

Proximate composition and antioxidant potentiality of underutilized and neglected edible plants for sustainable development in food security

Muktadhar Reang (✉ reangmukta@gmail.com)

Tripura University <https://orcid.org/0000-0003-1498-3725>

Dipan Sarma

Tripura University

Badal Kumar Datta

Tripura University

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Abstract

For decades, indigenous people of rural regions have been consuming wild edible plants as food and medicines. Wild edible plants are neglected and underutilized food plants whose utilization is only restricted to a specific location. It is also referred as *Future Smart Foods*. Nutritional analysis can provide valuable insights into the potentiality of native wild edible plants as sustainable and nutritious food source. This study aims to analysis the proximate and elemental composition, and antioxidant activity of underutilized and neglected plants in Tripura. In our findings, relatively high carbohydrate, protein and fats content was observed in *Oroxylum indicum* (13.34 ± 0.29), *Trachyspermum roxburghianum* (10.43 ± 0.19) and *Flacourtia indica* (4.25 ± 0.28) respectively. The highest Total energy was recorded in *Flacourtia indica* (107.97 Kcal). The highest moisture and ash content was observed in *Alpinia nigra* (94.95%) and *Trachyspermum roxburghianum* (42.16%) respectively. The quantitative concentration (Wt %) of six micronutrients (Mg, P, K, Ca, Fe and Cl) reveals that the highest was observed in potassium (K) *i.e.* 34.15% (34.15 mg/gm) in *S. pennata*. The free radical scavenging activity of the ethanolic extracts showed that *L. leucocephala* possessed high antioxidant activity ($IC_{50} = 125.4 \pm 1.78$). The nutritional values may be helpful for these underutilized crops to encourage future conservation plans and assess the level of dietary supplement dependency of the local communities. Therefore by promoting the cultivation and consumption of underutilized crops, we can support local communities and accomplish sustainable development in food security.

Introduction

For decades, indigenous people of rural regions have been consuming wild edible plants as food and medicines (Khan et al. 2017; Hazarika et al. 2012). Wild edible plants are neglected and underutilized food plants whose utilization is only restricted to a specific location. Neglected and underutilized species are referred to as Future Smart Foods. They are essential to combating hunger and malnutrition through diversity in diet and production (Li and Siddique 2018). The popularity of these wild products is only known for their taste, but there has yet to be evidence for the nutritional components. As a result, it has become a field of study for many researchers to analyze the nutritional components of these wild edible plants (Brahma et al. 2014). Hence this will allow us to understand the dietary supplements and check the properties of food safety that the ethnic people utilize. According to Sustainable development goals (SDG-2, 2023), the Zero Hunger goal aims to end hunger, achieve food security, improve nutrition, and promote sustainable agriculture. The goal identifies that having sufficient, safe, and nutritious food is a fundamental human right. Earth has tremendous resources, but millions of people need more access and effective food management (Gil et al. 2019). Therefore it is necessary to discover new food species with great potential for food security and to end food crisis issues worldwide.

Wild edible plants are an essential part of the diet for rural populations. They are the main ingredients in preparing different food and cuisine in many diets of rural ethnic communities (Konsam et al. 2016). The ethnic communities living in remote rural areas are bound to gather food around the nearby forest. The forest serves as a storehouse of resources for various purposes, such as food, medicines, housing materials, and fuels (Hazarika and Pongener 2018). The faunal is also utilized for resources such as meat, honey, leather, tendons (dried), horns and bones. However, the nutritional benefit of these plants needs to be better understood and acknowledged.

Nutritional analysis of underutilized food plants will provide a comprehensive evaluation of dietary content and health benefits, which includes protein, carbohydrate, fat, and mineral content (Md Noh et al. 2020). Analysis of other bioactive components and antioxidant levels can also provide valuable insights into the potentiality of native wild edible plants as a sustainable and nutritious food sources (Alaca et al. 2021). It can encourage their conservation and utilization on a large scale. According to *Food and Agriculture Organization (FAO 2017)*, promoting indigenous food systems and using wild plants is crucial because of their local availability, low cost, and safety. The main objective of this study is to analyze the nutritional components of the underutilized food plants so that one can utilize the existing native wild edible plants to initiate domestication. Especially in dealing with the issue of undernutrition, poverty and malnutrition; hence dynamic conservation of underutilized and neglected bioresources is essential (Komor 2016). Several indigenous foods have the potential to contribute to the global food supply and are likely to become significant food commodities if supported with additional research and adaptation.

Materials and Methods

Study area

Markets survey was conducted and observed that there were some wild edible plant species which were highly preferred in the locals of Tripura, India. Tripura is the third small hilly state covering 10,486 Km² and is located between 22°57' and 24°32' N latitude and 91°10' and 92°20' E longitude. The abundance of edible plants enabled the ethnic people of Tripura to rely on indigenous plant resources as a critical component of their livelihood. These species were consequently found to be in high demand amongst consumers in the local markets.

These species were available and collected in the forest, but some are semi-wild/cultivated (Jhum). Such dependency is prevalent in locations with cultural resources and restricted economic possibilities, primarily in the state's remote highland districts (Das et al. 2009).

