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# Phytochemical properties of some important medicinal plants of north-east India: A brief review

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**Abstract**
Plants have been the source of medicine since times immemorial. Numerous plants are known to have therapeutic potential which have been used in traditional health care system by various communities throughout the globe. Several modern medicines have also their origin in plant derived products. The therapeutic potential of medicinal plants is due to the presence of various phytochemicals in them. Phytochemicals are non-nutritive, chemical substances that arise naturally on plants and have numerous defensive properties. Most of the phytochemicals like tannins, saponins, carotenoids, terpenoids, flavonoids and polyphenols have antimicrobial, antioxidant and anti-inflammatory activities. North-eastern India represents one of the mega biodiversity hot spots of the globe. The region has a long history of traditional use of numerous plants for curing different ailments of human. In this article a brief review has been made on the ethno-medicinal uses of nine indigenous medicinal plant species along with their phytochemical analysis. The nine indigenous species, namely *Oldenlandia corymbosa, Ricinus communis, Ipomea aquatica, Terminalia bellerica* (*Bhumura*), *Bryophyllum pinnatum, Clerodendrum viscosum, Hibiscus sabdariffa, Xanthium strumarium, Mentha piperita* were considered for the study. Documentation on their ethno-medicinal uses by the indigenous communities has been discussed. Phytochemical analysis carried out by different workers on the plant species under study were surveyed and discussed. The study revealed that the listed medicinal plants have potential therapeutic properties with immense potential for their therapeutic use as well as being the source of new drugs in modern medicine.

**Keywords:** Medicinal plants, Northeast India, *Ethno-medicinal use*, phytochemical constituents

## Introduction
Medicinal plants have been playing a crucial role on the health care and well being of man since the dawn of human civilization. According to World Health Organization (WHO), medicinal plants were the best source to obtain variety of drugs. About 80 *per cent* of individuals from developed countries use medicines, which has compounds derived from different medicinal plants. However, such plants should be further investigated to better understand their properties, safety, and efficiency (Arunkumar, 2009) [5].
Phytochemicals are non-nutritive, chemical compounds and occur naturally on plants during metabolic processes having diverse defensive actions or disease preventive properties. Plants are known to produce these chemicals to protect them (Minakshi, *et al.*, 2016) [41]. The secondary metabolites are naturally occurring in leaves, vegetables and roots that have defense mechanism and protect from various disease (Sanjib *et al*., 2018). Phytochemicals appear to neutralize free radicals, inhibit enzymes that activate carcinogens, and activate enzymes that detoxify carcinogens (Saxena, 2013) [57]. Phytochemicals like alkaloids, flavonoid terpenoids, carotenoid,etc have antidiuretic, anti-inflammatory, antianalgesic, anticancer, anti-viral, anti-malarial, anti-bacterial and anti-fungal activities playing a vital role in preventing various diseases.
North-east India has been known for its rich biological diversity. Assam is one of the important states of North East India having rich traditional knowledge of using indigenous plant species for treating different ailments. Many medicinal plants and wild edible plants have been studied for their pharmacological properties (Narzary, 2015) [44]. Nature has endowed this region with full of medicinal plants, wild edible vegetables and various indigenous people of this region use these resources in their diet and in treating various diseases (Sanjib *et al*., 2018) Most of the medicinal plants used by local people and tribes of the state of Assam are indigenous, mostly grown in wild and has been under use since times immemorial. The active ingredients and potent phytochemicals with promising pharmacological properties present in

those plants are yet to be explored (Mao, 2000) [38]. A number of studies were made to investigate the traditional uses and the phytochemical constituents. However all these studies were fragmentary in nature and needs to be thoroughly reviewed. The current study was focused on the traditional therapeutic use and phytochemical constituents in nine medicinal plant species *viz*., *Oldenlandia corymbosa, Ricinus communis, Ipomea aquatica, Terminalia bellerica (Bhumura), Bryophyllum pinnatum, Clerodendrum viscosum, Hibiscus sabdariffa, Xanthium strumarium, Mentha piperita* native to North-eastern states of India, particularly in Assam.

