for specific use cases, including food, fodder, medicinal, and other socio-economic uses. The primary field data usually consist of descriptive use reports, which can form the basis for exploratory statistical analyses and hypothesis testing (Leonti 2022). Although several indices exist for the analyses of ethnobotanical data, many of them are not statistically validated (Leonti 2022). In this article, we propose a simple approach to assessing wild edible plants' importance based on their nutrient contents. We evaluated the amino acid, protein, carbohydrate, starch, fat, vitamin, dietary fibre, phytosterol, total phenol, and mineral contents (Ca, K, Na, Mg, S, Si, Ni, Cu, Fe, Mn, etc.) and physical parameters such as moisture and ash content for twenty-one wild edible plants selected based onan ethnobotanical survey in the Hamirpur district of Himachal Pradesh. We derived nutrient indices to assess the macronutrients, functional nutrients, dietary fibres, and minerals in each cited plant and their plant part. Then, we used these indices to address the following questions:i) How do various groups of nutrients vary among the species? ii) Which wild edible plants have the highest nutrient contents? and iii) How do these nutrients vary among the plant parts used?

METHODS

Ethnobotanical survey

An ethnobotanical survey was conducted in the Hamirpur district of Himachal Pradesh to identify the frequently used wild edible plants. A total of 1,720 informants (1069 males and 651 females) were face-to-face interviewed to gather information about plants regarding food and medicinal value. Out of these, 472 informants provided information about food plants. Based on the informant's consensus, a total of 90 plant species were found as edible, of which 21 plant species were selected for nutrient analysis based on the informant's perceptions, availability, and uses(Bhatti et al. 2022).

Biochemical analysis

The biochemical analysis includedthe estimation of the nutritional and bioactive content of edible parts of the selected plant species using previously described standard methods in each case: free amino acids(Lee and Takahashi 1966), proteins (Bradford 1976), carbohydrates(Whistler and BeMiller 1972), starch(McCready et al. 1950), fats(AOAC 1990), dietary fibre and its components(Goering H. K. and Van Soest 1970), vitamin C(Riemschneider et al. 1976), vitamin E (Baker et al. 1980), ash content (Harbers 1994), phenols(Singleton and Rossi 1965) and phytosterols (Srivastava 1990). Mineral elements were analysed through wavelength dispersion X-ray fluorescence (WDXRF). Overall, this study estimated 28 nutrient components, including ten minerals, ash, and moisture content.

Quantitative analysis

The relative importance of selected plant species was assessed using specific quantitative indices that were developed and employed (Table 1). Firstly, therelative nutrient content (RN_{ij}) of *j*th nutrient in *i*th species was calculated as the ratio of *j*th nutrient content in *i*th species to all species' total *j*th nutrient content. This relative content was then converted to a percentage by multiplying it by 100.

Table 1 Indices derived for the nutrient component analyses

Indices	Formula
Relative Nutrient Content	$RN_{ij} = \left(\frac{N_{ij}}{\sum_{i=1}^{n} N_{ij}}\right) \times 100$
Relative Nutrient Value Index	$RNVI_i = \sum_{j=1}^{7} RN_{ij}\ [j = AA, C, F, Pr, St, VC, VE]$
Relative Functional Food Index	$RFFI_i = \sum_{j=1}^{4} RN_{ij}\ [j = Phe, Phy, VC, VE]$
Relative Dietary Fibre Index	$RDFI_i = \sum_{j=1}^{5} RN_{ij}\ [j = ADF, NDF, Cel, Hmc, Lig]$
Relative Mineral Index	$RMI_i = \sum_{j=1}^{10} RN_{ij} \left[\begin{matrix} j = Ca, Cl, Cu, Fe, K, Mg, Mn, Ni, P, \\ S, Si, Zn \end{matrix}\right]$

where *Nij* = estimated content of *j*th nutrient in *i*th species; n = total number of plant species; AA = free amino acids; C = carbohydrates; F = fats; Pr = proteins; St = starch; VC = vitamin C; VE = vitamin E; Phe = Phenols; Phy = Phytosterols; ADF = acid detergent fibres; NDF = neutral detergent fibres; Cel = cellulose; Hmc = hemicellulose; Lig = lignin; Ca = calcium; Cl = chlorine; Cu = copper; Fe = iron; K = potassium; Mg = magnesium; Mn = manganese; Ni = nickel; P = phosphorus; S = sulphur; Si = silicon; Zn = zinc

RESULTS

Based on472 local informants, the local community eats edible parts of these plants in raw or cooked form. Maximum numbers of wild plants as fruits are generally eaten raw when they are ripe, and usually, unripe fruits, seeds, flowers, and leaves are cooked as vegetablesby the local people. In the case of individual edible plants, conventional and non-conventional processing is essential to make them palatable. For example, underground parts (tuber) of *Dioscorea* species require washing, slicing, and boiling in salty water for a particular time and keeping them in salty water overnight to discard the tuber's acid content.