Nutrients analysis

The proximate analysis can identify the levels of each macronutrient in food samples. Moisture, ash, fat, protein, and carbohydrate contents are all part of the proximate composition of foods (Thangaraj 2016). These values are described as nutritional facts, often displayed on the labels of finished food products. They are also a minimum procedure to be determined throughout the food manufacturing industries. Plant extracts/samples were prepared by washing them under running tap water, then drying them in the shade and storing them overnight at 60°C in a hot-air oven. The dried sample was then pulverized into powder using a mechanical grinder and stored in cold storage for nutritional analysis.

Evaluation of Proximate Composition

Moisture content is determined from fresh plant samples weighing 10 gm. The sample was then heated up upto 60°C in a hot-air oven overnight. After cooling at room temperature, the dried samples were weighed uniformly. The moisture percentage was calculated based on weight loss (Sadasivam and Manickam 2008).

Total Carbohydrate was estimated from dried samples (powdered) (Hedge and Hofreiter 1964). 100 mg of the material was placed in boiling tubes and hydrolyzed for 3 hours in 5 ml of 2.5 N HCl before being cooled at room temperature and neutralized with sodium carbonate pellets. The volume is increased to 10 ml and centrifuged for 15 minutes at 5000 rpm. The supernatant was collected, and aliquots of 1 ml were obtained for analysis. Then it was added with 4 ml of 2% anthrone reagent (w/v in concentrated H₂SO₄) and treated in a boiling water bath for 10 minutes. A spectrophotometer was used to measure absorbance at 630 nm. Glucose was used as standard.

The crude protein content was determined (Lowry 1951). 500 mg of the dried sample (powdered) was pulverized thoroughly using a pestle and mortar in 10 ml of potassium phosphate buffer (0.1 M, pH 7.5) and centrifuged at 5000 rpm for 15 minutes. The pellet was discarded, and the supernatant was utilized to calculate protein levels. 1 ml of supernatant was collected in dry test tubes, and 5 ml of reagent "C" was added. Reagent "C" was created by combining reagents "A" and "B" in a 50:1 (v/v) ratio (Reagent "A" is a mixture of 2% Na₂CO₃ and 0.1 N NaOH, whereas reagent "B" is a mixture of 0.5% CuSO₄ and 1% Na-K tartrate). The solution was briskly shaken and let to stand for 20 minutes. After that, 0.5 ml of Folin-Ciocalteu reagent was added and incubated in the dark for 30 minutes at room temperature. A spectrophotometer was used to detect absorbance at 660 nm. As a standard, bovine serum albumin (BSA) was used.

The fat content was determined (AOAC 1960). Petroleum ether was added to 2 grams of the sample, placed in dry test tubes, and allowed to sit for 24 hours. The next day, the petroleum ether evaporated to dryness. Then test tubes are finally weighed before and after for the resultant crude fat.

To be determined by Ash (AOAC 1965), 2 gm of dried (powdered) material was placed in a crucible. It is then ignited at 450°C to burn out any organic components. The required ash concentration is the inorganic material that does not volatilize at this temperature. The crucible's initial (empty) weight was recorded first, followed by the ultimate weight and ash content.

The total energy value in kcal/100g was estimated by using the method described by FAO (2003) as shown below: **Energy = (4×Crude protein) × (4×Carbohydrate) + (9×Crude fats).**

Determination element composition

To estimate the proportionate components in the ash, 2 gm of dried powdered sample was mineralized in the muffle furnace at 450°C. The chemical composition of the fundamental ash components (Na, P, S, K, Mn, Fe, Mg, Ca, Cr, Co, Cu, Ni, Zn, and Pb) may be easily identified using an analytical scanning electron microscope and the EDS-method (Gins et al. 2018). A novel approach to qualitative mineral identification and quantitative measurement was devised using scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS) (Liu et al. 2021). EDX analytical technique can be used for elements such as calcium and potassium analysis in food samples such as fruits, vegetables and spices (Md Noh et al. 2020).

Antioxidant Activity Evaluation

The free radical scavenging ability of the extracts was tested by DPPH radical scavenging (Rahman et al. 2015). In the presence of antioxidants, DPPH creates a violet/purple colour in ethanol solution and fades to yellowish. An ethanol solution of DPPH (0.5ml, 0.5 mM) was added to 5 different concentrations of sample extract ranging from 100–500 µg/ml. The solution was mixed thoroughly and left for 30 minutes in dark storage at room temperature. The absorbance of the solution was measured by a spectrophotometer at 517 nm using the standard calibration curve, and the sample concentration giving 50% inhibition (IC₅₀) was calculated. Ascorbic acid was used as a reference.

The percentage of DPPH radical scavenging activity was determined by the equation:

DPPH radical scavenging activity (%) = $\frac{A_0 - A_1}{A_0} \times 100$

[A₀ (absorbance of the control), A₁ (absorbance of the extractives/standard), percentage of inhibition was then plotted against concentration and the IC₅₀ was derived from the graph.]

