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Ethnobotany to bioprospecting of medicinal plants from Western Ghats, India – A review

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Plants are the sources of traditional medicine since time immemorial and several drugs that are currently used in clinics are of plant origin. Western Ghats of India, one of the hotspots in the world, comprises valuable medicinal plants and hardly a limited number of these have been scientifically validated. Thus, it is worth exploring the other medicinal plants from these regions. The information on ethnobotanical studies, indigenous and traditional knowledge on the medicinal plants from the Western Ghats of India were collected using online search engines such as Google, SCOPUS, Web of Science, Google Scholar, and PubMed. The collected information was analysed to understand the role of different plant species and families in treating various diseases and disorders using pharmacological approaches. It was found that around 1628 plant species belonging to 171 families were used for treating major ailments such as pain and inflammatory, gastrointestinal and, dermatological disorders. Furthermore, plant families including Fabaceae, Asteraceae and Acanthaceae were largely preferred. Amongst the reported species around 130 were endemic, 4 critically endangered and nearly threatened. Around 3 species were endangered and rare. One species is at risk. However, only 115 plants have been validated for their pharmacological properties using *in vivo* experiments and clinical trials/uses. The available literature on medicinal plants from the Western Ghats strongly suggests that these plants can be a potential source of the newer drug. Further in-depth studies on the screening of medicinal plants to isolate and characterize the pharmacologically important active principles are essential to contribute to the healthcare sector.

Keywords: Bioprospecting, Cancer, Ethnobotany, Inflammation, Western ghats

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Plants are the sources of traditional medicine since time immemorial. Years ago, the medicinal values of plants were expressed in non-verbal forms like painting, monuments, carvings, statues and writings on clay tablet cuneiforms[1]. The Chinese pharmacopoeia "Pen T'sao" prepared by the Emperor Shen Nung around 1600 years ago documents the herbal cures for numerous diseases and disorders. A recent study reports 403 traditional Chinese medicinal herbs, with 3962 formulations, 7274 herbal ingredients and 2266 validated drugs for 3027 related diseases. Countries like China, Korea, India and Japan have taken a leading role in evidence-based research to validate the fundamental principles of traditional medicine practices[1]. In India, the earlier work carried out by Janaki-Ammal (1956) and Jain (1963, 1965) has triggered intensive ethnobotanical studies among the researchers in Indian Institutes[2]. India forms the "medicinal garden" or "Botanical garden of the world" due to the presence of an enormous wealth of medicinal plants in India[3]. Out of the estimated 250000 to 350000 plant species identified so far 35000 plants are used for medicinal purposes worldwide. Around 3500 plant species from Western Ghats region alone are known to have therapeutic importance[4]. Ethnobotanical studies document wild plants used by tribes to meet diverse requirements and have been mentioned in earlier documents such as "colloquies on the simples and drugs of India" (1563), "catalogue of Indian medicinal plants and drugs" (1810), and "Materia Medica of Hindustan" (1813)[5]. A large number of plants from all over India have supportive medicinal background from Ayurveda, Unani and folklore[6,7]. In rural areas even today herbal practitioners follow traditional medicine system and use approximately 2500 plants for treating basic illness which are indeed considered as best methods in the Indian medical practices[8].

India is one of the 12 mega biodiversity hotspots of the world, and, with 16 agro-climatic zones, has 7000

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plant species recognized as medicinal among total of 45000 plant species. Out of 21000 medicinal plants listed by the World Health Organization, 2500 species are from India which makes India the largest producer of medicinal herbs[9]. Though, majority of the rural people in India still rely on traditional medicines[10] to treat sexually transmitted diseases, dermatological and skin diseases, hypertension, gynaecological disorders, childhood diseases and many more[11], the traditional practices and general knowledge of medicinal flora are being lost to times as the knowledge is dying along with the death of older and elderly healers and tribal people. Furthermore, only a limited number of studies have been carried out to prove the medicinal properties of plants listed in traditional practice using modern pharmacological methods. Hence, it is very essential to scientifically prove the pharmacological importance of traditional medicinal plants.

