

EXPLORATION OF WILD EDIBLES FOR FOOD SECURITY, CURRENT KNOWLEDGE, AND FUTURE PROSPECTS

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Abstract

The rapid increase in population and malnutrition is a major challenge for humanity. Factors such as climate change, desertification, loss of biodiversity and rise in water scarcity have adversely affected food security. Wild edibles can play a significant role in food security by contributing to dietary and agricultural biodiversity diversification. Wild edible plants are a potential source of nutraceuticals. These plant species are alternative sources of food and nutrition and possess medicinal properties. The current review focuses on exploring wild edibles for food security.

Keywords: Wild edible plants, Food security, Sustainability.

Introduction

The world population is rapidly increasing as per expected estimation It will reach 9.0 billion people in 2070[1] An increase in population size is predicted to more than double in the next 40 years for Africa and a 23% increase in the population of Asia. There will be a huge requirement for food in the future [2]. The World health organization pointed out about 3.7 billion are malnourished [3]. Food insecurity and malnutrition will most affect the population in developing

countries [4]. Factors such as climate change [5], population growth, and use conversion [6, 7], desertification [8], flood [9], loss of biodiversity [10], and rise in water scarcity [11] have adversely affected food security.

Wild edible plants are generally edible plant species that are not cultivated and grow spontaneously in self-sustaining natural ecosystems [12]. These plants are majorly consumed by tribes or indigenous communities. These communities belonging to forest areas have gained this knowledge on their own by dwelling in the forests for years. Tribal communities live in harmony with the forests; hence, have got a better understanding of phytoresources. Wild edible plants are the prime food source of these tribal/indigenous populations [13]. They are also reported to be consumed during food scarcity periods [14].

Wild edible plants have acquired recognition globally for their potential nutritional qualities. They have been acknowledged for holding plenty of nutrients, fibres, vitamins, and minerals [15] which can be a significant way to resolve the problem of malnutrition across the globe. These plants are essential for solving poverty issues, generating income in rural areas, and incorporating into agriculture for their cultivation, food security, and enhancing nutrition [12]. Many countries are exploring wild edibles as a boon to address global issues like food scarcity, malnutrition, hunger, climate change, loss of biological diversity, etc. Wild edibles can be potentially used to build up the local food market, lowering the dependency on imported food, and restoring biodiversity through their domestication/cultivation [13].

Indigenous communities are mostly dependent on forests for food, wood fuels, and medicine. Due to overexploitation of natural resources, loss of habitats, and over-collection of edible plants for food or medicine, there is immense pressure on forest areas which may lead to the extinction of wild plant species from the wild areas [16, 17].

Wild relatives of plants are untapped and unexplored genetic resources [18]. Documentation and understanding of genetic diversity and its distribution are significant for conservation. Conservation of germplasm requires genetic diversity and collection. The pool of genetic variation within an inter-mating population is the basis for selection as well as for plant improvement [19].

All countries on earth are dependent on plant genetic resources. Gene bank collections possess many duplicates, making aggregate numbers seem larger than they are. Information about individual accessions, particularly those found in situ, is often poor, reducing frequency and efficiency of use and ultimate benefits. Although not firmly established today, the link between conservation and use must be strengthened [20]. Wild food is an important ecosystem service [21]. These are not only exploited as a famine food during food scarcity but are proven beneficial in many ways. They serve as a food source for indigenous communities dependent upon forest ecosystems. They are utilised as traditional medicine/formulations to treat many diseases. These are also significant in maintaining biodiversity in an ecosystem. They form a gene pool having desirable genes responsible for withstanding adverse conditions[22] ,

The wild edibles can be thoughtful for global food security [23] income generation [22], forest sustainability, domestication or cultivation, livelihood, minimising poverty [24] and medicinal purposes [25].

The knowledge of these wild plants is observed to disappear from these indigenous communities. The major cause of this is the lack of interest of juveniles in the community [26], socio-cultural changes [15], socio-economic changes, lifestyle changes [27] developmental activities [28].

The loss of traditional knowledge from indigenous communities across the world is one of the major threats to biological diversity. Traditional knowledge is itself reported to be a major threat to these wild edible plants as it leads to the exploitation of wild edibles from forests. However, unplanned developmental activities and anthropogenic activities are serious threats [29]. Though the other dangers depend upon the type of ecosystem which might include uncontrolled fires, firewood gathering, changes in land use/ shrinking of forestland, etc. The other kind of risks involved are loss of awareness levels, herbicidal use in cultivation lands, agricultural expansions, the introduction of invasive species, cattle grazing, and changes in food consumption patterns over years [28].

Many wild edible plants have lesser productivity. Due to rapid changes in cropping patterns, some wild relatives that used to be cultivated earlier are not preferred to be cultivated. Wild Extinction of particular species from particular areas leads to loss of genetic diversity too. Hence there is an

urgent requirement to document and take steps for the conservation of wild edible plants. Wild edible plants are also addressed as “functional foods” as they don't just contain enhanced nutritional values but also physiologically active compounds which help in delivering health advantages. Food is considered functional food when they contain biologically active compounds altering the physiological responses for health benefits [30]. Recent articles have brought wild edible plants into the discussion of utilizing them as a functional food in proximate time [31, 32]. These wild edible species are rich in nutritive values and the country might need them as food demands are increasing with the increasing population.

2. Materials and Methods

The information for this review is based on published research articles. The subject matter has been gathered by the author from authenticated sources such as Google Scholar, PubMed etc. The data on the consumption pattern of wild edible plants- mode of consumption and plant part consumed is systemized and documented from all the ethnobotanical studies based on the consumption of WEP's by indigenous peoples. This information is put together in tabular form to analyse more thoroughly. Various scientific documents of this academic field were explored and research articles were reviewed and provided in the references. The data analysis was carried out in an excel spreadsheet to check the figure and percentage of wild edible plant parts consumed and their mode of consumption. The appropriate graphs were plotted to represent the analyzed data.

3. Consumption of wild edible plants by tribal populations

3.1 Consumption pattern:

Wild edible plants are consumed in various ways by indigenous populations. These may be eaten raw, boiled, fried, cooked, pickles, desserts, drinks, soups and salads [15, 31]. We reviewed some articles related to wild edible plants to find the consumption trend. We have listed 306 wild edible species, from which we have analysed the plant part utilisation and the mode of consumption by the indigenous communities. The figures and percentages represented in the graphs are purely

based on the data gathered from 306 species from the articles reviewed. The data obtained from these scientific articles are specified in Table 1.

Table 1: Consumption Pattern in Wild Edibles

Sr. no.	Name	Edible part	Method of Consumption	Season of Collection	References
1	<i>Acacia karroo</i>	Bark	The inner bark is chewed, edible gum		[33]
2	<i>Achyranthes aspera</i>	Leaves	Leaves are boiled & fried	June to Dec	[34]
3	<i>Actinidia kolomikta</i>	Fruit	As snack		[35]
4	<i>Aegle marmelos</i>	Fruit	Eaten as ripe, or as pickle	April to June	[34]
5	<i>Aesculus indica</i>	Fruit	Flour of fruits is used		[12]
6	<i>Akebia trifoliata</i>	Fruit	As snack		[35]

7	<i>Alangium salvifolium</i>	Stem, fruit	The stem is used as tooth floss and fruit is eaten	Oct to June	[34]
8	<i>Allium baeticum</i>	Leaves, stem, flower	As Kesra, couscous, kneff	Jan to March	[36]
9	<i>Allium humile</i>	Leaves	Used fresh for flavouring		[12]
10	<i>Allium macrostemon</i>	Whole plant	Whole plant-medicines, spices, primary food		[35]
11	<i>Allium ovalifolium</i>	Leaves	As primary food		[35]
12	<i>Allium roseum</i>	Leaves, stem, flower	Kesra, kneff, couscous, rice dish	Nov to April March to April	[36]
13	<i>Allium stracheyi</i>	Leaves	Used fresh for flavouring		[12]
14	<i>Alternanthera sessili</i>	Leaves	Consumed boiled	June to Oct	[34]

