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Ethnomedicinal Plants Used Against Diarrhea Available in Mizoram, Northeast India: A Systematic Review

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Abstract—Diarrhea is the frequent passing of watery stools not less than three times per day and may occur due to unhygienic lifestyle or infection. Diarrhea kills approximately 1.4 million people annually and is the 9th and 6th leading cause of death at a global level and India respectively. The therapy for diarrhea includes antibiotics and other agents, including a number of medicinal plants at global level. India, in particular northeast, is rich in medicinal plants and various Indian systems of medicine make use of these diverse flora. Mizoram lies within the Indo-Myanmar biodiversity hotspot and is blessed with a rich floral diversity. Though there are a number of available published literatures on medicinal plants that are used for various purposes, there is a lack of research information regarding the traditional medicinal plants used against diarrhea. The extent of the status of the research work carried out on medicinal plants used against diarrhea is still uncertain. Therefore this paper aims to systematically highlight the quantity, status of research work, and the scope for future research with medicinal plants available in Mizoram having ameliorative property against diarrhea. The literature survey revealed a total of 68 traditionally used medicinal plants available in Mizoram with a remedial property for diarrhea wherein 24 of these had been subjected to scientific evaluation. This paper provides a comprehensive compilation about the available ethnomedicinal plants that would facilitate in the search for newer and safer antidiarrheal therapeutic lead(s) and standardization of herbal medicine(s).

Keywords: Antidiarrhea, ethnobotany, ethnopharmacology, phytomedicine, secondary metabolites, traditional medicine.

INTRODUCTION

The humankind has relied on plants for food and curing diseases for thousands of years (Sen and Samanta 2015). Medicinal plant (MP) can be considered as any plant if any of its one or more organs contain phyto-material that can be utilized for curative action or that can act as precursors intended for chemo-pharmaceutical semisynthesis (Penso 1980). Plants with medicinal value are valuable sources for phytomedicines. They had been in cultivation since 60,000 years ago and are still the source of new drugs (Fatemeh *et al*. 2018; Shi-Lin *et al*. 2016). According to the World Health Organization (WHO), more than 80% of the world's population relies on plants for health care (Fatemeh *et al*. 2018). Globally, it is estimated that around 60,000 plant species are used for their medicinal, nutritional, and aromatic properties (Ana *et al*. 2016). From a total of 350,000 to 550,000 plant species that was estimated to be in existence, less than 20% were subjected to scientific investigation for their medicinal value (Wink 2000). It was reported that from a total of 56% of synthetic drugs that are currently prescribed, derivatives from plant species accounts for 24%, synthetic products that were modeled from natural products accounts for 9% and those that were extracted directly from plant species accounts for 6% (Kushiro *et al*. 2003).

In India, the use of plants as a source for medicine is an important component of the health care system and has been an ancient practice (Pandey *et al*. 2013). Ayurveda, Siddha, and Unani are three traditional medicinal systems

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in India (Subhose *et al*. 2005). These three systems used approximately 2000, 1300, and 1000 different plants respectively (Pandey *et al*. 2008). The rural population of about 70% in India depends on the Ayurvedic system of medicine (Pandey *et al*. 2013). In India, traditional and folk medicine utilizes around 25,000 effective plant-based formulations (Pandey *et al*. 2008). Studies in India indicate that in any local ecosystem, human and veterinary medicine utilizes between 40-70% of the plant diversity. The tribal communities in India utilized over 7500 species of plants for medicinal purposes (Shankar 1996).

The following textual literatures were selectively displayed to briefly highlight the importance of medicinal plants (MPs) for Northeast Indians. In Nalbari district of Assam, a total of 71 plant species are reported to be used for treating several reproductive problems for male and female (Adhikari *et al*. 2018). In Tripura, a study by Shil *et al*. (2014) revealed that Reang tribe utilizes a total of 125 MP species for treating 42 different ailments. In Meghalaya, 57 MP species were identified to treat different diseases before the advent of chemical medicines (Kayang *et al*. 2005). In Nagaland, a study revealed that Chungtia Village used a total of 135 plant species for medicinal and household maintenance applications (Kichu *et al*. 2015). In Sikkim, a study revealed the use of 490 MPs wherein 31 of them were reported to be more commonly used by folk healers (Panda and Misra 2010). In Manipur, Panmei *et al*. (2019) reported that Zeliangrong tribes used a total of 145 MPs in healing practices.