Methodology

The present review is drafted by collecting the research and review articles, conference proceedings, MSc and PhD dissertations published in Google, SCOPUS, Web of Science, Google Scholar, PubMed with keywords such as ethnobotanical studies, indigenous knowledge, traditional knowledge of Western Ghats, ethnobotany of Tamil Nadu, Kerala, Karnataka, Goa, Gujarat and Maharashtra that are published between January 2000 to October 2023. The review is focused on understanding the current status of ethnobotanical aspects of the plants in the Western Ghats of India starting from Gujarat to Tamil Nadu states. The data collected includes scientific names of plant species, family, their endemicity and conservation status. The scientific names of all the plants and their families mentioned in the current review are confirmed through the WFO Plant List (https://wfoplantlist.org/)[12], Flora of Peninsular India (Indian Institute of Science) and efloraofindia (database of plant of Indian subcontinent developed by the members of efloraofindia google group). Information on conservation status and endemicity are according to the information provided on the website of Flora of Peninsular India. An attempt is also made to review on the use of Western Ghats plants to treat various diseases and disorders along with its scope.

Ethnomedicinal species of Western Ghats, their endemicity and conservation status

Western Ghats is one among 18 biodiversity hotspots with about 35% of endemic species. The

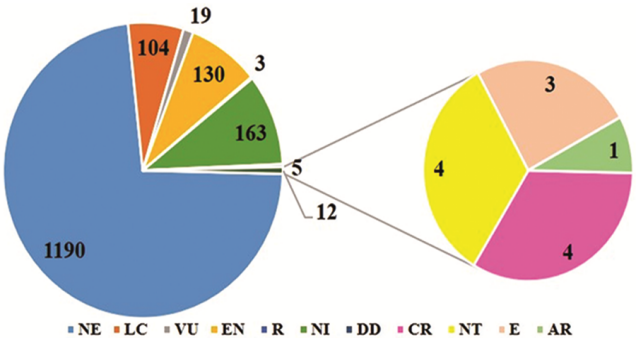

Fig. 1 — Conservation status and endemicity of plant species. Different colors in the chart represent the number of plant species with their status and endemicity. Where; AR: At risk, CR: Critically endangered, DDe: Data deficient, E: Endangered, EN: Endemic, LC: Least concerned, NE: Not evaluated, NI: No information, NT: Nearly threatened, R: Rare and VU: Vulnerable

present study documents 1628 medicinal plants belonging to 171 families. Among the listed ethno medicinally important plant species, 130 are endemic (Fig. 1 and Supplementary Table S1) (e.g.: *Andrographis lineata* Nees, *Capparis diversifolia* Wight & Arn, *Dalbergia malabarica* Prain, etc), 4 species are critically endangered (e.g.: *Chlorophytum borivilianum* Santapau & R.R. Fern, *Eugenia singampattiana* Bedd, *Hildegardia populifolia* Schott & Endl. etc), 19 species are vulnerable (e.g.: *Anaphalis beddomei* Hook.f, *Arenga wightii* Griff. and *Hydnocarpus macrocarpa* Warb. etc). Around 104 species are least concerned (e.g.: *Cyperus rotundus* L, *Acacia pennata* (L.) Wild, *Acanthus ilicifolius* L, *Acmella paniculata* (Wall.ex DC.) R.K. Jansen etc), 4 species are rare (e.g.: *Bulbophyllum acutiflorum* A. Rich, *Calamaria coromandelina* (L.f.) Kuntze, *Maerua cylindrocarpa* Hadj-Moust, *Oleandra musifolia* (Blume) C. Presl), 4 are nearly threatened (e.g.: *Baccaurea courtallensis* (Wight) Mull. Arg., *Dalbergia melanoxylon* Guil. & Perr., *Pleopeltis macrocarpa* (Bory ex Wild.) Kauf, *Psilotum nudum* (L.) P. Beauv), 3 are endangered (e.g.: *Memecylon gracile* Bedd, *Grewia gamblei* J.R. Drumm, *Humboldtia unijuga* Bedd., *Leucas pubescens* Benth.) and 1 species is at risk (*Marattia fraxinea* Sm.). The status of around 1190 species is not evaluated. No information on the conservation status and endemicity of 163 species is available. In addition, there are species such as *Myristica fragrans* Houtt, *Brassica oleracea* L, *Commiphora wightii* (Arn.) Bhandari *Diospyros ebenum* J. Koenig ex Retz, *Mangifera indica* L. with deficiency in data. The loss or destruction of their natural habitat has resulted in