15	<i>Amaranthus blitum</i>	Stem	As primary food		[35]
16	<i>Amaranthus hybridus</i>	Leaves	Boiled & cooked	June to Nov	[33, 34]
17	<i>Amaranthus paniculatus</i>	Leaves	Fried		[12]
18	<i>Amaranthus spinosus</i>	Leaves	Boiled	June to Nov	[34]
19	<i>Amaranthus thunbergii</i>	Leaves	Cooked		[33]
20	<i>Amaranthus viridis</i>	Leaves	Boiled	June to Nov	[34]
21	<i>Ampelocissus africana</i>	Fruit	Fruit is edible		[33]
22	<i>Ampelocissus obtusata</i>	Fruit	Fruits are edible		[33]

23	<i>Anethum graveolens</i>	Leaves, seeds	Used to prepare Kneff, Couscous, rice dish, bsissa	Feb to June	[36]
24	<i>Angelica glauca</i>	Roots	Roots are crushed for flavouring		[12]
25	<i>Angelica sinensis</i>	Roots	Root as primary food, medicines		[35]
26	<i>Annona squamosa</i>	Leaves, fruit, roots	Leaves, roots & barks are medically used while fruits are eaten as ripe	Sept to Nov	[34]
27	<i>Annona stenophylla</i>	Fruit	Fruits are edible		[33]
28	<i>Antidesma venosum</i>	Fruit	Fruits are edible		[33]
29	<i>Araiostegia divaricata var. formosana</i>	Roots	Root as medicine		[35]

30	<i>Aralia chinensis</i>	Stem	As primary food		[35]
31	<i>Arctium lappa</i>	Roots	Root as primary food, medicine		[35]
32	<i>Argyreia nervosa</i>	Leaves	Boiled & fried	June to Oct	[34]
33	<i>Arisaema tortuosum</i>	Leaves	Cooked, as pickle	June to July	[34]
34	<i>Aristolochia versicolor</i>	Roots	Root as medicine		[35]
35	<i>Artemisia capillaris</i>	Stem, aerial parts	Stem is consumed as famine food and Aerial parts as medicine		[35]
36	<i>Asparagus acutifolius</i>	Leaves, stem	Leaves & stem are stewed while the stem is also consumed with omelets		[37]

37	<i>Asparagus racemosus</i>	Roots	Roots are boiled and taken as soup	Whole year	[34]
38	<i>Asphodelus tenuifolius</i>	Leaves	Couscous	Dec to March	[36]
39	<i>Atriplex halimus</i>	Leaves	Couscous, kneff	Winter and spring	[36]
40	<i>Azadirachta indica</i>	Fruit	The ripe fruit pulp is eaten	March to June	[34]
41	<i>Azanza garckeana</i>	Fruit	Fruits are edible		[33]
42	<i>Babiana hypogea</i>	Corm	Corm is edible		[33]
43	<i>Bacopa monnieri</i>	Leaves	Boiled	Sept to Jan	[34]
44	<i>Bambusa arundinacea</i>	Stem	Boiled, stir-fried or as pickle	Once in 25 years	[34]

45	<i>Bauhinia racemosa</i>	Leaves, flowers	Stir-fried	Feb to May	[34]
46	<i>Bauhinia vahli</i>	Leaves, flowers	Stir-fried	Feb to May	[34]
47	<i>Begonia grandis subsp. sinensis</i>	Stem	As primary food		[35]
48	<i>Benkara pundulacakai</i>	Flowers	Stir fried	June to July	[34]
49	<i>Berberis aristata</i>	Fruit	Eaten Ripe		[12]
50	<i>Berberis jamesiana</i>	Fruit, roots	Fruits are consumed as a snack, spice, and roots as medicine		[35]
51	<i>Berberis lyceum</i>	Fruit	Eaten Ripe		[12]
52	<i>Berchemia discolor</i>	Fruit	Fruits are edible		[33]

53	<i>Beta macrocarpa</i>	Leaves	Couscous, cooked, in soup	Dec to March	[36]
54	<i>Bidens pilosa</i>	Leaves	Cooked		[33]
55	<i>Boerhavia diffusa</i>	Leaves	Boiled, Stir-fried	Whole year	[34]
56	<i>Bombax ceiba</i>	Flowers	Boiled & stir-fried	Feb to March	[34]
57	<i>Borassus flabellifer</i>	Flowers, fruit	Fresh juice from inflorescence is consumed and fruit is edible	Feb to May	[34]
58	<i>Borreria articularis</i>	Leaves	Boiled & stir-fried	All year	[34]
59	<i>Brachystegia boehmii</i>	Bark	Inner bark chewed		[33]

60	<i>Brassica tournefortii</i>	Leaves	Raw, couscous, kneff	Dec to March	[36]
61	<i>Bridelia cathartica</i>	Fruit	Fruits are edible		[33]
62	<i>Bridelia squamosa</i>	Leaves, fruit, roots	Leaves, roots & barks are used medicinally while ripe fruit is edible.	Jan to Feb	[34]
63	<i>Bridelia mollis</i>	Fruit	Fruits are edible		[33]
64	<i>Buchanania cochinchinensis</i>	Fruit	Eaten as ripe	Feb to May	[34]
65	<i>Bulbophyllum odoratissimum</i>	Whole plant	Whole plant as medicine		[35]
66	<i>Cannabis sativa</i>	Seed	Seeds are roasted		[12]

67	<i>Capsella bursa-pastoris</i>	Leaves, stem	Leaves are boiled and fried and stem is taken as primary food		[12, 35]
68	<i>Cardamine tangutorum</i>	Stem	As primary food, medicines		[35]
69	<i>Carissa bispinosa</i>	Fruit	Fruits are edible		[33]
70	<i>Carissa edulis</i>	Fruit	Fruits are edible		[33]
71	<i>Cassia tora</i>	Leaves	Stir fried	June to Aug	[34]
72	<i>Celosia argentea</i>	Leaves	Leaves are boiled & stir fried while seeds are consumed as famine food	June to Oct	[34, 35]
73	<i>Celosia trigyna</i>	Leaves	Cooked		[33]

74	<i>Centaurea bimorpha</i>	Leaves	Couscous, kneff	Dec to April	[36]
75	<i>Ceropegia bulbosa</i>	Tubers	Tubers are boiled	July to Aug	[34]
75	<i>Ceropegia fantastica</i>	Tubers	Tubers are boiled	July to Aug	[34]
77	<i>Chenopodium album</i>	Leaves, seeds	Leaves are boiled and fried, flour of seeds is used		[12]
78	<i>Chenopodium album</i>	Leaves	Cooked	June to Nov	[33, 34]
79	<i>Chenopodium hybridum</i>	Stem	As primary food		[35]
80	<i>Chlorophytum borivalianum</i>	Leaves	Stir fried	June to Aug	[34]
81	<i>Chlorophytum tuberosum</i>	Leaves	Used in daal	June to Aug	[34]

82	<i>Cirsium shansiense</i>	Roots	Root as primary food, medicine		[35]
83	<i>Cirsium wallichii</i>	Flowers	Fresh inflorescence is used		[12]
84	<i>Clematis hedysarifolia</i>	Stem	Used as vegetable	June to Aug	[34]
85	<i>Cleome gynandra</i>	Leaves, stem	Cooked		[33]
86	<i>Cleome monophylla</i>	Leaves	Cooked		[33]
87	<i>Cocculus hirsutus</i>	Leaves	Boiled & stir fried	All year	[34]
88	<i>Codonopsis pilosula subsp. tangshen</i>	Roots	Root as primary food, medicine		[35]
89	<i>Colocasia esculenta</i>	Leaves, tubers	Leaves & tubers are boiled and fried for consumption		[12]

