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Excavation of the reservoir of Indigenous foods for dual virtues of nutritional and medicinal benefits – A tenable approach for food & health security

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Abstract

The Indigenous food system is a consortium of native foods, nutrients and bioactive components. They are envisaged as more potent than normal foods owing to their ingenuity and to the myriad of physiological health benefits they execute on humans. Sparse information on the charismatic nutrient and phytochemical potential of these environmental foods hampered their utilisation expedited to the ignorance and disregard for these foods. Excavation of the complexity of interactions of indigenous foods, nutrients and phytochemicals with particular reference to achieving food security under the umbrella of proliferating scientific evidence can only address the challenges of malnutrition.

Keywords: Bioactive components, Indigenous food system, Malnutrition, Phytochemicals, Tribes

Introduction

Food is integral to life on Earth and survival of people. The discovery of food as medicine, not far short of few decades ago, ushered in a new era, the medicinal food era with promising results in the human health arena. The interest in research and development activities on wild or underutilized plant and indigenous species is presently increasing throughout the world because of their positive role against various diseases. Plethora of research studies in the past decade revealed propounding facts on the nutritional and phytochemical richness of indigenous foods. Thus, indigenous food, nutrient and phytochemical interactions have become central to understanding the complexity of health benefits bestowed.

Food and nature are inseparable and indispensable. The indigenous communities live in a rich habitat replete with food resources and practise deep-rooted knowledge of the forest environment.[1] Indigenous populations are defined as "communities that live within, or are attached to, geographically explicit traditional habitats or totemic territories, and who identify themselves as being part of a distinct cultural group".[2] According to the United Nations (2009), there are 370 million Indigenous people living in 90 different nations.[3] Indigenous people have strong affiliation to their lands and the natural resources in the area and who organise themselves into discrete social and cultural assemblage.[4]

India is home to numerous indigenous tribal communities that make up world's biggest population of tribal people, numbering about 84.4 million.[5] The tribes of India make up a

sizable portion of around 8% of the overall population of the nation, which likely has the most tribal communities per square mile in the entire globe.[6] Indian native tribes include the Gonds, Sahariya in Madhya Pradesh, Bhils in Rajasthan, Bhagata, Valmiki, Khodu, Konda Dora Khonds in Andhra Pradesh, Bodo in Assam, Muthuvans, Kadaras in Kerala,Gond, Sounti, bhumiz, Kol, Juang in Odisha, Jaintia in Meghalaya, Oraon in Jharkhand, Rongmei in Manipur, and Sheena tribes in Kashmir.

About 60% of the tribes in India reside in forested areas and rely on these places for a variety of edibles since generations.[7] Tropical forests are biologically diverse ecosystems that contain the highest terrestrial biodiversity per surface area. Wild plants have been playing a very momentous role in human life for thousands of years. Tribes endure on edible leaves, seeds, roots, honey, wild mushrooms and insects. They use herbs and medicinal plants to cure their diseases through knowledge acquired from ancestors. Indigenous crops have been proven to have more micronutrients than non-native vegetable species.[8] Tribal foods are rich sources of essential vitamins, minerals and anti-oxidants and disease preventive phytochemicals such as alkaloids and phenolic compounds. Since these crops depend on few external inputs, they fit well with the emerging concept of eco-friendly agriculture and occupy a unique place. These particular food crops are endowed with other faculties including cultivation friendly, resiliency to drought, low carbon foot prints, significant contribution to biodiversity and to local economies.

Nutritional status of the population largely depends on the consumption of food in relation to their needs, which in turn is influenced by the availability of food and purchasing power.[9] Nutrition and health of the tribal children continue to be a pressing concern in India. As per CNNS (2016-18), about 4.7 million children under 5 years of age suffer from chronic nutrition deprivation affecting their survival, growth, learning, performance in school, and productivity as adults. While the prevalence of mild and moderate stunting is similar in tribal and non-tribal children, the prevalence of severe stunting is higher (16% vs. 9%) in tribal children. Wasting is more profound among them as compared to the national average (17.3% vs 21.9 %). Micronutrient deficiencies are also quite prevalent among them. About 53% of tribal children suffer from anaemia against the national average of 40%. The tribal populations are 'at risk' of under nutrition because of household food and nutrition insecurity.[10]

The tribal populations are 'at risk' of under nutrition and faulter on all nutrition gauges albeit a rich biodiverse environmental bounty. Geographical seclusion, subsistence farming, erroneous social taboos, lack of awareness, fallacious treatment practices, poverty and other factors all contribute to the development of a variety of morbidities and undernutrition.[11-13] Food security, as defined by the FAO, is a situation that exists when 'all people, at all times, have physical, social and economic access to sufficient, safe, nutritious food to meet their dietary needs and food preferences for an active and healthy life'.[14] Conversely tribal populations are far from achieving the four dimensions of food security comprising availability to food, access to food, utilization and stabilisation. Consumption of indigenous wild foods such as wild plant foliage, vegetables and fruits can be an important mode of dietary diversification and a direct food-based intervention to address food insecurity.[15]

Deforestation, lamentably causing reduction in genetic resources, that includes several food species, endangering dietary diversity and traditional knowledge of indigenous people jeopardising the achievement of Sustainable Development Goals.[16-18]Understanding the vast diversity and complexity of food systems of indigenous people as well as improving and

strengthening these systems in the context of nutrition and health thus merit attention.[19,20] As India struggles to tackle malnutrition among women and children in the country, it is increasingly becoming clear that agro biodiversity has an important role to play in ensuring sustainable and diverse diets and enhance health and nutrition, and may help manage effects of climate change.[21]

Growing evidence has mirrored the great potential for food security if indigenous plants were studied more extensively and included more often as mainstream foods. It is obvious that further research in this area is imperative, to shed light. This review is curated to provide a synthesis of existing information on nutrient composition, nutrient adequacy ratio, phytochemicals and health benefits of indigenous foods in order to corroborate the veracity that these foods can contribute to food and nutrition security paving the way for medicinal security and to identify gaps where more research is urgently needed.

Methodology

All the available information about the botany, uses, nutritional composition, phytochemistry and pharmacological properties (85 Research papers) on various indigenous foods were collected via electronic search using PubMed, Scopus, Web of Science, Science Direct, J-Gate, Google Scholar, and other web search engines such as Google and a library search for articles published in peer-reviewed journals, unpublished materials, theses and some of the government survey reports. All obtained data from previously published literature are summarized in 3 tables (Botanical description, Proximate, Phytochemicals, Minerals and Fatty acid composition) and 5 figures.

List of foods

The ethnic people depend upon wild species for fruits, seeds, roots, tubers, flowers which are used for edible purpose. List of edible plants and their parts used by different ethnic groups residing in various geographical locations in India are presented in the table 1 distribution of the plants based on family in Fig.2.