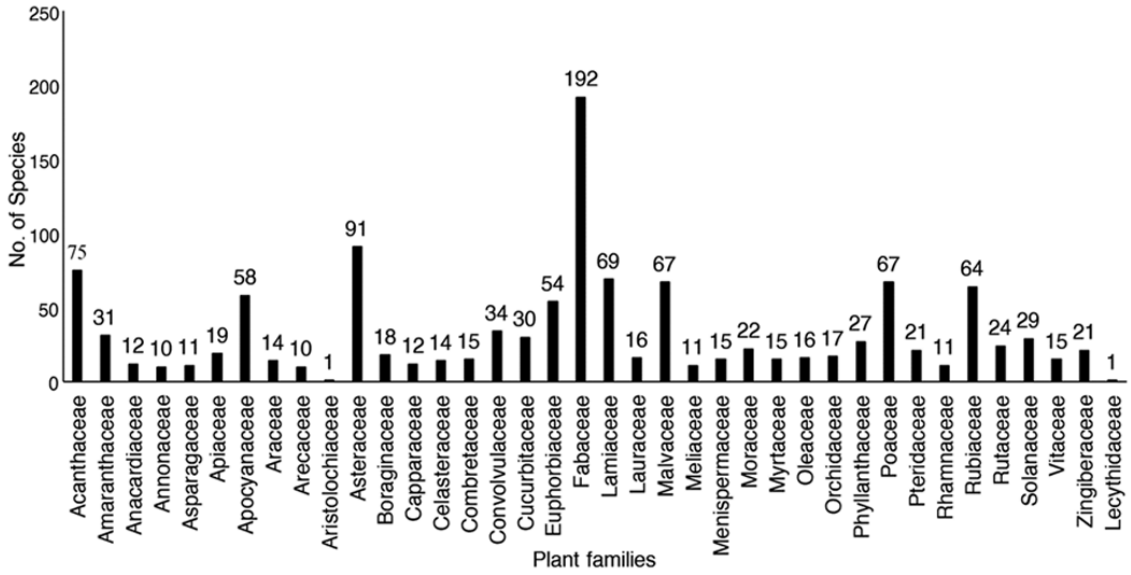

Fig. 2 — Most commonly referred ethnomedicinal plant families from the Western Ghats. Only those families with 10 ≤ species are shown in the figure

great loss of diversity of Western Ghats region in the recent years along with the vulnerability of endemic species such as *Anaphalis beddomei* Hook.f., *Capparis diversifolia* Wight & Arn., *Dalbergia malabarica* Prain. Endemic species like *Hildegardia populifolia* Schott & Endl., have now become critically endangered. Also, *Baccaurea courtallensis* (Wight) Mull.Arg. has become nearly threatened. Negligence on conservation of these plants may result in the complete loss of existing species in the near future. Critical measures on conservation of these species must be sensitized as each and every species have their own medicinal values. For instance a clinically approved anticancer compound camptothecin from *Nothapodytes nimmoniana* (J. Graham) Mabb, an endemic species of Western Ghats[13] has not only created an interest but also paved the way towards isolation of similar therapeutically important compounds. Hence, the basic information on the ethnomedicinal values of plants will be useful to develop newer drugs.

An over view on the most commonly referred ethnomedicinal plant families from Western Ghats with more than 10 species are shown in Figure. 2. The predominant families are Fabaceae (192 species), Asteraceae (91 species), Acanthaceae (75 species), Lamiaceae (69 species), Malvaceae (67 species), Rubiaceae (64 species), Poaceae (67 species). Furthermore 8 species fall under the families such as Sapindaceae, Cyperaceae, Polypodiaceae, Lythraceae, Ebenaceae etc., Other families include Dioscoreaceae and Verbenaceae (9 species), Bignoniaceae, Amaryllidaceae, Polygonaceae, Nyctaginaceae, Commelinaceae and Rosaceae, (7 species each), Oxalidaceae, Violaceae and Salicaceae (6 species). Around 5 species fall under the family Aristolochiaceae, Primulaceae, Gentiaceae, Crassulaceae, Sapotaceae, Cannabaceae, Dryopteridaceae, Polygalaceae. Plant species from families like Ophioglossaceae, Melastomataceae and Plumbaginaceae (4 species each), Zygophyllaceae, Calophyllaceae, Costaceae, Burseraceae, Dipterocarpaceae and Musaceae (3 species each), Malpighiaceae, Simaroubaceae, Scrophulariaceae, Brassicaceae, Thelypteridaceae, Colchicaceae, Caryophyllaceae, Achariaceae and Araliaceae etc (2 species each) are also reported to have ethnobotanical importance. Certain families are represented by single species (*viz.*, Cyathaceae, Hypoxidaceae, Gnetaceae, Costaceae, Aristolochiaceae and Lethicydaceae etc) and are also known to cure more than single ailments (Supplementary Table S2). Local communities or the ethnic people mostly depend on plants growing in their immediate surrounding. The long-term dependency on these plants/ families and the traditional medicine system becomes the most frequent approach to select species for phytochemical, pharmacological or drug discovery. Every individual species will have certain specific and effective pharmacologically active principle that cures the ailments.