Diarrhea is an infection of gastrointestinal tract by pathogenic microorganisms (Yongshi 2008). The prevalence of diarrhea across the states of India ranges from 0.1–33.8% in the year 2007–2008 and 0.6–29.1% in the year 2015–2016. Even though morbidity with diarrhea is highly preventable, it is still the leading cause for malnutrition (Nilima 2018). To children under the age of 5, diarrheal illness remained a threat and is accountable for 15% of mortality (Cunliffe *et al*. 2012). Antibiotics are often used for treating acute infectious diarrhea but are associated with adverse effects like depletion of mucosal and beneficial gut microorganism, immuno suppression, allergic reactions, antibiotic resistance and antibiotic induced diarrhea (Tsuji *et al*. 1990; Casburn-Jones and Farthing 2004; Dibbern and Montanaro 2008; Jernberg *et al*. 2010; Dethlefsen and Relman 2011; Larcombe *et al*. 2016). Due to an increasing resistance shown by common pathogens against many pharmacotherapeutic agents, scientists have regain interest in drug discovery using natural products (Rawat *et al*. 2017). Traditionally, treating diarrhea and associated symptoms with the use of plants and their preparations are well reported (Hernandez *et al*. 2003, Semenya and Maroyi 2012, Rawat *et al*. 2016). Few of the plant based medicinal preparations that have been subjected to clinical trials included *Croton lechleri* (also known as sangre de drago); *Camellia sinensis* (also known as black tea); *Mentha piperita* (also known as peppermint); leaves of *Psidium guajava* (also known as guava); Tong-xie-ning (TXNG), a Chinese polyherbal formulation composed of four herbs, namely, *Paeonia lactiflora* (root), *Atractylodes macrocephala* (rhizome), *Citrus reticulate* (green unripe exocarp) and *Allium macrostemon* (bulb); Entoban, a polyherbal formulation composed of *Holarrhena antidysenterica*, *Berberis aristata*, *Symplocos racemosa*, *Querecus infectoria* and *Helicteres isora* (Rawat *et al*. 2017). Recently, Rawat *et al*. (2017) identified traditional MPs with anti-diarrheal properties, such as *Alpinia oxyphylla*, *Anacardium occidentale*, *Achillea fragrantissima*, *Artemisia herba alba*, *Codiaeum variegatum*, *Cymbopogon citratus*, *Dalbergia sissoo*, *Gmelina arborea*, *Linum usitatissimum*, *Mentha longifolia*, *Maranta arundinacea*, *Musa paradisiaca*, *Vernonia amygdalina*, *Matricaria chamomilla*, *Manihot esculenta*, *Rhanterium epapposum*, *Echinops spinosus*, *Echinops hussoni*, *Polygonatum verticillatum*, *Mimosa diplotricha*, *Myrtus communis*, *Trichilia emetic*, *Pelargonium luridum*, *Calea zacatechichi*, *Solanum paniculatum*, *Polypodium vulgare*, *Ajuga remota*, *Adiantum capillus-veneris*, *Idigofera spicata*, *Detarium senegalense*, *Croton macrostachyus*, *Chebulae Fructus*, *Morinda citrifolia*, *Oxalis barrelieri*, *Mikania cordata*, *Litsea monopetala*, *Murraya koenigii*, *Acacia nilotica*, *Microcos paniculata*, *Pistia stratiotes*, *Pseudocedrela kotschyi*, *Aphanamixis polystachya*, *Cordia Africana*, *Gaultheria trichophylla*, *Syzygium cordatum*, *Rhus tripartite*, *Cynodon dactylon*, *Salacia lehmbachii*, *Sesbania grandiflora*, *Manilkara zapota*, *Alchornea cordifolia*, *Caladium bicolor*, *Alsotinia scholaris*, *Tridax procubens*, *Rumex maritimus*, *Ageratum conyzoides*, *Byrsocarpus coccineus*, *Artemisia indica*, *Curcuma zedoaria*, *Picralima nitida*, *Setaria italica*, *Cistus salviifolius*, *Rumex vesicarius*, *Jatropha curcas*, *Caesalpinia decapetala*, *Leptadenia pyrotechnica*, *Urena sinuate*, *Tamarindus indica*, *Bambusa bambos*, *Juglans regia*, *Blumea densiflora*, *Ziziphus oenoplia*, *Calamus rotang*, *Oroxylum indicum*, *Polygonum bistorta*, *Salvia schimperi*, *Aganosma dichotoma*, *Morinda pubescens*, *Celtis integrifolia*, *Byrsocarpus coccineus*, *Spondias mombin*, *Elephantorrhiza elephantine*, *Oncoba spinosa*, *Amaranthus tricolor*, *Croton grewioides*, *Wikstroemia indica*, *Tecurium oliverianum*, *Bombax buonopozense*, *Harungana madagascariensis*, *Khaya senegalensis*, *Commelina benghalensis*, *Calophyllum inophyllum*, *Alchornea laxiflora*, *Maytenus erythroxylon*,

Bidens biternata, *Citrus limon*, *Hopea odorata*, *Cenchrus ciliaris*, *Hygrophila spinosa*, *Triumfetta pilosa*, *Symplocos paniculata*, *Quercus ilex*, *Persicaria orientalis*, *Phrynium imbricatum* and *Nymphaea lotus*.

Southeast Asia as a Storehouse of Medicinal Plants

The Southeast Asian countries serve as a host for a great number of MPs. The abundance of medicinal herbs, particularly in the Indo-China region serves as an opportunity for pharmacists to enrich the pharmacopoeia (Bonnemain 2019). Over 250 MP species are utilized in Indonesia and around 2000 species in Malaysia alone (Izefri and Stephen 1998; Andy *et al*. 2010). In Southeast Asia and surrounding countries, nearly 2000 different plant species are reported to be used in over 5000 combinations traditionally for women's healthcare (de Boer and Cotingting 2014). In one study, 132 Southeast Asian MPs were reviewed (Sanusi *et al*. 2017). Another study in Thailand reported a total of 2,187 MPs as useful for medicinal purposes (Phumthum *et al*. 2019). One survey conducted in Myanmar reported a total of 472 MP species (DeFilipps and Krupnick 2018). All these information reveals that Southeast Asia is rich in MPs.