90	<i>Commelina benghalensis</i>	Leaves	Stir fried	June to Aug	[34]
91	<i>Commelina diffusa</i>	Leaves	Stir fried	June to Aug	[34]
92	<i>Commelina obliqua</i>	Leaves	Stir fried	June to Aug	[34]
93	<i>Corchorus asplenifolius</i>	Leaves, stem	Cooked		[33]
94	<i>Corchorus tridens</i>	Leaves, stem	Cooked		[33]
95	<i>Cordia dichotoma</i>	Flowers, fruit	Inflorescence is stir fried and unripe fruit is eaten as pickle	Dec to Feb (flower) March to June fruit	[34]
96	<i>Cordia gharaf</i>	Fruit	Eaten as ripe & unripe as pickle	Dec to May	[34]

97	<i>Cornus kousa</i> <i>subsp.</i> <i>chinensis</i>	Fruit	As snack		[35]
98	<i>Cotoneaster</i> <i>rotundifolius</i>	Fruit	Eaten ripe		[12]
99	<i>Cucumis</i> <i>anguria</i>	Leaves, stem	Cooked		[33]
100	<i>Cynara</i> <i>cardunculus</i>	Leaves	Couscous, stewed	All year	[36]
101	<i>Cynoglossum</i> <i>amabile</i>	Roots	Roots as medicines		[35]
102	<i>Cyperus</i> <i>esculentus</i>	Corm	Corm is edible		[33]
103	<i>Dalbergia</i> <i>volubilis</i>	Leaves	Cooked, stir fried	June to Nov	[34]
104	<i>Decaisnea</i> <i>insignis</i>	Fruit	As snack		[35]

10 5	<i>Dendrocalamus strictus</i>	Stem	Boiled, as vegetable, as pickle	July to Aug	[34]
10 6	<i>Dioscorea belophylla</i>	Bulbil	Bulbil is boiled & cooked	Aug to Sept	[34]
10 7	<i>Dioscorea bulbifera</i>	Bulbil	Bulbil is cooked	June to July	[34]
10 8	<i>Dioscorea hispida</i>	Bulbil	Bulbil - boiled & cooked	Aug to Sept	[34]
10 9	<i>Dioscorea pentaphylla</i>	Bulbil	Bulbil is boiled & cooked	Aug to Sept	[34]
11 0	<i>Dioscorea polystachya</i>	Roots, bulbil	Root as primary food, bulbil as snack		[35]
11 1	<i>Dioscorea wallichii</i>	Bulbil	Bulbil is boiled & cooked	Aug to Sept	[34]
11 2	<i>Diospyros lotus</i>	Fruit	As snack		[35]

11 3	<i>Diospyros lycioides</i>	Fruit	Fruits are edible		[35]
11 4	<i>Diospyros melanoxylon</i>	Leaves, fruit	Leaves are used for making cigarettes and ripe fruits are eaten while unripe as pickle	May to June	[34]
11 5	<i>Diospyros mespiliformis</i>	Fruit	Fruits are edible		[33]
11 6	<i>Diplazium maximum</i>	Fronds	Young Fronds as fried & as pickles		[12]
11 7	<i>Diplotaxis erucoides</i>	Leaves	Raw as salad, couscous, kneff	Sep to April	[36]
11 8	<i>Diplotaxis harra</i>	Leaves	Raw as salad, couscous, kneff	Sep to April	[36]
11 9	<i>Diplotaxis muralis subsp. simplex</i>	Leaves	Raw as salad, couscous, kneff	Sep to April	[36]

12 0	<i>Dregea volubilis</i>	Leaves	Boiled	Sept to Feb	[34]
12 1	<i>Eclipta prostrata</i>	Whole plant	Whole plant as medicine		[35]
12 2	<i>Ekebergia benguelensis</i>	Fruit	Fruits are edible		[33]
12 3	<i>Elaeagnus pungens</i>	Whole plant	Whole plant as medicine		[35]
12 4	<i>Enicostema littorale</i>	Leaves	Stir fried	June to Aug	[34]
12 5	<i>Equisetum giganteum</i>	Fruit	As snack		[35]
12 6	<i>Eriosema pauciflorum</i>	Tubers	Tuber is edible		[33]
12 7	<i>Eriosema shireense</i>	Tubers	Tuber is edible		[33]

128	<i>Euclea crispa</i>	Fruit	Fruits are edible		[33]
129	<i>Euclea divinorum</i>	Fruit	Fruits are edible		[33]
130	<i>Eucommia ulmoides</i>	Bark	Bark as primary food, medicine		[35]
131	<i>Eulophia herbacea</i>	Flowers	Cooked	July to Sept	[34]
132	<i>Fagopyrum esculentum</i>	Leaves	Boiled and fried. Dried in winters		[12]
133	<i>Fargesia spathacea</i>	Stem	As primary food		[35]
134	<i>Ficus burkei</i>	Fruit	Fruit is edible		[33]
135	<i>Ficus hispida</i>	Leaves, fruit	Leaves are used for medicinal purpose while	May to July	[34]

			fruits are edible		
13 6	<i>Ficus ingens</i>	Fruit	Fruits are edible		[33]
13 7	<i>Ficus natalensis</i>	Fruit	Fruits are edible		[33]
13 8	<i>Ficus pumila</i>	Fruit	As snack		[35]
13 9	<i>Ficus salicifolia</i>	Fruit	Fruits are edible		[33]
14 0	<i>Ficus sur</i>	Fruit	Fruit is edible		[33]
14 1	<i>Ficus sycomorus</i>	Fruit	Fruits are edible		[33]
14 2	<i>Ficus tikoua</i>	Fruit	As snack		[35]

14 3	<i>Flacourtia indica</i>	Fruit	Fruit is edible		[33]
14 4	<i>Flueggea microcarpa</i>	Fruit	Fruits are edible	July to Nov	[34]
14 5	<i>Flueggea virosa</i>	Fruit	Fruits are edible		[33]
14 6	<i>Foeniculum vulgare</i>	Leaves, stem, seeds	Leaves and stem are eaten raw as salad and snacks, or other stewed food. Leaves and seeds are used in Kneff, Couscous, in rice dish, bsissa. Seeds are also used for flavouring	Feb to June	[12]
14 7	<i>Fragaria nubicola</i>	Fruit	Eaten as ripe		[12]

14 8	<i>Fritillaria cirrhosa</i>	Bulb	Bulb as medicine		[35]
14 9	<i>Garuga pinnata</i>	Fruit	Eaten as pickle	Jan to May	[34]
15 0	<i>Gastrodia elata</i>	Rhizome	Rhizome as primary food & medicine		[35]
15 1	<i>Grewia bicolor</i>	Fruit	Fruits are edible		[33]
15 2	<i>Grewia flavescens</i>	Fruit	Fruit is edible		[33]
15 3	<i>Grewia hirsuta</i>	Fruit	Raw fruit is eaten	Aug to Oct	[34]
15 4	<i>Grewia monticola</i>	Fruit	Fruits are edible		[33]
15 5	<i>Grewia tiliaefolia</i>	Stem, fruit	Stem is used as tooth floss and raw fruit is eaten	Aug to Oct	[34]