Based on information available from literatures all the reported ailments are categorized to 20 groups (Fig. 3) *viz.*, cancer (C), cardiovascular disorders (CVD), diabetes (D), dermatological disorders (DD), eye disorders (ED), ear, nose and throat disorders (ENT), fever (F), gynaecological disorders (GD), gastrointestinal disorders (GI), head and hair disease (HH), infant health disorders (IH), nervous system disorders (ND), oral disorders (OD), other infections (OI), pain and inflammation (PI), poisonous bites (PB), respiratory disorders (RD), sexually transmitted disease (STD) and urino-genital disorders (UG). The study revealed that about 837 species are reported to be used for pain and inflammatory conditions *viz.*, joint, leg, back or knee pain, bed sores, gout, wound healing, rheumatism, arthritis, fractures, sprain, ulcers and lumbago. About 670 species are used in gastro intestinal disorders like diarrhoea, constipation, piles, cathartic, vomiting, dyspepsia, helminthic or intestinal worms, acidity and gastric and 441 species for dermatological disorders which include sunstrokes, scabies, itching, pimples, boils, skin eruptions, eczema, ringworm, corns, warts, herpes and vitiligo. Altogether 317 species were reported to be used against poisonous bites of snakes, scorpions or spiders, 268 species are in the treatment of amoebiasis, malaria, jaundice, leprosy, hepatitis which fall under the category of other infection, 335 species are for cough, bronchitis, asthma, tuberculosis, pneumonia, sinus, lung disorder and dyspnoea which are respiratory disorders. 309 species are used for premature ejaculation, menstrual disorders, increase sperm count, abortions, easy delivery, during early months of pregnancy, galactogogue, swelling of testis, conception, pre and post-natal care (gynaecological disorders). Around 299 species for fever, 219 species for urino-genital disorders like painful urination, renal calculi, leucorrhoea, dysuria, diuretic and as nephroprotective agents. 226 species are used in treatment of head and hair related problems like head lice, head ache and migraine, giddiness, baldness, hair fall and hair growth. 150 species are used against cancer, 156 species have also been reported veterinary or the livestock disease, 179 species for diabetes, 132 species are used in treatment of gum disease, toothache, mouth ulcers, foul odour which come under the category of oral disorders. 125 species are used in curing the problems related to ear, nose and throat *viz.*, speechlessness, sore throat, snoring, earache and tonsillitis. About 94 plants are also used in treatment of eye diseases (*i.e.*, vision related issues and eye infections). AIDS, gonorrhoea, syphilis are among the sexually transmitted disorders for which about 62 plant species are used. And, 79 species are used against cardiovascular disorders like high or low blood pressures, cardiac arrest, chest pain, hypertension and pulmonary disorders. However, around 22 plant species are documented in treating infant health issues *viz.*, are rickets, constipation in inborn and clarity of speech, 13 plants are used as nerve or brain tonic, to improve memory, depression,