Macronutrients

Macronutrients are required in large quantities to maintain a healthy body. A relative nutrient value index (RNVI) was developed to assess each species's macronutrients, including protein, carbohydrate, and fat. Values for RNVI varied from 6.36 to 34.76.The highest RNVI was estimated for the tubers of *C. esculenta* (34.76), followed by fruits with seeds of *A. marmelos* (31.32) and tubers of *D. deltoidea* (30.91). Local people of the study site were also informed about its efficacy for edible and medicinal purposes. Across species, ten species had RNVI values in the range of (20-30), and three species had above 30index values (Fig.1).

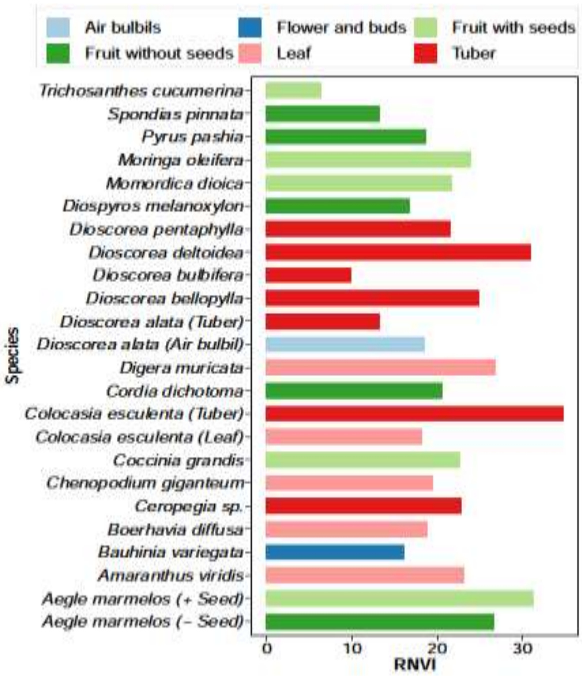

Fig. 1 The relative nutrients value index (RNVI) for the selected plant species

Functional nutrients

Relative functional food index (RFFI)provides sufficient information about rich food value content such as vitaminC, E, total phenol, and phytosterol. Based onthe analysed concentration of phytosterol and phenol, it is not easy to determinethe species quality. However, thisindex showed that the fruits of *S. pinnata*without seeds had the highest value (34.81), followed by tubers of *Dioscoreaalata* (26.11) andflowers of *Bauhinia variegata* (26.01). The remaining four species exhibited an RFFI value of around 20 (Fig.2).

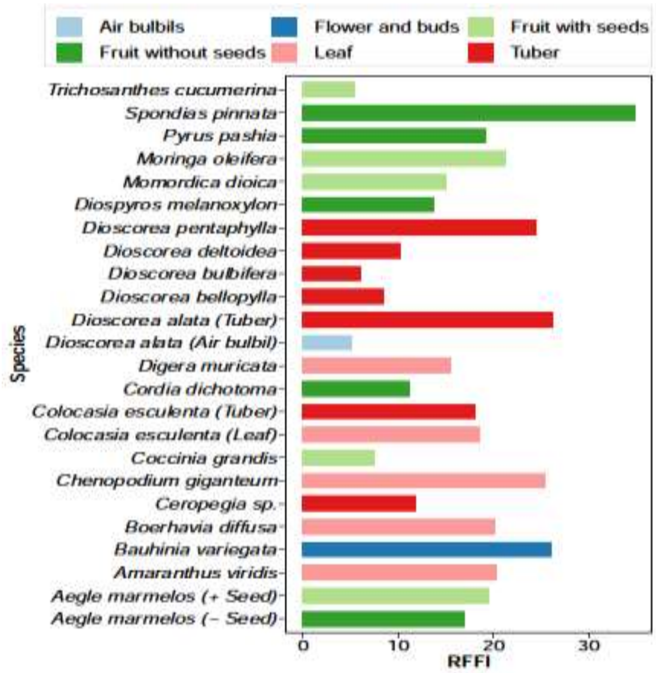

Fig. 2 The relative functional food index (RFFI) for the selected plant species

Dietary fibres

Relative dietary fibre index (RDFI) varied from 9.06 to 35.61, in which leaves of *C. esculenta* (35.61) and *C. giganteum* (35.53) both had the highest dietary fibres. At the same time,*Ceropegia* species exhibited the lowest value of RDFI (Fig.3). Across species, 12 species showed 12-25 RDFI values, while eight species had these valuesin the range of 10-12. This index can act as a better tool to distinguish species with a rich fibre content source. Therefore, through this index, we found these two species to have surprisingly better fibre content, followed by *C. dichotoma*(32.06), *P. pashia*(29.48) *A. viridis* (29.38), leaf of C. *esculenta* (25.92), and *Digera muricata* (25.36) respectively.