**Current scenario and importance of medicinal plant research**: With the increase in world population and widening economic disparity between the poor and the rich, affordability of healthcare systems to the under privileged is becoming a global concern. World Health Organization (WHO) recognized the potential of traditional and alternate systems of medicine to provide assurance to the health security of developing nations. Globally 72000-77000 (17-18% of world flora) plants are currently utilized for medicinal purpose. Many of them more than 200 therapies employed by different cultures to treat physical and psychological ailments employ medicinal plants as curative medicines. Global imports and exports (2000-2008) of medicinal plants were worth US$ 1.59 and 1.14 billion / year, respectively with > 40 *per cent*, growth rate per annum. Out of the 3000 medicinal plants traded internationally, only 900 are under cultivation and majority of the exported biomass is harvested from the wild. Loss of habitat, over harvesting, global warming and climate change are severely affecting medicinal plant populations, threatening (15000 species) their future existence. To conserve the global wealth of medicinal plants and their biodiversity, cultivation is emerging as an economically viable option. Many exporting nations are exercising this option as cultivated plant material is accepted by companies dealing with herbs. Future holds promise for cultivated medicinal plants as global commodity of commerce. India with a wealth of 8000 medicinal plants, availability of cultivation and processing technologies, has excellent potential to harness the economic power of these plants (Rao and Rajput, 2010) [52]. Globalization has opened up markets for transnational companies in medicinal plants exporting countries and intellectual property protection (IPR) issues have become a serious concern to protect indigenous knowledge from biopiracy. While India has successfully inventorized 220268 numbers of its medicinal formulations through TKDL (Traditional Knowledge Digital Library) project, many developing nations face the threat. In spite of the presence of great diversity, the medicinal plant research in North -east India, is in its infancy and it is the need of the hour to undertake appropriate scientific studies for conservation and use of these valuable resources.

**Phytochemical studies in medicinal plants**

It is estimated that up to four billion people (representing 80% of the world's population) living in the developing world rely on herbal medicinal products as a primary source of healthcare and traditional medical practice which involves the use of herbs is viewed as an integral part of the culture in those communities (Mukherjee, 2002; Bodeker *et al*., 2005; Bandaranayake, 2006) [43, 10, 6]. The beneficial effects of phytochemicals may arise from activation of feed intake and secretion of digestive secretions, immune stimulation, anti-bacterial, coccidiostatic, anthelmintic, antiviral, anti-inflammatory activity and inhibition and antioxidant (Mahato and Sen, 1997) [36].

Until the 18th century, the therapeutic properties of many plants, their effect on the human organism and their method of treatment were known, but the active compounds were unknown (Faridi, 2010) [27]. After centuries of empirical use of herbal preparation, the first isolation of active principles alkaloids such as morphine, strychnine, quinine etc. in the early 19th century marked a new era in the use of medicinal plants and the beginning of modern medicinal plants research (Saxena *et al*., 2013) [57]. Recently, several workers have significantly reported various ethnomedicinal informations (Baruah *et al*., 2013; Baro *et al*., 2015) [8, 7]. But only a limited number of local plants have been explored for their phytochemical and antioxidant potential in this region (Baruah *et al*., 2013) [8]. Therefore, the evaluation of ethnomedicinal plants and their phytochemical properties has great significance and becomes an essential part. Over the last decade, however, interest in drugs of plant and probably animal origin has grown steadily (Hamburger *et al*., 1991) [23]. Recent studies have reported that natural antioxidants obtained from therapeutic plants protect from toxic and harmful effects of free radicals and have wide range of pharmacological effects, including antimicrobial, antimutagenic, antiallergic, antioxidant free radical scavenging activity and anticarcinogenic effects (Lobo, 2010; Puertollano, 2011) [34, 48].

Phytomedicine almost went into extinction during the first half of the 21st century due to the use of the 'more powerful and potent synthetic drug'. However, because of the numerous side effects of these drugs, the value of medicinal plants is being rediscovered as some of them have proved to be as effective as synthetic medicines with fewer or no side effects and contraindications (Saxena, 2013) [57]. It has been proved that although the effects of natural remedies may seem slower,the results are sometimes better on the long run especially in chronic diseases (Akunyili). In recent years, assessment of phyto-constituents has been considered to be the most vital and promising step in the medicinal plant studies.

**Classification of phytochemicals**

The exact classification of phytochemicals has not been given so far, because of their diverse forms and structures. Classically, the phytochemicals have been classified as primary or secondary metabolites, depending on their role in plant metabolism. Primary metabolites include the common sugars, amino acids, proteins, purines and pyrimidines of nucleic acids, chlorophylls etc. Secondary metabolites are the remaining plant chemicals such as alkaloids, terpenes, flavonoids, lignans, plant steroids, curcumines, saponins, phenolics and glucosides (Hahn, 1998; Ramawat *et al*., 2009) [21, 51]. The therapeutic efficacy of plants is because of these secondary metabolites for curing many diseases. The phytochemicals and their pharmacological activities are given in table 1.