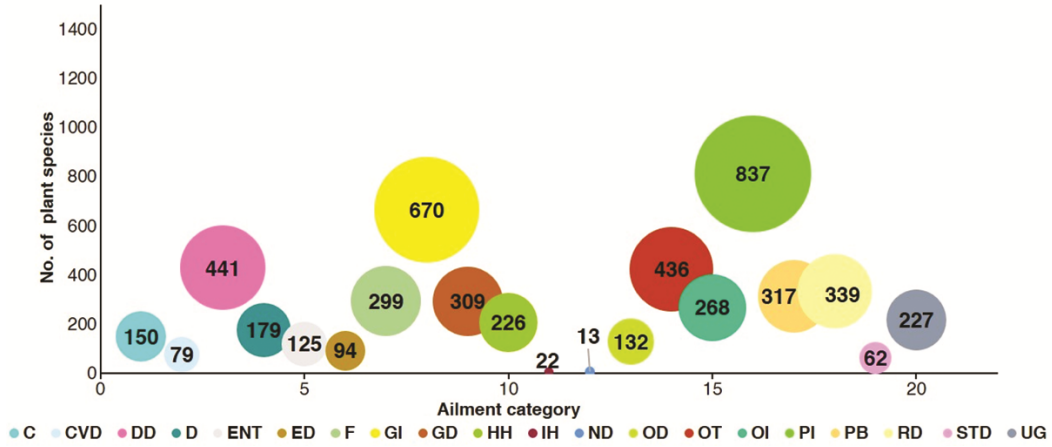

Fig. 3 — Frequency of plant species used in treating various ailments. Different colors in the bubble represent the ailment treated, and variations in the size represent no. of species reported. The larger the bubble size, the more plants used ethnobotanically to cure a particular ailment. C: cancer, CVD: cardiovascular diseases, DD: dermatological disease, D: diabetes, ENT: ear, nose and throat, ED: eye disease F: fever, GI: gastrointestinal, GD: gynaecological disorders, HH: head and hair diseases, IH: Infant health, ND: nervous system disorders, OD: oral diseases, OT: others, OI: other infections, PI: pain and inflammation, PB: poisonous bites, RD: respiratory disease, STD: sexually transmitted diseases, UG: urinogenital

psychological disorders, anxiety, stress, hysteria and epilepsy. All these ethnobotanical studies are often significant in revealing locally important plant species that can be subjected for drug discovery after thorough pharmacological studies.

Ethno pharmacological approach to drug discovery

Traditional knowledge, modern medicine and modern science make three faces of golden triangle which is systematically oriented and converge to form an innovative discovery engine for newer, safer, affordable and effective therapies[14]. Plant secondary metabolites provide a wide range of health benefits acting as substrate for biochemical reaction, co factors or inhibitors of enzymatic reactions, sequester or eliminate undesirable products, act as ligands that antagonize or agonize intracellular or cell surface receptors, scavenge reactive and toxic chemicals[15]. Furthermore, phytochemicals help in enhanced absorption of essential nutrients, growth factors and selective inhibitors of deleterious microorganisms. The present day pharmacological studies using *in vitro* and *in vivo* models[16] supports the ethnomedicinal claims of plants against ailments *viz.*, metabolic disorders, reproductive system disorders, respiratory disease, dermatological disorders, infection and inflammation, cancer, neurological disorders and other (Table 1).

The phytochemicals such as vincristine (*Catharanthus roseus* (L.) G. Don), paclitaxel (*Taxus* sps), camptothecin (*Camptotheca acuminate* Decne) etc. were isolated in their pure form and are currently being used to treat different types of cancers[17]. Similarly, aristolochic acid (*Aristolochia* sp.), quercetin (*Euphorbia hirta* L.), curcumin (C*urcuma longa* L.), artemisinin (*Artemisia annua* L.) are among the phytochemicals that have undergone *in vitro, in vivo* pharmacological studies to prove the nephrotoxicity, anticancer and antimalarial properties[18]. It is also reported that phytochemicals exhibit lower side effects compared to that of synthetic drugs[19]. Western Ghats of India, being a biodiversity rich hot spot there are hardly a few plant species have been explored for their medicinal values and hence, it is worth exploring the other plants in this region with ethnomedicinal claims. Supplementary Table S3 represents the list of ethnomedicinal plants used in the treatment of major diseases including cancer, cardiovascular disease and diabetes.

Medicinal plants and their isolated compounds can be used in future pharmaceutical drugs as an adjuvant to the conventional therapeutic approaches which might improve their efficacy and management of diseases.

Infections and inflammation

Natural products are well known to treat more than 87% of all known human diseases including bacterial, fungal, viral and parasitic infections[20]. Traditional therapies using honey and mushroom or their mixture along with plant extracts are being practised among most cultures[21]. Aqueous extract of ripe *Ceratonia siliqua* L. has been used for ages in Arab folk medicine to treat mouth inflammations[22]. Phytochemical analysis of plants exhibiting anti-inflammatory activities was reported to produce compounds such as eugenol, cannabinoids and oleocanthal[23]. The anti-inflammatory activities of these phytochemicals were proved using *in vitro* and *in vivo* models[23,24]. Several inhibitory drugs *viz.*, phospholipase inhibitors (Aristolochiaceae, Myristicaceae, Asteraceae etc), cyclooxygenase (Apocyanaceae, Clusiaceae,

Table 1 — Major plant families referred in ethnomedicine to treat various diseases and disorders

