Indian Journal of Natural Products and Resources
Vol. 14(2), June 2023, pp. 133-147
DOI: 10.56042/ijnpr.v14i2.4181

Commercially important medicinal plants of North East India and their current applications – A review

Asim Kumar Dutta[1], Partha P. Dutta[1,2], Bandita Pathak[1], Dipumoni Barman[1], Plabita Baruah[1], Deepmala Devi[1], Jagat C. Borah[1]* and Narayan C. Talukdar[1,2]*

[1]Quality Control and Quality Assurance Laboratory, Institute of Advanced Study in Science and Technology, Paschim Boragaon, Guwahati 781035, Assam, India

[2]Assam Downtown University, Sankar Madhab Path, Gandhi Nagar, Panikhaiti 781068, Assam, India

Received 08 September 2021; revised received 28 December 2022; accepted 28 February 2023

North East (NE) India is one of the 'biodiversity hotspots' of the world supporting about 50% of India's biodiversity. In the sparse to dense forests across alpine to tropical climatic conditions, the NE region has a vast distribution of medicinal plants. The present study has compiled and enlisted the wide range of medicinal plants used by different ethnic communities along with the highly traded medicinal and endemic plant species of superior quality attributes in the region. The results are derived from an extensive review of information published in different research papers including those in books, journals, public domain documents of government agencies, NGOs and business and trade databases. The number of important species used in traditional healthcare systems of the different sister states of NE India ranges from 400 to 952 and out of these, the number of different commercially promising species ranges from 7 to 14 species. Thirty-seven species of medicinal plants in NE India are identified to have importance in the national and international trade of medicinal plants and products and most of these are harvested from the wild. Despite of rich heritage and large plant diversity, the herbal drugs market of NE India has not grown at the pace observed the mainland India's herbal drug trade. Poor infrastructure in terms of quality control and quality assurance, GLP-compliant laboratories for herbal drugs, constraints of accessibility to the region, widespread collection of the medicinal herbs from the wild coupled with lack of sustainable harvesting and package of practices for domestic cultivation of medicinal herbs are issues need to be addressed in future for exploring maximum benefit to the economy of the region from medicinal plant resources.

Keywords: Herbal industry, Market scenario, Medicinal plants, North East India, Quality attributes

IPC code; Int. cl. (2021.01)−A61K 36/00

Introduction

Indigenous medicinal plant resources of different ethnic communities play an important role in the healthcare systems of different parts of the world. Progress in scientific validation of traditional knowledge-based herbal medicines and ethno-botanical plants has resulted in a continuous increase in demand for plant-based medicine, cosmetics and food supplements in both national and international market[1,2]. In India, the consumption of herbal products by the domestic herbal industry during the year 2014-15 was estimated to be about 3,77,410 MT and the estimated export during the same year was to the tune of 1,34,500 MT[3]. This reflected a sharp rise in the consumption of raw herbal materials from that of consumption of raw materials in the year 2005-06 which was estimated at 1,77,000[4]. The marketed herbal products during the year 2014-15 included 1622 botanicals corresponding to 1178 species mostly within three plant families of commercially high demand namely, *Fabaceae*, *Asteraceae* and *Laminaceae*[4]. During 2005-06, four major herbal manufacturing units of the country viz. Dabur, Sami Labs, Charak and Zandu (Emami) mostly used raw material of *Fabaceae*, *Asteraceae* and *Laminaceae* plant families and marketed their products, with an estimated annual turnover of Rs. 8,800 crores[4]. According to the Department of Commerce, India has been one of the major exporters of crude drugs to the USA, China, Germany, France, Vietnam, Afghanistan, Nepal, Tibet and the Trans Himalayan trade in medicinal plants and minerals has played a significant role throughout the history of Sowa Rigpa in Tibet. The importance of the Trans Himalayan trade can be gauged from the recent data published by the International Market Analysis Research and Consulting Group

*Correspondent author
Email: jagatcborah@gmail.com; nctalukdar@yahoo.com

(IMARC) group which showed that the Indian herbal products market reached a value of Rs. 515.5 billion in 2021 and is expected to reach Rs. 1,536.9 billion by 2027, exhibiting a CAGR of 19.78% during 2022-2027.

Globally, the medicinal plants or their product market was estimated to be $ 33 billion in the year 2014[5] and the estimated projection was that it would rise up to $ 5 trillion per year by the year 2050. The present export value of herbal raw materials and medicine in India constitutes less than 1% of the multi-billion dollar market of medicinal plants or their products[6]. Thus the current scenario of medicinal plants and their products in India and the continuous rise of trade volume in the world provide an opportunity for the contribution of this sector to India's economy. This, in turn, will demand increasing trade in medicinal plants from every region of the country including those of the biodiversity-rich north eastern region.

The Northeast (NE) India has the richest reservoir of floral diversity in India and is one of the 'biodiversity hotspots' falling under the Himalayas and the Indo-Burma mega biodiversity regions[7]. This forms a unique biogeographic province harbouring major biomes recognized in the world[8]. The region supports around 50% of India's total plant diversity and harbours 40% of India's endemic plant species[9,10]. The region's diverse physiography supports the growth of different species of medicinal plants which are used by various ethnic groups of the region for their primary healthcare needs. Medicinal plants distributed in the different climatic zones of the Northeast are *Acorus calamus*, *Andrographis paniculata, Aquilaria malaccensis, Asparagus racemosus, Bacopa monnieri, Berberis aristata, Coptis teeta, Curcuma spp.(Curcuma longa, C. zedoaria, C. amada, C. aromatica, C. caesia, C. aeruginosa, C. angustifolia), Embelia ribes, Emblica officinalis, Homalomena aromatica, Hydnocarpus kurzii, Illicium griffithii, Mucuna pruiens, Ocimum sanctum, Oroxylum indicum, Paris polyphylla, Piper longum, Rauwolfia serpentina, Saraca asoca, Smilax china, S. glabra, Solanum nigrum, Swertia chirata, Taxus wallichiana, Terminalia arjuna, T. bellerica, T. chebula, Tinospora cordifolia, Valeriana jatamansi, Zanthoxylum armatum, Zingiber officinale*etc. This rich pool of medicinal plant species in NE India are distributed in the various forests and the crude drugs produced from them are being traded in the markets of Assam, West Bengal, Bihar and even in the Central market of Delhi[11]. In the present study, details of currently traded medicinal plants of NE India and the constraints in the trade along with the possible solutions are reviewed and discussed. The overall objective of this paper is to review medicinal plants of the North Eastern Region (NER) that are of particular interest in trade with emphasis on their potential value, constraints in medicinal plants trade in the region and the holistic views on the future directions of this trade.

High-value commercial medicinal plants of NE India

The demand for plant materials has increased globally for medicinal, cosmetics as well as in nutraceutical sectors. Thus a number of business establishments have come up for trading medicinal plants and their products. However, with respect to NE India, a large number of plants are currently being exploited from wild or unorganised places. Medicinal plants of NE India, currently being sold in the domestic and international markets are listed in Table 1 and Fig. 1. National Medicinal Plants Board (NMPB), during 2006-07, constituted a nationwide study to assess the demand and supply of medicinal plants in India. The Foundation for Revitalisation of Local Health Traditions (FRLHT), Bangalore undertook this study from August 2006 to February 2007. Department of Biotechnology (DBT), Govt. of India under its mission program for Translational Research on Medicinal and Aromatic Plants" also prepared a list of high-priority medicinal plants in the country as well as NE India and developed Indian Bioresource Information Network (www.ibin.gov.in) platform. These plant species were documented based on the NMPB "Demand and Supply" list, available related literature on the public domain and deliberations with various State Medicinal Plants Board (SMPBs) of the NE region. Most of these species are found wild and not cultivated, therefore requiring urgent regulation against over-exploitation.