15 6	<i>Helwingia japonica</i>	Leaves	As primary food		[35]
15 7	<i>Heracleum grandis</i>	Leaves	Boiled & stir fried	All year	[34]
15 8	<i>Holarhena antidysenterica</i>	Leaves	As vegetable	June to Aug	[34]
15 9	<i>Holoptelea integrifolia</i>	Leaves	Boiled	Jan to May	[34]
16 0	<i>Holostemma annularium</i>	Leaves, flowers, roots	Leaves and roots are used medicinally to relieve menstrual issues while leaves are also used as vegetable and flowers are edible.	June to Aug	[34]
16 1	<i>Hoslundia opposita</i>	Fruit	Fruit is edible		[33]

16 2	<i>Huperzia squarrosa</i>	Whole plant	Whole plant as medicine		[33]
16 3	<i>Hylocereus undatus</i>	Flowers	As primary food		[33]
16 4	<i>Impatiens glandulifera</i>	Fruit	Eaten as ripe		[12]
16 5	<i>Imperata cylindrica</i>	Roots	Root as primary food & medicine		[35]
16 6	<i>Incarvillea diffusa</i>	Aerial parts	Aerial parts as medicines		[35]
16 7	<i>Ipomoea aquatica</i>	Leaves	Boiled & stir-fried	All year	[34]
16 8	<i>Ipomoea carneasp. Fistulosa</i>	Leaves	Stir-fried	July to Nov	[34]
16 9	<i>Ipomoea marginata</i>	Leaves	Boiled, stir-fried, as vegetable	June to Oct	[34]

17 0	<i>Iris forrestii</i>	Roots	Root as medicine		[35]
17 1	<i>Juglans regia</i>	Fruit	Eaten as ripe		[12]
17 2	<i>Kalimeris indica</i>	Stem, roots	Stem as primary food and root as medicine		[35]
17 3	<i>Kirganelia reticulata</i>	Leaves, stem	Stir fried	July to Aug	[34]
17 4	<i>Lansea discolor</i>	Fruit	Fruits are edible		[33]
17 5	<i>Lansea edulis</i>	Fruit	Fruits are edible		[33]
17 6	<i>Lantana camara</i>	Fruit	Fruits are edible		[33]
17 7	<i>Launaea nudicaulis</i>	Leaves	Eaten raw	Jan to March	[36]

178	<i>Launaea quercifolia</i>	Leaves	Eaten raw	Jan to March	[36]
179	<i>Leea asiatica</i>	Flowers	Inflorescence - cooked with oil	Aug to Nov	[34]
180	<i>Leea edgeworthii</i>	Flowers	Inflorescence - cooked with oil	July to Sept	[34]
181	<i>Leea macrophylla</i>	Flowers, fruit	The inflorescence is stir-fried & cooked and fruits are edible	July to Aug	[34]
182	<i>Lemmaphyllum carnosum</i>	Aerial parts	Aerial part as medicine		[35]
183	<i>Leycesteria formosa</i>	Stem	As medicine		[35]
184	<i>Limonia acidissima</i>	Fruit	Fruit is edible	Nov to March	[34]

18 5	<i>Litsea cubeba</i>	Fruit	Fruits and roots are used as spice		[35]
18 6	<i>Litsea pungens</i>	Fruit	Fruits and roots are used as a spice		[35]
18 7	<i>Lycopodium japonicum</i>	Spores	Spore powder as medicine		[35]
18 8	<i>Madhuca indica</i>	Flowers, fruit, seeds	Flowers are used for preparing liquor, fruits are edible and seeds are medicinally used	March to July	[34]
18 9	<i>Mahonia bealei</i>	Fruit, roots, bark	Fruit is eaten as a snack while roots and barks are used as medicine		[35]
19 0	<i>Malva aegyptia</i>	Leaves	Stewed	Dec to April	[36]

19 1	<i>Malva sylvestris</i>	Leaves, stem	Stewed		[37]
19 2	<i>Malva verticillata</i>	Whole plant	Whole plant as medicine		[35]
19 3	<i>Manilkara hexandra</i>	Fruit	Eaten as ripe	April to May	[34]
19 4	<i>Marsilea minuta</i>	Leaves	Stir-fried, as vegetable	All year	[34]
19 5	<i>Matteuccia struthiopteris</i>	Stem	As primary food		[35]
19 6	<i>Mentha canadensis</i>	Stem	As primary food, spice, medicine		[35]
19 7	<i>Mentha longifolia</i>	Leaves	Fresh leaves for chutney and tea		[12]
19 8	<i>Metaplexis japonica</i>	Fruit	As snack		[35]

19 9	<i>Mimusops zeyheri</i>	Fruit	Fruits are edible		[33]
20 0	<i>Momordica dioica</i>	Fruit	Stir-fried, as vegetable	July to Sept	[34]
20 1	<i>Morchella esculenta</i>	Fruit	Fruiting body - as boiled & fried		[12]
20 2	<i>Morinda tomentosa</i>	Fruit	Fruits are edible	Sept	[34]
20 3	<i>Moringa concanensis</i>	Leaves, flowers	Stir-fried	Sept to Feb	[34]
20 4	<i>Moringa oleifera</i>	Leaves, flowers, fruit	Leaves, flowers are boiled & stir-fried while fruits are boiled, as vegetable	Oct to Mar	[34]
20 5	<i>Morus australis</i>	Fruit	As snack		[35]

20 6	<i>Musa basjoo</i>	Flowers, fruit	Flowers are used as medicine while fruits are consumed as snack		[35]
20 7	<i>Myrica nana</i>	Fruit	As snack		[35]
20 8	<i>Nasturtium officinale</i>	Aerial parts	Aerial parts as medicines		[35]
20 9	<i>Oenanthe javanica</i>	Aerial parts	Aerial parts as the primary food		[35]
21 0	<i>Onopordum arenarium</i>	Flowers	Raw, couscous, stewed, bsissa	Nov to Aug	[36]
21 1	<i>Ophioglossum vulgatum</i>	Whole plant	Whole plant as primary food & medicine		[35]
21 2	<i>Opuntia ficus- indica</i>	Stem, fruit	The stem is used as primary food and medicine while fruits are edible		[33, 35]

21 3	<i>Osmunda japonica</i>	Stem	As primary food		[35]
21 4	<i>Oxalis corniculata</i>	Leaves, aerial parts	Fresh leaves are consumed and aerial parts are used as snack & spice		[12, 35]
21 5	<i>Oxalis latifolia</i>	Leaves, corm	Fresh leaves and corm is edible		[12, 33]
21 6	<i>Oxyria digyna</i>	Leaves	As chutney		[12]
21 7	<i>Parinari curatellifolia</i>	Fruit, kernel	Fruits & kernels are edible, fruit juice is used to make beer.		[33]
21 8	<i>Paris polyphylla</i>	Roots	Root as medicine		[35]
21 9	<i>Perilla frutescens</i>	Stem, seeds	Stem is consumed as primary food and seeds are used as spice		[35]

220	<i>Phoenix sylvestris</i>	Fruit	Fruit - edible	Jan to June	[34]
221	<i>Phyllanthus emblica</i>	Fruit	Eaten as raw, as pickle. Fruit powder used as medicine	Oct to Feb	[34]
222	<i>Physalis angulata</i>	Fruit	Eaten as ripe		[33]
223	<i>Phytolacca acinosa</i>	Leaves	Boiled & fried		[12]
224	<i>Piliostigma thonningii</i>	Fruit	Fruit is edible		[33]
225	<i>Pinus halepensis</i>	Seeds	Seeds are used for making desserts	Nov to April	[36]
226	<i>Pinus roxburghii</i>	Seeds	Seeds as raw		[12]

