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REVIEW ARTICLE OPEN ACCESS

Antimicrobial Potency of Some Traditional Medicinal Plants of North-Eastern India: An In-Depth Review

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Abstract

The hilly regions of Northeastern states of India are enriched with many medicinal plants. More than 50% of the total plant species present in this region are flowering plants, and majority of these flowering plants are gymnosperms. Various phytochemicals derived from these plants like terpenoids, tannins, saponins, polyphenols, and flavonoids have therapeutic properties against many human diseases. These phytochemicals need to be studied thoroughly to explore more about their therapeutic effects and develop targeted therapeutic strategies. Antibiotic resistance has posed serious threat to the treatment strategies against infectious diseases, as many microbes are becoming resistant to the existing antibiotics. In this context, the antimicrobial compounds derived from plants, can be an alternative to antibiotics and showing no resistance by the pathogenic microorganisms. Besides, the plants also play crucial role in sustainable agriculture, and nutrient cycling. The present review article discusses in details about the beneficial effects of these plants with their antimicrobial properties, presence of diverse bioactive compounds, and their therapeutic effects. This article provides substantial information on the medicinal plants of the Northeastern region of India, which will help the researchers working in this area to design their research work efficiently with more updated information available. However, more studies are required to make the best use of phytochemicals extracted from the plants, towards the development of targeted therapeutic strategies.

Keywords: Antimicrobial Properties, Antioxidative Properties, Bioactive Compounds, Medicinal Plant, Phytochemicals

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INTRODUCTION

India is a land of traditional medicine with various medicinal systems like Unani, Ayurveda, and Siddha in place. Antimicrobial compounds are those compounds that inhibit the growth of microbes on certain food products which are prone to microbial contamination. Therefore to protect tons of food products from spoilage there is an urgent need to find various phytochemicals that can easily protect the foods.[1] Microbiologists, chemists, botanists, biotechnologists are investigating wide spectrum of compounds to find natural leads that will be used for the treatment of many diseases, and also for better food production process. Studies revealed that on an average 25% to 50% of present pharmaceuticals comes from various types of plants, and surprisingly only a very less fraction of it are used as antimicrobials.[2] Northeastern states of India are enriched with abundant medicinal plants of therapeutic importance (Table 1). These states have a variety of tribes and cultures that share a significant connection to the origin of various herbal medicines. However, with time, these valuable diamond sources of information are usually lost due to scarcity of accessibility and storage of these data. So there is an utmost need to increase the research and development work on these areas of medicinal plants.[3]

There are lots of antimicrobial compounds found on this planet but among them antibiotics are the most significant antimicrobial compounds. But as time changes it happens that the emergence of antimicrobial resistance also occurred. This phenomenon has posed a serious threat by increasing mortality, morbidity, and elevated healthcare costs. As a result, multiple drug-resistance is seen rising among all types of pathogens.[4]

In the northeastern states, various types of medicinal plants are present according to their topographic location. Certain topographical locations are rich with diverse types of plants. The hills in the northeastern states such as Naga, Garo, Jayantiya, and Khasi hills are a good source of many medicinal plants and they need to be protected from increasing urbanization, and gradual depletion. If not conserved, various potential cures and uses against diseases such as tumours in piles, dysentery, epileptic seizures, rabies, and 4th stage cancer will be hampered.[5]

From serious disorders to minuscule abnormalities like stomach aches, headaches, fungal diseases, etc. can be cured using phytochemicals found in the flora of the northeastern states of India. For example, from the same region is that of the plant *Chenopodium ambrosioides Linn.* which is used to cure headaches, and fever, and normalizes the blood pressure.[6]

Northeast India has a wide variety of cultures and groups of ethnic populations. The people practise traditional healing techniques for a long time, and are enriched with traditional knowledge, which paves the way for ethnobotanical research in this region. Traditional medicine is an ancient form of structured drug regimen that is based on fundamental principles and elemental ideologies. Across historical periods, ethnic groups have continuously produced, improved, and transmitted conventional knowledge. Their needs, observation, intuition, experimentation, and long-term understanding play a crucial role in practising the medicinal plants.[7]