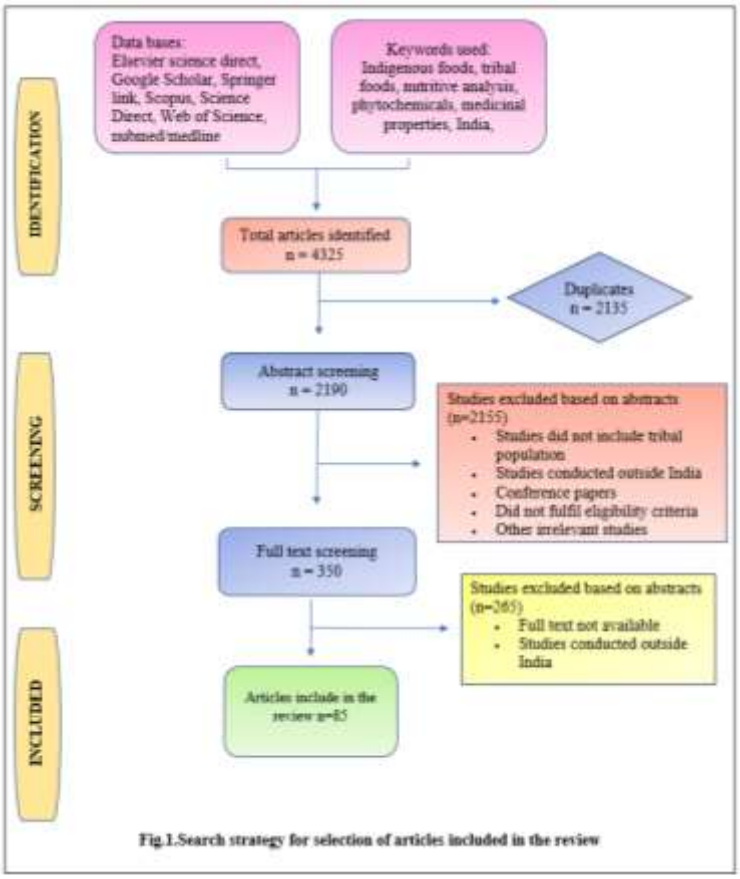

Fig.1.Search strategy for selection of articles included in the review

Table 1. List of indigenous flora and their distribution based on geographical location and tribal group

AREA	TRIBE	BOTANICAL NAME	REFERENCE
Andhra Pradesh	Bhagata Valmiki Khodu Konda Dora	Alangium salvifolium (L.f.)Wangerin; Amorphophalus paenofolius(Dennst.) Nicolson; Anisochilus carnosus (L.f.) Benth.; Atylosia scarabaeoides (L.) Benth.; Caralluma adscendens R.Br.; Ceropegia bulbosa Roxb.; Clerodendrum serratum (L.) Moon.; Dioscorea pentaphylla L.; Erythroxylum monogynum Roxb.; Hemidesmus indicus (L.) R.Br.; Mucuna pruriens (L.) DC.	22
Arunachal Pradesh	Adi	Clerodendrum glandulosum; Piper pedicellatum; Pouzolzia hirta; Spilanthes acmella; Zanthoxylum rhetsa; Amorphophallus campanulatus; Blume ex Decne.	23
Assam	Bodo	Blumea lanceolaria Druce asiaticatrifolia Domin; Drymaria cordata (L.)Roem.& Schult.; Hibiscus cannabinus L ; Hibiscus sabdariffa L.; Ipomoea aquatic Forssk.; Lasia spinosa; Lippia alba (Mill.) N.E.Br.; Premna herbacea Roxb.; Cardamine hirsuta L.; Melothria perpusilla (Blume) Cogn.; Natsiatum herpeticum Buch. -Ham. ex Arn; Persicaria	24,25

		chinensis (L) H.; Sphaerantus peguensis Kurtz ex C.B. Clarke,; Sphenoclea zeylanica Gaertn	
Chhattisgarh	Gond Kanwar Kamar	Aloe Vera Linn; Amaranthus tricolor; Amaranthus viridis L.; Andrographis paniculate; Azadirachta indica; Gallium aparine; Lucus cephalotes Spreng.; Mentha piperita; Ocimum sanctum; Phyllanthus emblica; Trigonella foenum-graecum	26
Jharkhand	Oraon	Allium Sativum; Brassica Campestris; Brassica Juncea; Centella Asiatica; Dioscorea Bulbifera; Enhydra Fluctuans; Ficus Geniculata	27
Kashmir	Sheena	Anaphalis triplinervis (Sims) Sims ex C.B.Clarke; Berberis lycium Royle; Centella asiatica (L.) Urban; Codonopsis ovata Benth.; Cyperus rotundus L.; Elsholtzia densa Benth.; Heracleum candicans Wall.; Rheum webbianum Royle; Trifolium repens L.	28
Kerala	Mullu Kuruma or Kuruma, Paniya, and Kattunaikka Kadaras, Malasars Muduvans, Malamalasars	Adenia hondala; Costus speciosus; Hygrophila schulli; Ophioglossum reticulatum; Thespesia populnea; Zehneria mysorensis; Acacia nilotica (Linn.) Armed tree; Aegle marmelos Corr.; Calamus rotang Linn.Dioscorea pentaphylla Linn.; Ixora brachiata DC.; Mesua ferrea Linn.; Passiflora foetida Linn.; Acacia sinuata (Lour.) Merr.; Alternanthera sessilis (L.) R. Br.ex. DC ; Amorphophallus commutatus; (Schott) Engl. ; Caryota urens L.; Achyranthes bidentata Blume; Begonia floccifera Bedd. ; Cleome viscosa L.; Kedrostis courtallensis Arn.; Rungia wightiana Nees; Trianthema portulacastum L.	29-32
Madhya Pradesh	Gonds and Sahariya	Achyranthes aspera Linn.; Amaranthus viridis Linn.; Bauhinia vahlii Wt. & Arn.; Boerhavia diffusa Linn.; Cassia fistula Linn.; Cassia obtusifolia Linn.; Moringa oleifera Lam.; Oxalis corniculata Linn.; Prosopis cineraria Linn.; Rhus parviflora Roxb.	33
Manipur	Rongmei	Brassaiopsis hainla Seem.; Gnetum gnemon L.; Pilea scripta (Buch.-Ham. ex D. Don) Wedd.; Rhynchotechum ellipticum (Wall. ex D. Dietr.) A. DC.; Sarcochlamys pulcherrima; Gaudich. Voy. Bonite	34
	Maring	Dalbergia stipulacea Roxb.; Justicia gendarussa Burm. f.; Lindernia ruellioides (Colsm.) Pennell; Trichosanthes bracteata (Lam.)Voigt	35
Meghalaya	Jaintia	Amblyanthus glandulosus A. DC.; Amorphophallus bulbifer (Roxb.) Bl.; Buddleja macrostachya Benth.; Chlorophytum arundinaceum Baker; Phlogacanthus thyrsiflorus (Roxb.)Nees.	36