India as a Global Botanical Garden

Among many Asian countries, India is a massive repository of MPs used for different ailments. India, called as the botanical garden of the world is the largest producer of medicinal herbs (Kavita *et al*. 2014). Around 45,000 MP species are recorded and more than 500 traditional communities use about 800 plant species for ameliorating various ailments (Grover *et al* 2002; Kavita *et al*. 2014). The Indian Himalayan region harbors a rich biodiversity, including a diverse medicinal flora wherein the majority (78%) of the species is native to this region (Bilal *et al*. 2019). Hence, India is rich in MPs that are needed for manufacturing phytomedicines as well as pharmaceutical drugs (Ravi and Bharadvaja 2019). In India, there are over 45,000 plant species which is about 11.8% of world flora. Around 15,000-20,000 plants seem to have good therapeutic and medicinal properties. Out of this, traditional practitioners utilize only about 7,000-7,500 plants (Bedi *et al*. 2016). In different parts of India, various communities used 14, 19 and 214 plant species for magico-religious, external and internal remedies for jaundice respectively (Sharma *et al*. 2012). Also, in Chilapatta Reserve Forest of West Bengal, a study conducted by Raj *et al*. (2018) documented a total number of 140 ethnomedicinal plant species.

North-east India as a Biodiversity Hub

The north-eastern region of India is the geographical gateway for much of India's endemic flora. The region represents a vital component of the Indo-Myanmar and the Himalayan biodiversity hotspots, included among the 25 global biodiversity hotspots recognized to date (Jagajjit *et al*. 2014; Seikuti and Shanmuganath 2020; Alemmeren and Pandey 2003). Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, and Sikkim together contribute 50% of India's biodiversity and are home to 130 tribal communities (De 2016). In Manipur and Nagaland, occurrence of a total of 4500 species of plants was estimated (Meetei *et al*. 2012). A study in Northeast India revealed that 68 plant species are used to treat malaria (Shankar *et al*. 2012a). Another study among the Mishing community revealed the use of 55 MPs to treat their ailments (Shankar *et al*. 2012b). A report from an ethno-botanical survey in Kamrup district of Assam reported 24 plant species that are used as phytomedicines to treat liver ailments (Kotoky and Das 2008).

Mizoram as a Reservoir of Medicinal Plants

Mizoram is rich in flora and fauna (Seikuti and Shanmuganath 2020; Lalfakzuala *et al*. 2007). According to the State of Environment Report of Mizoram - 2016, 88.93% of the state is covered by forest and is the highest forest cover in the country (Singh *et al*. 2016). It is located within the Indo-Myanmar biodiversity hotspots (whose geographical location is given in figure 1). According to plant species richness study conducted in Phawngpui National Park (PNP) during 2007–2009, the occurrence of a total of 208 species of plants was recorded (Alfred and Lalramnghinglova 2011). The diversity in flora and fauna of Mizoram coupled with a combination of its deep traditional knowledge results in enriched ethnozoological knowledge in the society (Chinlampianga *et al*. 2013). Therefore MPs of Mizoram were extensively documented for their general medicinal value and vegetative utilization. An ethnobotanical survey conducted by Bhardwaj and Gakhar (2005) among 54 villages of northeast state of Mizoram revealed that 17 species of plants belonging to 14 families were used by the tribals to cure cuts and wounds although they did not mention that these plants were used for other purposes. Field surveys among the Mizo tribes of Aizawl district conducted by Hazarika *et al*. (2012) documented 60 wild edible fruit species belonging to 35 families with medicinal value. A survey conducted by Laldinsanga *et al*. (2019) among different tribal communities in rural areas of Mizoram resulted in the documentation of 52 plant species

belonging to 36 families that were used as a folk remedy to cure malaria. Lalfakzuala *et al*. (2007) records 23 plant species having medicinal value belonging to 16 families in Mamit district of Mizoram. Lalmuanpuii *et al*. (2013) documented 82 plant species belonging to 42 families having medicinal value in Lunglei district of Mizoram. Rai and Lalramnghinglova (2010a) documented a total of 159 ethnomedicinal plants belonging to 56 families in Mizoram. Another study by Rai and Lalramnghinglova conducted in the tropical evergreen forests of Aizawl and Kolasib district and protected areas of Ngengpui and Palak wildlife sanctuaries of Mizoram resulted in the documentation of 57 ethnomedicinal plants belonging to 36 families (Rai and Lalramnghinglova 2010b). An interview conducted among indigenous people belonging to different tribes of Mizoram recorded 40 ethnomedicinal plants species under 25 families for the first time (Rai and Lalramnghinglova 2011). Sharma *et al*. (2001) documented 135 MPs under 65 families in Aizawl district of Mizoram.

The Need for Documenting Phytomedicines Used For Treating Diarrhea

Recently, increasing awareness related to the adverse effects of synthetic drugs among the people has led to a significant spur in the consumption of herbal-based drugs (Ravi and Bharadvaja 2019). Furthermore, it is also noteworthy that the WHO is planning to reduce/end preventable diarrheal related deaths by the end of 2025 (WHO 2013). It was reported that out of the approximately 500,000 world plant species, only 1% had been subjected to phytochemical investigation. Therefore, the potential for discovering novel bioactive compounds are huge. Investigation of the biological activity of plant extracts have validated the use of antidiarrhoeal medicinal plants traditionally and they are reported to suppress gut motility, induce antispasmodic effects, stimulate water adsorption or reduce electrolyte secretion and delay intestinal transit. Among different phytochemicals present in plant extracts, tannins and flavonoids are reported to induce antidiarrhoeal activity by increasing electrolyte re-absorption and colonic water. Other phytochemicals like terpenoids and glycosides act by inhibiting intestinal motility. However, evaluation of the safety of plant preparations is needed as there are some potentially toxic active ingredients (Palombo 2006). In developed as well as developing countries, the ethnopharmacological knowledge on medicinal plants is disappearing fast. In light of this, documentation of its botanico-historical roots by ethno-allied disciplines has become an essential task. By documenting ethnopharmacological information on MPs, we can preserve the cultural heritage, preserve the ethnopharmacological basis of drug research as well as preserve the biological diversity (Weldegerima 2009). Though Mizoram is rich in MPs as previously discussed, there hasn't been any document specifically dedicated to the MPs available in the state of Mizoram that are used as a natural curative agent for diarrhea.