**Table 1:** Pharmacological activities of different phytochemicals

| Phytochemicals | Pharmacological activities |
|---|---|
| Flavonoids | Antioxidant, antimicrobial, cytotoxicity, anti-inflammatory, antitumor activity, enzyme inhibition, oestrogenic activity, anti-allergic activity, vascular activity. |
| Tannin | Anti-inflammatory, antiseptic, antioxidant and haemostatic pharmaceuticals |
| Alkaloids | Antimicrobial, antihypertensive effects, anti-arrhythmic effect, antimalarial activity, anticancer actions, antimalarial, antispasmodic analgesic, diuretic activities. |
| Terpenoids | Anti-carcinogenic, anti-malarial, anti-ulcer, hepaticidal, anti-microbial or diuretic activity, sesquiterpenoid, antiviral, anthelmintic, anti-inflammatory properties |
| Saponin | Anti-inflammatory, antiviral, plant defence activities, antimicrobial, antioxidant, immunostimulant, hypocholesterolaemic and anti-carcinogenic properties |
| Glycosides | Antifungal and antibacterial properties |

**Botanical features of the plant species under study**

The botanical descriptions of the nine species under consideration for the present study are presented below. Photographs of identifying features of the plant species are presented in Fig. 1.

**A. *Oldenlandia corymbosa* (Diamond flower/Bonjaluk)**: A flowering plants of the genus *Oldenlandia* and family Rubiaceae. It is widely distributed in the tropical and temperate parts of both the hemispheres and has about 240 different species worldwide. The plant has ascending or erect stems which are 4-angled. Leaves are linnear-oblong or narrow elliptic, almost stalkless, measuring 1-3.5 cm long and 1.5-7 mm wide (Wagner *et al*., 1999) [64]. Flowers contain slender stalks ranging from 3-9 mm, and flowers white or slightly pinkish to purple. Flower tube consists of 4 petals and is about 1.5-2 mm in length (Das, *et al*., 2019) [16]. Fruit is capsular, sub-globose, ovoid and seeds are smooth and dark brown.

**B. *Ricinus communis* (Castor oil plant/Eragoch):** They are Perennial shrub belonging to spurge family, Euphorbiaceae. Stems are aerial, erect, herbaceaous but woody below, branched and hollow. Young branches are covered with hair like outgrowth. Leaves are petiolate, exstipulate, alternate, deeply palmately lobed with 7 or more lobes. Venation is palmately reticulate divergent. Fruit is covered by spinous outgrowths and splits into three one seeded cocci. However, the seeds from castor bean plant are poisonous to people, animal and insects. The toxicity is due to the presence of a glycoprotein 'ricin'. The seed is only toxic if the outer shell is broken or chewed. It may cause an acute and potentially fatal gastroenteritis in addition to neurological and opthalmological lesions.

**C. *Ipomea aquatic* (swamp morning glory/kolmou):** It is a semi aquatic, tropical plant which grows as a vegetable for its tender shoots and leaves. It is found throughout the tropical and subtropical regions of the world, although it is not known where it originated (Minakshi *et al*., 2016) [41]. Its stems are 2–3 metres or longer, rooting at the nodes, and they are hollow and can float. The leaves vary from typically sagittate (arrow head-shaped) to lanceolate, 5–15 cm long and 2–8 cm broad. The flowers are trumpet-shaped, 3–5 cm in diameter, and usually white in colour with a mauve centre.

**D. *Xanthium strumarium* (cocklebur/chota dhatura/ogora kata):** is a species of annual plants belonging to the Asteraceae family. *X. strumarium* is an annual plant, having 1 to 1.2 m height. The stems is stout, rough, green or brownish in color, frequently red-spotted and hairy. The leaves are alternate, dull green on the upper surface and paler below, with short bristly hairs on both surfaces; flowers are yellowish green and the fruit is covered with hooked spines. The plant produces allergic contact dermatitis in susceptible human (Khan *et al*., 2020) [30]. The herb as such is suspected to be poisonous, but the toxic substances are removed by washing and cooking (Stuart, 1981) [62]. A highly toxic glycoside (Carboxyatractyloside) is present in the seeds and seedlings of *X. strumarium*. The Young floral tops and the two leaves below are boiled in water and eaten as a pot-herb in Assam (Cole *et al.*, 1980) [14].