Orissa	Gond, Sounti Bhumiz, Kol Juang	Antidesma ghaesembilla Gaertn.; Bauhinia purpurea Linn.; Cochlospermum religiosum (Linn.) Alstm; Dioscorea bulbifera Linn.; Diospyros melanoxylon Roxb.; Ficus carica Linn.; Flacourtia jangomas Raeusch.; Melothria heterophylla (Lour.) Cogn.; Meyna laxiflora Robyns.; Semecarpus anacardium Linn. f.; Sesbania grandiflora Pers.; Syzygium cerasoideum (Roxb.) Raizada; Terminalia bellirica Roxb.; Trianthema decandra Linn.	37

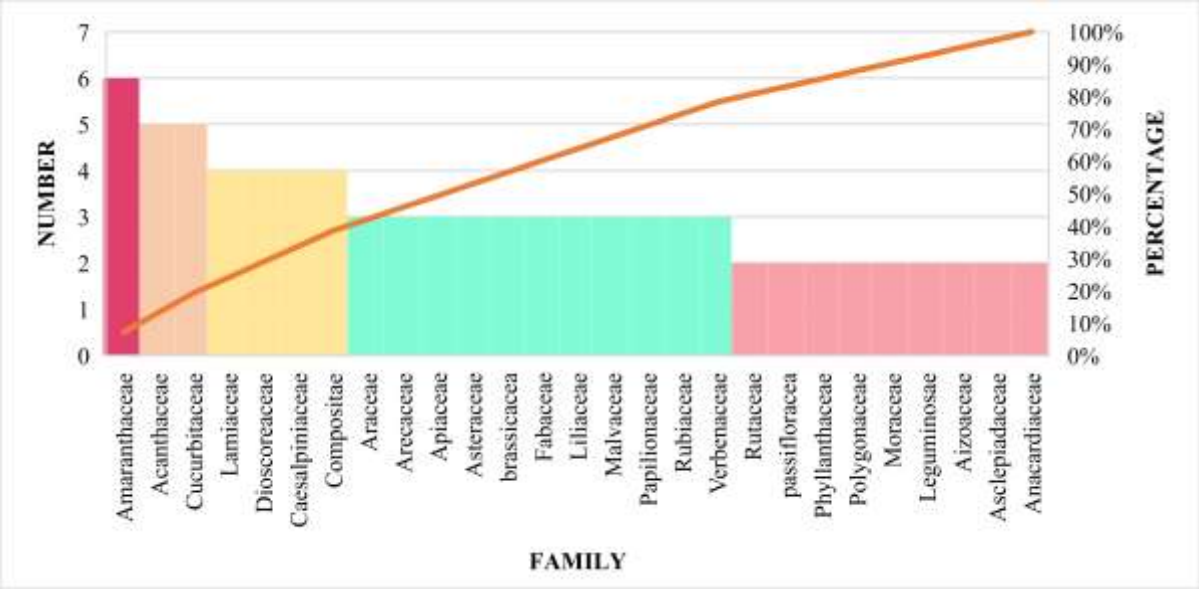

Fig 2. Family wise distribution of wild edible plants

Nutritive value

Food and its nutrients are essential for a healthy life. In India most of the tribal communities depend on wild edible plants to meet their food requirements. Indigenous foods obtained from natural ecosystem are nutritionally adequate. Leaves of Blumea lanceolaria Druce are rich in protein (23.66g/100gm).[38] Iron rich edible parts of plants are Drymaria cordata (L.) Roem. & Schult. (22.06 mg/100gm), Hibiscus sabdariffa L.(22.50, Lippia alba (Mill.) N.E.Br.(27.44 mg/100gm), Cayratia trifolia Domin (21.59 mg/100gm), Hibiscus cannabinus L (23.02 mg/100gm), Ipomoea aquatic Forssk.(22.42 mg/100gm), Amorphophallus campanulatus (20.94 mg/100gm)[39], Centella Asiatica (55.66 mg/100gm)[40], Achyranthes aspera L. var. (22.6 mg/100gm).[41]Vitamin C rich foods are Talinum portulacifolium (Forssk.) Asch. ex Schweinf (175.57 mg/100gm), Cassia tora L. (151.79 mg/100gm), Solanum nigrum L. (141.56 mg/100gm)[42], Sarcochlamys pulcherrima Gaudich. Voy. Bonite (111.11 mg/100gm).[43] Consolidated nutritive values of different indigenous plants are presented in Table.2. Fig.3 represents the percentage of Recommended Dietary Allowance (RDA) met by various indigenous plants for various nutrients.

Table 2. Nutritive composition of Indigenous foods

Botanical name	Vernacular name	Part	Moisture	Crude Fiber	Ash	Calorific value	Total sugar	Crude lipid	Crude protein	Zn	Mg	Cu	Fe	Mn	Vitamin C	Reference
Achyranthes aspera L. var. aspera	Latjeera, Chirchita	Leaves	84.2	1.1	-	-	-	0.36	4.05	1.37	0.29	0.44	22.6	23.8	43.1	44
Allium sativum	Lahsun saag	Leaves	-	4.9	-	34	5.4	ND	3.1	0.21	-	-	5.9	-	6	45
Alternanthera sessilis (L.) R. Br. ex DC	Matikaduri Ponnanganni	Leaves	81.6	2.5	-	-	-	0.73	4.6	0.51	0.23	0.34	14.7	9.5	48.9	46
Amaranthus spinosus L.	Mullancheera Mullukeera, Doggali	Leaves	80.3	1.4	-	-	-	0.13	3.9	2.35	0.26	0.19	15.4	4.6	105.4	
Amorphophallus campanulatus Blume ex Decne.	-	Leaves	94.5	-	34	284.8	48.4	2.32	17.5	0.24	1.1	0.49	20.9	3.4	-	47
Amorphophallus campanulatus Blume ex Decne.	-	Tuber	66.08	5.7	4.8		25.5	1.41	9.8	2.05	81.9	0.33	1.7	0.39	76.6	48
Aponogeton natans (L.) Engl. & K.Krause	-	Tuber	-	-	-	386	-	2.9	5.3	2.2	-	-	30.1	-	-	49
Bauhinia vahlii Wt. & Arn.	-	Seeds	-	-	-	-	4.79	28.5	24.2	-	-	-	-	-	-	50
Bauhinia variegata	Kachna phool Burju Baha	Flower	-	-	-	83	-	-	2.9	0.6	-	-	3.4	-	2.5	51