METHODOLOGY FOR REVIEW

To systematically highlight the quantity, status of research work done, and the scope for future research, an investigation for the MPs having remedial action against diarrhea was searched from all the accessible/available published papers using 'Medicinal plants of Mizoram' as the keyword. Academic search engines *viz*. Google Scholar, PubMed, Science Direct, Scopus, and Web of Science were used for retrieving relevant literatures. From the retrieved literature, MPs having ameliorative property against diarrhea were identified and underwent an in-depth review. Though the MPs might be used for treating other ailments, the review was limited to the ameliorative property of diarrhea.

The MPs with antidiarrheal activity were grouped separately. The MPs traditionally used for ameliorating diarrhea with no report on the scientific evidence for their antidiarrheal activity were also grouped separately. Reviewing of the secondary metabolites (SMs) of the MPs was done superficially at the class level (not at the isolated level). This was done to provide a better understanding on the possible role of the phytochemicals on the ameliorative effects of the MPs against diarrhea. A combination of short and precise information on the topic of diarrhea was also considered for review.

DIARRHEA

According to the WHO, the frequent passing of loose/watery stools not less than three times per day is defined as diarrhea (WHO 2005).

Several factors contribute to the onset of diarrhea like infectious organisms such as protozoa, bacteria, viruses, helminths, unhealthy lifestyle like consuming contaminated water and food, prolonged improper hygiene along with several medications (Abraham and Sellin 2007; Keusch *et al*. 2006; WHO 2017). Two of the most common microorganism responsible for diarrhea in low-income countries are rotavirus and *Escherichia coli*. *Cryptosporidium* and *Shigella* species are other pathogens of significant importance associated with diarrhea (WHO 2017). Alpha-glucosidase inhibitors, antibiotics, enteral feedings,

magnesium antacids, osmotic laxatives, poorly absorbed or non-absorbable carbohydrates and probiotics can induce watery diarrhea (Abraham and Sellin 2007). Antivirals (e.g., adefovir, zidovudine, tenofovir), antibiotics (e.g., ceftizoxime), antihypertensives (e.g., furosmide, olsesartan), chemotherapy agents (e.g., methotrexate, topotecan, irinotecan), rolipram, cilomilast, auranofin, calcitonin, prostaglandins, chenodeoxycholic acid and digoxin have been reported to cause diarrheal side effects (Moon *et al*. 2015). Antibiotics, carbamazepine, chemotherapeutic agents, immunosuppressive agents, methyldopa, non steroidal anti-inflammatory drugs, isotretinoin, penicillamine, proton pump inhibitors, selective serotonin reuptake inhibitors, stimulant laxatives, ticlopidine and tyrosine kinase inhibitors were also reported to induce diarrhea (Abraham and Sellin 2007).

Diarrhea can be prevented by having access to clean drinking water, better sanitation, soap for washing hands, maintaining a hygienic environment for living and processing food, awareness on how infections spread, and rotavirus vaccination (Weaver *et al*. 2016; WHO 2017; Wolf *et al*. 2018). Antibiotic associated diarrhea can be prevented using probiotics (living microorganisms used to restore gut health by changing the intestinal microbiota) wherein *Lactobacillus rhamnosus GG*, *Bacillus coagulans*, and *Saccharomyces boulardii* are few examples of probiotics (Doron *et al*. 2008). Studies have also found that diarrhea induced by rotavirus can be effectively prevented using vaccines (Soares-Weiser *et al*. 2019).

Diarrheal disease affect populations of all age groups and is responsible for the death of 1.4 million people annually and occupies the 9th position in the top 10 leading causes of death (WHO 2018). India is a country belonging to the category of low and middle-income country and as per WHO, diarrheal diseases are the 6th leading causes of death in low and middle-income countries (Mehta *et al*. 2017; WHO 2018). Globally, more than half of the deaths caused by diarrhea are contributed from India, Nigeria, Afghanistan, Pakistan, and Ethiopia (Nilima 2008). Mainly resulting from consuming contaminated food and water, diarrhoeal disease is the leading cause for child morbidity and mortality in the world. Globally, improved drinking-water is not accessible to 780 million individuals while improved sanitation is not accessible for 2.5 billion people. Hence, developing countries witnessed widespread diarrheal infections. Children under the age of 3 years in low-income countries experience an average of three episodes of diarrhoea annually. Each recurring episode in children results in deprivation of nutrition necessary for growth. This results in diarrhea being the major cause of malnutrition and severe illness with diarrhea is likely to occur in malnourished children (WHO 2017).

