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RESEARCH ARTICLES

Nutrient component analyses of selected wild edible plants from Hamirpur district of Himachal Pradesh, India: an evaluation for future food

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Abstract

Many wild edible plants have been traditionally used as foods and medicines among various ethnic groups. However, information about the nutrient components of these plants has yet to be scientifically tested. Therefore, this study evaluated the nutrient components of selected wild edible plants. It was found that nutrient content considerably varied among all the selected species. *Digera muricata* has the richest protein content among the selected plant species, and *Dioscorea bulbifera* has the highest fat content. Similarly, *Spondias pinnata* and *Boerhavia diffusa* were rich sources of vitamin-C and vitamin-E, respectively. *D. muricata* was found to be promising future food based on overall nutrient composition. These plants can offer a basis for developing dietary supplements and nutraceuticals on a commercial scale. Thus, scientific evaluation and validation of such underutilised plants and their products may prove an alternative future food.

Keywords Future food · Wild edible plant · Nutrient component · Relative nutrient indices

Introduction

A large fraction of the human population directly depends on staple food for their nutrient requirement. Although nutrient components vary among food sources, most staples lack proteins and micronutrients. It has been observed that only the richest 5% of Indians take the recommended balanced diet, and on an average, Indians take fewer calories from proteins than the recommended reference diet (Sharma et al. 2020). This imbalance in food diet widens as income of households lowered in developing countries like India. Consequently, India is growing as a hub for most undernourished, diabetic and obese people in the world (FAO 2020). According to FAO, more than 50% of reproductive women of India are anaemic, and 14% of total Indians are undernourished (FAO 2020).

More than 1400 edible wild food species have been identified in India (Ray et al. 2020), in which over 675 species are reported only from the Himalayan region (Thakur et al. 2017). Despite a great diversity of wild edible plants, their consumption is usually restricted to local indigenous people (Ray et al. 2020). Wild edible foods are now gaining attention for their high nutrients and health benefits (Mishra et al. 2021; Chandra et al. 2021). Many wild edible plants have higher nutritional values than commercialised fruits and vegetables (Maikhuri et al. 2000). Furthermore, fruits and vegetables also contain a vast and multifaceted array of bioactive secondary compounds that promise to promote good health and protect against many diseases (Nirmala et al. 2014; Santosh et al. 2019). Hence, these underutilised plants are not only used as a food, but now are being projected as healthy or superfoods (Nirmala et al. 2014).

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 in selecting important and valuable wild plant species.

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Knowledge of these plant species will explore new possibilities in further research work in food and other purposes. Exploration and domestication of these plants can combat with hunger and malnourishment in the country (Mishra et al. 2021). However, systematic explorations and scientific validation of the nutritional values of these plants are needed before commercialisation and domestication. Therefore, scientific studies are required to explore and validate the dietary importance of wild edible plants.

In this paper, we evaluated the nutrient components of 21 wild plants selected from the study area, and the following questions have been addressed: (1) which plants are rich in protein and carbohydrates and can be incorporated into a regular diet? (2) Which plants are rich in vitamin content and can be beneficial in vitamin deficiencies?

Material and methods

Study area

Hamirpur is a south-western district of Himachal Pradesh, which lies between 76° 17′ 50″ and 76° 43′ 42″ east longitudes and 31° 24′ 48″–31° 53′ 35″ north latitudes. This district covers an area of 1118 km^2, and its elevation varies from 400 to 1100 m. The climate is mainly sub-tropical with an average annual rainfall of about 1520 mm, where maximum rainfall occurs in July–September and minimum in April–June. The annual mean temperature ranges between 20 and 25 °C in most of the district's parts. Due to the variation of climatic conditions, it has a rich diversity of plants comprising wild fruits, leafy vegetables, and tubers (Chand et al. 2016, 2017).

Field survey

A total of 1720 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 (Table S1).

Sample collection

Field trips of 3–4 days were made in different seasons to collect the samples of screened plants used for edible purposes. The aboveground plant parts were manually hand-picked, and the underground parts were dug out using a digger and spade with assistance from the local people. The collected plant samples were kept in separate thermocol (polystyrene) boxes to retain freshness during transportation. Then samples were brought to the laboratory for nutrient and mineral analysis.

Biochemical analysis

The biochemical analysis included the estimation of nutritional and bioactive content of edible parts of the selected plant species using previously described standard methods in each case: proteins (Bradford 1976), carbohydrates (Whistler and BeMiller 1972), fats (AOAC 1990), vitamin-C (Riemschneider et al. 1976) and vitamin-E (Baker et al. 1980).