Blumea lanceolaria Druce	Jaglaori	Leaves	84	-	32	259.5	40	0.5	23.6	10.9	2.57	0.30	15.9	2.4	-	[52]
Brassica campestris	Chiniya saag	Leaves	-	3.5	-	31	6.3	ND	1.5	ND	-	-	5.9	-	11	[53]
Brassica juncea	Lotni saag	Leaves	-	3.3	-	28	4.3	ND	2.2	0.7	-	-	19.7	-	4	
Cardamine hirsuta L.		Leaves	92.8	1.6	1.7	22.4	1.70	0.2	3.9	0.3	5.6	1.6	6.1	0.64	35.6	[54]
Cassia tora L.	Thakara	Leaves	77.8	1.7	-	-	-	0.9	5.2	1.4	0.1	0.4	6.6	2.6	151.7	[55]
Cayratia trifolia Domin		Leaves	83	-	22	197.4	26.18	1.6	19.5	5.1	4.1	0.2	21.5	1.6	-	[56]
Centella Asiatica	Muthil	Leaves	86.2	1.4	-	-	-	0.2	3.1	2.03	0.08	0.1	13.6	3.3	56.2	[57]
Colocasia antiquorum Schott	-	Leaves	86.1	1.09	-	-	-	0.3	2.6	0.16	0.20	0.19	0.57	7.8	66.1	
Colocasia esculenta (L.) Schott	Vayalthaalu	Leaves	85.9	2.2	-	-	-	0.75	2.7	1.2	0.07	0.09	3.8	5.8	27.7	
Dioscorea bulbifera	-	Tuber	-	3.5	-	95	21.1	ND	2.4	0.38	-	-	4.09	-	4	[58]
Dioscorea oppositifolia	Pan Alu Arika tega	Tuber	-	-	-	40.9	-	6.3	13.8	1.4	-	-	49.1	-	104.7	[59]
Dioscorea pentaphylla	Nappe, Pandimukku tega, Panja Sanga	Tuber	-	-	-	395	-	6.0	5.4	3.2	-	-	113.4	-	91.7	
Dioscorea tomentosa	-	Tuber	-	-	-	409	-	5.9	8.5	3.2	-	-	23.6	-	6.2	
Diplazium esculentum (Retz.) Sw.	Churuli	Leaves	88.3	1.99	-	-	-	0.36	3.55	0.94	0.08	0.3	1.8	0.7	32.03	[60]
Drymaria cordata (L.)Roem.& Schult.	Jabshri	Leaves	86	-	23	153.5	23.3	0.54	13.81	7.7	2.1	0.3	22.06	0.7	-	[61]
Enhydra Fluctuans	Hirmichiya saag	Leaves	-	4.4	-	38	6.5	ND	2.1	0.7	-	-	16.9	-	4	[62]
Ficus Geniculata	Phutkal	Leaves	-	45.1	-	324	58.4	1.8	18.7	4.6	-	-	8.8	-	5	
Gomphogyne cissiformis	Sohthliem	Fruit	-	-	-	-	-	3.6	14.4	3.8	-	-	6.2	-	273.5	[63]
Gnetum gnemon L.	Ganmakhen	Leaves	-	39.8	-	-	7.02	2.1	20.1	-	-	-	-	-	66.6	[64]
Hibiscus cannabinus L	-	Leaves	86	-	30	258.1	39.01	2.01	21	6.3	3.03	0.2	23.02	0.4	-	[65]
Hibiscus sabdariffa L.	Ambadi Bhaji Pulichchai kerai, Gongura, Chukiar	Leaves	91.5	-	35	251.2	43.5	1.8	15.1	8.8	6.4	0.4	22.5	1.9	-	
Hibiscus sabdariffa L.		Leaves	58.9	7.2	2.6	133.1	22.5	1.7	6.9	15.8	-	1.2	3.32	1.5	-	[66]
Ipomoea aquatic Forssk.	Mandey, Tuuti kaada	Leaves	88.5	-	30	207.9	34.9	1.2	14.3	0.3	1.1	0.1	22.4	3.4	-	[67]
Kaempferia galanga L.	Sying smoh	Tuber	-	-	-	-	-	10.2	4.7	8.4	-	-	69.9	-	182	[68]
Lasia spinosa	Sibru, Neerugaddalu	Leaves	17.6	-	1.16	224.04	17	83	17.6	7.4	6.2	0.3	17.06	1.3	-	[69]

Leucas aspera (Willd.) Link	Durun bon, Tummikura	Leaves	83.3	1.42	-	-	-	0.5	2.6	0.6	0.1	0.3	3.5	1.9	34.1	[70]
Lippia alba (Mill.) N.E.Br.	Onthai bazab	Leaves	66	-	20	124.03	7.6	1.3	20.2	0.7	1.1	0.5	27.4	3.3	-	[71]
Melothria perpusilla (Blume) Cogn.,	Timijora	Leaves	82.8	3.03	13.6	0.66	67.03	0.20	2.6	0.2	5.10	2.6	17.0	0.8	57.07	[72]
Momordica sahyadrica Kattuk. and V.T.Antony	Kaattupaaval	Leaves	81.1	1.3	-	-	-	0.5	2.6	1.68	0.56	0.28	5.2	2.8	54.8	[73]
Natsiatum herpeticum Buch. -Ham. ex Arn	-	Leaves	83.7	1.9	3.4	54.7	6.8	0.6	5.3	0.70	4.5	2.10	2.4	0.7	85.7	[74]
Perilla Frutescens L.	Bhanjeer,Hanshi chhawhchhi	Seeds	6.02	-	3.3	-	23	42.2	25.3	4.2	261.7	0.20	9.5	4.9	-	[75]
Persicaria chinensis (L) H.	-	Leaves	92.3	2.5	1.5	25.9	2.0	0.3	3.6	0.30	4.2	2.60	1.6	0.6	27.7	[76]
Pilea scripta (Buch.-Ham. ex D. Don) Wedd.	Turingnong	Leaves	-	13.5	-	-	6.8	2.9	15.3	-	-	-	-	-	66.6	[77]
Portulaca oleracea L.	Kozhuppacheera	Leaves	90.4	0.9	-	-	-	0.1	1.9	0.7	0.2	0.24	11.8	1.7	36.8	[78]
Premna herbacea Roxb.	Mathi gadab	Leaves	81	-	43	249.8	41.7	2.3	15.3	7.7	5.04	0.30	18.2	0.5	-	[79]
Prunus bracteopadus koehne	Sohlang	Fruit	-	-	-	-	-	0.7	4.6	1.5	-	-	10.7	-	608.9	[80]
Rhynchotechum ellipticum (Wall. ex D. Dietr.) A. DC.	Gankarek	Leaves	-	39.8	-	-	13.7	1.3	8.9	-	-	-	-	-	33.3	[81]
Sarcochlamys pulcherrima Gaudich. Voy. Bonite	Goibalei	Leaves	-	10.5	-	-	5.5	1.4	20.3	-	-	-	-	-	111.1	
Solanum indicum L.	Sohngang rit	Fruit	-	-	-	-	-	18.8	14.1	3.5	-	-	4.5	-	826.4	[82]
Solanum nigrum L.	Mudungachappu	Leaves	81.0	1.6	-	-	-	0.8	4.3	1.6	0.08	0.3	4.7	2.7	141.5	[83]
Sphaerantus peguensis Kurtz ex C.B. Clarke,	-	Leaves	92.8	1.2	1.4	23.7	2.5	0.1	3.0	0.7	4.9	2.5	1.8	0.5	40.3	[84]
Sphenoclea zeylanica Gaertn	-	Leaves	90.8	1.9	2.3	28.3	3.3	0.2	3.1	0.2	4.1	2.1	2.4	0.6	15.2	