22 7	<i>Pinus wallichiana</i>	Seeds	Seeds as raw		[12]
22 8	<i>Plantago major</i>	Aerial parts	Aerial parts as snack & spice		[35]
22 9	<i>Pleurotus sp.</i>	Fruit	Fruiting body - as boiled & fried or stir fried	July to Aug	[12, 34]
23 0	<i>Polygonatum</i>	Roots	Root as medicine & primary food		[35]
23 1	<i>Prinsepia utilis</i>	Fruit	Eaten as ripe		[27]
23 2	<i>Prunus armeniaca</i>	Fruit, nuts	Ripe fruits and nuts are eaten		[12]
23 3	<i>Prunus cornuta</i>	Fruit	Eaten as ripe		[12]
23 4	<i>Prunus persica</i>	Fruit	Eaten as ripe		[12]

23 5	<i>Pseudognaphalium affine</i>	Flowers	Famine food		[35]
23 6	<i>Pteridium aquilinum</i>	Stem, roots	Stem as primary food and roots as a famine food		[35]
23 7	<i>Pueraria montana var. lobata</i>	Roots	Root as snack		[35]
23 8	<i>Pueraria tuberosa</i>	Fruit	Stir-fried, boiled	All year	[34]
23 9	<i>Pyrus pashia</i>	Fruit	Eaten as ripe		[12]
24 0	<i>Quercus schottkyana</i>	Seeds	Seed as snack		[35]
24 1	<i>Randia spinosa</i>	Fruit	Fruits are edible	Jan to May	[34]
24 2	<i>Reynoutria multiflora</i>	Leaves, roots	As medicine		[35]

24 3	<i>Rheum australe</i>	Leaves	Boiled & fried		[12]
24 4	<i>Rhododendron arboreum</i>	Flowers	Fresh is used to prepare chutney and also used as dried		[12]
24 5	<i>Rhus longipes</i>	Fruit	Fruits are edible		[33]
24 6	<i>Rhus pyroides</i>	Fruit	Fruits are edible		[33]
24 7	<i>Rhus tenuinervis</i>	Fruit	Fruits are edible		[33]
24 8	<i>Rorippa dubia</i>	Stem	As primary food		[32]
24 9	<i>Rorippa nasturtium-aquaticum</i>	Leaves, stem	Raw as salads, stewed		[37]

25 0	<i>Rosa canina</i>	Fruit	Eaten as ripe		[12]
25 1	<i>Rubus ellipticus</i>	Fruit	Eaten as ripe		[12]
25 2	<i>Rubus foliolosus</i>	Fruit	Eaten as ripe		[12]
25 3	<i>Rubus ulmifolius</i>	Fruit	Raw, Jams		[37]
25 4	<i>Rumex dentatus</i>	Leaves	Fresh		[12]
25 5	<i>Rumex hastatus</i>	Aerial parts	Aerial parts as raw		[12]
25 6	<i>Rumex roseus var. eu tingitanus</i>	Leaves	Raw	Jan to May	[36]
25 7	<i>Rumex roseus var. lacirus</i>	Leaves	Raw	Jan to May	[36]

25 8	<i>Sambucus adnata</i>	Fruit, aerial parts	Fruit as a snack and aerial parts used as medicines		[35]
25 9	<i>Sambucus williamsii</i>	Leaves, bark	As medicine		[35]
26 0	<i>Schleichera oleosa</i>	Fruit	Eaten as ripe	Feb to July	[34]
26 1	<i>Sclerocarya birrea</i>	Fruit, kernel	Fruits and kernel are edible, fruit juice is used to make beer		[33]
26 2	<i>Scolymus hispanicus</i>	Leaves, stem	Leaves are stewed, boiled and fried in olive oil while stem is stewed and used in couscous	Dec to March	[36, 37]
26 3	<i>Scorzonera undulata</i>	Leaves, flowers, roots	Leaves, flowers and roots are eaten raw, while leaves are used to prepare couscous, kneff	Jan to March, April to May, March to June	[36]

26 4	<i>Selinum tenuifolium</i>	Roots	Roots for brew production		[12]
26 5	<i>Silene vulgaris</i>	Leaves, stem	Leaves and stem are stewed, leaves are also used as a garnish		[37]
26 6	<i>Silybum eburneum</i>	Flowers	Raw, couscous, stewed, bsissa	Nov to Aug	[36]
26 7	<i>Solanum nigrum</i>	Leaves, stem, fruit	Leaves are cooked, boiled, as a vegetable, the stem is cooked and ripe fruit is eaten	June to Nov	[33, 34]
26 8	<i>Sonchus asper</i>	Leaves	Boiled & fried		[12]
26 9	<i>Sonchus oleraceus</i>	Leaves, stem	Leaves and stem are consumed raw while stems are also consumed	Jan to March	[35, 36]

			as primary food		
270	<i>Spatholobus suberectus</i>	Stem	As medicine		[35]
271	<i>Spondias acuminata</i>	Fruit, bark	Fruit is eaten raw while bark is used to treat rashes	May to June	[34]
272	<i>Stellaria media</i>	Aerial parts	Aerial parts as boiled & fried		[12]
273	<i>Strychnos cocculoides</i>	Fruit	Fruits are edible		[33]
274	<i>Strychnos madagascariensis</i>	Fruit	Fruits are edible		[33]
275	<i>Strychnos spinosa</i>	Fruit	Fruits are edible		[33]
276	<i>Syzygium cumini (L.)</i>	Fruit	Eaten as ripe	May to Sept	[34]

27 7	<i>Tamarindus indica</i>	Leaves, flowers, seeds, bark	Leaves and flowers are stir fried, ripe fruits are edible & unripe are used to prepare chutney, seeds and barks are medicinally used	Feb to July	[34]
27 8	<i>Taraxacum mongolicum</i>	Leaves, whole plant	Leaves are consumed as primary food while whole plant is used as medicine		[35]
27 9	<i>Taraxacum officinale</i>	Leaves	Boiled & fried		[12]
28 0	<i>Taxus baccata</i>	Leaves, bark	For flavouring tea		[12]
28 1	<i>Telosma pallida</i>	Leaves	Boiled & stir fried	June to Nov	[34] [34]
28 2	<i>Terminalia bellirica</i>	Fruit	Fruits are edible	Jan to May	

28 3	<i>Thymus linearia</i>	Seeds	Seeds for flavouring tea		[12]
28 4	<i>Tinospora glabra</i>	Leaves	Stir fried	Jan to May	[34]
28 5	<i>Toona sinensis</i>	Stem	As primary food		[35]
28 6	<i>Toxicodendron vernicifluum</i>	Stem	As primary food		[35]
28 7	<i>Trichosanthes kirilowii</i>	Flowers	As medicine		[35]
28 8	<i>Uapaca kirkiana</i>	Fruit	Fruits are edible		[33]
28 9	<i>Urtica dioica</i>	Leaves	Boiled & fried		[12]
29 0	<i>Vaccinium fragile</i>	Fruit	As snack		[35]