Results and discussion

Carbohydrate

The allocation of carbohydrates was calculated and presented in (Fig. 1). Since carbohydrates are primary energy generating (yielding) substances, they are regarded as the chief energy source for each organism. They are mainly composed of starch and sugars. Among species, *Dioscorea bulbifera* showed the richest allocation of carbohydrate

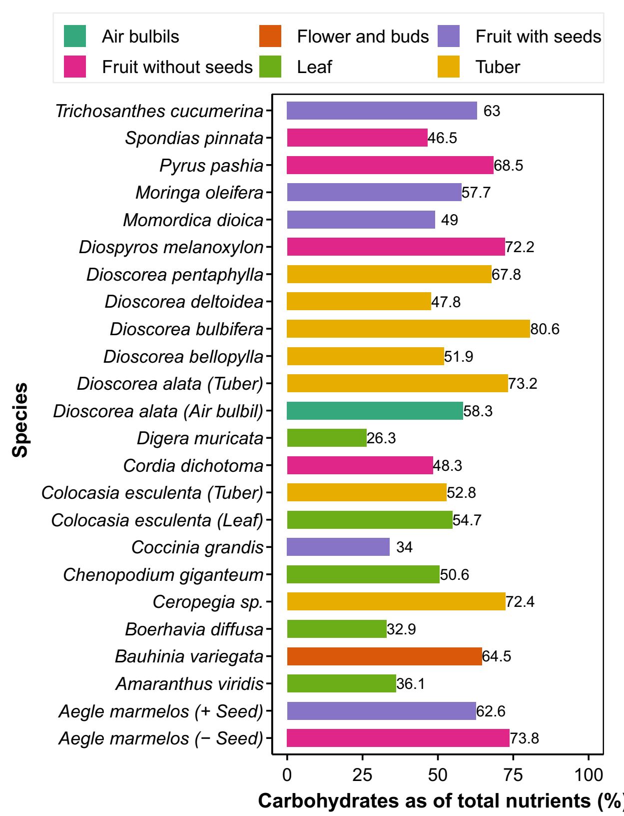

Fig. 1 Fraction of carbohydrate content to the total nutrients in the selected plant species

(80.57%), followed by *Aegle marmelos* (73.8%), *D. alata* (73.19) *Ceropegia* sp. (72.36%), and *D. melanoxylon* (72.2%). Remaining some other species (*D. pentaphylla*, *T. cucumerina*, *B. variegata*, *Pyrus pashia*, and *S. pinnata*) also exhibited a comparable allocation range of carbohydrates. It has been noted that *D. muricata* has the highest allocation for protein but least for carbohydrates. However, a variable degree of carbohydrates as total nutrients was found in the selected species, where 50% of species allocated 50% of carbohydrates and 25% species showed 30% allocation (Fig. 1).

Based on this finding, few species such as *D. bulbifera*, *Ceropegia* sp., *D. pentaphylla*, *D. alata*, *B. variegata, A. marmelos,* and *D. melanoxylon* can be recommended as a good source of carbohydrates. The starch allocation was higher in all *Dioscorea* species except *S. pinnata* with the maximum allocation (37.0%). In agreement with our study, some earlier studies, for example, Baliga et al. (2011) reported 31.8% carbohydrate in the fruit of *A. marmelos* and another recent study, Binish and Pushpa (2018) revealed 34.43–46.16 g/100 g highest nutrient value of carbohydrates in tubers of three *Ceropegia* sp. (Baliga et al. 2011; Binish and Pushpa 2018).

Fat

Fat is also the primary source of metabolic energy, which indirectly regulates the flow of materials into and out of the cell. Dietary fat serves as a carrier of vitamins, A, D, E, K, and hormones. In our study, allocation of fat of the total nutrients provides impressive results among all selected species. For example, *Colocasia esculenta* is rich in carbohydrates but provided the highest fat allocation, followed by *Boerhavia diffusa* and *T. cucumerina*. The least amount was recorded in the fruit of *D. melanoxylon* (Fig. 2). Generally, plant components, leaves, and seeds provide a rich source of fat. In our study, fat content was analysed from leaf, and a high content was recorded, for example, *C. esculenta*, *B. diffusa*, *Chenopodium giganteum,* and *A. viridis*. Furthermore, few species were observed to have a high concentration of fat (lipid) content in the present study that can be an excellent fat source.