Results and Discussion

Selection of neglected and underutilized species for nutrient analysis

The criteria for selecting the species for nutrient analysis are the neglected and underutilized species sold in local markets, which could be alternative sources to commercial vegetables, fruits and spices. These have a high preference among locals and are found primarily in the wild, and most importantly, these native plants were cultivated to a minimal extent. Hence, determining the nutritional components will allow the selection of these species to form a province for initiating large-scale cultivations for sustainable development in the food sector.

Table 1: List of selected wild edible plant species based on 3 categories (Spice, Vegetable and Fruits)					
Edible categories	Species name	Family	Vernacular name*	Part used	Mode of Preparation
Spices	<i>Alpinia nigra</i> (Gaertn.) Burt	Zingiberaceae	Thrai (Rea), Tara (Ben)	Stem Pith	Stem pith is cooked with any dish.
	<i>Zanthoxylum rhetsa</i> (Roxb.) DC.	Rutaceae	Muiching (Rea),	Leaf	Leaf is added and cooked in any cuisine.
	<i>Ocimum americanum</i> L.	Lamiaceae	Manda (Rea), Ban tuls (Ben)	Leaf and Stem	Leaf and stem is cooked along with any cuisine.
	<i>Trachyspermum roxburghianum</i> (DC.) H.Wolff	Apiaceae	Khundrupui (Rea)	Leaf and Stem	Leaf and stem is cooked along with any cuisine.
	<i>Homalomena aromatica</i> Schott	Araceae	Kaimaitru (Rea), Gandagi (Ben)	Stolon	Young fresh stolon is added in certain dish.
Vegetables	<i>Neptunia oleracea</i> Lour.	Fabaceae	Thoraiha (Rea)	Leaf and Stem	Leaf and stem is stir fried as eaten as side dish.
	<i>Oroxylum indicum</i> (L.) Benth. ex Kurz	Bignoniaceae	Taukharung (Rea)	Fruit	Fruit skin was peeled and pulp is stir fried and eaten.
	<i>Leucaena leucocephala</i> (Lam.) de Wit	Fabaceae	Wakre ste (Rea)	Fruit	Fruit is boiled mildly and mix with salads.
	<i>Senegalia pennata</i> (L.) Maslin	Fabaceae	Muikambu (Rea)	Leaf	Young leaf is eaten by steaming.
Fruit	<i>Flacourtia indica</i> (Burm.f.) Merr.	Salicaceae	Pahela (Rea), Tokroi (Ben)	Fruit	Fruit is eaten when ripe.

*Vernacular names: Reang (Rea), Bengali (Ben)

Proximate composition and nutritional values of selected species

The proximate composition of selected bioresource species is presented in **Table 2**. Based on the percentage of the ten studied samples, total *carbohydrate* (%) content range from 3.65% 13.34%; crude *Protein* (%) content range from 1.23% 10.43%; crude *fats* (%) content range

from 0.05% 2.375%; *total energy* content range from 41.055 Kcal - 79.86 Kcal; *moisture* content was found to vary from 73.81% 94.95% in fresh weight, and the *ash* content of these plants ranged from 7.61% 42.16% in dry weight. As our result depicted (**Figure 1**), *Oroxylum indicum* has a relatively high carbohydrate content (13.34%), followed by *Flacourtia indica* (13.23%), *Homalomena aromatic* (8.88%) and the least belongs to *Zanthoxylum rhetsa* (3.65%). The highest protein content was observed in *Trachyspermum roxburghianum* (10.43%), followed by *Homalomena aromatica* (9.74%), *Neptunia oleracea* (8.74%), and the least was *Ocimum americanum* (1.23%). The highest fats content was observed in *F. indica* (4.25%), *S. pennata* (3.375%), *Zanthoxylum rhetsa* (2.975%), *Trachyspermum roxburghianum* (2.755%), *Ocimum americanum* (2.375%), *Oroxylum indicum* (2.175%), *Leucaena leucocephala* (1.91%), *Neptunia oleracea* (1.825%), *Alpinia nigra* (1.775%) and *Homalomena aromatica* (1.525%). The highest nutritive value (Total energy) was recorded in *Flacourtia indica* (107.97 Kcal), followed by *Oroxylum indicum* (106.855 Kcal), *Homalomena aromatica* (88.205 Kcal) and the lowest in *Alpinia nigra* (41.055 Kcal).

The highest moisture content was observed in *Alpinia nigra* (94.95%), *Homalomena aromatica* (94.21%), and *Oroxylum indicum* (89.5%), while the least was *Zanthoxylum rhetsa* (73.81%). The highest ash content was observed in *Trachyspermum roxburghianum* (42.16%), *Neptunia oleracea* (37.8%), and *Homalomena aromatic* (36.98%), while the least was observed in *Senegalia pennata* (7.68%).