Family	Disease *								Total
	C	DD	II	MD	ND	RD	RPD	OT	
Acanthaceae	1 (6)	19 (3)	60 (0)	28 (0)	5 (1)	15 (1)	14 (1)	11 (0)	153 (12)
Asteraceae	2 (2)	22 (5)	58 (4)	30 (2)	2 (4)	25 (5)	18 (1)	15 (2)	172 (25)
Euphorbiaceae	4 (0)	18 (0)	35 (0)	26 (0)	1 (0)	9 (0)	11 (0)	12 (0)	116 (0)
Fabaceae	5 (7)	54 (5)	113 (2)	90 (1)	6 (2)	57 (6)	42 (3)	45 (6)	412 (45)
Lamiaceae	5 (0)	31 (7)	50 (1)	43 (1)	2 (4)	30 (6)	15 (2)	10 (0)	186 (21)
Malvaceae	1 (1)	12 (1)	35 (2)	28 (1)	4 (1)	17 (2)	24 (2)	24 (2)	145 (12)
Poaceae	3 (1)	12 (0)	25 (1)	24 (0)	6 (0)	17 (1)	16 (0)	33 (0)	136 (3)
Rubiaceae	2 (0)	17 (1)	44 (0)	27 (2)	9 (6)	13 (0)	16 (1)	4 (0)	132 (10)
Total	23 (17)	185 (22)	420 (10)	296 (7)	35 (18)	183 (21)	156 (10)	154 (10)	1452 (115)

*C: Cancer, DD: Dermatological disorders, II: Infection and inflammation, MD: Metabolic disorders, ND: Neurological disorders, RD: Respiratory disease, RPD: Reproductive system disorders, OT: Others. Number given inside the parenthesis indicates the number of plants with proven pharmacological properties using *in vivo* experiments and under clinical trials/use.

Asteraceae), lipoxygenase (Clusiaceae, Asteraceae, Apiaceae etc) elastase (Asteraceae) were also isolated and they are known to target pain and inflammatory conditions[22]. *Cyperus rotundus* L, a least concerned species from Western Ghats is used for pain and inflammation both ethnobotanically and has also proven its anti-inflammatory activity through *in vivo* studies[25]. *Aristolochia bracteolata* Lam, *A. indica* L. and *A. krisagathra* Sivar. & Pradeep are species from Aristolochiaceae family well mentioned in ethnomedicine to treat poisonous bites and, the compounds from these plants have undergone *in vivo* trials[26]. Among the listed medicinal plants from Western Ghats region the majority of species (837) are found to have ethnomedicinal importance in treating pain and inflammatory conditions (Fig. 3). Members of Fabaceae and Asteraceae are the most reported ethnobotanical family. *Cinnamomum vernum* J. Presl, *Rosmarinus vulgaris* L and *Thymus vulgaris* L are reported to be among the most studied species which also have ethnomedicinal values[27].

Metabolic disorders

Phytochemicals present in the food act as a potent modulator of several metabolic disorders[28-30] including gastrointestinal, diabetes, cardiovascular and hepatoprotective. Metformin, isolated from *Galega officinalis* L act as potent antidiabetic drug and is currently under clinical use to treat type 2 diabetes[31]. Similarly, imeglimin is an investigational new drug that is currently in phase 3 clinical trial[32] against type 2 diabetes. It has also been observed that the phytochemicals present in *Gentiana asclepiadea* L. (Gentianaceae), *Satureja montana* L. (Lamiaceae), *Achillea millefolium* L. (Asteraceae) will act as potent modulators in the growth of probiotic intestinal microorganisms[33]. *Psydrax dicoccos* Gaertn a vulnerable species, *Enicostema axillare* (Poir.ex Lam.) A. Raynal, *Exacum pedunculatum* L. are members of Gentianaceae reported from Western Ghats are used to treat gastro intestinal disorders ethnobotanically (Fig. 3). *Mentha piperita* L. is an extensively used species in ethnomedicine that has reached the level of clinical trial against gastrointestinal diseases including diabetes and hepatoprotective[34,35]. Endemic species of Western Ghats *Memecylon malabaricum* Kostel, least concerned species *Merremia emarginata* (Burm.f.) Hallier f and critically endangered species *Vateria indica* L, are used by folklore. Antipyretic drugs such as chloroquine, artemisinin and quinine that target pathogens and aspirin and salicylates that target disease symptoms are also isolated from plant origin[28,36-38]. However, the limited number of several ethnomedicinally important plant species in the wild act as a limitation to carry out quality research and bioprospecting of the plants.