State-wise availability of the studied plants

NE India comprises of the states of Arunachal Pradesh, Sikkim, Mizoram, Assam, Manipur, Nagaland, Meghalaya, and Tripura. This region of India is rich in biodiversity due to high rainfall, abundant sunlight and diverse topography. Two major biodiversity hotspots i.e. Eastern Himalayas and the Indo-Burma region fall in this part of the country. This region represents a wide range of forests ranging from tropical to sub-tropical, temperate to alpine regions favouring availability of wide range of flora[12]. Although, the region constitutes about 8% of the country's total land mass, but has 25% of the total forest area. It is interesting to note that one-third of

Table 1 — List of highly traded medicinal plant species (wild/cultivated) of North East India

Medicinal plants	Trade name	Major supply source	Estimated annual Trade-All India (MT)	Average price (Indian Rs. per kg)
Acorus calamus	Bach	Whole NER	500-1000	50-65
Aegele marmalos	Bael	AS	10600	45-60
Aloe vera	Ghitakumari	AS	>10000	10
Alstonia scholaris	Saptaparnai	AS, AP, MZ	approx.350	-
Asparagus racemosus	Satmul	AS, AP	2000-5000	300-500
Bacopa monerri	Brahmi	AS	1000-2000	30-50
Bamboosa bambos	Banslosan	MH, MZ, AS	2000	250-10,000
Blumea lacera	Mugongreng/ Gangrima	AS, NG	<10	-
Boerhavia diffusa	Punarnava	AS	2000-5000	35-45
Calotropis gigantea	Aakon	AS	approx. 350	-
Capsicum chinense	BhutJolokia (Naga King Chilli)	AS, NG	200	200-350
Cinnamomum verum	Dalcheni	MH, AS	200-500	250-300
Clerodendrum indicum	Akol-bih	AS, AP, MH	200-500	35-45
Coptis teeta	MismiTeeta	AP	100-200	500-2000
Curcuma longa	Haldi	MH, AS	1000-2000	200-450
Desmodium gangeticum	Sarivan	AS	500-1000	30-40
Embelia ribes	Vidanga	AP, MH, MZ	100-200	450-550
Emblica officinalis	Amla	AS, MH	>10000	100-200
Garcinia Sp.	Therkera	AS	200-300	50-65
Homalomena aromatica	Sugandhamantri	AP, AS, MH	200-500	300-400
Hydnocarpus kurzii	Tubaraka	APMN, MZ, TR	<10	-
Illicium griffithii	Star Anise	AP	<10	150-300
Kalanchoe pinnata	Duportenga	AS, MH, MN	<10	-
Mesua ferrea	Nagakeshara	Whole NER	200-500	250-325
Mucuna pruriens	BandorKekua	AS, SK	500-100	60-100
Oroxylum indicum	Shyonaka	AP, AS, MH	500-1000	30-40
Panax pseudoginseng	Ginseng	SK, AP, MN, MH	-	-
Piper longum/silvaticum	Pipli	MH, AS	1000-2000	600-850
Rauvolfia serpentine	Sarpagandha	AS, AP	200-500	800-1000
Rubia cordifolia	Manjistha	AS, NL	1000-2000	160-200
Saraca asoca	Ashoka	AP, AS, MZ, TR	1000-2000	65-150
Sida cordifolia	Bor-sonbarial/Bala	AS	1000-2000	20-50
Smilax china	Chobchini	MN, MH, NG	100-200	300-600
Swertia chirata	Chirata	AS, ML	500-1000	300-325
Syzygium cumini	Kola jamu	AS	500-1000	30-40
Taxus baccata	Yew	AP, MH	>5000	20,000.00
Terminalia arjuna	Arjun	AS, MN, MH, NG	2000-5000	20-25
Tinosporia cordifolia	Giloy	AS, AP, SK	2000-3500	35-40
Zingiber officinale	Ginger	AS, MH, MN	2000-5000	100-250

Source: Ved and Goraya, 2007[4], Goraya and Ved, 2017 [6]

the flora of Northeast India is endemic to this region only[13]. Along with this, the region hosts more than 200 tribes of different ethnic groups with distinct cultural entities and rich indigenous traditional medicine knowledge. The inhabitants hugely depend on available plant resources for their livelihood and for the treatment of common ailments.

Arunachal Pradesh

Arunachal Pradesh is the largest state of NE India, sharing international boundaries with Bhutan, China, Tibet and Myanmar. Of the total forest area, 5.138 million ha is owned by the state and only 15,500 ha are under private ownership[14]. Most of the diversity belongs to the state of Arunachal Pradesh, which

(*Contd.*)

Fig. 1 — Photographs of NER medicinal plants of commercial importance (no copyright infringement intended). 1) *Acorus calamus*; 2) *Alstonia scholaris*; 3) *Asparagus racemosus*; 4) *Bamboosa bambos*; 5) *Clerodendrum indicum*; 6)*Bacopa monerri*; 7) *Blumea lacera* ; 8) *Aloe vera*; 9) *Aegele marmalos*; 10) *Boerhavia diffusa*; 11) *Calotropis gigantean*; 12) *Capsicum chinense*; 13) *Cinnamomum verum*; 14) *Coptis teeta*; 15) *Curcuma longa*; 16) *Desmodium gangeticum*; 17) *Embelia ribes*; 18) *Emblica officinalis*; 19) *Garcinia* sp.; 20) *Homalomena aromatica*; 21) *Hydnocarpus kurzii*; 22) *Illicium griffithii*; 23) *Kalanchoe pinnata*; 24) *Mesua ferrea*; 25) *Mucuna pruriens*; 26) *Oroxylum indicum*; 27) *Panax pseudoginseng*; 28) *Piper longum*; 29) *Rauvolfia serpentina*; 30) *Rubia cordifolia*; 31) *Saraca asoca*; 32) *Sida cordifolia*; 33) *Smilax china*; 34) *Swertia chirata*; 35) *Taxus baccata*; 36) *Tinosporia cordifolia*; 37) *Zingiber officinale*; 38) *Syzygium cumini*; 39) *Terminalia arjuna*; 40) *Aquilaria malaccensis*; and 41) *Zanthoxylum armatum*.

covers most of its areas falling under tropical in foot hills adjoining to Assam and temperate and alpine areas neighbouring to China, whereas subtropical forest areas in the middle region of the state thus gives platform for high scope of medicinal plants cultivation and trade[14].

There are over 500 species of medicinal plants reported so far from Arunachal Pradesh[15]. Some of the most economically promising medicinal plants are *A. calamus*, *A. paniculata*, *A. malaccensis*, *Dioscorea composita*, *H. aromatica*, *O.indicum*, *R. serpentina*, *T. cordiflia*, *Withania somnifera*, etc in low altitudes, while for high altitudes it is *Aconitum heterophyllum*, *C. teeta*, *I. griffiti*, *Panax pseudo-ginseng*, *Paris polyphylla*, *P. kurroa*, *T. baccata* etc.[14,15]. *T. baccata* grows wild in moist temperate Himalayas between 1600-3600 m from sea level altitudes. In Arunachal Pradesh, it is found in the shady and humid tracts of Tawang district above 1800 m from sea level[16]. *O. indicum* is locally known as Panokni or Bhatghila in Arunachal Pradesh is abundantly found in the foot hills of Papumpare, East Siang, West Siang, East Kameng, West Kameng, Changlang, Tirap, Lohit and Lower Dibang Valley of Arunachal Pradesh[17]. *C. teeta* locally known as Mishmi teeta, is a perennial herbaceous medicinal plant which is native to Arunachal Pradesh (Mishmi Hills), Sikkim and Bhutan[18]. It is cultivated in a small scale in Arunachal Pradesh and China (Yunnan). As it is a climate and region specific crop, Department of Environment and Forest, Arunachal Pradesh, has taken up the responsibility of cultivation of this plant in small areas of Dibang Valley and Lohit districts. It grows at the elevation height of 1700 - 2800 m[19] *I. griffithii* (Munsheng or Monpa) is found in open and shady areas in hill slopes of moist temperate forests within 1600-2500 m altitudes of West Kameng and Tawang in Arunachal Pradesh. Dried seed and fruits/pods are the economically valuable parts of *I. griffithii*[20]. Shikimic acid is used as a substrate for industrial synthesis of Tamiflu (inhibitor of human influenza virus H_1N_1). Majority of the world supply of this

compound comes from isolating it from the Chinese star anise (*Illicium* spp.) making it highly lucrative for pharmaceutical industry[21].