PHARMACOTHERAPY OF DIARRHEA

Diarrheal episodes are limited and many recover without undergoing diagnosis. Rotavirus is mostly the identified pathogen in diagnosed children, apart from other bacterial, parasitic, and viral agents (Duong *et al*. 2016). Diarrhea is generally treated with oral rehydration solution, zinc, probiotics, loperamide, and antibiotics (Binder *et al*. 2014; Dickinson and Surawicz 2014; Johnston *et al*. 2012; Riddle *et al*. 2017). Treatment of acute infectious diarrhea includes antibiotics such as tetracycline, ciprofloxacin, norfloxacin, fleroxacin, cinoxacin, erythromycin, metronidazole, ampicillin, amoxycyline, doxycycline, vancomycin, and paromomycin (Casburn-Jones and Farthing 2004).

CLINICAL CLASSIFICATION OF DIARRHEA

Clinically, diarrhea is classified into acute watery diarrhea (it includes cholera and can last for several hours if not days where there is a great risk for dehydration); acute bloody diarrhea (also known as dysentery where intestinal mucosa can be damaged and is accompanied by complications such as dehydration, sepsis and malnutrition); persistent diarrhea (as the name suggests, it may last 14 days or even longer and is associated with complications such as dehydration, serious non-intestinal infection and malnutrition) and diarrhea with severe malnutrition (also termed as kwashiorkor or marasmus where heart failure, dehydration, vitamin and mineral deficiency along with severe systemic infection can occur if untreated) (WHO 2005).

SCIENTIFICALLY VALIDATED MEDICINAL PLANTS HAVING ANTIDIARRHEAL ACTIVITY AVAILABLE IN MIZORAM

In-depth evaluation discloses that 24 MPs had been reported as scientifically evaluated for their antidiarrheal activity (Table 1). In general, the plant parts used in traditional practice included leaf, stem, rhizome, root, bark, fruit, seed coat, latex and shoot. Infusion, decoction and boiling were generally used for processing the plant parts. Sharma *et al.* (2001) reported that *Alstonia scholaris* Linn. R. Br., *Artocarpus chaplasha* Roxb., *Benincasa hispida* (Thunb.) Cogn., *Carica papaya* Linn., *Chukrasia tabularis* A. Juss., *Dillenia indica* Linn., *Lagerstroemia speciosa* Linn., *Melastoma malabathricum* Linn., *Paederia foetida* Linn. and *Tamarindus indica* Linn. are used for treating diarrhea in Aizawl district. Further, Bhardwaj and Gakhar (2005) reported that *Curcuma domestica* Val., *Emblica officinalis* Gaertn. and *M. malabathricum* Linn. are used for treating

diarrhea in Aizawl district. Hazarika *et al.* (2012) reported that *Amomum dealbatum* Roxb., *A. chaplasha* Roxb., *D. indica* Linn., *E. officinalis* Gaertn., *Ficus racemosa* Linn., *Punica granatum* Linn., *Rhus semialata* Murray., *Syzygium cumini* (Linn.) Skeels and *T. indica* Linn. are used for treating diarrhea in Aizawl district. Additionally, Lalmuanpuii *et al.* (2013) reported that *B. hispida* (Thunb.) Cogn., *C. papaya* Linn., *Catharanthus roseus* Linn., *C. tabularis* A. Juss., *Curcuma longa* Linn., *D. indica* L., *E. officinalis* Gaertn., *L. speciosa* Linn. and *Psidium guajava* Linn. are used in Lunglei district. Lalfakzuala *et al.* (2017) also reported that *A. chaplasha* Roxb., *Ficus bengalensis* Linn. and *L. speciosa* Linn. are used for treating diarrhea in Mamit district. Recently, Laldinsanga *et al.* (2019) reported that *A. scholaris* Linn. R. Br, *A. chaplasha* Roxb., *C. tabularis* A. Juss. and *D. indica* Linn. are used for treating diarrhea in Serchhip and Lunglei districts.

The different classes of SMs of the 24 MPs were superficially reviewed at the class level (Table 2). Out of a total of 24 MPs, 12 MPs contain alkaloids, 2 MPs contain curcuminoids, 19 MPs contain flavonoids, 11 MPs contain glycosides, 14 MPs contain phenols, 3 MPs contain saponins, 12 MPs contain phytosteroids, 11 MPs contain tannins and 15 MPs contain terpenoids.

MEDICINAL PLANTS TRADITIONALLY USED AGAINST DIARRHEA AVAILABLE IN MIZORAM

There are 44 MPs that are traditionally used for ameliorating diarrhea (Table 3). However, these 44 MPs are not yet scientifically proven for their antidiarrheal activity. In general, the plant part used in traditional practice included leaf, root, rhizome, fruits, bark, flower, stem and stem bark. Infusion, decoction, boiling, grounding and squeezing were generally used for processing the plant parts. The classes of SMs of the 44 MPs were also reviewed (Table 4). Out of a total of 44 MPs, 21 MPs contain alkaloids, 32 MPs contain flavonoids, 17 MPs contain glycosides, 14 MPs contain phenols, 14 MPs contain saponins, 25 MPs contain phytosteroids, 20 MPs contain tannins, 22 MPs contain terpenoids and 1 MP contain xanthones. Till the date of communication, the authors find no information for *Bruinsmia polysperma* (C. B. Cl.) Steenis, *Chrysophyllum lanceolatum* (Blume) A. DC., and *Rhus acuminate* E. Mey. regarding their phytoconstituents.