Talinum portulacifolium (Forssk.) Asch. ex Schweinf	Saambaarcheera	Leaves	90.04	1.2	-	-	-	0.2	1.9	0.5	0.14	0.15	1.3	2.4	175.5	[85]

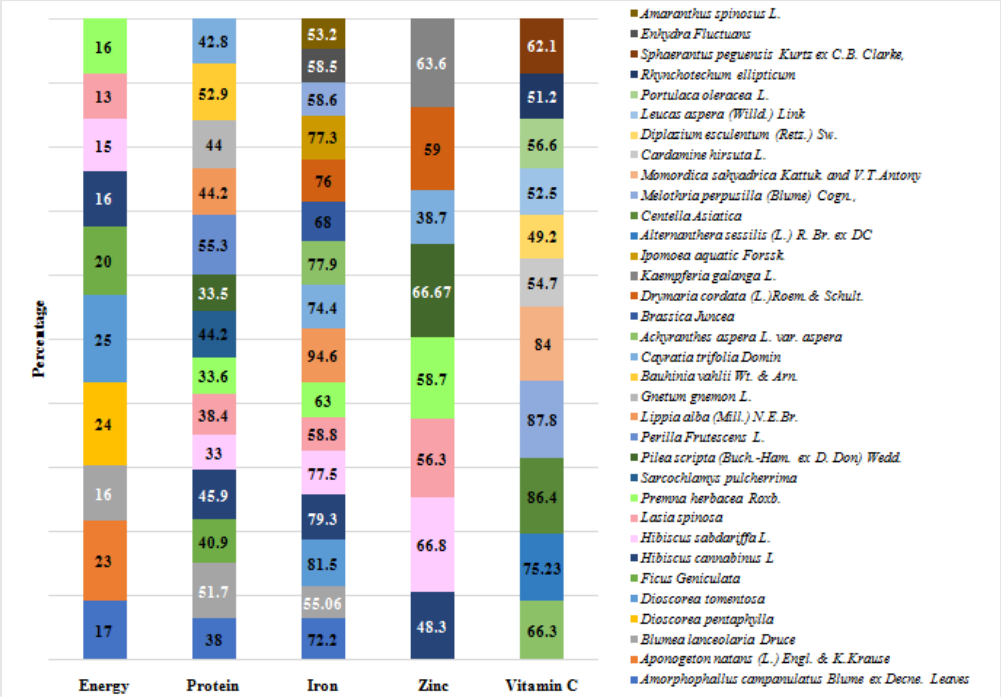

Fig.3. Percentage of RDA met by various indigenous plants for various nutrients

Medicinal properties

The tribal foods are not only rich in nutrients but are also used for curing several diseases. Most of the plant species are of great importance to tribes as they are used in treating many health problems. This can be achieved by using leaves, tuber, stem, root, flowers in appropriate dosage to the patients. According to World Health Organization (WHO) more than 80% of the world's population relies on traditional medicine for their primary healthcare needs. Use of herbal medicines in Asia represents a long history of human interactions with the environment. Plants used for traditional medicine contain a wide range of substances that can be used to treat chronic as well as infectious diseases. A vast knowledge of how to use the plants against different illnesses may be expected to have accumulated in areas where the use of plants is still of great importance.[86]The medicinal value of plants lies in some chemical substances that produce a definite physiological action on the human body. The most important of these bioactive compounds of plants are alkaloids, flavonoids, tannins and phenolic compounds.[87]

Figure.4. shows that indigenous treatment can be done by using indigenous foods for various ailments such as fever, cold, hypertension, diabetes, gastrointestinal problems, rheumatism, respiratory disorders, diarrhoea, dysentery, nervous disorders and menstrual problems.

Plants used for treating diabetes are *Madhuca indica Gmel., Sarcochlamys pulcherrima Gaudich. Voy. Bonite*. Roots of *Cissampelos pareira L*used to increase milk in lactating mother by tribes of Orissa. Plants such as *Hibiscus sabdariffa L.Lippia alba (Mill.) N.E.Br*. are used to treat hypertension. Boiled leaves of *Gnetum gnemon L*. are taken for curing irregular menstrual cycle by Rongmei tribes of Manipur. For treating nervous disorders gums of young shoot of *Gardenia gummifera L.f.,* roots of *Rauvolfia serpentina (L.) Benth. Ex Kurz* are used (Ray, R. C., & Swain, M. R. 2013). Khonds of Andhra Pradesh use ground paste made from *Desmodium gangeticum DC*. for treating epilepsy or fits.[88]

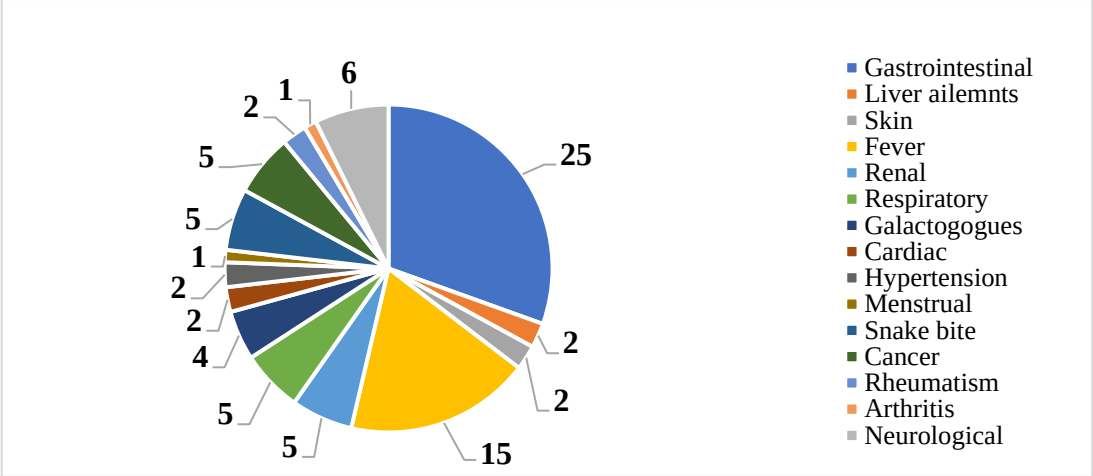

Fig.4. Percentage of Indigenous plants utilized for treating various ailments[89-100]