Reproductive system disorders

Unani and Ayurveda system[39] of medicine offer treatment to several of the diseases and disorders associated with reproductive system including urino-genital, gynaecological, sexually transmitted disorders[14,36]. *In vitro* and clinical studies on plant species from Asteraceae, Lamiaceae and Myrtaceae have been carried out against reproductive system disorders including non-viral sexually transmitted infection[40,41]. Compound such as berberine (*Berberis aristata* DC, *B. asiatica* Roxb.ex DC.) is comparable with the potency of metronidazole drug against trichomonas infection. Other drugs *viz.*, pseudolarix acids A and B (*Pseudolarix kaempferi* (Lamb) Gordon)[42], gossypol (members of family Malvaceae)[43], gardenic acid, glycosides, gardenodic acid acts as antifertility drugs[8]. Similarly, essential oils from clove, oregano, thyme are used traditionally against sexually transmitted diseases (STD) caused by common bacterial, fungal, viral, protozoan and ectoparasites[14]. Reports are available on the use of *Hypoxis obtuse* Burch. ex Ker Gawl. *Ziziphus mucronata* Wild. as the most commonly referred plant families in ethnomedicine to treat STD. Besides, the clinical trials conducted on *Punica granatum* L. and *Commiphora molmol* (Engl.) Engl. ex Tschirch have shown an effective inhibitory effect against pathogenic strains that cause STD[41].

Respiratory and oral disorders

Respiratory disorders like asthma, bronchitis, cold and cough though seems to be common with changing environmental conditions and food habits, they sometime become life threatening[44]. Natural products prevent or treat imbalances in the equilibrium of the oral microbiome, along with poor hygiene, trauma, malnutrition etc. that cause oral disease. Herbal remedies using locally available plants are the primary treatment modality to respiratory and oral disease[45,46] (Fig. 3). Phytochemical compounds such as bicalin, asiaticoside, resveratrol are used as an antivascular remodel, besides, polydatin and apple polyphenols are used as vasodilators[45]. Clinical trials have been conducted on *Tylophora indica* (Burm.f.)

Merr, an indigenous species of India and *Boswellia serrata* Roxb. ex Colebr. to treat asthma[47]. Plant species of Fabaceae, Asteraceae, Lamiaceae families accounts larger ethnobotanical contributions to respiratory and oral disease (Table 1). Plant species *Allium sativum* L, *Satureja hortensis* L, *Eucalyptus globulus* Labil, *Acacia nilotica* (L.) Delile along with bioactive compounds gallic acid, catechol and catechins are included in mouthwash, pastes to maintain healthy oral microflora[48]. Besides, compounds such as menthol, cardamomin, allicin are reported to exhibit therapeutic importance[48].

Dermatological disorders

Dermatological disorders include acne, psoriasis, ulcers, hair fall, microbial infections that has become a global health concern and ranks the fourth highest cause of nonfatal disease burden[49]. Podophyllin (from *Podophyllum peltatum* L.), salicylates (from *Salix alba* L.), tannin (from *Quercus robur* L.) are plant derived compounds[49] already established in dermatological complications such as acne, skin cancer, alopecia, vitiligo and wounds[50,51]. Topical capsaicin is used either as therapy or as an adjuvant in dermatological conditions characterized by neurogenic pain, psoriasis, alopecia areata, etc[52]. Furthermore, clinical trials conducted on *Aloe vera* (L.) Burm.f. and avocado against psoriasis were also reported[50,53]. Curcumin, berberine, ellagic acid, fustin play a major role in inflammatory signalling pathways[54]. Xanthones a versatile group commonly found in *Garcinia mangostana* L, *Calophyllum inophyllum* L. and *Swertia chirayita* (Roxb.) H. karst. exhibit a wide range of biological activities and thus currently has become promising lead compound in treating skin disorders[55,56]. Ethnobotanically *Cardiospermum halicacabum* L., *Alstonia venenata* R.Br. (EN), *Anaphalis beddomei* Hook.f., (EN & VU) are used to treat dermatological disorders. Members of Lamiaceae, Fabaceae and Asteraceae are majorly referred families to treat dermatological disorders in Western Ghats region (Fig. 3).

Cancer

Traditional ethnomedicine claim the use of different parts of plants in the form of decoctions, infusions or as pastes, chewing or mixed with tea to treat cancer or cancer associated symptoms[57]. *Nothapodytes nimmoniana* (J. Grah.) D.J. Mabberley, *Saraca asoca* (Roxb.) Wild, *Sesbania grandiflora* (L.) Pers, *Sida rhombifolia* L, *Santalum album* L. (VU) and *Ophioglossum lusitanicum* L. (VU) are among ethno botanically used species from Western Ghats to treat cancer. Besides, almost 60% of the approved anticancer drugs are from natural origin[58]. To name a few, vincristine, camptothecin, paclitaxel, etc are the potent plant derived anticancer drugs in market[59]. Among these, camptothecin and taxol are the leading plant derived anticancer drugs in the market. Adjuvant treatment with cytotoxic agents (taxanes analogs, colchicine, paclitaxel poliglumex) not only provides equivocal tumor control, but also offers better quality of life[60,61]. Clinical trials of berberine against breast, gastrointestinal, oral, liver and pancreatic cancer and curcumin against breast, head and neck cancer are under phase 3 clinical trials[62]. Randomized, double-blind, placebo-controlled study on the efficacy of combination of curcumin and paclitaxel is at phase 2/3 clinical trials.