**E. *Terminalia bellerica* (Bahera/Bhumura):** *Terminalia bellerica* Roxb. (Combretaceae) is mostly found in decidous forests in India except a dry area (Meena *et al*., 2010) [40]. It is a large deciduous tree with broadly leaves cluster at the ends of the branches, a thick brownish grey bark, attaining a height 20 to 30 meters in elevation (krthikeyan *et al.,* 2012) [33]. Leaves are petiolate and around 8-20 cm long. The flowers are pale greenish yellow. The fruits are ovioid grey drupes with 1.5-2.5 cm in diameter (Das *et al.,* 2012) [15].

**F. *Bryophullum pinnatum*(air plant/dupor tenga):** It is a succulent, perennial plant from the family Crassulacea. It has become naturalized in Tropical and Sub-tropical areas. Leaves are decussate, succulent, glabrous, oval to elliptical, long petiolate, thick, fleshy and dark with crenate border, reaching up to 150 cm in height. The inflorescences are hermaphrodites, tubular, pendulous, monopetalas, pale green or yellow-red, with cup swollen and corolla longer than the cup. The fruit are in the form of hoods which become scaly polispermos follicles that are housed within the hoods (Amaral *et al*., 2005; Jessica, 2008; Joseph *et al*., 2011; Moreira *et al*., 2012) [4, 27, 28, 42].

**G. *Clerodendrum viscosum* (hill glory bower/ bhet-tita):** It is a perennial shrub belonging to the family Lamiaceae. It is distributed in nearly all the states of India. In Assam, it is by and large observed in Bongaigaon. It is characterized by its entire or toothed, oppositely arranged leaves, terete stems, terminally or axillary cymose inflorescence, hypogynous bisexual flowers and exalbumenous seeds (Kirtikar & Basu, 1991; Steane *et al*., 1999) [31, 61]. Flowers are white, in large terminal panicles. Fruit is a drupe, bluish black when ripe, enclosed in accrescent calyx.

**H. *Hibiscus sabdariffa* (Roselle/Tengamora):** It is a flowering, annual or perennial herb or woody-based subshrub, belonging to the family Malvaceae, believed to be of native to East Africa, Asia (India to Malaysia) or Tropical Africa. The plant is about 3.5m tall and has a deep penetrating taproot. It

has smooth, cylindrical, dark green to red stems. Leaves are alternate, green with reddish veins and long or short petioles. Flowers borne singly in the leaf axils are upto 12.5 cm wide, yellow or buff with a rose or maroon eye. The typically red calyx consists of 5 large sepals with a collar of 8-12 slim, pointed bracts. Seeds are kidney shaped, light brown, covered with minute stout and stellate hairs (Mahadevan *et al*., 2009) [35]

**I. *Mentha piperita* (Peppermint/Pudina):** Peppermint (Mentha × piperita L) is a perennial, glabrous and strongly scented herb belongs to the family Lamiaceae. Peppermint is a hybrid mint. It is a rhizomatous, upright perennial which is most commonly grown as a culinary or medicinal herb and/or ground cover. It typically grows 1 to 2 ft. tall and wide but will spread further by rhizomes forming an attractive ground cover. Features rounded to lance-shaped toothed dark green leaves (1 to 2 in. long) and terminal spikes of small pink to lavender flowers in summer that rarely set seed.