The tribal people primarily rely on timber and wild edible species for their daily earnings, and the medicinal plants have been valuable for them due to their therapeutic importance in context to the presence of secondary metabolites.[8] The major phytochemicals found in plants that have medicinal value, are terpenoids, tannins, saponins, polyphenols, and flavonoids which have anti-inflammatory, antioxidant, and antibacterial properties (Table 2). Northeastern India is one of the World's big biodiversity hotspots with many medicinal plants that are used traditionally to treat various forms of human illnesses.[9]

Herbal medicines derived from the medicinal plants, have the potential to prevent and cure many diseases. Accessibility and safety while using medicinal plants are of utmost importance in this modern era. Like any other medicine, medicines derived from herbal plants do have risks and thus there is a lot of research required to get these medicines completely safe from adverse effects. The potential to cure many incurable diseases is significantly higher in traditional medicinal plants or herbalism.[10] The history of World is enriched with the utility of medicinal plants. The earliest known evidence of

Table 1. List of 40 Medicinal Plants used for the treatment of various microbial diseases

No.	Botanical Name	Local Name in Northeast	Family/State	Part of Plant	Mode Of Action/Used For Treating Various Diseases/Properties	Ref.
1.	*Vanda coerulea*	Bhatou Phul	Orchidaceae	F,L	Eye drops required for treating Glaucoma and Cataracts	(20)
2.	*Acorus calamus* L.	Vacha	Acoraceae	RC	Respiratory Diseases, nerve tonic	(21)
3.	*Aquilaria malaccensis* Lam.	Agaru	Thymelaeaceae Juss.	B	Immunosuppressant	(22)
4.	*Abrus precatorius*	Latumoni	Fabaceae	L	Growth of hair and used in fever, cough, common cold	(23,24)
5.	*Thunbergia coccinea*	Nilata/ Nilakontho	Acanthaceae	R	Stomach Disorders and sterility	(23,25)
6.	*Colocasia esculenta*	Kola kochu	Araceae	C	Piles and tonsillitis	(23,26)
7.	*Enydra fluctuans*	Helechi	Asteraceae	L	Ringworms	(23,27)
8.	*Nymphoides indica*	Tal japori	Menyanthaceae	P	Jaundice	(23,28)
9.	*Ageratum conyzoides*	Pashpaya	Asteraceae/Arunachal Pradesh	L, S	Wound Healing and antihelmintic	(29)
10.	*Artemesia nilagirica*	Tipintarin	Asteraceae/Arunachal Pradesh	L	Headache, stomach pain and asthma	(29)
11.	*Centella asiatica*	Barang	Apiaceae/Arunachal Pradesh	W	Mixed with honey as juice form to cure stomach ulcers, leprosy	(29)
12.	*Colocasia esculenta*	Yaksar	Araceae/Arunachal Pradesh	L,S, R	Fever and cough. Its juice is used as a stimulant	(29)
13	*Dillenia indica*	Ahutenga	Dilliniaceae/Arunachal Pradesh	FP, L	To cure dandruff, wound healing and for diarrhoea as well	(29)
14.	*Musa sapientum*	Nyoro-kopa	Musaceae/Arunachal Pradesh	FP L	Unripe fruits are good for dysentery, diabetes and in anemia	(29)
15.	*Solanum khasianum*	Thitbya-ke	Solanaceae/Arunachal Pradesh	SD, berries, R	Malaria and anti-inflammatory	(29)
16.	*Swertia chirayita*	Chirata	Gentianaceae/Arunachal Pradesh	W	Fever and as anti-hepatitis B	(29)
17.	*Zanthoxylum armatum*	Honyur	Rutaceae/Arunachal Pradesh	FP, SD,B	Fever and times of cholera and stomach disorder	(29)
18.	*Tacca integrifolia*	Tagoon	Dioscoraceae/Arunachal Pradesh	R	Wound healing, leprosy, stomach aches, and dysentery	(29)
19.	*Andrographis paniculata*	Kalmegh	Acanthaceae/Tripura	L	Dog bites plus Dysentery and diarrhea	(30,31)
20.	*Achyranthes aspera* L.	Apamarga	Amaranthaceae/Tripura	R	Shivering and epilepsy	(30)

Table 1. Cont...