Generally, food plant species possess fat content ranging from 0.1 to 5% or even above. Earlier studies observed that edible plant species' fat content varies with species, parts, and study area. For example, the fat content in *B. diffusa* was found to be 1.16% (Puranik et al. 2012), whereas it was 0.7% in leaves of *Amaranthus* sp. (Misra et al. 2008). Similarly, the fat content was reported about 1.8% (Nowak et al. 2016) and 5.5–7.4% in the same species *Chenopodium quinoa* (Vilcacundo et al. 2018), but from different study areas. These studies altogether support the present study's findings as the fat content of all leafy vegetables was approximately within the range recorded by earlier studies.

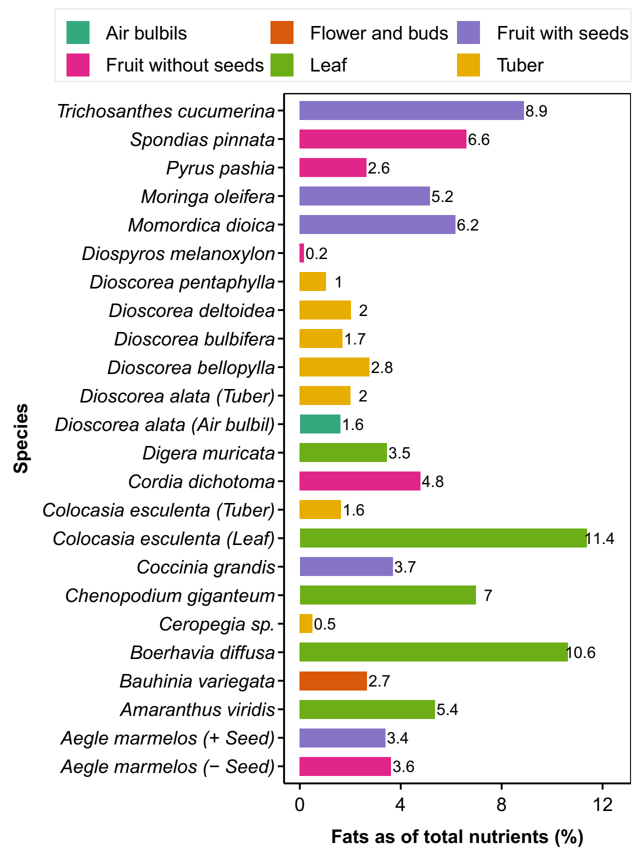

Fig. 2 Fraction of fat content to the total nutrients in the selected plant species

Protein

Dietary protein is the most critical constituent among all nutrients, primarily involved in the growth, maintenance, and repair. Excess protein is used as a source of energy. Based on the allocation of total protein among selected plant species, *D. muricata* is found most important edible species and is allocated with a high percentage of protein (46.52%) as of total nutrients (Carbohydrate + fat + protein) followed by *A. viridis* (22.73%), *C. giganteum* (19.82%) and *B. variegata* (17.97%), whereas, least allocation was found in *Ceropegia* species (1.46%). Sharma and Vijayvergia (2011) and Usmani et al. (2014) reported protein content 78.0 mg/g and 4.3 (g/100 g) in *D. muricata* respectively on a dry basis, which is lower than the present estimation of the same species (Sharma and Vijayvergia 2011; Usmani et al. 2014). Out of all selected plant species, seven species showed more than 10% while four species had less than 5% protein allocation. It was further observed that more than 15% allocation of protein was recorded in all leafy vegetable plants except *C. esculenta*. Specifically, one fruit plant (*C. grandis*) exhibited more than 15% protein allocation. Hence, those plants with a high protein percentage are presumably the most important edible species as a protein source that can be recommended to people deficient in protein nutrients. Therefore, the variation in the protein contents depends upon the season of collection, location and genetic variations of the species, etc. However, leafy vegetables' variation ranged from 0.33 to 21.79 g/100 g (Verma 2014). The lowest value (0.57 g/100 g) was found in the fruits of *Trichosanthes cucumerina*. The result of the same was confirmed and reported precisely by Badejo et al. (2016), who reported protein 0.37–0.51 (g/100 g on a fresh weight basis) in the same species (Badejo et al. 2016). The amino acid allocation was recorded maximum in the species like *A. viridis* (27.9%) followed by *B. diffusa, C. grandis, M. dioica, C. dichotoma*, and *C. giganteum* (Fig. 3).