Table 2: Proximate composition of the selected wild edible plant species

Species	Carbohydrate (%)	Protein (%)	Fats (%)	Total Energy (%)	Moisture (%)	Ash (%)
<i>Alpinia nigra</i>	3.93±0.67	2.34±0.06	1.775 ± 0.08	41.055	94.95±0.24	34.78±1.13
<i>Zanthoxylum rhetsa</i>	3.65±0.37	3.82±0.1	2.975±0.4	56.655	73.81±0.34	35.16±1.17
<i>Ocimum americanum</i>	5.21±0.70	1.23±0.04	2.375 ± 0.02	47.135	86.49±0.30	21.77±1.59
<i>Trachyspermum roxburghianum</i>	4.81 ± 0.09	10.43 ± 0.19	2.1 ± 0.05	79.86	89.29 ± 0.77	42.16±2.13
<i>Homalomena aromatica</i>	8.88±0.69	9.74±0.05	1.525±0.39	88.205	94.21±0.31	36.98±0.8
<i>Neptunia oleracea</i>	6.88 ± 0.05	8.74 ± 0.46	1.825 ± 0.08	78.905	82.25 ± 0.26	37.8±1.97
<i>Oroxylum indicum</i>	13.34±0.29	8.48±0.05	2.175±0.4	106.855	89.5±0.15	12.15±1.08
<i>Leucaena leucocephala</i>	5.14±0.23	5.88±0.02	1.91±0.7	61.27	78.1±0.65	12.13±1.61
<i>Senegalia pennata</i>	4.27±0.26	3.96±0.39	3.375±0.18	63.295	80±0.42	7.68±0.71
<i>Flacourtia indica</i>	13.23±0.28	4.20±0.02	4.25±0.28	107.97	76.17±0.87	25.07±0.22

*Each Triplicate experimental data (n=3) is represented as Mean±standard deviation

Comparative concentration of elemental composition in the ash of the selected species

The quantitative concentration (Wt %) of six main elements constituent have been studied from the ten selected wild edible plant species. The chemical composition of the basic ash components (Mg, P, K, Ca, Fe, Cl) was determined by energy dispersive spectrometry (EDS). X-ray microanalysis data are presented in the form of standard protocols which contain the microstructure picture of the studied sample; the data in weighting and atomic correlation, spectra and histograms were recorded as shown in **Figure 2**.

Micronutrient analysis

The results of micronutrients in each studied edible plant were noted (**Table 3**). In *Alpinia nigra* the proportion of K (18.23%) is detected to be highest, followed by P (1.72%), Ca (1.57%), Mg (1.03%), and Cl (0.97%). In *Zanthoxylum rhetsa*, the proportion of K (9.55%) is highest, followed by Mg (2.94%), Ca (2.71%), Cl (0.75%) and Fe (0.21%). *Ocimum americanum* consists high proportion of K (20.89%), Ca (13.23%), P (3.81%), Mg (2.98%) and Cl (3.61%). In *Trachyspermum roxburghianum* higher proportion of K (17.02%) is observed, followed by Cl (4.84%), Ca (2.36%), Mg (0.74%) and P (0.48%). In *Homalomena aromatic*, the highest proportion of K (42%) is observed, followed by Cl (8.58%), Ca (2.66%) and Fe (0.23%).

Neptunia oleracea has the highest amount of K (14.64%), followed by Ca (1.53%), Cl (1.24%), Mg (0.88%) and P (1.76%). In *Oroxylum indicum*, K (25.12%) is the highest, followed by Ca (7.73%), P (5.09%), Mg (4.27%), Cl (3.51%) and Fe (0.28%). In *Leucaena leucocephala* Ca (9.28%) content is highest, followed by K (8.79%), Cl (5.53%), Mg (2.28%), P (1.35%) and Fe (0.17%). In *Senegalia pennata*, the mineral

contents observed are K (34.15%), P (12.17%), Cl (4.19%), Ca (3.78%), Mg (2.19%) and Fe (0.11%). Lastly, *Flacourtia indica* has a higher minerals proportion in K (31.84%) followed by Ca (7.09%), Cl (5.88%), P (2.11%), Mg (1.23%) and Fe (0.2%) respectively (**Figure 3**).

Table 3: Quantitative Wt %) of 5 main elements constituent in the ash sample

Element	Weight (%) of 10 studied species									
	<i>A. nigra</i>	<i>Z. rhetsa</i>	<i>O. americanum</i>	<i>T. roxburghianum</i>	<i>H. aromatica</i>	<i>N. oleracea</i>	<i>O. indicum</i>	<i>L. leucocephala</i>	<i>S. pennata</i>	<i>F. indica</i>
Mg	1.03	2.94	2.98	0.74	-	0.88	4.27	2.28	2.19	1.23
P	1.72	-	3.81	0.48	-	1.76	5.09	1.35	12.17	2.11
K	18.23	9.55	20.89	17.02	42	14.64	25.12	8.79	34.15	31.84
Ca	1.57	2.71	13.23	2.36	2.66	1.53	7.73	9.28	3.78	7.09
Fe	-	0.21	-	-	0.23	-	0.28	0.17	0.11	0.2
Cl	0.97	0.75	3.61	4.84	8.58	1.24	3.51	5.53	4.19	5.88

Antioxidants DPPH Scavenging

The free radical scavenging activity of the ethanolic extracts of *A. nigra*, *Z. rhetsa*, *O. americanum*, *T. roxburghianum*, *H. aromatic*, *N. oleracea*, *O. indicum*, *L. leucocephala*, *S. pennata* and *F. indica* was performed at various concentrations ranging from 100 500 µg/ml (**Table 4**). Ascorbic acid (Vitamin C) was used as a standard antioxidant agent. IC₅₀ value of the DPPH scavenging assay for the studied sample was tabulated in **Table 5**. It was found that in the lowest concentration (100µg/ml), the percentage scavenging is lower than the higher concentration (500µg/ml); these suggest that the percentage of free radical scavenging activity increase with the increase of sample concentration in a dose-dependent manner.