No.	Botanical Name	Local Name in North East	Family/State	Part of Plant	Mode Of Action/Used For Treating Various Diseases/Properties	Ref.
21.	*Centella asiatica* (L.) Urban	Samsota-Kokborok	Apiaceae/Tripura	W	The plant is boiled to generate dark juice which is then used for brushing and as mouthwash	(30)
22.	*Holarrhena antidysenterica* Linn.	Kurchi	Apocynaceae/Tripura	L	Dysentery, diarrhoea and as well as anthelmintic	(30)
23.	*Calotropis gigantea* Linn.	Akanda	Asclepiadaceae/Tripura	L	Snake bite and as long as poison remains in the body the taste is bitter but as poison fades away the taste of the plant turns sweet	(30)
24.	*Ageratum conyzoides* L.	Ujaru	Asteraceae/Tripura	L	Cuts and Wounds	(30)
25.	*Enhydra fluctuans* Lour.	Helencha/ Harkuch	Asteraceae/Tripura	S	Stomach Ailments and skin diseases	(30)
26.	*Adhatoda vasica* Nees.	Sangtam tu	Acanthaceae/Nagaland	L	Lumber pain, Joint Pain and sprains	(32)
27.	*Allium ascalonicum* Linn.	Rupchi	Liliaceae/Nagaland	L	Wounds of injured animals and sometimes it is used as anthelmintic	(32)
28.	*Amorphophallus campanulatus*	Shitsu Nupang	Araceae/Nagaland	B	Anthelmintic	(32)
29.	*Verbena officinalis* Linn.	Shunutamtsu	Verbenaceae/Nagaland	W	Bitter tonic and appetizer. High fever and Malaria	(32)
30.	*Terminalia chebula* Retz.	Nankgka jang	Combretaceae/Nagaland	FP	antispasmodic and antiemetic and to suppress or reduce the effects of cough and constipation too	(32)
31.	*Stephenia hernandifolia* Walp.	Takulaizu	Menispermaceae/ Nagaland	R	Abdominal colic as well as used to treat diarrhoea, nausea and vomiting	(32)
32.	*Spondius mangifera* Willd.	Mezunglashi	Anacardiaceae/Nagaland	L	Foot and toe infections as well as used as cooling agent on burns.	(32)
33.	*Rhododendron campanulatum*	Metsiiben Naro	Ericaceae/Nagaland	F	Its flowers are used to remove fish bones when they get stuck in the throat	(32)
34.	*Polyalthia longifolia* Benth.	Mongmong/ masttree	Annonaceae/Nagaland	L, FP	Carminative and anthelmintic	(32)
35.	*Dregea volubilis*	Ankha-pui	Asclepiadaceae/Mizoram	L,B	Ulcers and is used in Herpes	(33)
36.	*Dysoxylum procerum*	Thingthu-pui	Meliaceae/Mizoram	L	Dysentery	(33)
37.	*Hibiscus surattensis*	Leitha	Malavaceae/Mizoram	S,L	Ureteritis	(33)
38.	*Perilla ocymoides* Linn.	Khamella	Lamiaceae	L,FP	Cough and Ling infection	(34)
39.	*Plantago erosa* Wall	Yempat	Plantaginaceae	L,SD,R	Fever and Muscular Sprain	(34)
40.	*Pinus kesiya*	Uchan	Pinaceae	W,L	Cough And Headache	(34)

Abbreviations: F = Flower, L = Leaves, R = Root, C = Corm and runners, B = Bark and Wood, RC = Rhizome cuttings, P = Plant Juice, S = Stem, W = Whole plant, FP = Fruit Pulp, SD = Seeds

Table 2. Bioactive compounds derived from medicinal plants and their inhibitory effects on microorganisms