Table 3. Phytochemical composition of indigenous foods

Botanical name	Total phenol (mg/g)	Total tannin (mg/g)	Total flavonoid (mg/g)	Reference
Achyranthes aspera L. var. aspera (root)	400±57.00	–	0.054±0.011	101
Cardamine hirsuta L.	71.77±5.8	–	0.47±0.23	102
Dalbergia stipulacea Roxb.	201.1± 0.3	190.53 ± 0.28	43.73 ± 1.43	103
Dioscorea wallichii Hook. f.	0.486±0.098	–	0.212±0.024	104
Diplazium esculentum	126.67 ± 8.16	–	94.33 ± 6.12	105
Ficus geniculata	12.07±0.20	–	41.73±0.11	106
Hibiscus sabdariffa L.	20.85±0.08	–	38.34±0.11	107
Justicia gendarussa Burm. f.	32.2 ± 0.35	25.1 ± 0.12	13.06 ± 0.29	108
Lindernia ruellioides (Colsm.) Pennell	30.26 ± 0.03	19.03 ± 0.17	71.3 ± 0.40	
Leucas aspera (Willd.) Link (leaf)	14.01	0.83	15.97	109
Leucas aspera (Willd.) Link (flower)	4.28 ±0.00	–	2.08 ±0.00	110
Melothria perpusilla (Blume) Cogn.,	239.62±5.4	–	1.66±0.10	111
Natsiatum herpeticum Buch. -Ham. ex Arn	10.45±0.68	–	0.29±0.11	
Persicaria chinensis (L) H.	52.12±2.35	–	0.65±0.17	
Sphaerantus peguensis Kurtz ex C.B. Clarke,	54.08±7.21	–	0.77±0.19	
Sphenoclea zeylanica Gaertn	36.39±5.31	–	0.23±0.10	
Trichosanthes bracteata (Lam.)Voigt	15.1 ± 0.01	10.13 ± 0.03	9.13 ± 0.14	112

Health benefits of indigenous foods

Antioxidant activity

Singlet oxygen, superoxide anion, hydroxyl radical, and hydrogen peroxide (H_2O_2) are all examples of reactive oxygen species (ROS) that are often produced as by-products of biological events.[113]Being highly reactive substances, they lead to oxidative destruction of cellular components including DNA and form the basis for pathogenesis of degenerative diseases.[114] Accumulating evidence reveals that flavonoids and similar phenolic compounds generated from indigenous plants, fight oxidative stress in the body by balancing oxidants and antioxidants.[115] Although antioxidant phytochemicals have been identified in tribal foods, further data on the antioxidant activity is scanty with few sporadic reports.

An elegant study by Basumatarya and Hwiyang Narzary (2017) affirmed that the methanolic extracts of *S. zeylanica and M. perpusilla* possessed stronger DPPH free radical scavenging activity (91.71±0.08%, and 90.29±0.23 respectively).[116] It has been reported that the high molecular weight phenolics such as tannins have more ability to quench free radicals and their effectiveness depends on the molecular weight, number of aromatic rings, and nature of hydroxyl group's substitution than the specific functional groups. Similarly, methanol extract of *D. wallichii* exhibited the highest free radical scavenging activity with 68.82% at 100 µg/ml with corresponding antioxidant effects of decrease in superoxide anion and cellular lipid peroxidation.[117]Likewise, methanolic extracts of *Centella asiatica and B. lanceolaria*were found to exhibit potential antioxidant activities.[118,119]With respect to *Enhydra fluctuans* Lour., a widely used plant in indigenous system of medicine, the ethyl acetate fraction exhibited the highest free radical scavenging activity than the methanolic, chloroform and n-butanol soluble fractions.[120]Furthermore, *Leucas aspera (Willd.)* leaves, leaves of *D. regia and* roots and inflorescences of *Achyranthes aspera L. var. aspera* are good sources of antioxidant molecules reflecting the antioxidant potential and could be useful in treating the disease associated with oxidative stress.[121-123]

The phytochemicals responsible for antioxidant activity were identified as flavonol glycoside,7-O-β-D-glucopyranosyl-dihydroquercetin-3-Oα-D-glucopyranoside in *Ipomoea aquatic Forssk*.leaves,phenolics and flavonoids in fresh calyces of *Hibiscus sabdariffa L* and polyphenols in *Ficus geniculate,* consumed by tribes of Meghalaya.[124-126] In consonance, *Diaplazium esculentum,* an adored vegetable by tribes of Paniya and Chetti tribes of Western Ghats possesses inherent antioxidant activity due to phytochemicals such as Phosphoric acid, phytol, 2,6,10-Trimethyl,14 ethylene-14-pentadecene, Hexadecanoic acid methyl ester, Pentadecanoic acid, Stigmasta-5,22-dien-3-ol, acetate.[127-129]

Antimicrobial activity

Mechanistic studies established the antimicrobial activities of tribal foods. Leaf extracts of *D. wallichii* at 4mg/ml concentrations have shown significant antimicrobial activity against fungi, gram positive and gram negative pathogenic bacteria.[130]Likewise, *Achyranthes aspera L. var. aspera* and *Leucas aspera*has shown remarkable antimicrobial activity.[131,132] Research conducted by Bhakta etal. in the year 2009revealed that *Enhydra fluctuans* had potent significant antibacterial and antifungal activities against selected fungi such as *Aspergillus niger, Fusarium spp. and Aspergillus fumigatus*.[133]In a study it was found that the ethyl acetate extract of Perilla seeds and its isolated polyphenol fraction containing luteolin had prospective antimicrobial activity against oral pathogenic bacteria *Streptococci* and strains *of Porphyromonas gingivalis*.[134]Likewise, *Diaplazium esculentum* showed promising antimicrobial activity against *S. aureus* and *B. subtilis*. The antimicrobial activity may be ascribed to the presence of phytochemicals such as beta-Ocimene, 2,6,10-Trimethyl,14 ethylene-14-pentadecene, 1,2-Benzenedicarboxylic acid, BIS(2-Methylpropyl)ester, Hexadecanoic acid, methyl ester, 1-Heneicosanol, Phytol, 5,8,11,14- Eicosatetraenoic acid, methyl ester(all Z), 1,2-benzenedicarboxylic acid, Ergost-5-en-3-ol, (3.beta), Stigmasta-5,22-dien-3-ol, acetate, (3.beta.), stigmast-5-EN-3-OL, (3.beta).[135]

Anti diabetic

Diabetes mellitus is a metabolic condition caused by a total or partial lack of insulinsecretion and its activity. As a result of the body's failure to metabolise glucose, bloodglucose levels rise.[136,137]Experimentaldata suggests that free radicals play a role in diabetes pathogenesis and, more crucially, thedevelopment of diabetic complications.[138]Several investigationspromulgated the anti-diabetic potential of indigenous foods. Antioxidants capable ofneutralising free radicals have been shown in several recent studies to be helpful inpreventing experimentally induced diabetes in animal models as well as lowering the severity of diabetic complications.[139,140]Certain phytochemicals present in indigenous foods bring about antidiabetic effects in experimental models through diverse mechanisms. Some of the mechanisms unearthed in recent studies include increase in insulin secretion, enhanced expression of glucose transporters, inhibition of α glucosidase and α amylase, amelioration of glycated haemoglobin and others.[141]