Table 4: DPPH scavenging activity of the studied samples showing Antioxidant potentials					
% DPPH scavenging					
Species name	100 (µg/ml)	200(µg/ml)	300(µg/ml)	400(µg/ml)	500(µg/ml)
<i>A. nigra</i>	16.18±2.63	26.48±0.64	36.14±0.65	41.53±2.88	49.19±1.8
<i>Z. rhetsa</i>	41.86±1.58	77.25±0.71	91.07±0.8	91.78±0.85	91.4±0.67
<i>O. americanum</i>	36.64±0.46	59.44±0.61	78.12±0.1	90.53±0.55	91.13±0.23
<i>T. roxburghianum</i>	25.57±0.63	38.83±0.68	50.92±0.84	63±0.28	74.22±0.04
<i>H. aromatica</i>	34.46±0.3	56.83±0.59	78.01±1.12	90.15±1.67	94.88±0.43
<i>N. oleracea</i>	7.68±1.1	23.68±0.35	36.62±0.84	48.25±0.7	51.97±0.39
<i>O. indicum</i>	36.04±0.06	63.75±2.56	77.97±0.12	90.65±0.53	92.07±0.2
<i>L. leucocephala</i>	56.56±0.94	87.59±0.3	93.33±0.06	94.03±0.41	93.39±0.05
<i>S. pennata</i>	7.68±0.73	23.68±0.82	36.62±1.66	48.25±1.47	51.97±0.67
<i>F. indica</i>	12.53±0.35	23.89±0.99	31.56±0.53	39.19±0.18	51.66±0.88
Vit C	91.91±1.58	92.02±0.94	92.13±1.05	92.13±0.45	91.91±0.97

Triplicate experimental data (n=3) is represented as Mean±standard deviation

Our results show that *L. leucocephala* possessed the lowest IC₅₀ (125.4±1.78) value, followed by *Z. rhetsa*, which indicates a high antioxidant activity; whereas *F. indica* fruit extract demonstrated higher IC₅₀ (485.44±5.82), suggesting low antioxidant activity (**Figure 4**).

The decreasing order of free radical scavenging activity in terms of IC₅₀ value of the studied plant extracts was in the following: Vit. C > *L. leucocephala* > *Z. rhetsa* > *O. indicum* > *O. americanum* > *N. oleracea* > *T. roxburghianum* > *H. aromatica* > *S. pennata* > *A. nigra* > *F. indica*.

Table 5: IC ₅₀ value of DPPH Scavenging assay for the studied sample	
Sample name	IC ₅₀
<i>A. nigra</i>	456.86±1.01
<i>Z. rhetsa</i>	162.24±1.04
<i>O. americanum</i>	198.78±0.42
<i>T. roxburghianum</i>	305.87±2.04
<i>H. aromatica</i>	365.15±2.83
<i>N. oleracea</i>	202.18±2.89
<i>O. indicum</i>	196.25±3.12
<i>L. leucocephala</i>	125.4±1.78
<i>S. pennata</i>	444.96±4.22
<i>F. indica</i>	485.44±5.82
Vit C	47.07±2.56

Experimental data represented as Mean±standard deviation

Discussion

Nutritional contribution of underutilized and neglected food plant

Ten underutilized and neglected food plant species documented belong to wild or semi-wild edible plants. Our result have investigated Nutritional contribution 5 Spices and condiments (*A. nigra*, *Z. rhetsa*, *O. americanum*, *T. roxburghianum* and *H. aromatica*); 4 vegetables (*N. oleracea*, *O. indicum*, *L. leucocephala* and *S. pennata*); and 1 Fruit (*F. indica*).

Our results have reported a total carbohydrate content range from 3.65% 13.34%, crude Protein content range from 1.23% 10.43%, and crude fats content range from 0.05% 2.375%. Similar observations also reported by several other researchers and authors have reported the Nutritional importance of neglected and underutilized food plants from Northeast India (Sundriyal and Sundriyal 2001; Ningombam et al. 2012; Hazarika and Nautiyal 2012; Brahma et al. 2014; Goswami et al. 2023). According to FAO (2003), standard energy conversion from protein, fat, and carbohydrate are 4 kcal/g, 9 kcal/g and 4 kcal/g, respectively. Carbohydrates, lipids, and proteins are macronutrients that must be consumed in substantial quantities. Carbohydrates are a primary energy source in our diets, providing 4 Kcal/g of energy. Proteins are complex entities of several amino acids (essential) that must be taken from proteins in the diet. Proteins provide a variety of tasks and give 4 Kcal/g of energy. Oils and fats are dietary sources of energy that provide 9 Kcal/g (ICMR 2011).