FUTURE CHALLENGE

Among the 10 reported class of SMs, the antidiarrheal activities of only 8 classes of SMs i.e. flavonoids, terpenoids, alkaloids, tannins, glycosides, saponins, curcuminoids, and xanthones had been reported (Calzada *et al*. 2007; Yao *et al*. 2011; Jalilzadeh-Amin and Maham 2015; Zhang *et al*. 2012; Tiwari *et al*. 2011; Chen *et al*. 2009; Abubakar *et al*. 2015; Ismail *et al*. 2017; Negi *et al*. 2013). The ameliorative property of phenols and phytosteroids against diarrhea has not been evaluated so far. There is also no report on the class of SMs most effective in ameliorating diarrhea. The safety a medicinal plant may also be evaluated using suitable techniques at the pre-clinical level (*in vitro* and *in vivo*) as the potential adverse effect of a herbal drug had been reported (Zothantluanga *et al. 2019; Vanlalhriatpuii et al.* 2020).

Plant extract contains a mixture of different classes of SMs and there are a handful of subclasses or single phytochemicals present under a single class of SMs (Pagare *et al*. 2015). The majority of the scientific investigations were carried out at the extract level and some plant parts subjected to scientific evaluation differs from the plant parts traditionally used in Mizoram (refer to Table 1). It is also not known whether the antidiarrheal activity of the MPs is a result of a single phytochemical, a single class of SMs, or a synergistic action of two or more than two classes of SMs. Hnahthial, Saitual and Khawzawl districts are newly formed districts of Mizoram (DIPR, 2019). So far, there is no research works carried out in documentation of traditional MPs used in these areas.

CONCLUSION

The exhaustive literature study revealed the present status of the MPs available in Mizoram, Northeast India. Out of a total of 68 identified MPs, 24 MPs were successfully subjected to scientific evaluation for their antidiarrheal activity while 44 MPs are yet to be scientifically explored for their therapeutic action against diarrhea. Out of 10 classes of SMs, only 8 classes of SMs were reported to have antidiarrheal activity while two classes of SMs (phenols and phytosteroids) remains unexplored. Also, there is no information on the class of SMs most effective for treating diarrhea. Therefore further scientific investigation is suggested to identify the potential candidates. Hence, there exists a bright future scope for research. It may be noted that the MPs are not endemic to Mizoram and may be available in other regions as well. Also, some MPs not accessible in published articles may exist elsewhere. However, this piece of literary work may improve the existing scientific knowledge for the betterment of the pharmaco/phytotherapy for diarrhea.

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Table 1: A Systematic Complication of Scientifically Validated MPs Having Antidiarrheal Activity Available in Mizoram

Sl No.	Scientific Name; Mizo Name	Plant Part Used Traditionally in Mizoram	Scientific Investigation					Citation
			Plant Part Used	Extract/ Isolated Compound Used	Model Used for Evaluation	Inducer of Diarrhea	Standard Drug	
1	*Ageratum conyzoides* L.; Vailenhlo	Stem and leaf	Leaf	Aqueous	Wistar rats	Castor oil	Loperamide	Rai and Lalramnghinglova 2010a; Atiar *et al.* 2013
			Whole plant	Ethanol	Wistar rats	Castor oil	Loperamide	
2	*Alstonia scholaris* L. R. Br; Thuamriat	Decoction of stem	Whole plant	Methanol	Albino mice	Castor oil	Loperamide	Sharma *et al*. 2001; Laldinsanga *et al*. 2019; Mohammad *et al*. 2014
3	*Amomum dealbatum* Roxb.; Aidu	Stem	Leaf	Ethanol	Mice	Castor oil	Loperamide	Hazarika *et al*. 2012; Azimul *et al*. 2019
4	*Artocarpus chaplasha* Roxb.; Taktawng	Juice from inner coat of bark	Heartwood	Atrocarpanone extract	Plate Method	Gut pathogens	-nil-	Hazarika *et al*. 2012; Sharma *et al*. 2001; Laldinsanga *et al*. 2019; Lalfakzuala *et al*. 2007; Jagtap and Bapat 2010
5	*Benincasa hispida* (Thunb.) Cogn.; Maipawl	Fruit juice	Fruit	Methanol	Rats	Castor oil	Loperamide	Sharma *et al*. 2001; Lalmuanpuii *et al*. 2013; Vrushabendra *et al*. 2005
6	*Carica papaya* L.; Thingfanghma	Ripe fruit	Roots and leaves	Methanol and Aqueous	Albino rats	*E. coli*	Loperamide	Sharma *et al*. 2001; Lalmuanpuii *et al*. 2013; Bright *et al*. 2017; Prabhu *et al*. 2017
			Fruit	Petroleum ether, benzene, chloroform, acetone, ethanol and aqueous	Plate Method	Gut pathogens	-nil-	

(Table 1: Contd.)...