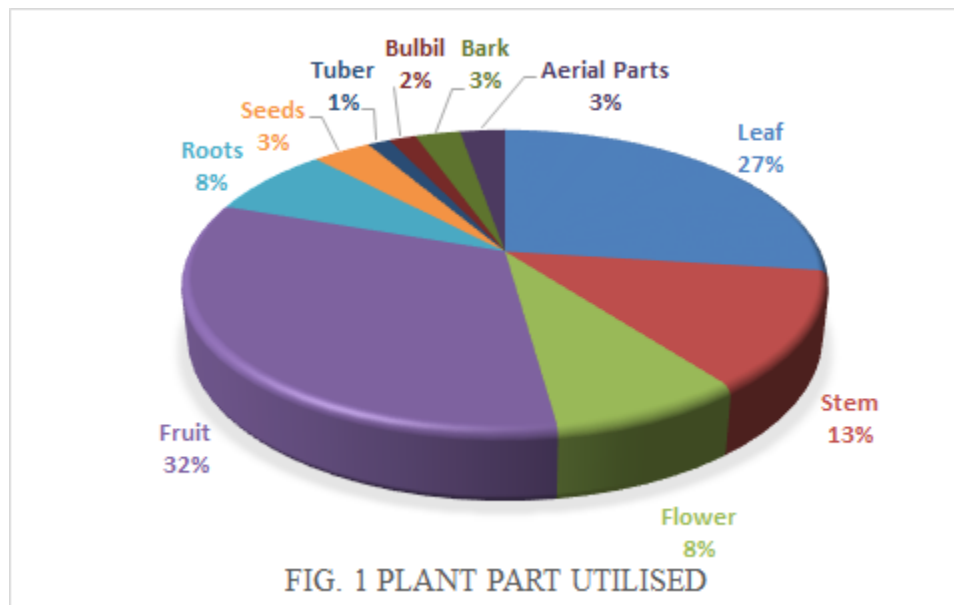
29 1	<i>Vangueria infausta</i>	Fruit	Fruits are edible		[33]
29 2	<i>Vangueriopsis lanciflora</i>	Fruit	Fruits are edible		[33]
29 3	<i>Viburnum betulifolium</i>	Fruit	As snack, spice		[35]
29 4	<i>Vicia sativa</i>	Stem	As primary food		[35]
29 5	<i>Viola pilosa</i>	Leaves, flowers	Flavouring tea		[12]
29 6	<i>Vitex payos</i>	Fruit	Fruits are edible		[33]
29 7	<i>Wrightia tinctoria</i>	Flowers	Stir fried	March to June	[34]
29 8	<i>Wrightia tomentosa</i>	Flowers	Stir fried	March to July	[34]

29 9	<i>Ximenia americana</i>	Fruit	Fruits are edible		[33]
30 0	<i>Ximenia caffra</i>	Fruit	Fruits are edible		[33]
30 1	<i>Zanthoxylum armatum</i>	Fruit	Eaten as ripe		[12]
30 2	<i>Ziziphus lotus</i>	Fruit	Eaten fresh or dried	Aug to Sep	[36]
30 3	<i>Ziziphus mauritiana</i>	Fruit	Fruits are edible	Jan to March	[34]
30 4	<i>Ziziphus mucronata</i>	Fruit	Fruit is edible		[33]
30 5	<i>Ziziphus oenopila</i>	Fruit	Fruits are edible	Jan to April	[34]
30 6	<i>Ziziphus xylopyra</i>	Fruit	Fruits are edible	Jan to March	[34]

3.2 Plant parts used for consumption

The data reflect that various plant parts are consumed by tribal communities in different ways. The various parts of plants such as fruit, leaves, flowers, roots, stems, bark, bulb, and seed are consumed by the traditional or local communities in diverse ways by traditional or local communities [38]. After scanning through a few research articles on wild edible consumption patterns and analysing data of 306 wild edible species study finds that the fruits (32%) and leaves (26%) are widely consumed followed by stems (12%), roots (8%) and flowers (8%) and other parts such as seeds (3%), tubers (1%), bulbil (2%), bark (3%), aerial parts (3%) are hardly utilised.

It is reported that fruits, leaves and aerial parts are usually consumed [38]. Several other reports also suggest that fruits are more widely consumed than other plant parts [23, 39, 40]. The leaves rank second i.e. they are commonly consumed after fruits of wild edible plants [41, 42].



3.3 Mode of consumption

The wild edible plants are utilised either as raw (31%) or cooked food (12%). The fruits are usually eaten as ripe (12%) and unripe fruits (2%) are employed to prepare pickles, jams or sauce (chutney). The fruits are also commonly observed to be utilised as snacks. Moreover, they are also

used to brew liquors. The leafy vegetable, stems, flowers and roots are consumed post-boiling (19%) or stir-frying (24%) as cooked food.

Stems of wild edible species are commonly consumed as primary food. The leaves are sometimes directly eaten as raw and they are also used for diverse medicinal purposes. The roots are majorly used for medicinal purposes and as a spice to flavour the dishes. Flowers, occasionally are observed to be utilised raw and the juice from flowers/inflorescence of some species is also imbibed (Table 1). In Mediterranean coastal regions, some special dishes/recipes such as kneff, kesra, bsissa are prepared out of these wild edible plant parts.

Many studies have reported that wild edibles are majorly consumed as raw [42].

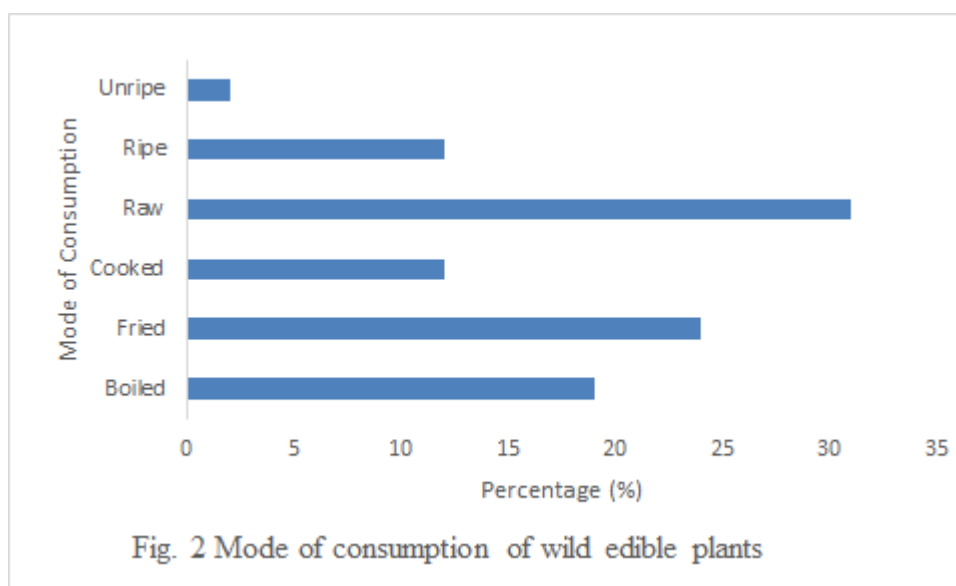


Table 2. Use Pattern and culinary treatment of Wild Edible Plants

Cooking food improves digestion and increases the absorption of many nutrients. We cook foods to change and improve the taste, enhance the appearance, change the texture e.g. hard to soft, kill food poisoning bacteria and ensure we can digest the foods

Cooking food can reduce some nutrients, such as vitamin C and some B vitamins, but other nutrients (such as lycopene in tomatoes or beta carotene in carrots) are more available to our bodies if they are cooked.

Sr. no.	Mode of Consumption	No. of Species
1	Boiled	43
2	Fried	49
3	Cooked	23
4	Raw	22
5	Ripe	29
6	Unripe	4
7	Medicines	41
8	As Primary food	35
9	Others	25

3.4 Season of collection:

Recent publications on the consumption pattern of wild edible plants were studied. These included 306 species used as wild edible plants. It was observed from the data, that current publications focus on recording consumption patterns covering plant parts used for consumption, mode of consumption, and recipes but most of them remain devoid of the season of collection or not much information is available on collection season.

The season of collection varies from region to region and culture to culture among indigenous communities. In a case study of Berek Natural Forest, Ethiopia 34 wild edible species have been studied. Of which it mentions that majority of them are collected in spring (15) followed by winters (8) and rest are available in all the seasons [43].

Another study on collection of wild edible plants in Yemen outlines that majority of species are collected in rainy season (38) followed by species harvested throughout the year (16) followed by summer season (7) out of 58 wild edible species studied [44].