Assam

Having a forest area of about 26,832 km^2 accounting for 34.21% of its geographical area, Assam is home to a good number of plants having medicinal uses described by traditional village practitioners, Ayurvedic, Unani, Homeopathic and even modern medical practices. Altogether, 952 plants species have been identified in the state, which have uses in various medical practices (ENVIS Centre: Assam, Status of Environment and Related Issues). Some high valued medicinal and aromatic plants of Assam with prospect for marketing are *A. paniculata, A. racemosus, A. malaccensis, B. monnieri, Curcuma* spp., *E. officinalis, H. aromatica, K. galangal, Ocimum sanctum, Piper longum, R. serpentina, Santalum album, Saraca asoca,* and *T. cordifolia*. *A. racemosus* belonging to family *Liliaceae* is a perennial, prickly climber with tuberous roots and locally known as Satamul. Its trade name is Shatavari[22]. Locally the roots are used mainly as galactagogue which stimulates the secretion of breast milk and also as an aphrodisiac[23]. *E. officinalis* (Amlakhi in Assamese) is a commonly used medicinal fruit of Assam. It is one of the ingredients of locally manufactured and consumed herbal tonic-'Triphala'[24]. *B. monnieri* locally known as Brahmi grows exceptionally well in poorly drained soils and waterlogged areas under sub-tropical conditions[25]. The yield capacity of fresh and dry Brahmi herb is about 300 Q/ha and 60 Q/ha respectively, in the state. (NMPB publications- Brahmi). *T. cordifolia* locally known as Amorlota or Sogoonilota is a large extensively spreading, perennial woody climber with succulent stems. It grows well in almost any type of soils and under varying climatic conditions[26]. Mature plants are collected, cut into small pieces and dried in shade (NMPB publications- Giloe). People of this region used it as a stomachic, antispasmodic, stimulant, antidiabetic, aphrodisiac and antiperiodic. *R. serpentina* commonly known as Sarpagandha is an erect evergreen, perennial shrub with prominent roots. The root bark, which constitutes 40-60% of the whole root, is rich in alkaloids known for their ability in reducing high blood pressure and as a sedative[27] (NMPB publications- Sarpgandha). A selected strain from this region is approved for commercial cultivation by NMPB. Assam is the highest Ginger (*Z. officinale*) producing state in the country. A total of about 54,000 hectare area is under cultivation of ginger in whole NE region including other states like Meghalaya, Mizoram, Nagaland. About 4, 25,000 tonnes were produced from the region during the year 2018-19[20]. The medicinal use of ginger is well known in India and its neighbouring countries for more than 2000 years as one of the most versatile medicinal plants. Locally it is used for curing heart problems, stomach upset, diarrhoea, and nausea, relief cough and cold, throat infection[28].

Manipur

It is situated in the eastern-most corner of Northeast India. Manipur has comparatively smaller forest areas and have less alpine forest and therefore lesser scope for commercial cultivation and trade of medicinal plants. With about 3,268 km^2 of area covered by bamboo forests, Manipur is one of India's largest bamboo producing states including the highly demanded Ayurvedic bamboo product like Banslochan or Tabasheer[29]. About 1,500 species of medicinal and aromatic plants have already been recorded so far from Manipur for treatment of various ailments. Some lists of important commercially important medicinal plants found in Manipur are *A. calamus*, *H. aromatica*, *C. tamala*, *Curcuma caesia*, *Z. armatum*, *Ficus cunia*, *S. glabra. H. kurzii. M. ferrea, T. baccata etc.*[30]. Sheikh *et al.*[31], has thoroughly elucidated the anti-diabetic potential of *Curcuma* sp. and *Ficus cunia* (important ethno-medicinal plants of Manipur). *A. calamus* locally known as oak- hidak is a perennial, aromatic plant with creeping and branched rhizomes. The plant prefers swampy or marshy habitats and grows mainly in tropical and subtropical climates found in the state[32]. Temperature ranging from 10 to 38°C and annual rainfall between 70 and 250 cm is suitable for its cultivation. During the year 2014-15, the state of Manipur harvested a 7 and 0.07 and 167 quintal of *A. malaccensis* and *H. Aromatic* respectively along with adaptation of scientific farming under NMPB.

Meghalaya

Meghalaya is rich in floral diversity, a significant part of which comprises medicinal and aromatic plants and there is a long-standing tradition of use of medicinal plants in the State. It has a long history of presence of local practitioners in the traditional system of medicine[33]. Prominent species of medicinal

plants are *Catharanthus roseus*, *Solanum khasianum*, *D. composita*, *Artemisia nilagarica*, *T. baccata*, *Litsea citrata*, *Gaultheria fragrantissima*, *Aristolochia* spp., *S. chirata*, *Potentilla fulgens*, *P. wangianus*, *S. glabra*, etc. Several medicinal plant species found in Meghalaya have been classified under threatened category; some of these are *T. baccata*, *P. pseudoginseng*[33,34]. The state has diverse range of soil types, including red loamy and laterite, which supports various medicinal plants[35,36]. About 8 of the top 20 medicinal plants that are highly traded in the country are found in Meghalaya. Also, about 14% of Meghalaya is covered by bamboo forests, and is one of the leading bamboo producers in the country[33]. *A. calamus* and *P. pseudoginseng* are found in the northern undulating hill region of the state comprising Ri Bhoi districts and some parts of West Khasi Hills having tropical moist deciduous forests[37]. *S. china* (Chobchini), *R. serpentina*is found in the south precipitous region comprising West, East Khasi Hill, Jaintia Hill and small parts of South Garo Hills[38]. The state of Meghalaya is a home to a variety of spices,out of which turmeric (*C. Longa*) is one of the prominent among others. The variety has its own uniqueness with a very high curcumin content and therefore grown at a commercial scale. It covers about 96 per cent area under turmeric cultivation[39].

Mizoram

Mizoram lies in the extended Himalayan southern tip of NE India sharing international borders with Myanmar and Bangladesh, and Cachar district of Assam in the North. The terrain is mostly undulated mountainous blue-green variegated topography with the highest peak in the Blue mountain and lowest at Tlabung mountain[40]. Many species belonging to *Asteraceae, Menispermaceae, Apiaceae, Lamiaceae*, etc. grows inopen habitats and found abundantly in the state. *M. ferrea* is the State-Tree of Mizoram locally called as Herhse or nahar for its wide use and availability[41,42]. Traditionally, it is used to treat for piles, cough and dysentery; commonly found in sub-tropical forests, across the state. *H. aromatica* locally known as Aacheeri are extensively found in damp places near rivers under forests of Kolasib, Bairabi regions of Mizoram. *M. pruens* locally known as Uiteme is found in old Jhum fields in the state. *Syngium cummini* locally known as Hmuipui, is abundantly found in semi-evergreen forests of Phullen, Bunghmun regions of Mizoram[40]. A number of tropical and sub-tropical medicinal plants are selected for commercial cultivation by NMPB in Mizoram, e.g., *A. vera, Stevia rebaudiana, C. zeylanicum, S. asoca, E. officinalis, R. serpentina, Garcinia indica, Gnetum gnemon* etc. (NMPB 2002, 2008). Traditional use of plants like *G. gnemon* as anti-malarial, has also been corroborated with research studies as having effective anti-plasmodial activities[43]. During the year 2014-15, the state produced about 66 and 9 qt. of *M. ferrea* and *P. pseudoginseng* respectively[4].