No.	Botanical Name	Local Name/State	Family	Bioactive Compounds	Organisms Inhibited	Ref.
1.	*Elaeagnus latifolia* L.	Sikkim	Elaeagnaceae	β-carotene, Ascorbic acid, Lycopene	*Serratia marcescens* and *E. coli*	(35)
2.	*Aegle marmelos* Correa	Bael/Sikkim	Rutaceae	alkaloids, flavonoids, and phenols	*S. epidermidis* and *S. aureus*	(36)
3.	*Asparagus racemosus*	Kurilo/Sikkim	Liliaceae	Steroids, Cardiac Glycosides, Phenols and tannins	*E. coli, S. aureus, C. albicans* and *B. pumilis,*	(37,38)
4.	*Astilbe rivularis*	Buriokahti/Sikkim	Saxifragaceae	terpenoids, flavonoids, tannins, phenols, alkaloids	*Flexibactor* sp., *A. liquefaciens, Pseudomonas* sp.	(39)
5.	*Edgeworthia gardneri*	Argaily/Sikkim	Thymelaeaceae	Baicalin, Phenol	*S. aureus, E. coli*	(40,41)
6.	*Eucalyptus globosa*	Tarpin/Sikkim	Myrtaceae	Phenol, thymol	*Staphylococcus aureus*	(42,43)
7.	*Fagophyrum esculentum*	Mithey Phapur/Sikkim	Polygonaceae	Phenol	*Xylella fastidiosa, S. aureus, E. coli*	(44,45)
8.	*Ferula narthex*	Hing/Sikkim	Apiaceae (Umbelliferae)	Chloroform and aliphatic carbon compound	*E. coli, P. aeruginosa, S. pneumoniae, S. typhi*	(46,47)
9.	*Ficus semicordata*	Khasrey Khaneu/ Sikkim	Moraceae	Phenol, Flavonoid	*Klebsiella pneumoniae, Streptococcus pyogenes*	(48,49)
10.	*Oroxylum indicum*	Totola/Sikkim	Bignoniaceae	phlobatannins, flavonoids, phenols and tannins and glycosides	*Pseudomonas aeruginosa* and *Bacillus subtilis*	(50)
11.	*Phyllanthus emblica*	Amla/Sikkim	Euphorbiaceae	Alkaloids, phenols, Flavonoids, tannins, organics acid	*Pseudomonas aeruginosa*	(51,52)
12.	*Thysanolaena maxima*	Amliso/Sikkim	Poaceae	Terpenoids, tannins, Flavonoids, Saponins, Glycosides	*Staphylococcus aureus, Bacillus subtilis, E. coli*	(53)
13.	*Curcuma Longa* Linn.	Halodi/Arunachal Pradesh, Assam	Zingiberaceae	Curcuminoids	*Bacillus subtitlis, Bacillus licheniformis*	(54)
14.	*Zingiber zerumbet*	Awapuhi/Manipur	Zingiberaceae	Terpenoids, zerumbone, limonene	*Streptococcus mutans, Pythium myriotylum*	(55-57)

the usage of medicinal plants was discovered on a Sumerian clay slab in Nagpur, India which is almost 5000 years old. In other parts such as in China, the Chinese book of roots and grasses "Pen T'Sao", written by the emperor Shen Nung circa as early as 2500 BC, mentioned 365 drugs that are still used even today for various practices. The Vedas (Indian holy books) have signified various types of spices plants which are used even today not only in India but all over the World.[11]

Over the period of time, the knowledge on traditional medicinal plants is getting reduced in the younger generation due to a lack of knowledge, resources, and awareness. India is a vast country enriched with various types of biodiversity hotspots. Northeastern states cover the eastern Himalayas as well as there are many Indo-Burman biodiversity hotspots. WWF (World Wide Fund for Nature-India) has signified that the entire eastern Himalaya is a priority among the global 200 ecoregions while it has been stated by Conservation International that they have upscaled the eastern Himalayan hotspots which fall under the area of Sikkim, Arunachal Pradesh, and Darjeeling hills. Out of the nine important types of vegetation in India, six are found in Northeastern region which shows the richness in flora and fauna here. The forests of Northeast India possess more than half flowering plant species out of the total plant species present in that region. Out of 54 flowering plant species found in North eastern India 40 belongs to gymnosperms.[12]