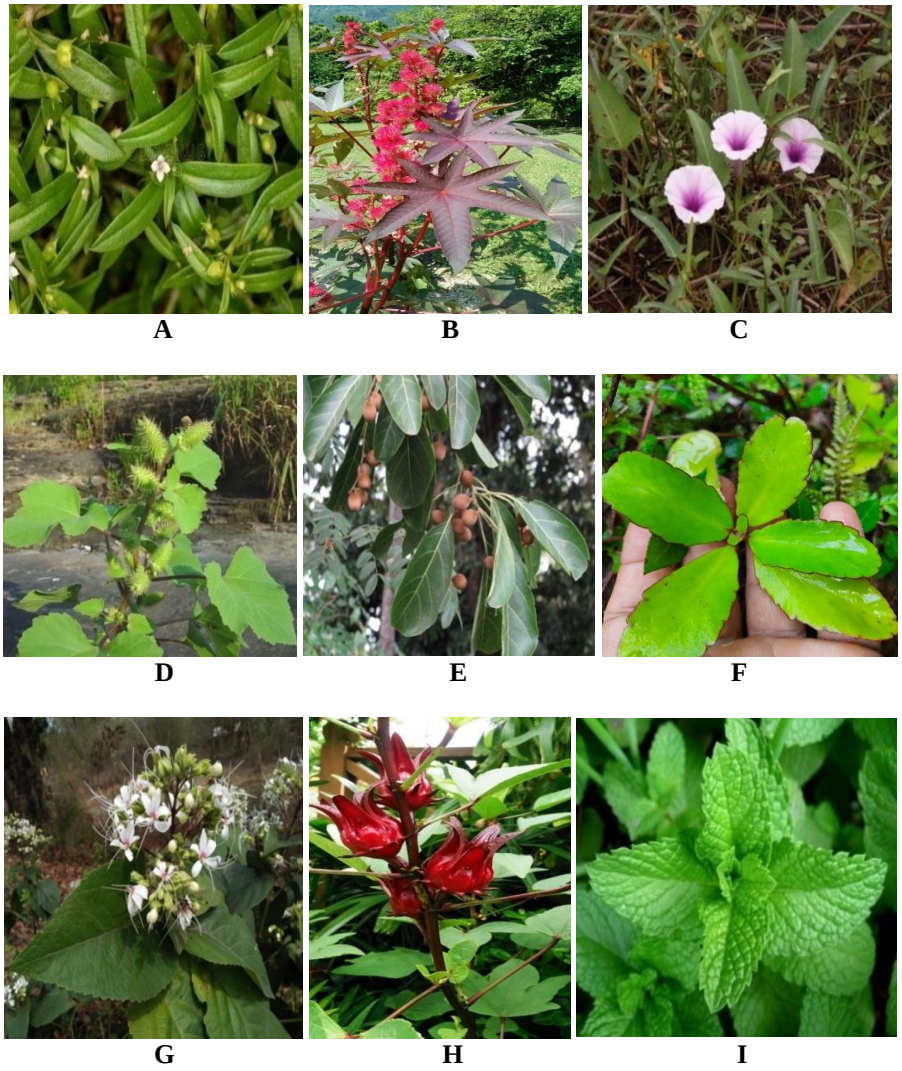


**Fig. 1:** A. *Oldenlandia corymbosa* B. *Ricinus communis* C. *Ipomea aquatic* D. *Xanthium strumarium* E. *Terminalia bellerica* F. *Bryophullum pinnatum* G. *Clerodendrum viscosum* H. *Hibiscus sabdariffa* I. *Mentha piperita*

**Ethnomedicinal uses of nine plant species in Assam, India:** The traditional use of medicinal plants for the treatment of various diseases and disorders is an age-old practice. A survey was made over the reported literatures about the traditional uses of the nine medicinal plant species under this report. The summery of ethnomedicinal uses of the species are presented in Table 2.

**Table 2:** Ethnomedicinal uses of the Common Medicinal Plants of North-East India.

| Medicinal plant species | Ethnomedicinal uses |
|---|---|
| *Oldenlandia corymbosa* | Leaves used to cure stomach problems and sore eyes; treats internal and external inflammation and infection, e.g., tonsillitis, bronchitis, pneumonia, mumps, acute appendicitis, cholecystitis, pelvic infection, urinary tract infection, rheumatic fever and gout (Bashera *et al*., 2021) [3]. The plant is used as a painkiller, tonic and treats Jaundice, viral infections, cancer, acne, skin ailments, hepatitis, eye disease and bleeding (Chen *et al*., 1992) [12], while roots are used as a depressant. |
| *Ricinus communis* | Abdominal disorders, arthritis, backache, muscle aches, bilharziasis, chronic backache and sciatica, chronic headache, constipation, expulsion of placenta, gallbladder pain, period pain, menstrual cramps, rheumatism, sleeplessness, and |