Vitamin-C

Allocation of vitamin-C of total nutrients in the selected species reflected a contrasting range from 0.01 to 1.0%. *S. pinnata* had the highest allocation, followed by *M. dioica*, *B. diffusa*, *A. viridis*, and *B. variegata* (Fig. 4). However, 6–7 species showed an intermediate range, but those species that showed a higher allocation range for protein and

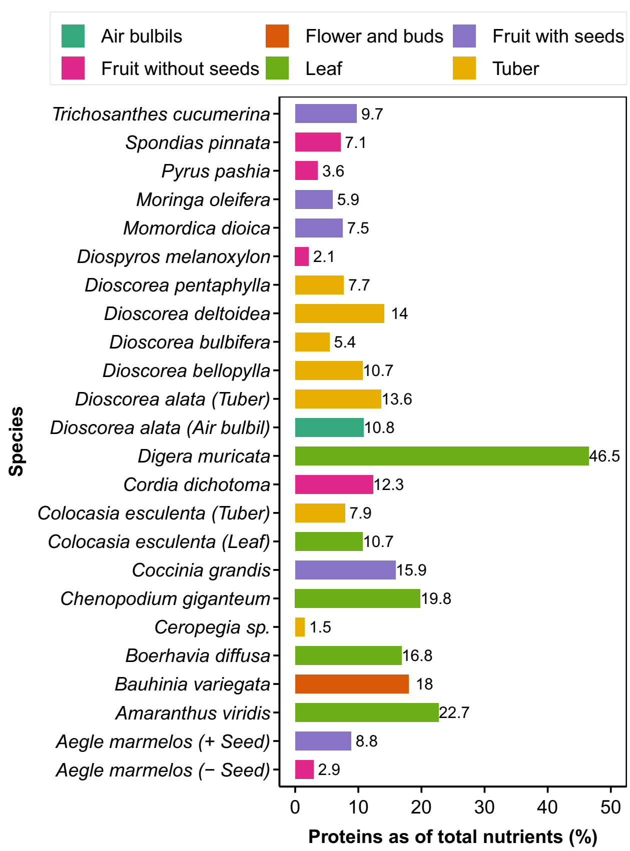

Fig. 3 Fraction of protein content to the total nutrients in the selected plant species

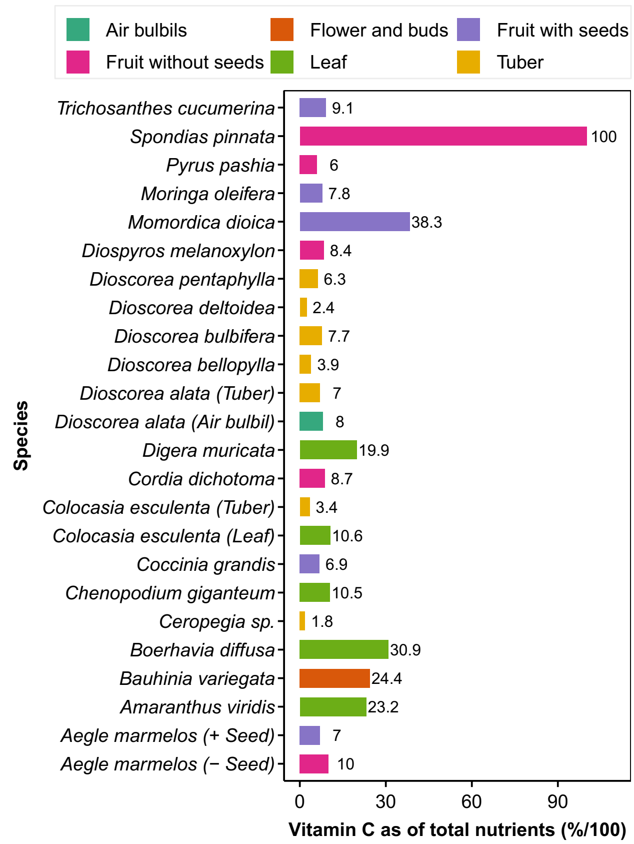

Fig. 4 Fraction of vitamin C (%/100) content to the total nutrients in the selected plant species