Minerals are micronutrients that are required in small amounts. These nutrients are required for physiological and biochemical processes that the human body uses in order to sustain health and biological activity (ICMR 2011). In our investigation, we have observed five micronutrients, namely Mg, P, K, Ca, Fe and Cl, of which potassium (K) is seen to be the highest, i.e. up to 34.15% (34.15 mg/gm); and studied species for spices, vegetable and fruit with high potassium minerals are *S. pennata*, *F. indica*, *O. indicum*, *O. americanum*, *A. nigra*, *T. roxburghianum*, *N. oleracea* and the least observed in *Z. rhetsa*. Our findings also resemble the general mean composition of minerals contained in fruit and vegetables, which contains Ca (10–170 mg/100gm), P (12–125 mg/100gm), Fe (0.2-8 mg/100 gm) and K (200–600 mg/100 gm) (Seal et al. 2017).

Free radicals promote the oxidation of proteins, DNA, and lipids, causing disruptions and functional loss of biological membranes and enzymes, ultimately producing toxins. Secondary metabolites in plants are non-nutritive yet effective in treating many ailments owing to their antioxidant activity (Pizzino et al. 2017). Antioxidants are crucial in free radical scavenging (Talang et al. 2023). Free radicals are assumed to be at the root of various diseases, including cancer, neural disorders and other inflammation (Bhatt et al. 2018). According to our findings, vegetables such as *L. leucocephala* and *O. indicum* and herbs and spices such as *Z. rhetsa* and *O. americanum* exhibit antioxidant activity, indicating that these species substantially correlate with antioxidant capacity.

Despite their potential benefits, these wild/semi-wild edible plant resources are still underutilized and face several challenges. These plants are often difficult to harvest (*i.e.* from wild/forest), and there needs to be more knowledge about their nutritional and medicinal benefits, making it difficult to market them to more comprehensive consumers. Also, there is a perception of these underutilized crops as inferior or weeds that has limited their consumption and adoption. Therefore, increasing awareness and knowledge about underutilized wild edible crops is essential through research and education.

Traditional Knowledge and sustainable livelihood

In Tripura, indigenous people are selling wild edible plants for their livelihoods. The forest of Tripura is blessed with numerous wild edible plant products utilized by these ethnic communities. The primary income source is generated by jhum cultivation, but the results are temporary. It is because jhum cultivation can only be done once every 3–4 years in the same land after harvesting (Shangpliang 2019). It makes their living very constricted to a single phase of jhum harvesting. The rest of the time, their livelihoods relied on either temporary labour jobs or collecting wild edible plants. Therefore, their economy relies on selling wild edible plants in the village markets, sometimes along the highways, or there is a third person (middleman) with whom resources are exchanged for money. But the primary wealth can be generated in the larger city markets (Chaudhury et al. 2021). Only a large market provides the best product value compared to other venues (village markets and highways). Thus, these create a market linkage for the poor community to earn their livelihoods at the best value.

Market linkage for wild edible plants is the best media to increase the popularity of such wild edible plants in mainstream markets (Raj et al. 2018). Wild edible native plants grow naturally in the forest for long periods. These plants are often native to specific regions and are adapted to local climates and soil conditions. Hence wild vegetables are healthier because they are pure organic with no chemical fertilizers (Sundriyal and Sundriyal 2001). On the other hand, wild vegetables are much cheaper and gaining attention amongst many people. Some wild vegetables are underutilized, with many nutritional components necessary for our bodies. Hence underutilized and neglected wild edible plant has the potential to promote sustainable food systems.

Conclusion and Future Prospects

Nutritional evaluation of underutilized and neglected edible plants, such as their proximate composition and *in vitro* antioxidant level and dietary mineral contents, can expose nutritional and medicinal benefits. The nutritional values will be helpful for these underutilized crops to encourage future conservation plans and assess the level of dietary supplement dependency of the local communities. Policies and programs that support cultivation and marketing can help to create demand for the adoption of these underutilized crops since native plants require fewer resources, such as water and fertilizer, to grow and also can be cultivated using traditional farming practices. In addition, underutilized wild edible crops can provide important ecosystem services, such as biodiversity conservation. Therefore by promoting the cultivation and consumption of these crops, we can support local communities as well as accomplish sustainable development in food security.

Declarations

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Conflict of interest: The authors declare that they have no conflict of interest.