| | |
|---|---|
| | insomnia (Marwat *et al*., 2017) [39]. |
| *Ipomea aquatica* | Used in curing nose bleeding, piles and high blood pressure. Further, leaf extract can be used to reduce blood sugar levels and as antibiotics against *Escherichia coli*, *Pseudomonas aeruginosa* and *Bacillus subtilis*, used against jaundice and nervous debility. The floral buds are used as an Anthelminthic. |
| *Xanthium strumarium* | The plant parts i.e. leaves, root, stem and seed used in the treatment of malaria, epilepsy, salivation, leucoderma, rheumatism, tuberculosis, allergic rhinitis, sinusitis, urticaria, rheumatoid arthritis, constipation, diarrhoea, leprosy, lumbago, pruritis, bacterial and fungal infections; Treatment of tumor and strumous diseases (Rosangkima *et al*., 2010) [55] |
| *Terminalia bellerica* | The dried ripe fruit has been used in the treatment of diarrhoea, cough, hoarseness of voice, eye diseases and scorpion-sting and as a hair tonic. A decoction of the fruit is used for treating cough and pulp of the fruit is useful in treating dysenteric- diarrhoea, dropsy, piles and leprosy (Chauhan *et al*., 2013) [11]. The fruits are also used in astringents, digestive, aperients, stypic, narcotic, Unripe fruit is a mild laxative and ripe fruit is an astringent (Rastogi *et al*., 2004) [53] |
| *Bryophullum pinnatum* | treatment of hypertension, kidney stones, headaches, inflammation, cancer and as a popular remedy for fever, ear-ache, cough, diarrhoea, dysentery, abscesses, ulcers, insect bites, heart-troubles, epilepsy, arthritis, dysmenorrhea and whitlow (Gill, 1992) [20]. The leaves have been used for the treatment of gastritis, various bacterial, viral and fungal infections, leishmaniasis, pain, inflammation, some tumors, respiratory infections, diabetes, hypertension, flu and fever (Fernandes *et al*., 2019) [18]. |
| *Clerodendrum viscosum* | Fresh and clean leaves are used for the cure of diarrhoea, liver issues, and headache. The leaves and the roots are used for malaria, scabis, scorpion sting, snake bite and tumours, fever, pain, diabetes, inflammation, wounds, rheumatism, deworming, dysentery, diarrhea, snakebite, blood pressure, and cancer. Leaves, roots and flowers of *C. infortunatum* are used as medicine in the form of paste, juice and ash (Prashith Kekuda *et al*., 2019) [47]. Roots are used to treat bronchitis and asthma in Assam, India (Kalita *et al*., 2014) [29]. Leaves and flowers are used as antidote for scorpion sting while sprout is used as antidote for snakebite (Shetty *et al*., 2002; Punekar *et al*., 2011) [59, 49]. In Manipur, the plant is used against boils (Ramashankar *et al*., 2015) [50]. |
| *Hibiscus sabdariffa* | Health benefits of consuming the herbal tea involves the hypotensive effect, hypolipidemic effect, diuretic, antimicrobial, anti-carcinogenic, remedy for relieving coughs and biliousness, toothaches, urinary tract infections, improves the kidney functions and is neuroprotective (Riaz *et al*., 2021) [54]. It has been utilized to cure degenerative diseases like hypertension, hyperlipidemia, cancer and other inflammatory diseases of liver and kidney. It's also proven to treat cardiac, diuretic, sore throat and cough, cholerectic, febrifugal and hypotensive effect, liver disorder, decrease the viscosity of the blood, induce lactation and stimulate intestinal peristalsis (Nguyen, 2020) [45]. |
| *Mentha piperita* | It has proven health benefits for irritable bowel syndrome (IBS), nausea, skin conditions, headaches, cold and flu. In addition to traditional food flavoring uses, it is also recognized for their traditional use to treat fever, cold, digestive, anti-viral, anti-fungal and oral mucosa and throat inflammation (Mahendran *et al*., 2020) [37] |

**Phytochemical analysis**

Phytochemical analyses of traditional medicinal plants were carried out by various workers. However, the works reported were very much fragmentary. There are repetitions of these species investigated by various workers. At the same time, different species are also investigated by different workers, so it is the prime necessity to compile this investigation and the reports under one umbrella so that we can have a comprehensive understanding about the scientific investigation made on the traditional medicinal plants. With this view, as a case study we undertook nine important medicinal plants prevalent in North-eastern region on which various workers have reported their medicinal properties along with the presence of therapeutically important bio-molecules. Phytochemical analysis for leaves (L), stem (S) and roots (R) of *Oldenlandia corymbosa*, *Ricinus communis*, *Ipomea aquatica*, *Terminalia bellerica (Bhumura)*, *Bryophyllum pinnatum*, *Clerodendrum viscosum*, *Hibiscus sabdariffa*, *Xanthium strumarium*, *Mentha piperita* are tabulated in Table 3.