In India, from the Himalayan region to Northeastern states to wide stretching Eastern Ghats and Western Ghats, the variety of flora and the potential abundance of medicinal plants will certainly give rise to lots of phytochemical compounds and its diverse properties. Any medicinal value of a plant lies in the fact that how much of a definite physiological positive change it can have on the human body. The compounds that bring about a change in the body are known as bioactive compounds. Some of the highly valuable bioactive compounds are tannins, alkaloids, flavonoids, and phenolic compounds. These are not only used as additives for food and spices, but also used for pregnant and lactating mothers for medicinal use.[13]

Synthetic microbial substances if used without any restraint, can lead to serious infectious diseases. Acquisition of antibiotic resistance by the microbes is a serious threat, which can be caused by the synthetic medicines that have been used frequently to treat the same diseases. The exposure of synthetic medicines induce gene transformation in microbes, leading to resistance development and making the drugs ineffective or that their doses must be increased to abnormal levels for treatment purpose. This in turn causes a cascade of adverse reactions in the body, leading to increased toxicity and side effects in the body. Hence, it is the need of time to create novel effective pharmaceutical drugs in a manner that the microbes will not be able to develop resistance against them in a long run, with safe use against human diseases.[14]

Drug discovery is the most important tool in modern-day biological science. The remedies that have been long unknown lie in the lock that is governed by the key of drug discovery. Mother nature has already produced a vast and amazing source of novel therapeutic targets. Usually, most of the drugs that have been discovered from a natural drug that is approved for commercial use are anti-infectives as well as anti-cancerous drugs.[15] Throughout time immemorial, various practices of practicing medicine were performed. One of them is "allopathy", the term used for modern western medicinal and diagnostic approaches to treat a disease. The prefix "allos" means opposite and "pathos" means suffering, i.e. in ancient times, a disease was cured by focusing on the symptom and doing the opposite of it. It received a lot of backlashes for this approach but now life has come full circle, and allopathy is the leading form of modern medicine at present. Allopathy focuses on specific treatment by providing or narrowing down the scope of knowledge to one point focus which is usually the root cause of the disease.[16]

Bioactive compounds

Plants produce various metabolites, among which secondary metabolites are highly effective in medicine production. There are many phytochemicals such as alkaloids, flavonoids, terpenes, and phenolic compounds are found in plants as secondary metabolites. Secondary metabolites may not be required for a living organism to survive but they play a role in how that organism interacts with its environment.

Table 3. Antimicrobial Screening performed on various Medicinal Plants found in various North Eastern States of India

No.	Botanical Name	Family	North-Eastern Name	Parts used	Extract	Organisms Inhibited			Ref.
						Gram-positive	Gram-negative	Fungi	
1.	*Cassia fistula*	Fabaceae	Sonalu/Sonaru	F,R	E	*S. aureus*	*S. typhi*	*Aspergillus niger*	(58)
2.	*Rubus moluccanus*	Rosaceae	Eelkek, Jutuli-poka, Katsol and Anshu,	L	E	*B. subtilis*	*E. coli*	*Candida albicans*	(59)
3.	*Ixora acuminata*	Rubiaceae	Flame of woods	F,FLW	E	*S. aureus*	*P. aeruginosa*	Nil	(60)
4.	*Plantago major*	Plantaginaceae	Singa gach, Lahuriya	SD,L	E	*S. aureus, S. pyogenes*	*P. aeruginosa*	*Candida albicans, Candida tropicalis*	(61)
5.	*Panicum maximum*	Poaceae	Ginipullu, Guinea grass	L,S,FLR	E	Nil	Nil	*Aspergillus tamari, Aspergillus niger*	(62)
6.	*Schima khasiana*	Theaceae	Noga-bhe	R	EA	*Bacillus cereus*	*E. coli, S. typhi*	Nil	(63)
7.	*Garuga pinnata*	Burseraceae	Dubdabey, Dieng khiang	L	M	*S. aureus, B. subtilis*	*Sbigelli boydii, Vibrio mimicus, E. coli*	*Candida albicans, Saccharomyces cerevisiae*	(64)
8.	*Litsea citrata*	Lauraceae	Mejangkori	L	E	Nil	*Vibrio campbellii, Vibrio parahaemolyticus*	Nil	(65)
9.	*Rhus javanica*	Anacardiaceae	Nutgall tree, Chinese sumac	L,B	E	*S. aureus, Listeria monocytogenes, S. epidermidis*	*S. pullorum*	Nil	(66,67)
10.	*Citrus medica*	Rutaceae	Bira-Jora, Bakel-Khowa-Tenga	F,R,B	E	*B. subtilis, S. aureus, Micrococcus luteus*	*E. coli*	Nil	(68)