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7	*Catharanthus roseus* Linn.; Kumtluang	Root, stem and leaf	Leaf	Ethanol	Wistar rats	Castor oil	Loperamide and Atropine sulphate	Rai and Lalramnghinglova 2010a; Lalmuanpuii *et al*. 2013; Kyakulaga *et al*. 2011
8	*Chukrasia tabularis* A. Juss.; Zawngtei	Seed coat	Bark and Leaves	Methanol	Wistar albino rats	Castor oil	Loperamide	Rai and Lalramnghinglova 2010a; Sharma *et al*. 2001, Laldinsanga *et al*. 2019; Lalmuanpuii *et al*. 2013; Sharmin *et al*. 2015
9	*Cinnamomum tamala* (Buch-Ham.) Sweet; Tejpatta	Leaf	Leaf	Ethanol	Rats	Castor oil	Atropine sulphate	Rai and Lalramnghinglova 2010a; Chandana *et al*. 2008
10	*Curcuma domestica* Val.; Aieng	Rhizome	Whole plant	Curcumin	Albino rats	Castor oil	Loperamide	Bhardwaj and Gakhar 2005; Anil *et al*. 2019; Kumar *et al*. 2019
11	*Curcuma longa* L.; Aieng	Rhizome	Whole plant	Curcumin	Albino rats	Castor oil	Loperamide	Lalmuanpuii *et al*. 2013; Anil *et al*. 2019; Kumar *et al*. 2019
12	*Dillenia indica* L.; Kawrthingdeng	Infusion/ decoction of bark, fruit	Bark	Methanol	Mice	Castor oil and Magnesium sulphate	Loperamide	Rai and Lalramnghinglova 2010a; Hazarika *et al*. 2012; Sharma *et al*. 2001; Laldinsanga *et al*. 2019; Lalmuanpuii *et al*. 2013; Yeshwante *et al*. 2009
			Leaf	Methanol and Aqueous	Mice	Castor oil	Loperamide	
13	*Emblica officinalis* Gaertn.; Sinhlu	Aqueous extract of stem bark	Fruit	Methanol	Albino Wistar rats	Castor oil and Magnesium sulphate	Loperamide	Hazarika *et al*. 2012; Lalmuanpuii *et al*. 2013; Bhardwaj and Gakhar 2005; Perianayagam *et al*. 2005
14	*Ficus bengalensis* Linn.; Hmawng	Infusion of bark	Leaf	Methanol	Swiss Albino mice	Castor oil	Loperamide	Rai and Lalramnghinglova 2010a; Lalfakzuala *et al*. 2007; Saeed *et al*. 2011; Mahalakshmi *et al*. 2014
			Bark	Ethanol	Wistar Albino rats	Castor oil	Diphenoxylate	
15	*Ficus racemosa* L.; Thei-chek/ Chho he	Latex	Leaf	Ethanol	Wistar Albino rats	Castor oil	Diphenoxylate	Hazarika *et al*. 2012; Vikas *et al*. 2012

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16	*Lagerstroemia speciosa* L.; Chawn-pui/ Thlado;	Bark infusion, root	Root	Methanol	Swiss Albino mice	Castor oil	Loperamide	Rai and Lalramnghinglova 2010a; Sharma *et al*. 2001; Lalfakzuala *et al*. 2007; Lalmuanpuii *et al*. 2013; Fahad *et al*. 2014
17	*Melastoma malabathricum* Linn.; Builukham	Leaf	Leaf	Water	Albino Swiss mice	Castor oil	Loperamide	Rai and Lalramnghinglova 2010a; Sharma *et al*. 2001; Bhardwaj and Gakhar 2005; Sunilson *et al*. 2009
			Leaf	Ethanol	Albino Swiss mice	Castor oil	Loperamide	
18	*Oroxylum indicum* Linn.; Archangkawn	Root bark	Bark and fruits	Methanol	Swiss Albino mice	Castor oil	Loperamide	Rai and Lalramnghinglova 2010a; Laldinsanga *et al*. 2019; Mamun-Or-Rashid *et al*. 2017
19	*Paederia foetida* L.; Vawihuihhrui	Decoction of young shoot	Whole plant	Ethanol	Swiss-Webstar mice	Castor oil and Magnesium sulphate	Loperamide	Sharma *et al*. 2001, Afroz *et al*. 2006
20	*Punica granatum* L.; Theibuhfai	Fruit juice	Peels	Aqueous	Albino rats	Castor oil	Diphenoxylate	Hazarika *et al*. 2012; Qnais *et al*. 2007
21	*Psidium guajava* Linn.; Kawlthei	Aqueous extract of stem bark and leaf	Fruit	Ethanol	Albino rats	Castor oil	Loperamide	Lalmuanpuii *et al*. 2013; James *et al*. 2013
22	*Rhus semialata* Murray.; Khawmhma	Fruit juice	Fruit	Methanol	Wistar Albino rats	Castor oil	Atropine sulphate	Hazarika *et al*. 2012; Bose *et al*. 2007
23	*Syzygium cumini* (L.) Skeels; Hmuipui	Fruit and seeds	Leaf	Methanol	Mice	Castor oil	Loperamide	Hazarika *et al*. 2012; Shahidulla *et al*. 2019

Table 2: List of Scientifically Validated Medicinal Plants Having Antidiarrheal Activity Available in Mizoram with Their Possible Class of SMs

Sl. No.	Scientific Name	Different Class of Secondary Metabolites	Citation
1	*Ageratum conyzoides* L.	Alkaloids, flavonoids, phytosteroids, terpenoids	Yadav *et al*. 2019a
2	*Alstonia scholaris* L. R. Br.	Alkaloids, glycosides, terpenoids	Khyade *et al*. 2014
3	*Amomum dealbatum* Roxb.	Terpenoids	Huong *et al*. 2015
4	*Artocarpus chaplasha* Roxb.	Flavonoids	Wang *et al*., 2004
5	*Benincasa hispida* (Thunb.) Cogn.	Flavonoids, glycosides, phenols, phytosteroids, terpenoids	Shakya *et al*. 2019
6	*Carica papaya* L.	Alkaloids, flavonoids, tannins	Priyadarshi and Ram 2018
7	*Catharanthus roseus* Linn.	Alkaloids	Almagro *et al*. 2015
8	*Chukrasia tabularis* A. Juss.	Phenols, phytosteroids, terpenoids	Wang *et al*. 2019; Kaur *et al*. 2008

(Table 2: Contd.)...