While in a study on wild edible fruit species from Orissa, India suggests that different fruits ripen in different seasons. After the observation that some species ripen in summer, many in monsoon and others with onset of winters of all species studied, it concludes that the fruit setting varies at different locations because of the different climatic and edaphic conditions [45]. A study conducted by [46] Ojelel et al., (2019) in Uganda on hundred wild edible species reflects that majority of species are harvested in monsoon (64 species) followed by summer season (27 species) followed by the ones found throughout all the seasons (9 species).

A recent study from eastern Ethiopia reports that majority of the species are gathered in March to May which is light rainy season (*Badheysa*) followed by June to August (*Ganna*) followed by species collected around all year.

Several studies on wild edible mushroom across the globe describe the collection of mushroom in wet or monsoon season because of its availability in only season. Hence the consumption pattern of mushrooms are observed widely only limited to rainy season [47-50]

4. Nutritional value of wild edible plants:

Last few decades wild edible plants have been explored for their nutritional value. The consciousness for health, safe and nutritious food has increased hence better plants can be explored in the future[13].

Wild edible plants are a significant source of nutrition in developing countries. Such plants are important from an ethnobotanical perspective. Wild plants are part of a generic and cultural heritage they need to be conserved [51]. Wild plants have a significant role in the global food index. Their value is going to increase as pressure on the agroecosystems is increasing [52].

Wild edible plants possess several properties such as high antioxidants [53]. Wild edible plants are used as vegetables, fruits, and important medicinal plants [54]. Wild edible plants of

the Himalayan region are a rich source of elements such as Phosphorus, Calcium, Potassium, iron, and other important micronutrients [55]. Some wild edible plants of turkey show the presence of ascorbic acid, dehydroascorbic acid and carotenes [56]. Leafy wild edible plants show rich content of fat, fibre, protein, and micronutrients like iron, zinc, copper, and manganese as well as scavenging activity (IC 50 = 115.27 ± 0.24 micro ml) [57]. *Amaranthus Viridis*, *Chenopodium murale*, and *Nasturtium officinale* are promising sources of essential fatty acids and macronutrients [58]. About fourteen species have been reported to be consumed by Khasi tribes. They are consuming different parts such as Roots, fruits, berries, and nuts. These species are rich sources of iron, zinc (23 mg %), vitamin C (826.4 mg), and beta carotene (257. 1 mg) [59]. Many wild varieties of crops have not been documented which are used in forest areas or outside forest areas. Due to modernization, there is a depletion in knowledge and uses and wild edible plants, other. Such wild varieties need to be documented and need to be conserved.

Water soluble vitamins [60], ascorbic acid, tannin, and total flavonoids [61], Wild edible plant shows a wide range of phytochemicals which has health benefits such as these plants are rich in Phenolic compounds [62, 63], Polyphenol [64], carboxylic acids [65], β-carotene and lycopene [66].

Table: Mineral content of wild edible angiosperms

Sr. No	Plant species	Nutritional value	location of Collection	References
1	<i>Urtica urens</i>	Calcium (830 mg/100g)	Eastern Anatolia	[67]
2	<i>Nepeta concolor</i> Boiss	Mg (293.08 mg /100 g)	Eastern Anatolia	[67]
3	<i>Portulaca oleracea</i> L	Na (59.32 mg 100 g), Na (7.17), K, 14.71, Ca	Eastern Anatolia	[67, 68]

		(18.71)		
4	<i>Eulophia ochreatea</i>	Fe (5.04 mg/g) and Zn (3.83 mg/g)	Iran	[68]
5	<i>Rivia hypocrateriformis</i>	Ca (%) 0.99, Mg (%) 0.34, P (%) 0.32, Zn (%) 0.011	India	[69]
6	<i>Crithmum maritimum</i>	Na (292 mg/ 100g)	Europe	[70]
7	<i>Grewia tillifolia</i>	N (0.96 mg/100g), P (2.52 mg/100g), Mg (402.2 mg/100g)	Kolhapur, India	[71]
8	<i>Ficus racemosa</i>	Ca (928.4 mg/100g), Na (259.6 mg/100g), K (1922 mg/100g)	Kolhapur, India	[71]
9	<i>Meyna laxiflora</i>	Fe (35.55 mg/100g)	Kolhapur, India	[71]
10	<i>Elaeagnus conferta</i>	Zn (5.51 mg/100 g)	Kolhapur, India	[71]
11	<i>Flacourtia indica</i>	Cu (7.6 mg/100g), Mn (10.37 mg/100 g)	Kolhapur, India	[71]
12	<i>Mimusops elengi</i>	Ca (1975.16 mg/100g), Na (52.97 mg/100g)	India	[72]
13	<i>Phyllanthus acidus</i>	Ca (163.2 mg/100g)	India	[72]

14	<i>Eugenia rothii</i>	K (2009.9 mg/100g)	India	[72]
15	<i>Yerminalia citrina</i>	K (1460.72 mg/100g)	India	[72]

Table: Vitamins in wild edibles:

Sr. No	Group	Species	Vitamins	Content	References
1	Mushrooms	<i>Cantharellus tubaeformis</i>	D	29.82	[73]
2	Mushrooms	<i>Cantharellus cibarius</i>	B12	1.82	[74]
3	Mushrooms	<i>Craterellus cornucopioides</i>	B12	1.89	[74]
4	Pteridophytes	<i>Diplazium maximum.</i>	C	25.38	[75]
5	Pteridophytes	<i>Tectaria coadunata</i>	C	22.25	[75]
6	Pteridophytes	<i>Dryopteris cochleata</i>	C	23.13	[75]
7	Angiosperms	<i>Rubus ulmifolius</i>	Total tocopherol content	13.48	[76]
8	Angiosperms	<i>Arbutus unedo</i>	C	182.41	[76]
9	Angiosperms	<i>Raphanus raphanistrum</i>	E	1.07 mg/100 g	[77]

10	Angiosperms	<i>Dovyalis longispina</i>	A	903	[78]
11	Angiosperms	<i>Manilkara mochisia</i>	A	25	[78]
12	Angiosperms	<i>Garcinia livingstonei</i>	A	11	[78]
13	Angiosperms	<i>Syzygium guineense</i>	A	1.7	[78]

Nutrition after culinary treatment:

The culinary treatment as cooking can lead to destruction of thermolabile components such as folates, vitamin C and minerals. However, amount of dietary fiber is less affected by boiling process. The retention of nutrients vary depending upon factors such as cooking time, temperature, pH and the specific characteristics of the food suggests [79]. The study also suggests decline in protein and mineral content after cooking. Also, grilling is found as the effective method in preserving nutrients in wild vegetables among all the other methods of cooking.

A study about effect of culinary treatment nutritional characteristics of Cucurbita pepo L. (zucchini) describes that cooking temperature alters the nutritional profile, texture, color and taste of food. Stir frying leads to loss of phenol content and antioxidant capacity of the zucchini. Although steam cooking largely kept the nutritional content intact [80]. Cooking treatments like boiling, frying, microwaving and grilling lead to alter the proximate composition and antioxidant activity of mushrooms. Frying method as compare to other methods leads to severe loss of proximate composition while the microwaving and grilling method escalated antioxidant capacities of mushrooms. The article highlights that the preference of food processing methods plays an important role in keeping nutrients intact [81]. Heating treatment is reported to increase the concentration of flavonoids and phenols in food but boiling shows the contrasting effect on phenols and flavonoids. The increase in phenol and flavonoid content adds to the antioxidant activity [82]. Boiling is seen to decrease the vitamin content in food. Infusion is another treatment that leads to further lowering of vitamin content. But drying process by microwave or convection suggests the vitamin C and beta- carotene augmentation. Hence, drying at temperature around 65°C to 75°C bring about preservation of the vitamin content [83].