Nagaland

Nagaland shares its borders with the state of Assam to the west, Arunachal Pradesh and part of Assam to the north, Burma to the east and Manipur to the south. Its diverse agro-climatic conditions with several types of forest covered with coniferous trees, broad leaved varieties of flora, medicinal plants has immense potential to utilize and cultivate almost all varieties of medicinal and aromatic plants[44]. The state has reported around 650 species of medicinal plants used in various traditional healing methods. Commercially important medicinal plants of the state are *A. calamus, A. racemosus, Costus speciosus*, *C. longa, O. indicum, Phyllanthus amarus, Sida cordifolia, S. glabra* etc.[45]. Other than this, considering the topography and climate of the state, recently NMPB is promoting extensive cultivation of medicinal plants like *P. pseudo-ginseng*, *P. polyphylla*, *Valeriana wallichii*, *T. baccata*, *Zanthoxylum sp*., *H. aromatica*, *A. paniculata*, *O. sanctum*, *A. malaccensis*, *Albizia procera*, *A. indica*, *Clematis buchananiana*, *Eryngium foetidum*. Nagaland is also is home to the world renowned Naga King Chilli or Ghost Pepper (*Capsicum chinense*) due to its high capsaicin content[46]. It is reported that capsaicin is used for relieving cold, sore throat, rheumatism, stomach disorder, treatment of tonsillitis, diphtheria and snake bite etc[47]. Its chemical constituents are in use in pharmaceutical and food industry; which has gained much importance in global market besides using as dried powder products[48].

Sikkim

Sikkim is a part of eastern Himalaya which is globally known for its unique biogeography and biodiversity. Sikkim has a rich repository of medicinal and aromatic plant resources and there are records of over 400 plants of therapeutic value[49]. It shares international boundaries with Nepal, Bhutan, Tibet and national border with the Darjeeling district of West Bengal, India. The unique geographical position, wide range of topography, highly fertile soil, sufficient rainfall and presence of large number of

perennial stream makes the state as one of the of biodiversity hotspots in the country. Some of the economical important medicinal plants are; *A. calamus*, *C. speciosus, O. indicum* found on tropical, sub-tropical to temperate zones; *P. pseudo-ginseng, T. baccata* found in temperate to alpine zone[50]. Two endemic Panax species namely *P. sokpayensis* and *P.bipinnatifidus* have been recognised from Sikkim Himalayan region[51]. *Panax pseudo-ginseng i*s found in high altitudes above 8000ft. Due to high medicinal value, rhizomes of these species are harvested for commercial and domestic use from wild habitats[52]. *Panax* species are also used in many traditional medicines by different ethnic communities[53].

Tripura

It is a small hilly state situated in the southernmost part of northeast India. It is a land-locked state and its geographical limits touch International boundaries with Bangladesh and national boundaries with Assam and Mizoram. Currently, the state has 60.02% recorded forest area, of which 66.33% are forest reserves[54]. A total of 892 species of medicinal plants have been recorded by FRLHT, Bengaluru with support from State Forest Department and State medicinal plant board of Tripura[55]. Out of 892 species, 416 belongs to herbs, 167 shrubs, 99 climber, and 210 trees. *Hydnocarpus kurzii*, *H. aromatica*, *L. glutinosa*, *S. ovalifolia*, *C. glanduliferum*, *A. malaccensis*, *A. racemosus*, *A. paniculata*, *T. arjuna*, etc. are some of the important commercial medicinal plants of Tripura. Many of these are reported to be used by Chakma, Marma and Tanchangya communities of Chittagong Hill Tracts districts of Tripura for preparation of traditional herbal medicines[56]. The Reang tribes of Tripura use therapeutically important wild plant, *S. glabra* for the treatment of asthma, tuberculosis, dysentery, hyperglycaemia, fever, intestinal complaints etc.[57]. Dutta *et al.*[58], reported potential anti-diabetic activity of its (*S. glabra*) major active compound Tetrahydroplamitine (THP), an alkaloid. *M. ferrea* (locally known as Nageswar) is the state flower of Tripura State commonly found in the evergreen forests near streams and rivers[59] (Botanical Survey of India, Shillong). Under the initiative of the Tripura Forest Department, Tripura and NMPB, Ministry of AYUSH, Govt. of India; currently, the state has initiated commercial cultivation of *H. aromatica* at Kailashahar Division and *A. racemosus* at Ambassa Division[60].

Superior quality attributes of medicinal plants of NER

Plants have a plethora of phytoconstituents that add to their bioactivity and highlight their premium attributes. However, the bioactivity of the plants is highly variable and depends on parameters like time of collection (day, season etc.), types of growth origin (wild or cultivated), harvesting & post harvesting techniques and region (arid, marshy, tropical etc.).

As most of the available medicinal plants of NER are either grown in wild or organic cultivation, the quality attributes are found to be much higher than other counterparts. Its high endemism in many medicinal plants like *C. teeta, I. griffithii, H. kurzii, M. pruriens, P. longum, S. chiratya, T.baccata* also enhances its super quality traits. The bioactive secondary metabolites are found to be enhanced in plants in their natural habitat under particular conditions of stress, competition, association, threat of predators and adverse climate etc.[61]. The Lakadong variety of turmeric originating from the Jaintia hills district of Meghalaya (Lakadong Village) is considered to be one of the world's best varieties of turmeric with its curcumin content of about 6.8-7.5% and volatile essential oil (dry) of about 3.6-4.8%[39,62]. Naga King chilli is considered the world's hottest chilli with a "Guinness Book of world records" (measuring 8,55,000 Scoville heat units), outscoring the "Mexican red savana habaneros" (5, 77,000SHU)[46,63]. The Nagaland Government also got the patent rights of Naga King Chilli and got Geographical Indication (GI) tag under the Registration and Protection Act, 1999[64]. Karbi Anglong district of Assam produces one of the best organic gingers in the world. The ginger grown in this region has low fibre. Varieties of ginger such as Nadia and Aizwal, having dry rhizomes and high recovery of oleoresin in oil, are in demand among domestic buyers and exporters[65]. *R. serpentina* collected from this region is found to contain a much higher percentage of alkaloids than in other parts of the country. A few plant species with superior traits in terms of their chemical composition (premium attributes) are detailed in Table 2.

Market scenario of medicinal plants

National herbal market scenario

As it is not recorded or is poorly classified, it is difficult to assess the volume of trade of medicinal plants business accurately[66]. The first attempt to assess the nationwide annual demand and supply of

medicinal plants was made by the NMPB during 2001-02, when it commissioned a study through the Centre for Research, Planning and Acton, Delhi (CERPA). This was followed by studies conducted by the FRLHT, Bangalore, again commissioned by NMPB during 2006-07. The consolidated commercial demand for herbal raw drugs during the year 2014-15 has been estimated at 5, 12,000 MT[67,6]. Isabgol (*Plantago ovata)*, Chakoda/ Powad Beej (*Senna tora*) and Sonpatta (*Senna alexandrina*) were recorded as the top three exported botanical drugs with export volumes of more than 32,000 MT, 28,000 MT and 13,000 MT respectively during the year 2014-15 MT[6]. Other than this opium alkaloids, *Vinca* extract, cinchona alkaloids, menthol, gudmar herb, mehndi leaves etc. are major pharmaceutical exported items from India[68]. Apart from the requirements of medicinal plants for internal consumption, India exports crude drugs mainly to developed countries, viz. USA, Germany, France, Switzerland, the UK and Japan, share between them 75 to 80 per cent of the total export of crude drugs from India[2,69]. About 1178 medicinal plant species are recorded in the practices of trade both in national and international markets. Out of which, 242 plant species are used more than 100 MT annually[6]. These are estimated to cover 7, 800 herbal products manufacturing units in India licensed to manufacture ASU and Homoeopathic formulations[70]. In respect of botanical drugs consumed by the domestic herbal industry, *A. vera*, with an annual estimated consumption of 15,700 MT (DW) emerged as the entity in highest consumption, replacing *E. officinalis*[6].

Medicinal plants are traded both as raw herbage or crude drug and processed products. Herbal products are nowadays classified as traditional and conventional herbal medicinal products, fortified foods, dietary supplements, foodstuffs and cosmetics[71]. Crude drugs are used in pharmaceutical companies for isolation of single purified drugs, development of advanced plant extract or as a starting material for the production of other semi-synthetic pharmacologically active substances[72,73]. Few industrial applications in Indian context of the selected medicinal plants are detailed in the Table 3.