Abbreviations: F-Fruit, R-Root, B-Bark, L-Leaves, S-Stem, FLR-Floret, SD-Seed, FLW-Flower, E-Ethanol, M-Methanol, EA-Ethyl Acetate

These metabolites protect the plants against various abiotic and biotic stresses. Besides, these compounds have high commercial and economic value as therapeutics for human use. However, with more diversified research, ultra-rare and new medicinal compounds with high therapeutic potential can be discovered.[17]

Various essential amino acids are of paramount importance in health-related activities and affect lots of organs if the proper amount of these essential compounds is not taken. Hence, it is always said to take a balanced diet. However not only these, the various plant metabolites have various properties including anti-oxidative, anti-diabetic, anti-allergic, anti-microbial, and anti-inflammatory properties. Certain plant extracts can significantly lower the cholesterol level in humans and improve bad nutrition. One example is that of beta-carotene content in golden rice which helps to combat vitamin A deficiency.[18]

Medicinal plants, especially those thriving in the biodiversity-rich northeastern states of India, heavily rely on their interaction with the rhizosphere microbiome. The rhizosphere, a dynamic region surrounding plant roots, plays a crucial role in soil nutrient cycling, microbial activity, and secondary metabolite production. As shown in Figure, microbial inoculants and tillage patterns significantly influence the physicochemical and biochemical properties of the soil, which, in turn, enhance nutrient uptake, abiotic stress tolerance, and plant resilience. These factors not only support plant health but also contribute to the biosynthesis of bioactive compounds such as alkaloids, flavonoids, and terpenoids, which hold immense antimicrobial potential. This interdependence highlights the importance of integrating rhizosphere management strategies into the conservation and sustainable utilization of medicinal plants.

Medicinal plants used in north eastern states of India

The Northeastern states of India comprise of Nagaland, Assam, Tripura, Manipur, Arunachal Pradesh, Sikkim, Meghalaya, and Mizoram.