Activities and health benefits of wild edibles:

Wild edibles shows various activities such as antioxidant activity [64, 66, 84-86], antihyperglycemic [87-90], anticancer [91-93], antidiabetic [94-96], hepatoprotective activity [97-99], antitumor [100-102], antimicrobial [103, 104], anti-inflammatory [96, 105, 106], hypoglycemic [107], antihypertensive [94, 108].

5.1 Misidentification of wild edible plants

The cases of poisoning due to wild edible plants are rising. Misidentification of species is a major cause of such food poisoning [62]. Similar cases were confronted by Italy. The poisonings were reported because of the consumption of wild edible plants [109, 110]. Study had examined 457 mushroom poisoning in cases, and misidentification is one reason for mushroom poisoning [111]. The misidentification of *Mandragora autumnalis* Bertol. (Mandrake) and *Digitalis purpurea* L. (foxglove) as *Borago officinalis* L. (borage) in the south and north Italy respectively lead to the toxicity. The resemblance of young leaves of borage with that of poisonous species accelerated the accidental consumption of these poisonous species. The study also reports microscopic characteristics, and phytochemical and molecular analysis for correct identification [112].

Author have reported two cases in northern Italy. *Foeniculum vulgare* Mill. and *Conium maculatum* L. have similarities in leaves, one can easily get confused between these two species. *C. maculatum* shows the presence of piperidine alkaloids which are toxic to human beings [110].

5.2 Presence of toxic/anti-nutritional compounds

Wild edible plants are widely known for their nutritional value [113]. Aroma [114], medicinal properties [42, 115], creating livelihood for the people [116], dietary diversity [117]. But wild edibles have their own limitations. Some wild edible plants have been observed to contain chemical compounds that are toxic in nature, hence, unfit for human consumption. Many studies have reported cases of toxicity caused due to the presence of some metabolites. These metabolites at certain concentrations possess health hazards. Not every metabolite bears toxic properties, some induce reactions to produce a toxic product.

5.2.1 Nitrates

The nitrites and oxalic acid are most commonly present in wild edibles in high concentrations. The nitrites have the ability to interfere with the oxygen-binding capacity of haemoglobin, affecting the oxygen transport in the blood. Further, nitrites also produce carcinogenic substances - nitrosamines[31]. [56] have reported nitrate content in 47 mg/100g in *Salicornia europea* L. and 597 mg/100g in *Amaranthus viridis* L.

5.2.2 Oxalic acid

Oxalic acid occurs in both soluble and insoluble forms in nature. It has the propensity to form kidney stones by accumulating calcium as calcium oxalates, also known as raphides. Oxalic acid concentrations range from 0.7 mg/100 g to 1545 mg/100g in plants. Various wild edible species contain different levels of oxalic acid. Furthermore, the levels also vary at the different developmental stages of plants. Yet it remains unclear whether oxalic acid itself or the production of calcium oxalates puts human health at risk [51]. A significant concentration of oxalic acid is reported in wild edible plants belonging to the genus *Oxalis*, *Rumex*, *Chenopodium*, and *Amaranthus* [118, 119].

5.2.3 Alkaloids

Alkaloids are the class of nitrogenous compounds bearing aromatic rings, produced by the plants as secondary metabolites. Several wild edible plants possess toxic secondary metabolites such as alkaloids, terpenes, and phenols setting human health at risk. One such example is commonly consumed WEP *Borago officinalis*, which contains certain alkaloids like thesinine, lycopsamine and intermedine - that damages the liver and are mutagenic.

Pyrrolizidine alkaloids are found in several plant families such as Asteraceae, Boraginaceae, Fabaceae (tribe Crotalarieae), and Orchidaceae. The plants like *Senecio vulgaris* L. and *Echium vulgare* carrying these compounds are believed to be most poisonous and impact livestock and animals. These alkaloids are popular for showing hepatotoxic, genotoxic, pneumotoxic, and carcinogenic effects [120].

Pyrrolizidine alkaloids are also reported to cause toxicity when present in plants. These alkaloids are found in aerial parts of *G. hederacea*, having structures like tropane alkaloids[51, 62].

5.2.4 Saponins

Saponins are structurally triterpene glycosides, a wide group of secondary metabolites known for bitter taste and producing toxic effects. The saponins sometimes act as an antinutritional compound as their presence reduces the intake of some foods because of their bitter taste (Pinela et al., 2017). They show membrane destabilization, cytotoxicity [121] and haemolytic effects [122], while, in contradiction, they also show anti-inflammatory [123] and anticancer activities [124, 125].

5.2.5 Other compounds

Phenylpropanoids such as estragole with hepato-carcinogenic properties are present in wild edible species *Foeniculum vulgare* [31]. Brydiofin is another toxic compound revealed from fruit extracts of *Bryonia dioica*. However, the extracts from leaves and roots were not found to be lethal [120, 126].

The toxicity is also dependent on the plant part consumed. Not necessarily every part of the plant would certainly be toxic. For example, the pits of stone fruits like peaches, and apricots are poisonous and don't fit for human consumption while the fruit pulp is edible. Similar examples are the bark of *Sambucus nigra* [127] (Battelli et al., 1997) and *Berberis vulgaris*, leaves of *Ribes uva-crispa*, whole plant *Robinia pseudoacacia* except flower is toxic. In agricultural practices, everything else is considered weeds except the cultivated ones; hence pesticides are sprayed on them. As a result, the traces left in the plants coming from herbicides or pesticides could be another cause of toxicity [62].

6. Use of wild edible plant or plant part in traditional herbal formulations:

The flowers, leaves, and barks are used for herbal tea formulations. The flowers of wild edible plants *Bauhinia variegata*, *Shorea roxburghii*, *Viburnum inopinum*, *Gmelina arborea* and *Glycyrrhiza glabra* while the leaves of *Camellia sinensis* and bark of *Glycyrrhiza glabra* are utilised for tea formulations [128]. Many plant species from India are formulated as herbal remedies for the treatment/ control of diabetes [129]. The wild edible tuber, *Dioscorea* spp. in traditional herbal remedies by local people of Similipal Biosphere Reserve of India [130, 131] have discussed herbal formulations prepared by 66 wild plant species in their article.

6. Current trends in wild edibles

Novel research in food and nutrition has become a trend because of the nutritional demands across the globe. Edible fungi are becoming popular for their high nutritional value. The presence of bioactive compounds in wild edibles gains the attention of researchers to offer them as a functional food to the consumers. This way wild edible plants have been highlighted for their consumption. At present, mushrooms are recognized as a high-value-added food resource. Mushrooms have an ample amount of bioactive compounds and show high antioxidant and antimicrobial properties. Also, secondary metabolites like ergosterol and ergosterol peroxide in mushrooms make them anti-inflammatory, anti-cancerous, antivirulence, anti-tumour, immunologic and beneficent in reducing the risk of cardiovascular disease. Several articles specify that the food products of edible fungus are considered among the top 10 healthy food products. Hence, mushrooms are looked at as a potential source of nutrition and are envisioned for nutraceutical use.[132-135].

7. Conclusion:

Wild edible are popular for their nutritional value. Wild edible are potential solve the problems of nutrition deficiency, livelihood, food security at remote areas and developing countries. The wild edibles can be a source of potential nutritional in future. They can be resource of important genetic information for the production of potential products by the utilization of plant cell factory in future. Wild edibles are also source of secondary metabolites which possess anti-inflammatory, anti-cancer, antioxidant, anti-virulence properties. These wild edibles can play significant role in drug discovery.

DECLARATIONS

1. Ethics approval and Consent to participate

Not applicable

2. Consent for publication

All authors agree to this publication

3. Availability of Data and materials

Not applicable

4. Competing interests

Both the authors declare that there are no competing interests regarding this publication.

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6. Author's Contributions

First author carried out the planning, design, data collection and drafting of the article. While the second author has carried out the critical revision and final approval of the article.

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