NER herbal market scenario

The medicinal plant sector has great potential to boost the economy of NE India. Wild bioresources are indispensable for the survival and sustenance of ethnic and rural communities, of Northeast India. A recent report observed that the trade of wild bio resources contributes 5–75% to the total income of a majority of the households of Assam[74]. At present, the plant raw materials from the region is traded mainly in the markets of Delhi, West Bengal, and Bihar as there is no mandi system in NER[11]. Most of the herbal raw material is collected directly from the wild and not from cultivated sources[75]. As there is no open market for herbal raw materials in this region, the middlemen take it directly with approval from Divisional Forests Officers and sell it to open markets in other parts of the country. The farmers of this region are also not properly availing of NMPB facilities/mandates, as they usually have less than the specified minimum requirement of land. Currently, State Forests Department is allowing direct purchases of these raw materials as Non-timber forest products (NTFPs) or Minor Forest Produce (MFP), which include all biological materials other than timber extracted from natural forests for human use[76]. Except for Assam with only four licensed herbal units, none of the North Eastern states have any licensed herbal

Table 2 — Superior Quality attributes of high-value medicinal plants of NER

Medicinal Plants	Chemical Class	Superior Trait	References
Capsicum chinense	Capsaicinoids	5.36 % capsicin	83
Cinnamomum verum	Phenylpropanoid and Allylbenzene	Characteristic warm, pungent sweetness	84
Coptis teeta	Alkaloid	native to Arunachal Pradesh (Mishmi Hills)	85
Curcuma longa	Curcuminoids	6.8-7.5 % of curcumin	39
Hydnocarpus kurzii	Cyclopentenic fatty acids	Native to Tripura	86
Illicium griffithii	Terpene alcohol	Native to Arunachal Pradesh	87
Illicium arunachalensis	Terpene alcohol	Native to Arunachal Pradesh	87
Mucuna pruriens	Amino acid	Native to NER	88
Piper longum	Alkaloid	Native to NER	89
Rauvolfia serpentine	Alkaloid	Highest root yield in Assam	90
Rubia cordifolia	Anthraquinone	Native to Arunachal Pradesh	91
Taxus wallichiana	Diterpenoid	Native to Arunachal Pradesh (West Kameng)	92

Table 3 — Current industrial applications of medicinal plants

Medicinal plants	Product/Drug Name	Company	Claims
Acorus calamus	Dabur Janma Ghunti	Dabur	Prevents flatulence & loss of appetite. Useful in dyspepsia and choleric diarrhoea
	Liceol powder	Aravindh Herbals	Anti-lice & strengthens hair.
	Vacha powder	Planet Ayurveda	Supports healthy functioning of the nervous and digestive system
Aegele marmalos	Bilva fruit powder	Bixa Botanical	Healthy bowel functions, anti-inflammation
	Vilvathi legiyam	Aravindh Herbals	Against cough, loss of appetite, anorexia, hyper-acidity, gastric problems
	Bel candy	Patanjali	Relief from constipation, indigestion, respiratory problems, diarrhoea etc.
Aloe vera	Aloe vera juice	Baidyanath	Useful for the digestive system, immunity booster, weight loss
	Aloe vera face wash	Himalaya	Hydrates, softens, and nourish the skin.
	Light hydrating facial gel	Forest essentials	Hydrate, soothes, retains moisture of the skin, and stimulates skin regeneration.
Alstonia scholaris	Mahatiktam kashayam	Arya Vaidya Sala	Against anaemia, thyroid dysfunction, leucoderma and leucorrhoea
Asparagus racemosus	Lukol tablet	Himalaya	Used for post-IUCD leukorrhea, post-tubectomy etc.
	Asparex	ACME Laboratories Ltd.	Against sexual weakness, oligospermia, physical stress
	Pradarcare capsule	AyurHeals	Against leucorrhoea and uterine tonic.
Bacopa monerri	Branolia	Branolia Chemical Works	For memory, concentration and well being
	Braintel	ACME Laboratories Ltd.	Against memory deficiency, impaired speech, and rough & defective voice.
	Pure brahmi hair oil	Devine Herbs	Improves hair and skin problems
Bamboosa bambos	Drakshavaleha	Dabur	Acidity, Indigestion and Ulcers
Blumea lacera	Equibrom capsules	LA Medicca India	Against stress, anxiety and depression.
	Body revival syrup	Health reactive	Body Rejuvenation
Boerhavia diffusa	Chiruvilvadi kashayam	Aeya Vaidyasala	Against hemorrhoids, fistula, indigestion
	Turaico tablets	J & J DeChane Labs Pvt Ltd.	Diuretic and urinary antiseptics.
Capsicum chinense	Capsicum extract	Global Merchants	Blood Flow Activator, Anti-cellulite, Rubefacient
Cinnamomum verum	Dabur restora syrup	Dabur	Body rejuvenation
	Cinnamon leaf oils	R.K's Aroma Shop	Useful for skin care and rheumatism.
	Vihado cinnamon oil	Vihado	Anti- dandruff, overall skin and hair health
Clerodendrum indicum	Kaso-Dee syrup	Goswami Drugs	For Dry cough, Asthmatic cough, Allergic cough
	Pranrakshaak churna	Planet Ayurveda	Anti-histaminic and anti-asthmatic
Coptis teeta	Mamira Eye Drop*	Haslab	Acute or chronic conjunctivitis
Curcuma longa	Turmeric 95™	Himalaya	Joint support
	Afpin CL	Zuventus Healthcare Ltd.	Treatment of osteoarthritis.
	HydroCurc®	Gencor *, Pharmako Biotechnologies*	Anti-inflammatory, pain, and modulate energy metabolism.
Desmodium gangeticum	Kumkumadi face oil	Natures Veda	Improves skin texture and complexion, and also relieves skin issues such as acne, scars, blemishes, dark circles and wrinkles.
Embelia ribes	Abhayarishta	Dabur	Relieves piles, constipation, dysuria, flatulence, anuria, gas and abdominal distension
Emblica officinalis	Amla Juice	Baidyanath	Boosts immunity, effective for cough and cold, weight loss
	Dabur Vatika Shampoo	Dabur	Healthy Hair
	Keshkanti anti dandruff hair	Patanjali	Anti-dandruff

(*Contd*.)

Table 3 — Current industrial applications of medicinal plants

Medicinal plants	Product/Drug Name	Company	Claims
Garcinia Sp.	Pure Garcinia Plus extract	Perennial Life Sciences	Weight loss supplement
Homalomena aromatica	Sugandh Mantri Oil	Salvia	aromatherapy oils
	Sugandh Mantri Oil	Essential Oils	aromatherapy oils
Hydnocarpus kurzii	Tuvrak Chaulmogra Tel	Dabur	Against mild dermatitis and itching
	Chaulmoogra Oil	Alvia	Moisturizes skin, improves skin tone, gives rejuvenating glow to the skin
Illicium griffithii	Tamiflu (Oseltamivir)	Roche Products Limited	Anti-viral used to treat and prevent influenza
Kalanchoe pinnata	Patharchur Juice	Axiom	Against prostate diseases, ideal in kidney stones/diseases, gallstones
	Herbal Supplement	HerbalTerra	Against prostrate diseases, ideal in kidney stones/diseases, gallstones
Mesua ferrea	Pile Off capsule	Planet Ayurveda	Anti-piles medicine
	Nagkeshar capsules	Dr.Wakde	Dietary Supplement
	Turaico tablets	J & J DeChane Labs	Diuretic and urinary antiseptics.
	Pradarcare capsule	Ayur Heals	Against leucorrhoea and Uterine Tonic.
Mucuna pruriens	Dabur Shilajit Gold	Dabur	Improves vitality, sperm count
	Vigo-Fort	ACME Laboratories Ltd.	Against reduced libido, Impotence, premature ejaculation,
	Kapikachhu	Ayur leaf Herbals	Improves sperm count
Oroxylum indicum	Vitilig	Ukkinadkas	Against vitiligo and other autoimmune diseases.
Panax pseudoginseng	Men's Formula	Tiens	Mens sexual health
	Gintonic	ACME Laboratories Ltd.	Against fatigue and debility, erectile dysfunction andaphrodisiac.
Piper longum/silvaticum	Trikatu syrup and capsule	Himalaya	Relieves indigestion
	Dabur Red tooth powder	Dabur	Dental health and hygiene
	Hajmola	Dabur	For proper digestion
Rauvolfia serpentine	Sarphgandhachurna	Gunmala Herbals	Regulate blood pressure
Rubia cordifolia	Manjishtha	Himalaya	Skin wellness
	Manjishthadi Kwatham	Arya Vaidya Sala	Against chronic skin diseases including eczema, psoriasis, varicose ulcer, genital ulcers, and diseases of the joints.
	Organic Manjistha root powder	Merlion Naturals	Removes natural toxins, blood purifier
Saraca asoca	Evecare	Himalaya	Regularize menstrual cycle, anti-spasmodic and anti-inflammatory
	Ashokarishta	Dabur	Overall women's health, especially gynaecological conditions
	Ashoka powder	Alps Goodness	Helps detoxify skin, and aids in soothing skin irritation and burns.
Sida cordifolia	Balarishtam	Arya Vaidyasala	Against musculoskeletal and neuropathic pain
	Dhanvantaram Kashayam	Arya Vaidyasala	Post-natal care, anxiety, mental stress
	Santonic	ACME Laboratories Ltd.	Against Physical & mental weakness, Senile debility, and nervous exhaustion &stress.
Smilax china	Nirmali syrup	Baljiwan Medicine Pvt Ltd	herbal blood purifier
Smilax glabra	Chopchini powder	Bixa Botanical	Supports healthy kidney &digestive function, removal of toxins & harmful germs, healthy lymphatic system
Swertia chirata	Chirata capsule	Sage Herbals	Blood purifier, haemostatic, bronchial infections
	Beauty infusion swertia	Skin Authority	Anti-wrinkles, and roughness