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Figures

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Figure 1

Legend not included with this version

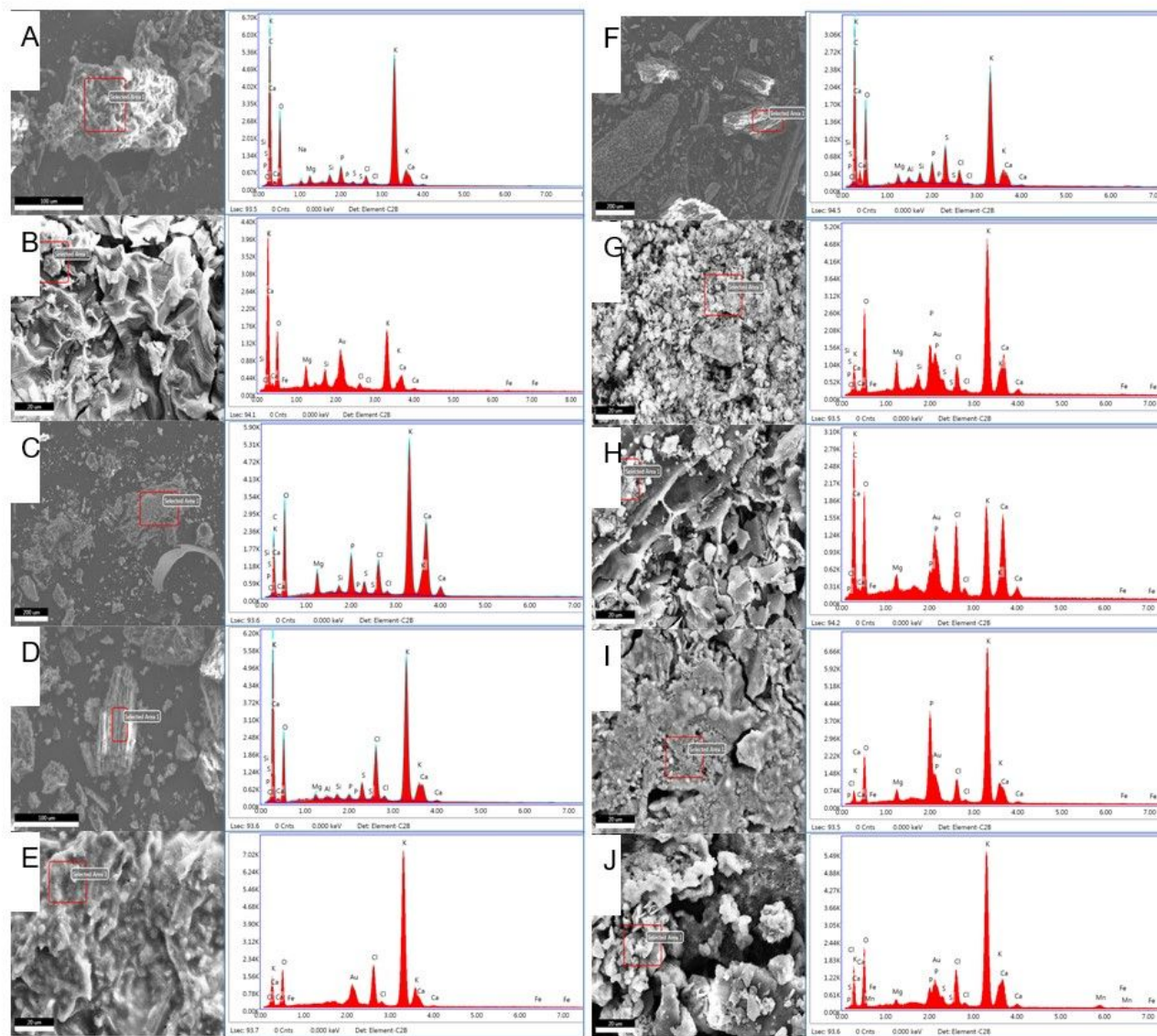


Figure 2

Microstructure picture and X-ray spectrum lines that show the elements presence in the analyzing area of the studied sample: **A)** *Alpinia nigra* **B)** *Zanthoxylum rhetsa* **C)** *Ocimum americanum* **D)** *Trachyspermum roxburghianum* **E)** *Homalomena aromatic* **F)** *Neptunia oleracea* **G)** *Oroxylum indicum* **H)** *Leucaena leucocephala* **I)** *Senegalia pennata* **J)** *Flacourtia indica*