carbohydrate had low allocation for vitamin-C. Surprisingly, one species *D. muricata* with the highest allocation for protein, a substantial amount of carbohydrates, exhibited an acceptable range of vitamin-C allocation slightly lower than *A. viridis* (a leaf vegetable). Vitamin-C generally is a good source for immunity enhancement, protection from various diseases. Various workers (Gosh et al. 2017) have reported vitamin-C content in *S. pinnata* in the range of 21–218 mg/100 g. In another study, contents of vitamin-C (3.0–13 mg/100 g) fresh weight basis) in the shoots of bamboo species were reported (Nirmala et al. 2007). In comparison, another study conducted by Badejo et al. (2016) reported 39.32–56.58 vitamin-C content in the fruits of *Trichosanthes cucumerina* on a dry weight basis, which is in line with our findings.

Vitamin-E

Boerhavia diffusa had the highest allocation of vitamin-E followed by *C. giganteum* and *S. pinnata* whereas it was lowest in *Ceropegia* sp. and *C. dichotoma* (Fig. 5). The remaining 18 species were found in the range of 0.001–0.009%. Important vitamin-rich plant species mentioned above can

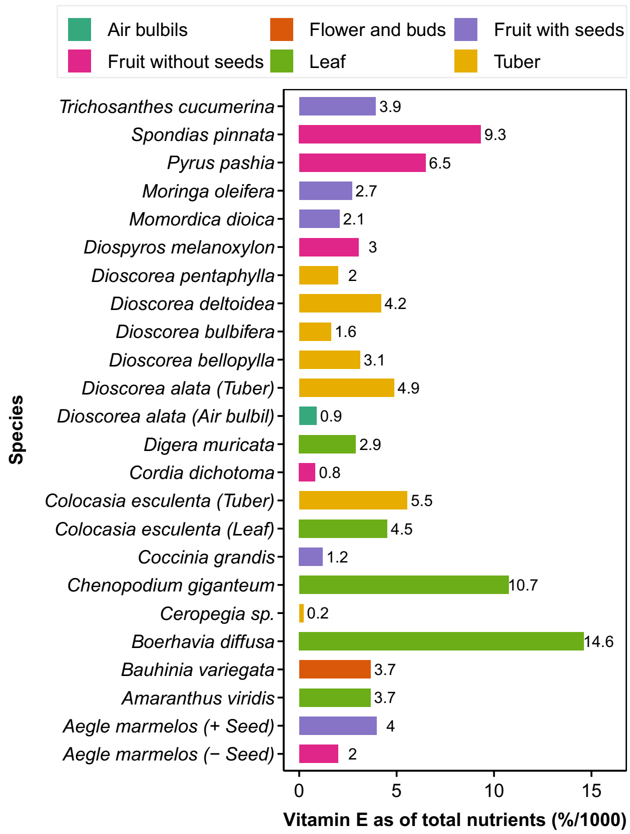

Fig. 5 Fraction of vitamin E (%/1000) content to the total nutrients in the selected plant species

be recommended as healthy diets, especially for nutrient-deficient areas. Vitamin-E is required for skincare, hair growth and also regarded as a beauty vitamin. It is a powerful antioxidant that protects the heart, blood vessels, chest pain, high blood pressure, blocked arteries, anti-aging, cancer, and liver toxicity (Aziz and Karboune 2018). The range of vitamin-E content varied from 0.05 to 16.4 mg/100 g in different species mentioned above by different workers. Hence, these plants such as *A. marmelos*, *P. pashia*, *S. pinnata*, *B. diffusa*, *C. giganteum*, etc. can be considered the sources for vitamin-E supplement for local people, if it is commercialised.

Conclusions

This study found that nutrient content varied among selected species and their plant part analysed. Some plants are found to have a higher content of protein (*D. muricata*, *A. viridis*, *Chenopodium* sp.), Carbohydrates (tuber of *Dioscorea* sp. *Ceropegia* species, *A. marmelos*), vitamin-C (*S. pinnata* fruit, *M. dioica, A. marmelos,* and leafy plants *Amaranthus* species) and vitamin-E (*C. esculenta* tuber, *A. marmelos, P. pashia, S. pinnata*). Although the present study documented the various underutilised plants, their use values as food along with their medicinal importance. Therefore, further research is warranted 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 fulfill the ever-increasing requirements of the human population.

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

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Availability of data and materials All data available from the corresponding author on reasonable request.

Declarations

Conflict of interest 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.

Ethics approval Not applicable.

Consent to participate Not applicable.

Consent for publication Not applicable.

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