(*Contd.*)

Table 3 — Current industrial applications of medicinal plants

Medicinal plants	Product/Drug Name	Company	Claims
Syzygium cumini	Jamun juice	Nutriorg	Detoxifying agent, treats ulcers, skin health, blood purifying agent.
	Karela jamun juice	Baidyanath	Anti-diabetic, dysentery and diarrhoea.
	Jamun vinegar	Patanjali	Anti-diabetic, anti-diarrhoea, good for digestion
Terminalia arjuna	Gandaga parpam	Aravindh Herbals	Against skin diseases, leproma, fistula and diabetes.
	Arjuna powder	Alps Goodness	Removes excess skin oil, soothes skin, reduces signs of ageing and treats acne
Tinosporia cordifolia	Guduchi tablets	Himalaya	Strengthens immunity
	Seenthil chooranam	Aravindh Herbals	Against Diabetes mellitus & skin diseases.
	Giloy juice	Patanjali	immune booster, blood purifier,anti-diabetic
Zingiber officinale	Talisapatradi churnam	Arya Vaidyasala	Against Anorexia, nausea, vomiting, bronchitis
	Ginger juice	Bhumija Lifesciences	Helps the immune and nervous systems, hair, skin, and anti-oxidant activity

Source: Deshpande, 2015[91]; Handique, 2009[92]

units for processing of available medicinal plants. North East India holds a dominant position in the ginger (*Z. officinale*) economy of the country and spices having numerous medicinal properties like large cardamom, turmeric, bay leaf, black pepper, chilli etc. have been showing an increase in demand[77]. In this direction, North Eastern Regional Agriculture Marketing Corporation Limited (NERAMAC) under the Ministry of Development of North Eastern Region (DoNER) also has been playing a major role by sourcing, procuring and marketing these products including other cash crops from the farmers and the growers of the region[78].

NER herbal industry

There are about 30 Ayurveda, Siddha and Unani (ASU) drug manufacturers in Assam out of which four are NMPB authorized. There are very few fully functional ASU drug manufacturers in other parts of the region. These ASU drugs are sold in various retail Ayurvedic stores of the state and other parts of NER. A few of the locally available products are Triphala, Madhumehantak, Danta Mukta, Ashoka powder, Wheatgrass powder, Punarnava powder, Jambu Beej Powder (*S. cumini*), Dashmool Powder etc. Triphala, is an Ayurvedic polyherbal preparation comprising *T. bellirica, E. officinalis* and *T. chebula* which is widely popular in the region[79]. Assam Prakritik Udyog, Divine Herbs, Agri Vista Tech, Adarsh Herbal Associates, Rashi Ayurveda, Hindustan Responces, Moon Moon Ayurvedic, Jeev Anksh Eco Products Private Limited, Uniray Lifesciences are few leading herbal products manufacturers of the region. It is worth mentioning here that most of these manufacturing units are in Assam with very little to none in other parts of the region. A few of these enterprises along with NMPB are involved in contract farming, cluster cultivation and processing of *Alpinia galangal*, *A. calamus, Saussurea costus, Inula racemosa, P. sikkimensis, Dactylorhiza hatageria, Angelica glauca, A. heterophyllum, Nardostachys jatamansi*, and *Valeriana spp*.[4].

Constraints to the development of trade in medicinal plants in NER

Harsh geographic terrain and the resulting difficulty in building infrastructure have kept the NE region underdeveloped, making any economic activity very difficult to accomplish. Due to this and other factors lime land holding pattern, social unrest, tribal laws; landlocked NE India has remained somewhat inaccessible for trade and economics[68]. Most of the raw materials are collected directly from the wild and not from cultivated land, and often by untrained farmers. Collections of plants from the wild were often plagued by adulterations either intentionally or unintentionally (substitution) leading to species substitution and adulterations. These are sold directly to the middlemen or traders due to the absence of any "Herbal Mandis" in the region[76,80]. This makes the whole process highly secretive and unorganised. Among the few cultivated medicinal plants, farmers/growers often do not follow Good Agricultural Practices (GAP) to provide good quality raw materials. Subsequently, improper Good Post Harvesting methods (GHP) lower the quality of herbal products[81]. Above mentioned and many others are a few issues which pose bottlenecks in the proper trade of medicinal plants in the region[11,82].

Conclusion

The study reveals that there is a large number of important medicinal plants used in the formulation of various herbal products available in the NE region. Along with this, there are few endemic and exotic varieties of related species in this region with premium quality attributes. However, there are concerns about sustainable collection methods and the quality of the raw plant materials from this region. In order to do this, the farmers need to be trained on GAP to provide good quality raw material and proper post-harvesting methods GHP of herbal products. Government intervention in creating cluster centres for larger land holdings for bigger cultivation areas, herbal drug testing laboratories and a fair marketplace (or Herbal Mandis) is the need of the hour. Further works on more taxonomic and systematic molecular-based studies of the bioresources to better understand their full genetic and metabolic diversity; chemical studies to identify the active chemical compounds or marker compounds for finding any superior quality attributes; horticultural studies to find out if the plants are suitable for large-scale production or sustainable harvesting are necessary based on the identified plant species.

Conflict of interest

The authors declare no conflicts of interest.

References

1 Ravi S and Bharadvaja N, Market analysis of medicinal plants in India, *Curr Pharm Biotechnol*, 2019, **20**, 1172-1180.

2 Sachdeva V, Roy A and Bharadvaja N, Current prospects of nutraceuticals: A review, *Curr Pharm Biotechnol*, 2020, **21**, 884-896.

3 Mishra S K, Indian Scenario in World Market of Herbal Products, *SSRN*, 2010.

4 Ved D K and Goraya G S, Demand and supply of medicinal plants in India, *NMPB, New Delhi & FRLHT, Bangalore, India*, 2007, **18**(85), 210-52.

5 Karan V, Sharma N and Karan M, Current perspective in the international trade of medicinal plants material: An update, *Curr Pharm Des*, 2016, **22**, 4288-4336.

6 Goraya G S and Ved D K, Medicinal Plants in India: An Assessment of their Demand and Supply, National Medicinal Plants Board, Ministry of AYUSH, Government of India, New Delhi and Indian Council of Forestry Research & Education, Dehradun, 2017.

7 Myers N, Mittermeier R A, Mittermeier C G, Da Fonseca G A and Kent J, Biodiversity hotspots for conservation priorities, *Nature*, 2000, **403**, 853-858.

8 Mao A A, Hyniewta T M and Sanjappa M, Plant Wealth of Northeast India with reference to ethnobotany, *Ind J Tradit Knowl*, 2009, **8**, 96-103.