In a study Streptozotocin (STZ) induced diabetic rats were challenged with hydroalcoholic extract (500 mg/kg) of leaves of *Diplazium esculentum*, consumed by tribes of North eastern states and western ghats. Results revealed a 50.2% reduction in fasting blood glucose level, significant reduction in serum marker enzymes and necrosis of beta cells reflecting the anti-diabetic effects.[142] A study carried out in the Meitei-pangal community of the Thoubal district of Manipur established that *Enhydra fluctuans* extract can be effectively used as an antidiabetic plant by boiling and cutting it at the nodes.[143]Furthermore, the leaves of *Aegle marmelos* are extolled to possess antidiabetic potential and are consumed by Muduvans and Kadaras tribes native to Kerala. The aqueous extract of *Aegle marmelos* leaves in alloxanized rats decreased blood sugar, urea, and serum cholesterol when compared to controls.[144]The proposed mechanism of anti-diabetic action was reduction in excessive hepatic glycogen deposits and possibly decreased gluconeogenesis. *Caesalpinia bonducella*is widely distributed along India's coast and is used by tribal people in India to manage blood sugar levels. Evidences from earlier studies have shown that, both the aqueous and ethanolic extracts of seeds had a considerable hypoglycaemic effect in chronic type II diabetic rats. The mechanism elicited was

induced glycogenesis, increase in the quantity of glycogen in the liver and the potential of seed extracts to limit glucose absorption.[145]

Anti-inflammatory

The immune system is stimulated by inflammation, which is a biological process. It is a crucial physiologic mechanism that defends the host against diseases and toxins. It starts with acute inflammation symptoms progressing towards chronic inflammation and finally to the host's health being mutilated.[146]A study conducted by Namsa et al. 2009, Bombax ceiba, Canarium strictum, Chloranthus erectus, Xanthium indicum, Lycopodium clavatum, Coleus blumei, Batrachospermum atrum, Chlorella vulgaris, Marchantia palmata, Marchantia polymorpha, Eriapannea, Sterculia villosa and Alpinia galanga are reported for the first time for the treatment of inflammation-related diseases.[147]

Chloranthus erectus (Buch.-Ham.) Verdcourt (Chloranthaceae) is a shrub native to tropical and temperate zone of Eastern Himalaya of India has traditionally been used as a folklore medicine to treat localised swelling, joint pain, skin inflammation, fever and body ache. In an experimental study, methanolic extract obtained from Chloranthus erectus leaves (MECEL) at a dose of 200 mg/kg produced s inhibition of edema. Even lower doses of20 and 50 mg/kg produced suppression of cotton pellet-induced tissue granuloma formation in rats thus revealing significant anti-inflammatory activity in the tested models, and may provide the scientific rationale for its popular folk medicine as anti-inflammatory agent.[148]In a study conducted by Sunmathi et al. (2016), *Alternanthera sessilis* **(L.)** was found to be effective in inhibiting the heat induced hemolysis of Human Red Blood Cell (HRBC) at different concentrations (100-500µg/ml) in a dose responsive manner. The inhibition of hypotonicity induced HRBC membrane lysis i.e., stabilization of HRBC membrane was taken as a measure of the in vitro anti-inflammatory activity.[149]

Anti-cancer

*Enhydra fluctuans*is native to the tribes of Assam and widely consumed was screened for anticancer activity against Ehrlich's ascites carcinoma (EAC) bearing Swiss albino mice. The ethyl acetate fraction containing flavonoids baicalein 7-O-glucoside and baicalein 7-O-diglucoside caused a significant decrease in the tumour cell volume and increase of life span exemplifying the anti-cancer effects of this indigenous plant.[150] Many experimental reports proved that different solvent extracts of *C. asiatica* has anti-cancerous activity. *In vitro* study on HeLa, HepG2, SW480 and MCF-7 cell lines showed that methanolic extract had induced apoptosis in human breast cancerous MCF-7 cells.[151] Water extracts induced apoptosis in colonic crypts and exerted chemopreventive effect on colon tumorigenesis in male F344 rats.[152] In a study conducted by Perumal, P. C et al (2014), ethanolic extract of *Cayratia trifolia* (L.) containingCyclopentadecane, 9- Borabicyclo [3.3.1] nonane, 9-(2-propen-1-yloxy)-.1, 4,8,12,16- Tetramethylheptadecan-4- olide, Oxirane and Vitamin E shows the better interaction with PPARγ protein. Thus, these bioactive compounds may act as a good agonist for PPARγ. In future, it may lead to development of a novel PPARγ agonist and therapeutic agent for the cancers.[153] Similarly, Paris polyphylla Smith a traditional food and medicinal herb from the Melanthiaceae family has been used to treat a variety of diseases including cancer, Alzheimer's disease, irregular uterine bleeding, and leishmaniasis. Dioscin, polyphyllin D, and balanitin are the main phytoconstituents.[154]A novel triterpenoid has been isolated from the root bark of Ailanthus excelsa Roxb. (Tree of Heaven), AECHL-1, and has potential as an anticancer agent.[155]

Anti ulcerogenic

Paederia foetida Linn. belonging to the family Rubiaceae (Sanskrit, Prasarini) is an extensive foetid smelling climbing plant. The aerial parts of the plant contain iridoid glycosides *viz.* asperuloside, scandoside and paederoside.[156] Different tribal communities of North East to Southern part of India use the plant as a vegetable and also use to treat different stomach disorders like diarrhoea and dysentery, stomach swelling, to clean stomach, gastritis, in loose motion, indigestion, abdominal pain etc.[157-161]The leaf is also used as an anti ulcer agent. Methanol extract at a dose level of 100 mg/kg and 200 mg/kg body weight showed ulcer protection and HPTLC analysis confirmed the presence of β-sitosterol in the extract.These observations establish the traditional claim and thus *Paederia foetida* could be a potent gastro protective agent for use in future. The gastroprotective activity might be mediated by the Nrf2 mediated antioxidant and anti-secretory effects.[162]Bauhinia variegata is a medium-sized, deciduous tree and its flower buds are used as a vegetable. A decoction of the bark is taken for dysentery and dried buds are used for diarrhoea, dysentery and hemorrhoids. Five flavonoids isolated from the different organs of *B. variegata* were identified as Quercetin, rutin, apigenin and apigenin 7-O-glucoside seem to possess anti ulcer effects. Saponins, steroids, flavonoids, alkaloids, tannins, sugars had also been identified as anti ulcerogenic compounds