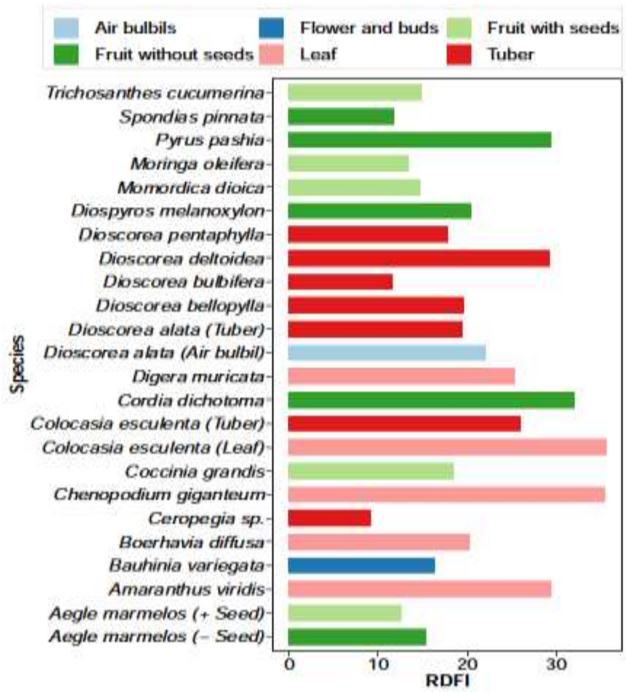

Fig. 3 The relative dietary fibreindex (RDFI) for the selected plant species

Minerals

Relative mineral index (RMI) included 12 main mineral elements (Ca, Cu, Fe, K, Mg, Mn, Ni, P, Zn, Na, Si, S). Values for the correspondingindex (RMI) varied from 13.42 to 174.03 in which *D. muricata* exhibited the highest value, followed by *A. viridis* (101.39), *C. esculenta* (98.45), *C. giganteum* (85.04), *B. diffusa* (73.25), and *Ceropegia*(67.1). The remaining other species (12) had a more or less similar range of RMI,while eight species had a range below 30 (Fig.4).

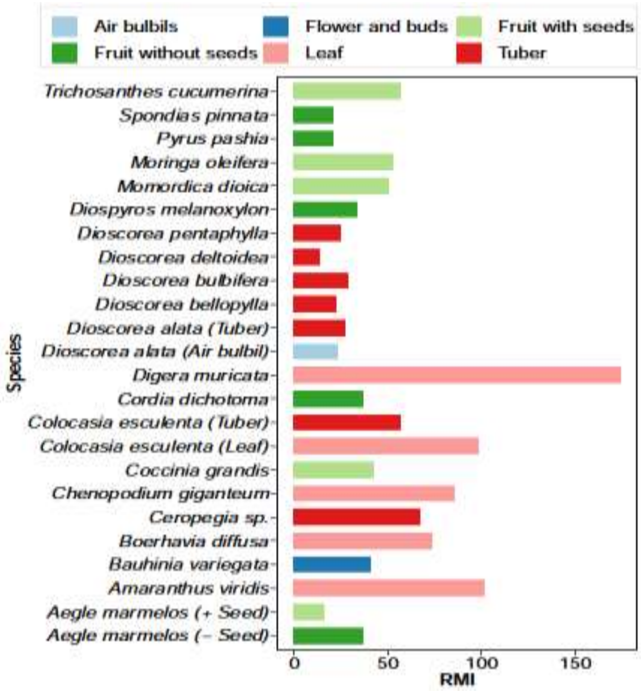

Fig. 4 The relative mineral index (RMI) for the selected plant species

DISCUSSION

In the present scenario of population expansion, economic slowdown and unaffordability of food sources, it becomes imperative to search for alternative cheaper and more nutritious food sources. Wild edible plants can potentially address this challenge by increasing dietary diversity, leading to global food security and environmental sustainability. The use of these plants depends on the local abundance and traditional knowledge passed from generation to generation. Many ethnic communities in the Indian Himalayan region still use the locally available plants for food and medicinal purposes.