9 Dutta B K and Dutta P K, Potential of ethnobotanical studies in North East India: An overview, *Indian J Tradit Knowl*, 2005, **4**, 7-14.

10 Mao A A and Hynniewta T M, Plants used as Agricultural seasons indicator by Mao Naga tribe, Manipur, India, *Indian J Tradit Knowl*, 2009, **10**, 578-580.

11 Shankar R and Rawat M S, Conservation and cultivation of threatened and high valued medicinal plants in North East India, *Int J Biodivers Conserv*, 2013, **5**, 584-591.

12 Pawar S S, Birand A C, Ahmed M F, Sengupta S and Raman T S, Conservation biogeography in North-east India: Hierarchical analysis of cross-taxon distributional congruence, *Divers Distrib*, 2007, **13**, 53-65.

13 Ramakantha V, Gupta A K and Kumar J, Biodiversity of Northeast India, *http://wiienvis.nic.in/Database/Key_Biodiversity_Areas*, Last assessed on 28 January, 2023.

14 Benniamin A, Medicinal ferns of North Eastern India with special reference to Arunachal Pradesh, *Indian J Tradit Knowl*, 2011, **10**, 516-522.

15 Haridasan K, Anupam S, Bhuyan L R and Bisht N S, Medicinal Plants Sector in Aruncahal Pradesh: An Overview, *Indian For*, 2003, **129**, 37–47.

16 Sharma H and Garg M, A review of traditional use, phytoconstituents and biological activities of Himalayan yew, *Taxus wallichiana*, *J Integr Med*, 2015, **13**, 80-90.

17 Shankar R and Tripathi A K, Exploration, conservation and cultivation of *Oroxylum indicum* Vent. (Shyonak) in North East India, *Int J Med Plants- Photon*, 2015, **108**, 650-657.

18 Tandon P, Rathore T S and Kumaria S, Micropropagation of *Coptis teeta* Wall.–Threatened medicinal plant of Arunachal Pradesh, India, *Indian J Biotech*, 2007, **6**, 280-282.

19 Bajpay A, Nainwal R C and Singh D, *Coptis teeta*: A potential endemic and endangered medicinal plant of Eastern Himalayas, *J Pharmacogn Phytochem*, 2019, **8**, 245-248.

20 Kalita J and Khan M L, Medicinal plants from the high altitudes of the western part of Arunachal Pradesh, India and their trade, *Int J Conserv Sci*, 2013, **4**(3).

21 Borah J C, Shikimic acid: a highly prospective molecule in pharmaceutical industry, *Curr Sci*, 2015, **109**,1672-1679.

22 Goyal R K, Singh J and Lal H, *Asparagus racemosus*-an update, *Med Sci*, 2003, **57**, 408-414.

23 Kumar S, Mehla R K and Dang A K, Use of shatavari (*Asparagus racemosus*) as a galactopoietic and therapeutic herb–a review, *Agric Rev*, 2008, **29**, 132-138.

24 Rao P K, Antioxidant effect of Triphala: Critical review, *J Ayurveda Integr Med Sci*, 2017, **2**, 213-219.

25 Phrompittayarat W, Jetiyanon K, Wittaya-Areekul S, Putalun W, Tanaka H, *et al.*, Influence of seasons, different plant parts, and plant growth stages on saponin quantity and distribution in *Bacopa monnieri,Songklanakarin*, *J Sci Technol*, 2011, **33**(2).

26 Kumawat N K, Kishore D, Vaishya J K, Balakrishnan P and Nesari T M, *Tinospora cordifolia*: A wonderful miracle herb of 21st century of India, *Med Plants-Int J Phytomed Relat Ind*, 2019, **11**, 117-122.

27 Abhijit D and De J N, *Rauvolfia serpentina* (L). Benth. exKurz.-a review, *Asian J Plant Sci,* 2010, **9**, 285-298.

28 Shukla Y and Singh M, Cancer preventive properties of ginger: A brief review, *Food Chem Toxicol*, 2007, **45**, 683-690.

29 Sharma G J, Survey, collection and utilization of bamboo resources, Final technical report submitted to the G. B. Pant

Institute of Himalayan Environment and Development, Almora, India, 1996.
30 Athokpam R, Bawari M and Choudhury M D, A review on medicinal plants of Manipur with special reference to hepato-protection, *Int J Adv Pharm Res*, 2014, **5**, 182-91.
31 Sheikh Y, Maibam B C, Biswas D, Laisharm S, Deb L, *et al.*, Anti-diabetic potential of selected ethno-medicinal plants of north east India, *J Ethnopharmacol*, 2015, **171**, 37-41.
32 Lokesh G B, Sweet flag (*Acorus calamus*) — Cultivation and economics aspects, *Nat Prod Radiance*, 2004, **3**(1), 19-21.
33 Rao R R, Ethnobotany of Meghalaya: Medicinal plants used by Khasi and Garo tribes, *Econ Bot*, 1981, **35**, 4-9.
34 Chhetri R B, Trends in ethnodomestication of some wild plants in Meghalaya, Northeast India, *Indian J Tradit Knowl*, 2011, **16**, 170-175.
35 Upadhaya K, Thapa N, Lakadong N J, Barik S K and Sarma K, Priority areas for conservation in northeast India: A case study in Meghalaya based on plant species diversity and endemism, *Int J Ecol Environ Sci*, 2013, **39**, 125-136.
36 Thapa N, Upadhaya K, Baishya R and Barik S K, Effect of plantation on plant diversity and soil status of tropical forest ecosystems in Meghalaya, Northeast India, *Int J Ecol Environ Sci*, 2011, **37**, 61-73.
37 Pandey A K, Ali M A and Mao A A, *Genus Panax* L. (Araliaceae) in India, *Pleione*, 2007, **2**, 46-54.
38 Tynsong H, Tiwari B K and Lynser M B, Medicinal plants of Meghalaya, India, *Newsletter of MAPPA/ICIMOD, NMPB and MPCN*, 2011, 7-10.
39 Shreeranjan, SHG Federation to cultivate Lakadong Turmeric, Quarterly Newsletter on SHG movement in Meghalaya, 2006, **1**, 2.
40 Lalramnghinglova H, Documentation of medicinal plants based on traditional practices in the Indo-Burma hotspots region of Mizoram, North East India, *Emergent Life Sci Res*, 2016, **2**, 10-45.
41 Singh H B and Sundriyal R C, Common spices and their use in traditional medicinal system of ethnic groups of Manipur state, North eastern India, *Indian J Tradit Knowl*, 2003, **2**, 148-158.
42 Lim T K, *Mesua ferrea*, In *Edible medicinal and non-medicinal plants*, (Springer, Dordrecht), 2014, 641-652.
43 Dutta P P, Bordoloi M, Roy S, Narzary B, Gogoi K, *et al.*, Antiplasmodial activity of *Gnetum gnemon* leaves and compounds isolated from them, *Nat Prod Comm*, 2018, **13**(10), 2018, 1263-1265.
44 Jamir T T, Sharma H K and Dolui A K, Folklore medicinal plants of Nagaland, India, *Fitoterapia*, 1999, **70**, 395-401.
45 Shankar R, Ashish K T and Abhimanyu K, Conservation of some pharmaceutically important medicinal plants from Dimapur District of Nagaland, *World J Pharm Res*, 2014, **3**, 856-871.
46 Shetalu V, *Production and marketing of King Chilli cultivation in Dimapur District of Nagaland*, A M.Sc. (Ag.) thesis submitted to the Department of Agricultural Economics, Nagaland University, SASRD, Medziphema: Campus, District Dimapur, Nagaland, 2010.
47 Baruah S J and Baruah M, Birds eye chilli - a Forex earner for north east, *Spice Ind*, 2004, **25**, 40-43.
48 Sharma A, Sustainable economic analysis and extent of satisfaction level of King Chilli growers in Nagaland, *Small*, 2014, **30**(18), 30.
49 Rai L and Sharma E, *Medicinal plants of the Sikkim Himalaya: Status, usage and potential*, (Bishen Singh Mahendra Pal Singh, Dehradun), 1997.
50 Mandal D, Panda A K and Rana M, Medicinal plants used in folk medicinal practice available in rich biodiversity of Sikkim, *Environ Ecol*, 2013, **31**, 1445-1449.
51 Sharma S K and Pandit M K, A morphometric analysis and taxonomic study of *Panaxbipinnatifidus* Seem. (Araliaceae) species complex from Sikkim Himalaya, India, *Plant Syst Evol*, 2011, **297**, 87–98.
52 Gurung B, Bhardwaj P K and Talukdar N C, Subtractive transcriptome analysis of leaf and rhizome reveals differentially expressed transcripts in *Panaxsokpayensis*, *Funct Integr Genomics*, 2016, **16**, 619–639.
53 Badola H K and Pradhan B K, Plants used in healthcare practices by Limboo tribe in South-West of Khanchendzonga Biosphere Reserve, Sikkim, India, *Indian J Tradit Knowl*, 2013, **12**, 355–369.
54 Debbarma M, Pala N A, Kumar M and Bussmann R W, Traditional knowledge of medicinal plants in tribes of Tripura in northeast, India, *Afr J Tradit Complement Altern Med*, 2017, **14**, 156-168.
55 Deb D B, Medicinal plants of Tripura state, *Indian Forester*, 1968, **94**, 753-765.
56 Roy S, Uddin M Z, Hassan M A and Rahman M M, Medico botanical report on the Chakma people of Bangladesh, *Bangladesh J Plant Taxon*, 2008, **15**, 67-72.
57 Das D and Datta B K, New distributional record of *Stephania glabra* (Roxb.) Miers (Menispermaceae) in Tripura, India and its domestication in Reang Home-Gardens, *Pleione*, 2018, **12**, 337-340.
58 Dutta A K, Tandon V and Das B, Biocomputational analysis of phosphoenolpyruvate carboxykinase from *Raillietina echinobothrida*, a cestode parasite, and its interaction with possible modulators, *Parasitol*, 2016, **143**, 300-313.
59 Chahar M K, Geetha L, Lokesh T and Manohara K P, *Mesua ferrea* L.: A review of the medical evidence for its phytochemistry and pharmacological actions, *Afr J Pharm Pharmacol*, 2013, **7**, 211-219.
60 farmersportal.tripura.gov.in (last assessed on 28 January, 2023).
61 Datta S K, Market Imperfections In *Phyto-Medicinal Trade In India - The Need For Institutional Interventions*. XII World Forestry Congress, Qubec City Canada, 2003.
62 Jha A K and Deka B C, Present status and prospects of ginger and turmeric in the NE States, ICAR Research Complex for NEH Region, (Meghalaya, Kiran Publications), 2012.
63 Ananthan R, Subhash K and Longvah T, Capsaicinoids, amino acid and fatty acid profiles in different fruit components of the world hottest Naga king chilli (*Capsicum chinense* Jacq), *Food Chem*, 2018, **238**, 51-57.
64 Annyomous, Patent Rights of Naga Chilli, Nagaland Post, 2009, **4**.
65 Rahman H, Karuppaiyan R, Kishore K and Denzongpa R, Traditional practices of ginger cultivation in Northeast India, *Indian J Tradit Knowl*, 2009, **8**, 23-27.
66 Kuipers S E, Trade in Medicinal Plants, In *Medicinal plants for conservation and health care: Non-Wood Forest Products* 11, Italy: Food and Agriculture Organization, 1997.