Neurological disorders

Neurological diseases such as Alzheimer's disease and Parkinson's disease that effect central and peripheral nervous system are associated with huge socioeconomic burden. *Ficus platyphylla* Delile, *Senna occidentalis* (L.) Link, *Glycine max* (L.) Merr, *Zingiber officinale* Roscoe and *Alstonia scholaris* (L.) R. Br. are some of the plants that are used in traditional herbal therapies to treat neurological diseases[63]. The *in vitro* and *in vivo* pharmacological studies on withanolides *Withania somnifera* (L.) Dunal revealed an increased dendritic regeneration by exhibiting neurotrophic activity and further protects neurons and glial cells[64]. In addition, ginsenosides (*Panax ginseng* C.A. Mey)[29] and acacetin *Centella asiatica* (L.) Urb.[30] reported to exhibits neurological protection through lowering the production of ROS, plaque formation and apoptosis[65]. In addition, these compounds also promote neurogenesis by upregulating neurotrophic factors[66]. Similarly, alvidin, curcumin, ellagic acid, exifone, myricetin, resveratrol, salvianolic acid B and tannic acid are under *in vitro* and *in vivo* studies to treat various neurological diseases[67,68]. Huperzine A which is under phase V clinical trial, has played an important role in cognition improvement in Alzheimer's disease[69]. Galantamine alkaloid extracted from *Galanthus* species is currently prescribed as an acetylcholinesterase inhibitor under clinical conditions to treat Alzheimer's disease and dementia[63].

Other diseases

Use of traditional medicines and medicinal practices are not only limited to human beings, but also applied to various animal diseases[18]. Indigenous practise including plant species offers an added advantage of being easily available, affordable and are believed to show lesser side effects to livestock. *Abrus precatorius* L, *Acalypha indica* L., *Arisaema leschenaultii* Blume (EN) are among few reported species from Western Ghats having ethnobotanical importance in treating various veterinary disorders. Plant species such as *Panax ginseng* L. and *Withania somnifera* Dunal are used as adaptogens, *Angelica sinensis* (Oliv.) Diels and *Rehmannia glutinosa* (Gaertn.) DC as blood tonics and Echinaceae sps as immune modulators in veterinary related complications[1]. In addition, plant species like *Aegle marmelos* (L.) Correa, *Caesalpinia bonduc* (L.) Roxb, *Clitoria ternatea* L. and *Cheilocostus speciosus* (J. Koenig) C.D. Specht are used as freshener drinks, as a substitute for liquor, laxative, astringent and carminative etc. Hence, finding new plants with ethnomedicinal values and screening their phytochemicals for pharmacological potential with aim of identifying active compounds from them and such plants may result in unique therapeutic agents and topics of interest in current research.

Conclusion

Plants act as life-saving drugs since time immemorial. Western Ghats of India comprise a rich source of medicinally important plants and according to the ethnobotanical studies, about 130 medicinal plants are endemic to this region. Several active principles such as camptothecin, vincristine, curcumin etc have been isolated from the plants and used either in clinic or are under clinical trials to treat various diseases such as inflammation, cancer, diabetes and diseases of the nervous system. However, many more plants from the Western Ghats have not been explored to detect their medicinal values. The collective effort from plant taxonomy, ethnobiology, biotechnology and pharmacology will be able to explore the plant diversity in the Western Ghats to identify and screen the pharmacologically important bioactive compounds. This will help to protect and use the natural resources in a scientific manner.

Supplementary Data

Supplementary data associated with this article is available in the electronic form at https://nopr.niscpr.res.in/jinfo/ijtk/IJTK_24(1)(2025)63-72_SupplData.pdf

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Conflict of Interest

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

Author Contributions

SKJ prepared the manuscript, graphical explanations, supporting tables and figures. BN reviewed and finalised the manuscript and images.

Data Availability

Data supporting the findings of this study are available upon reasonable request from the corresponding author.

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