From the detailed survey on works carried out by various workers, it was observed that the common compounds *viz*., flavonoid, tanin and saponin are available almost in all the medicinal plants. However the study revealed the differential presence of phytochemicals in different plant species. Looking into this aspect, it was observed that *Ipomea aquatic* and *Terminalia bellerica*, were among the plant species studied, which contained almost all the phytochemicals under consideration. Yadav and Agarwala (2011) carried out qualitative and quantitative phytochemical analysis in seven plants *viz.*, *Bryophyllum pinnatum, Ipomea aquatica, Oldenlandia corymbosa, Ricinus communis, Terminalia bellerica, Tinospora cordifolia, and Xanthium strumarium.* They used different methods of extraction of plant parts to produce a marked difference in the yield and time of extraction and their findings provided evidence that crude aqueous and organic solvent extracts of these tested plants contain medicinally important bioactive compounds and it justifies their use in the traditional medicines for the treatment of different diseases. Minakshi *et al*. (2016) [41] also investigated preliminary phytochemical analysis for leaves, stem and roots of *Oldenlandia corymbosa*, *Ricinus communis*, *Ipomea aquatica*, *Xanthium strumarium*, *Mentha piperita* showed positive results for saponins, tannins flavonoids, terpenoids, glycosides, alkaloids, carbohydrates, steroids, coumarin and protein.

**Table 3:** Quantitative results for phytochemicals in the studied nine medicinal plant

| Species/Phytochemicals | Steroid | Terpenoid | Alkaloid | Flavonoid | Tanin | Saponin | Glycoside | Coumarin | Carbohydrate |
|---|---|---|---|---|---|---|---|---|---|
| *Oldenlandia corymbosa* | - | - | - | ++ | ++ | ++ | - | - | - |
| *Ricinus communis* | - | + | - | ++ | ++ | ++ | + | + | - |
| *Ipomea aquatica* | + | + | + | ++ | ++ | ++ | + | ++ | + |
| *Terminalia bellerica* | + | + | + | ++ | + | + | + | + | - |
| *Bryophyllum pinnatum* | + | + | + | + | + | + | + | - | + |
| *Clerodendrum viscosum* | - | - | - | ++ | - | + | - | - | ++ |
| *Hibiscus sabdariffa* | - | - | - | + | ++ | - | - | - | - |
| *Xanthium strumarium* | - | - | ++ | ++ | ++ | ++ | ++ | ++ | - |
| *Mentha piperita* | - | - | + | ++ | + | ++ | + | ++ | - |

- = indicates absence of phytochemicals + = indicates presence of phytochemicals ++ = shows high concentration

Qualitative screening of the phytochemical components of the hexane, ethyl acetate and methnol extracts were made by Phukan *et al*. (2014) [46]. The results revealed the presence of alkaloids, polyphenols, flavonoids, terpenoids, carbohydrates and glycosides while absence of steroids in *Bryophyllum pinnatum.* Phytochemical screening in *Bryophyllum pinnatum* revealed the presence of tannins, alkaloids, flavonoids, saponins and terpenoids while steroids were found absent (Adeniyi *et al*., 2010) [1]. Higher concentration of carbohydrates based on Fehlings test was observed while investigating the phytochemical property of in *Clerodendrum viscosum* (Swargiary *et al*., 2019) [63]. Chukwu *et al*. (2019) [13] investigated the phytochemical properties in raw seeds of *Hibiscus sabdariffa* and found that flavonoids, tannin, polyphenols, alkaloids and saponins were present, while there is absence of terpenes, steroids, glycosides and tannins. From the qualitative analysis, it was observed that the most abundant phytochemical was tannin followed by flavonoid.

The qualitative analysis for phytochemicals in all the nine medicinal plants indicated that a number of phytochemicals showed positive results in their specific tests. Although a few had been determined in abundance whilst a few in trace quantity. In the present study, the phytochemical screening of nine medicinal plants showed positive results for steroid, terpenoid, alkaloid, flavonoids, tannins, saponins, glycosides, coumarin and carbohydrates. From the Table 3, it could be realised that, flavonoids were present in all the plants. Tanins were found to be present in the extracts of all the plants except *Clerodendrum viscosum*, while saponins were absent only from *Hibiscus sabdariffa.* The phytochemical investigation of *Oldenlandia corymbosa* shows the presence of flavonoid, tannin and saponin in high concentration. In *Ricinus communis*, phytochemicals *viz*., terpenoid, glycoside, coumarin with high concentration of flavonoids, tannins and saponins were present. However, relatively concentration of tannins and saponins were higher in comparision to the others. Out of the above nine medicinal plants, *Ipomea aquatica* was found to be unique having all the phytochemicals present. The results revealed the presence of all the phytochemicals except carbohydrate in *Terminalia bellerica.* In *B. pinnatum* the presence of all of the studied phytochemicals except steroids and coumarin were observed. *C. viscosum* possessed an excessive quantity of flavonoid and carbohydrate and considerable amount of saponin. It was observed that methanolic extract of *Hibiscus sabdarifa* calyces possessed higher phenolic content, tannin and a considerable amount of flavonoids. In *Xanthium strumarium* confirmed the phytochemical like alkaloids, saponins, tannins, flavonoids, glycosides and coumarins. In *Mentha piperita* the phytochemical *viz*., alkaloids, saponins, tannins, flavonoids, glycosides and coumarins were found to be present.