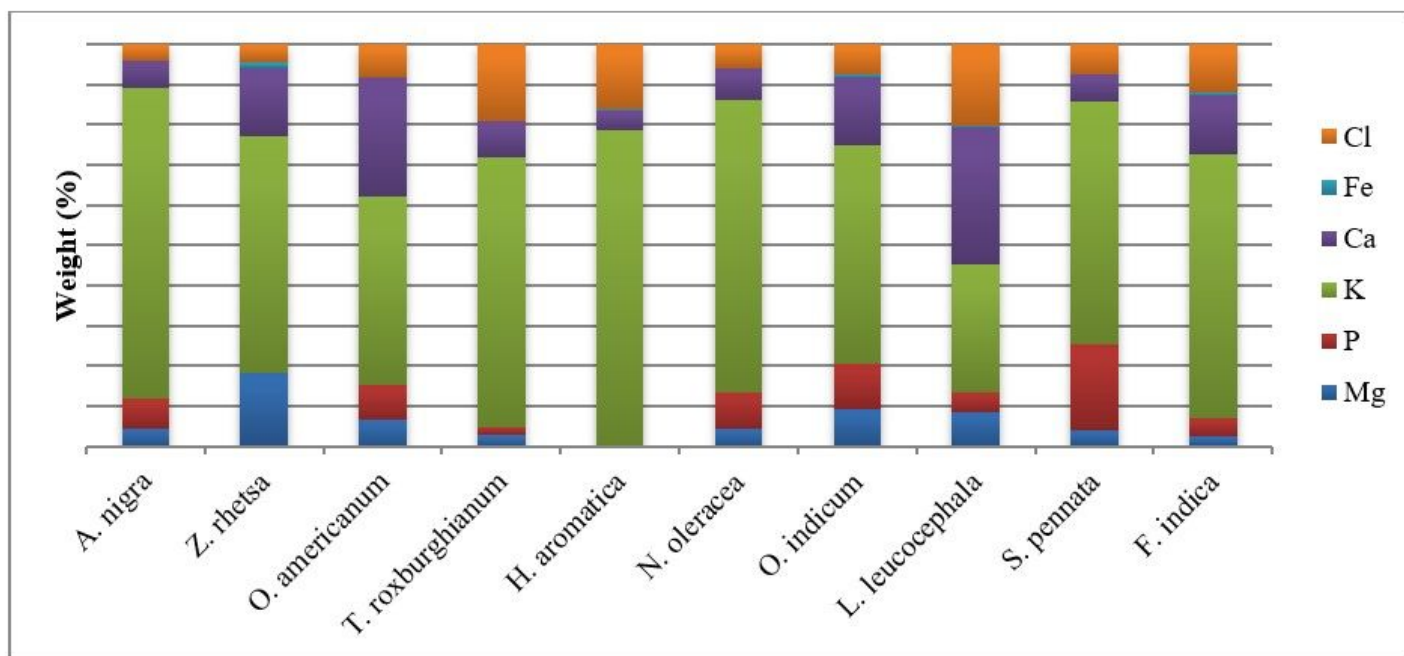


Figure 3

Graph showing proportionate concentration (Wt %) of 5 main elements in 10 studied samples

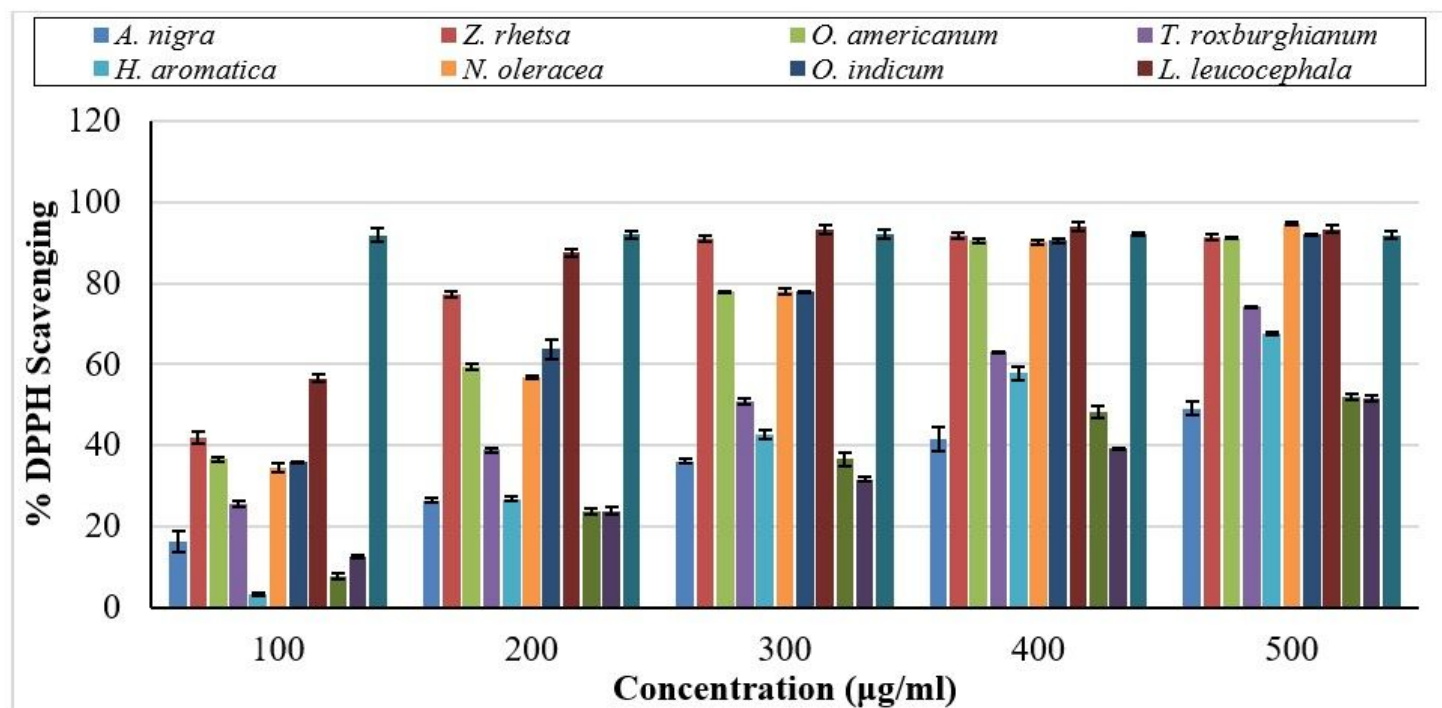


Figure 4

(%) DPPH scavenging for each species along with standard antioxidant