67 Vasisht K, Sharma N and Karan M, Current perspective in the international trade of medicinal plants material: An update, *Curr Pharm Des*, 2016, **12**, 4288-4336.

68 Singh S and Kumar S, Medicinal plant sector in India: Status and sustainability, *Int J Econ Plants*, 2021, **8**, 081.

69 Exim Bank Report, 2022 (last assessed on 28 January, 2023).

70 Planning Commission, Transforming the North East: Tackling Backlogs in Basic Minimum Services and Infrastructural Needs, High Level Commission Report to the Prime Minister, New Delhi, 1997.

71 Sharangi A B and Suchand D, *Value addition of horticultural crops: Recent trends and future directions*, (Springer India), 2015.

72 Handa S S, Future trends of plants as drugs, *Pharmatimes*, 1991, **23**, 13-23

73 Khanna H K and Nagin C, Global scenario of pharmaceutical industry with special reference to Indian pharmaceutical industry, *Indian J Tradit Knowl*, 2002, **61**, 167-183.

74 Chaudhury G, Basumatari M, Darji C, Ahmed A F, Borah D, *et al.*, Economic significance of wild bioresources to rural communities in the Eastern Himalayan state of Assam, Northeast India, *Trees*, *Forests People,* 2021, **5**, 100102.

75 Dutta D N, Wealth of medicinal and aromatic crops of North East India and their commercial exploitation, Directorate of Agriculture, Government of Assam, India, *NEDFi R & D Centre, Khetri, Kamrup*.

76 Tiwari B K, Non-timber forest produce of North East India, *J Hum Ecol*, 2000, **11**, 445-455.

77 Spices Board, Spice export potential of North Eastern States Spices Board, Govt of India, 2007.

78 Das K, Production conditions of spices In *Northeast India: Cases of Ginger and Chilli*, NRPPD Discussion Paper no.51, 2016.

79 Das R R, Folk medicine and traditional markets a study in Assam, xiii, 2010, 187.

80 Kumar J S, Krishna V, Seethapathy G S, Ganesan R, Ravikanth G, *et al.*, Assessment of adulteration in raw herbal trade of important medicinal plants of India using DNA barcoding, *3 Biotech*, 2018, **8**, 1-8.

81 WHO guidelines on good agricultural and collection practices (GACP) for medicinal plants, (Geneva), 2003.

82 Kala C P, Medicinal and aromatic plants: Boon for enterprise development, *J Appl Res Med Aroma*, 2015, **2**, 134-139.

83 Liu Y and Nair M G, Capsaicinoids in the hottest pepper Bhut Jolokia and its antioxidant and anti inflammatory activities, *Nat Prod Comm*, 2010, **5**, 1934578X1000500122.

84 Baruah A and Nath S C, Systematics and diversities of Cinnamomum species used as" Cinnamon" species in North East India, *J Econ Taxon Bot*, 2007, **31**, 872-887.

85 Payum T, Distribution, ethnobotany, pharmacognosy and phytoconstituents of *Coptis teeta* Wall.: A highly valued and threatened medicinal plant of eastern Himalayas, *Pharmacogn J*, 2017, **9**, s28-s34.

86 Majumdar K, Adhikari D, Datta B K and Barik S K, Identifying corridors for landscape connectivity using species distribution modeling of *Hydnocarpus kurzii* (King) Warb., a threatened species of the Indo-Burma Biodiversity Hotspot, *Landsc Ecol Eng*, 2019, **15**, 13-23.

87 Marbaniang E J and Venugopal N, A new species of Illicium (*Illicium arunachalensis*) from Arunachal Pradesh, India, *Res J Sci IT Manage*, 2015, **4**, 36-43.

88 Tripathi P K, Jena S N, Rana T S and Sathyanarayana N, High levels of gene flow constraints population structure in *Mucuna pruriens* L. (DC.) of northeast India, *Plant Gene*, 2018, **15**, 6-14.

89 Oommen S, Ved D K and Krishnan R, Tropical Indian medicinal plants: Propagation methods. Bangalore, India: FRLHT, Foundation for Revitalisation of local health traditions, 2000.

90 Bhagat N R, Mital S P and Hardas M W, Variation in *Rauvolfia serpentina* genetic resources in India, *Euphytica*, 1980, **29**, 747-750.

91 Bhuyan R and Saikia C N, Isolation of colour components from native dye-bearing plants in northeastern India, *Bioresour Technol*, 2005, **96**, 363-372.

92 Saikia D, Khanuja S P S, Shasany A K, Darokar M P, Kukreja A K, *et al.*, Assessment of diversity among *Taxus wallichiana* accessions from northeast India using RAPD analysis, *Plant Genet Resour Newsl*, 2000, 27-31.