Immunomodulatory

A systemic review by Sharma et al. 2015, revealed the information on 1953 ethno-medicinal plants documented from India's northeast, with 1400 species being used as both food and ethnopharmacological resources by the tribal communities.[163]Recently, three diosgenyl saponins isolated from *Paris polyphylla* have been reported to have immunostimulant properties.[164] Likewise, lymphocyte stimulation tests were performed on eight cycloartane-type saponins isolated from *Astragalus melanophrurius*,to determine the role of saponins in the immunomodulating effect. Higher concentrations of tested compounds have exhibited inhibitory effects.[165] Cycloartane and oleanane-type triterpenes from these species have unmistakably induced interleukin-2 activity.[166]Immunomodulatory activities of terpenoid compounds such as glycyrrhizinic acid, ursolic acid, oleanolic acid, and nomilin also have been reported.[167]Furthermore, methanolic extractof **C.asiatica** dramatically increased phagocytic index and total WBC in Swiss Albino mice mirroring the immunomodulatory effect.[168]

Cradioprotetctive

C. asiatica extract demonstrated the cardioprotective effect at a dose of 200 mg/kg of body weight in adult male albino rats of Wistar strain on antioxidant tissue defence system during adriamycin induced cardiac damage.[169]Bamboo shoots can also help lower LDL cholesterol levels while keeping blood sugar levels steady. This was owing to the fact that bamboo shoots had very little fat and were very low in calories. Consumption of bamboo shoots improved cholesterol, lipid, and gastrointestinal function, according to research conducted by Park and Jhon in 2009.[170]

Neuroprotective

The discovery and characterisation of new medicinal plants to treat neurodegenerative illnesses and stroke-related brain damage has piqued scientists' curiosity in recent years. In the Indian system of medicine, *Enhydra **fluctuans*** is one of the numerous medicinal plants showing promising activity in neuro-psychopharmacology.[171]The loss of dopaminergic neurons in the *Substantia nigra* is connected with ageing, Alzheimer's diseaseand Parkinson's disease, all of which are common causes of dementia.[172]

The widespread usage of Curcuma among Indians may explain the much lower prevalence of Alzheimer's disease in India compared to the United States.[173] Supplementation with a low dose of Curcumin (160 ppm) for six months lowered indicators of inflammation and oxidative stress in a transgenic animal model of Alzheimer's disease. The levels of the proinflammatory cytokine IL-1, oxidised proteins, and a peptide in particular fell dramatically.[174] Curcumin's anti-amyloidogenic effect has been well shown in both in vitro and animal models.[175] Caffeine, like other adenosine A2A receptor antagonists, may help to prevent or delay the onset of Alzheimer's disease, according to human epidemiological studies. A case-control study involving 50-year-olds with a probable diagnosis of Alzheimer's disease and sex-matched controls discovered that people who drank 2 cups of coffee (approximately 200 mg of caffeine) per day for the previous 20 years had a significantly lower risk of developing the disease than those who drank less caffeine.[176]

Strawberry extracts have a mild inhibitory impact on COX-1 and are more strong inhibitors of COX-2. COX-2 is known to create certain gastro protective prostaglandins, while COX-1 is known to increase the production of inflammatory prostaglandins. Because the inflammatory process is involved in the aetiology of a wide range of neurodegenerative illnesses, including Alzheimerís Disease and Parkinson's Disease, selective inhibition of COX-2 could be essential.[177]

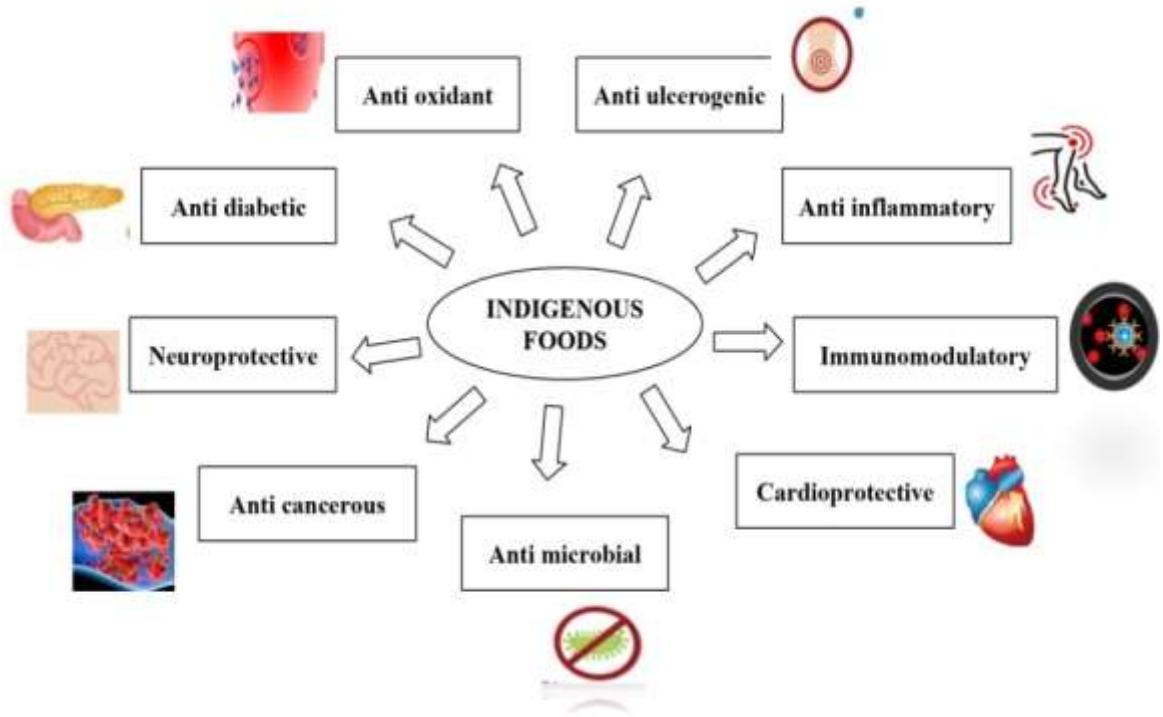

Fig.5. Health benefits of Indigenous foods

Conclusion

Indigenous tribal foods are a commixture of not only nutrients but also a repository of health-promoting phytochemicals, which, when consumed in prudent form build the nutritional status coupled with coveted health benefits. A bidirectional relationship appears to exist between indigenous food consumption and food security resulting in nutrition and health security. The tribal communities in India seem to be in a state of nutritional adversity in food diversity. The tribal population today is in nutrition transition phase, facing the dual burden of pretransition diseases like

undernutrition and infections as well as post-transition lifestyle-related diseases such as obesity and diabetes. These diseases are etiologically linked with the reduced consumption of fruits and vegetables and increased intake of imprudent diet. Phytotherapy and Indigenous food nutritionology are in vogue, implying the fact that procuring the right nutrition is essential to avert diseases. Challenges related to indigenous food sovereignty are incredibly complicated due to the interlinkage of multiple factors. Therefore, it is imperative to develop more resilient and robust strategies to improve food and nutritional diversity based on indigenous foods to achieve sustainable food and health security. Indigenous foods must be safeguarded to prevent overexploitation. Efforts must be taken to prevent the exploitation of indigenous foods and to safeguard them. There should be focused efforts to promote traditional foods and to protect the rich biodiversity of India.

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