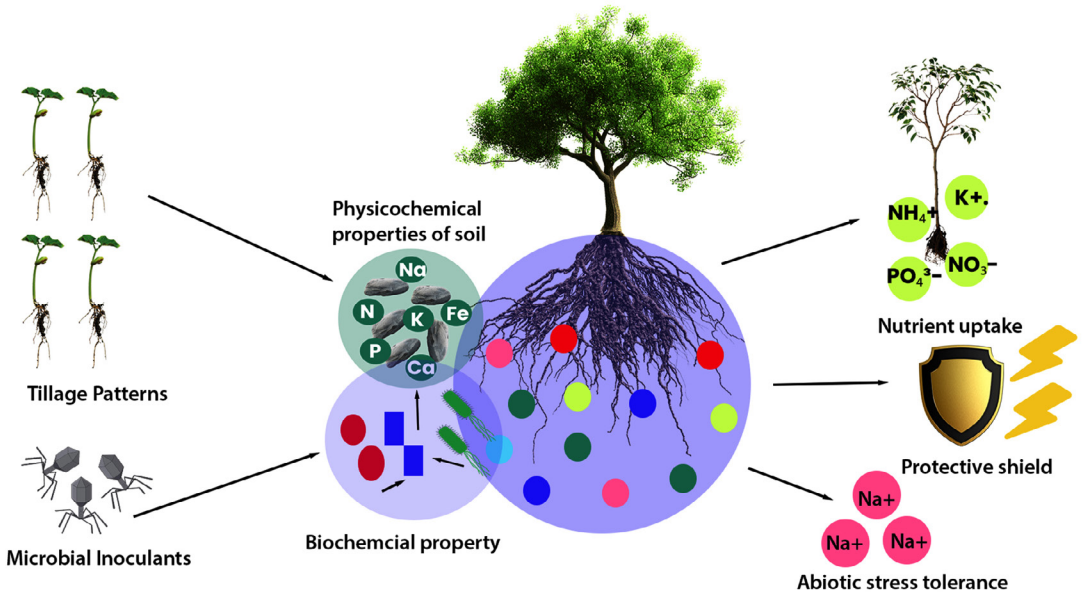

Figure. Rhizosphere microbiome and its influence on sustainable agriculture, nutrient cycling, and plant resilience: Tillage practices and microbial inoculants modulate the rhizosphere by altering soil physicochemical properties, thereby enhancing nutrient bioavailability and uptake efficiency. Rhizospheric microbes also establish a defensive barrier around root systems, limiting colonization by pathogenic organisms. Moreover, they contribute to ionic homeostasis under saline stress conditions. These interactions collectively support plant health and sustainable agricultural productivity

Demographically they all fall under the Northeast hills, Eastern Himalayas and the Brahmaputra and Barak valley plains. The northeastern states give us an abundance of valuable biota with a massive level of endemism. This region is so enriched with biota that various organizations such as WWF (World Wide Fund for Nature-India) have taken significant steps to protect these areas. Report suggests that this region must be rich in wild as well as native relatives of crop plants.[19]

The increasing research on traditional medicine and ethnomedicine can become the leading cause of the discovery of many novel therapeutic agents. Plants with the possibility of having antimicrobial properties must be tested against various microbes to confirm their activity. Researchers are working in this direction to develop better and highly efficient drugs against cancer and other diseases.

Antimicrobial screening

Throughout the centuries, there are certain bacteria and fungi have always clogged the progress made by humans. Certain notorious bacteria such as *Escherichia coli*, *Salmonella typhi*, and *Staphylococcus aureus* along with some strains of fungi like *Aspergillus niger* and *Candida albicans* posed serious threats to mankind. In-depth research on the therapeutic effects of various phytochemicals has made it possible to combat against these microorganisms. The plants found in forests and valleys of northeastern states of our magnificent India have been explored very much like all other regions and yet the extensive research has no match to these variety of potential uses hidden in the flora of Northern eastern States.

Certain plants found in this abode of India ranging from *Cassia fistula* to *Plantago major* have proved to be highly beneficial to mankind. In Table 3 the antimicrobial screening of various medicinal plants has been shown which can be pivotal in gaining knowledge for researchers to carry out various studies in regard to finding cure for various bacterial and fungal diseases.

Bacteria have been categorized as either Gram-positive or Gram-negative bacteria. This categorization is quite essential as to give the researchers a firsthand boost and knowledge of which exact extracts of which exact parts of plants are beneficial to stop the growth of targeted microorganisms.

It is very important to know that not all parts of all plants can inhibit the growth of targeted microbes. For example, as given in Table 3. The fruit and flower only of *Ixora acuminata* if extracted by ethanol can be used for retarding the growth of *S. aureus* as well as *P. aeruginosa* The need of specification is of utmost requirement in this modern world of vastness and diversity.

CONCLUSION

North-Eastern India is a hub of many medicinal plants with anti-inflammatory, anti-oxidant, and anti-microbial properties that have been discussed in the article. In the present scenario the antibiotic resistance has posed a serious threat to the human beings due to rampant use of antibiotics. The phytochemicals derived from the medicinal plants can be a better alternative to the antibiotics, and solving the issue of antibiotics resistance by the bacteria. However, in-depth research is required to prepare therapeutics, targeting the microorganisms with high precision and efficacy. Besides the anti-microbial property, other therapeutic benefits of these plants should be explored using latest technologies for better health and welfare of human being.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORS' CONTRIBUTION

PSJ conceptualized and supervised the study. PSJ and PB wrote the manuscript. SK, PK, GM and MKJ reviewed and edited the manuscript. All authors read and approved the final manuscript for publication.

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DATA AVAILABILITY

All datasets generated or analyzed during this study are included in the manuscript.

ETHICS STATEMENT

Not applicable.

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