Phytochemical analysis conducted on the plant extracts revealed the presence of constituents which are known to exhibit medicinal as well as physiological activities (Sofowra, 1993) [60]. Presence of steroid, terpenoid, alkaloid, flavonoids, tannins, saponins, glycosides, coumarin and carbohydrates were recorded in the present study. These compounds are responsible for the pharmacological activities i.e. antimicrobial, antioxidant, anti-salmonella, hepatoprotective, antispasmodic, and anticancer activities, etc. Hence, the plants under study could play a significant role in the prevention and treatment of many diseases and disorders. Further evaluation needs to be carried out in order to explore the concealed areas and their practical clinical applications, which can be use for the welfare of the mankind. In this review, we carried out an extensive literature survey to compile information available on the traditional uses, pharmacological and phytochemical properties of all the selected nine medicinal plants of North-east India by referring standard literatures available, which could be a benchmark for further comprehensive studies on the medicinal plants of the region.

**Future prospects**

In the face of the increasing use and fast-growing market of herbal medicines and other herbal healthcare products, in both developing and developed countries of the world, policy-makers, health professionals and the public are increasingly expressing concerns about the safety, efficacy, quality, availability, preservation, and further development problems of these herbal products. In order to allay these concerns, extensive research on herbal medicines is needed to be undertaken. Fortunately, quite extensive phytochemical and pharmacological researches on medicinal plants and herbal medicines are already in place throughout the world and efforts are being made to isolate and identify their active chemical constituents.

Herbal medicine-based Traditional Medicine (TM) practices remain widespread in developing countries and that of Complementary and Alternative Medicine (CAM) is increasing rapidly in developed countries. In order to ensure quality and safety of herbal medicines, their production, sale and use should be officially and legally controlled by established rules and regulations in all countries where they are used for medical and therapeutic purposes and efforts should be made to raise public awareness about the risks and benefits of using herbal medicines (Ghani, 2013) [19].

Alternative medicine is better than our conventional allopathic medication and can enhance the impact of conventional drugs if used properly. Natural product derived from plants may be do not have any side effects till date if used in a specific dose. Some of the medicinal plants work

unbelievably in certain diseased conditions according to the tribal people of Assam. Maybe while hunting for drugs in laboratories for certain deadly diseases day and night, researchers and scientists are missing some miraculous and potent phytochemical constituents which could be modified for formulating the drug, which are present in the plants grown in wild and ignorance on the roadside backyards and valleys of North-East India. It may be concluded safely that herbal medicines hold good future prospects and they may, one day emerge as good substitutes or better alternatives for synthetic chemicals-based allopathic drugs or may even replace them.

## Conclusions

The selected nine medicinal plants are the source of the secondary metabolites *i.e*., alkaloids, flavonoids, terpenoids, tannin, steroid, saponin and coumarin. Medicinal plants play a vital role in preventing various diseases. The antidiuretic, anti-inflammatory, antianalgesic, anticancer, anti-viral, anti-malarial, anti-bacterial and anti-fungal activities of the medicinal plants are due to the presence of the above mentioned secondary metabolites. Secondary metabolites could explain the use of traditional medicinal plant for treatment of some illnesses. These plants can also be used to discover bioactive natural products that may serve as leads for the development of new pharmaceuticals. Medicinal plants are used for discovering and screening of the phytochemical constituents which are very helpful for the manufacturing of new drugs. The phytochemical analysis of the medicinal plants are also important and have commercial interest in both research institutes and pharmaceuticals companies for the manufacturing of the new drugs for treatment of various diseases. There is a need for further study for the isolation and identification of individual phenolic compounds, other biologically active components and also *in vivo* studies are needed for better understanding of their mechanism of action.

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