Functional food provides some extra health or physiologic benefit to the body. Although all food is functional somehow, some ingredients like vitamins and phenols can provide health benefits like a reduced risk of cancers, cardiac arrest, and microbial infections. The relative functional food index suggested that fruits of *Spondias pinnata* can prove beneficial for people at risk of cardiac arrest due to increased cholesterol. Based on thisindex, *S. pinnata*, *D. alata*, *D. pentaphylla*, *C. giganteum* can be recommended as good sources for functional food development. They have several bioactive properties with possible implications for human health, such as the serum cholesterol-lowering effect that might prevent colon cancer and benign prostatic hyperplasia (Corrêa et al. 2017).

Plant food contains non-digestive carbohydrates like acid detergent fibre, neutral detergent fibre, cellulose, hemicellulose, and lignin. These indigestible carbohydrates are designated as dietary fibre(Modgil and Sood 2015; Vilcacundo et al. 2018). Although they do not constitute the nutritive value of foods, their dietary fibre intake has essential metabolic and physiological effects. The presence of fibre is commonly called roughage of diet, which is necessary for digestion and waste elimination. It helps to solve constipation and blood glucose levelsand reduce the risk of colon cancer. Our body needs some elements to function normally and maintain good health. Hence, the leaves of *Colocasia esculenta* and *Chenopodium giganteum* can be used as better sources of dietary fibre. The proposed relative mineral index included essential minerals (12 in our case) and suggested that *Digera muricata* has the highest mineral content among the selected plant species. Since *D. muricata*hasthe most elevatedprotein and mineral contents, this plant can be recommended as a good food source for people affected bymalnutrition.

Overall, the present study suggested that selected wild plants have variable amounts of different nutrient components. Further, we observed that the nutrient contents varied among the species and their part used. Some plants are found to have a higher content of protein (*Digera muricata*, *Amaranthus viridis*, *Chenopodium sp.)*, Carbohydrates(tuber of *Dioscorea sp. Ceropegia species*, *Aegle marmelos)*, vitamin C(*Spondias pinnata* fruit, *Momordica dioica*, *Aegle marmelos,* and leafy plants *Amaranthus species*),vitamin E(*Colocasia esculenta* tuber, *Aegle marmelos, Pyrus pashia, Spondias pinnata*),Iron(*Digera muricata, Amaranthus sp, Colocasia esculenta*),Calcium(*Digera muricata, Colocasia esculenta*, *Amaranthus sp.*, *Boerhaviadiffusa*),Potassium(*Digera muricata; Amaranthus sp.*, *Colocasia esculenta*),Magnesium(*Digera muricata*, *Amaranthus sp.*, *Ceropegia sp.*). Thus, the use of these edible plants can be recommended depending on the requirements of nutrient status of an individual.

These plants' higher mineral content and nutritive components (proteins and vitamins) may provide an array to utilise the plants to form dietary supplements on a commercial scale. In addition to their nutritional importance, selected underutilised plants also have high medicinal importance that can be further investigated to commercialise their use for medicinal purposes (which can be a good option for searching for new medicines). Although the present study documented the various underutilised plants, their use values as food along with their medicinal importance, further research is required to efficiently conserve and commercialise these underutilised plants to save the traditional knowledge of ethnobotany and to utilise them for their dietary and medicinal importance to fulfil the ever-increasing requirements of the human population.

ACKNOWLEDGEMENTS

We are very thankful to the local people and administration of the Hamirpur district of Himachal Pradesh for providing the necessary facilities and kind cooperation during the fieldwork. Thanks are due to the Chairperson,Department of Botany, Panjab University, and Chandigarh to provide the required facilities during work. Also, RCBis grateful to the Department of Higher Education, Haryana, and Principal, Smt. Aruna Asaf AliGovernmentPostgraduate College, Kalka, for granting study leave for doctoral research work.

DECLARATIONS

Funding: RCB is grateful to the University Grants Commission (UGC), Government of India, New Delhi for financial support in the form of a Teacher Fellowship Award. AK, PK, and SS are thankful to the University GrantsCommission (UGC), Government of India, New Delhi, and SH is thankful to CSIR, New Delhi, India for the financial support in the form of a Junior Research Fellowship (JRF).

Conflicts of interest/Competing interests: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Availability of data and materials: All data generated or analysed during this study are available from the corresponding author upon reasonable request.

Authors' contributions: Conception and design (ANS and CN); Field data collection (RCB, RP, VK, and SS); Identification and biochemical analysis (RCB, RP, and VK); Data analysis and interpretation (SH, AK, RCB, RP and ANS); Initial draft (RCB, RP, PK, and AK); Revision (SH, AK, PK, ShS and ANS); Supervision (ANS and CN). All authors read and approved the final manuscript.

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