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9	*Cinnamomum tamala* (Buch-Ham.) Sweet	Alkaloids, flavonoids, glycosides, phenols, tannins, terpenoids	Sharma and Rao 2014
10	*Curcuma domestica* Val.	Curcuminoids	Jantan *et al*. 2012
11	*Curcuma longa* L.	Alkaloids, curcuminoids, flavonoids, phenols, phytosteroids, terpenoids	Sabale *et al*. 2013
12	*Dillenia indica* L.	Flavonoids, phytosteroids, terpenoids	Kaur *et al*. 2017
13	*Emblica officinalis* Gaertn.	Flavonoids, glycosides, phenols, tannins, terpenoids	Vakriya *et al*. 2016
14	*Ficus bengalensis* Linn.	Flavonoids, glycoside, phytosteroids	Naquvi *et al*. 2012
15	*Ficus racemosa* L.	Alkaloids, flavonoids, glycosides, phytosteroids, tannins, terpenoids	Yadav *et al*. 2015
16	*Lagerstroemia speciosa* L.	Flavonoids, glycosides, phenols, tannins, terpenoids	Koduru *et al*. 2018
17	*Melastoma malabathricum* Linn.	Flavonoids, phenols, phytosteroids, tannins	Aslam *et al*. 2017
18	*Oroxylum indicum* Linn.	Alkaloids, flavonoids, glycosides, phenols, phytosteroids, terpenoids	Radhika *et al*. 2011; Fan *et al*. 2015
19	*Paederia foetida* L.	Alkaloids, flavanoids, glycosides, phenols, phytosteroids, tannins	Kakati and Sikdar 2017
20	*Punica granatum* L.	Alkaloids, flavonoids, glycoside, phenols, saponins, phytosteroids, tannins, terpenoids	Sreekumar *et al*. 2014
21	*Psidium guajava* Linn.	Flavonoids, phenols, saponins, tannins, terpenoids	Gayathri and Kiruba 2014
22	*Rhus semialata* Murray.	Flavonoids, phenols, tannins	Devi and Singh 2018
23	*Syzygium cumini* (L.) Skeels	Alkaloids, flavonoids, glycosides, phenols	Ayyanar and Subash-Babu 2012
24	*Tamarindus indica* L.	Alkaloids, flavonoids, phenols, saponins, phytosteroids, tannins, terpenoids	Samina *et al*. 2008

Table 3: A systematic Compilation of MPs Traditionally Used Against Diarrhea Available in Mizoram

Sl. No.	Scientific Name	Region where MPs are Used*	Mizo Name	Family	Plant Part Used Traditionally	Citation
1	*Adhatoda zeylanica* Medic.	Mizoram	Kawldai	Acanthaceae	Leaf	Rai and Lalramnghinglova 2010a
2	*Aegle marmelos* (Correa) Linn.	Aizawl	Belthei	Rutaceae	Root decoction	Hazarika *et al*. 2012
3	*Amomum subulatum* Roxb.	Aizawl	Ailaidum	Zingiberaceae	Rhizome decoction	Sharma *et al*. 2001
4	*Annona squamosa* L.	Aizawl	Theiarbawn	Annonaceae	Fruits	Sharma *et al*. 2001
5	*Anogeisus acuminate* Roxb.	Aizawl, Kolasib, Lawngtlai, Lunglei, Saiha, Serchhip	Zairum	Combretaceae	Bark decoction	Rai and Lalramnghinglova 2010b; Laldinsanga *et al*. 2019.
6	*Bauhinia variegata* Linn.	Mizoram	Vaube	Caesalpiniaceae	Bark decoction	Rai and Lalramnghinglova 2010a; Sharma *et al*. 2001
7	*Bergenia ciliata* (Haw.) Sternb.	Mizoram	Pan-damdawi	Saxifragaceae	Leafs& roots	Rai and Lalramnghinglova 2010a; Laldinsanga *et al*. 2019

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8	*Bergenia ligulata* Wall Engl.	Aizawl	Pandamdawi/ kham-damdawi	Saxifragaceae	Root decoction	Sharma *et al*. 2001
9	*Bidens pilosa* (Lour.) Merr. & Sheriff.	Mizoram	Vawkpuithal	Asteraceae	Flower	Rai and Lalramnghinglova 2010a
10	*Bombax ceiba* L.	Aizawl	Pang	Bombacaceae	Leaves decoction and bark along with *Magnifera indica*	Sharma *et al*. 2001
11	*Bruinsmia polysperma* (C.B.Clarke) Steenis.	Aizawl	Theipalingkawh	Styraceae	Fruit	Hazarika *et al*. 2012
12	*Canna indica* L.	Lunglei, Serchhip	Kung-pui-mu-thi	Cannaceae	Root powder	Laldingsanga *et al*. 2019
13	*Catunaregam spinosa* (Thunb.)	Aizawl	Sazukthei	Rubiaceae	Fruit juice	Hazarika *et al*. 2012
14	*Chromolaena odorata* (L.) R.M. King & H. Rob	Aizawl, Champhai	Tlang-sam/Pho-leng	Compositae	Whole plant	Shantabi *et al*. 2014
15	*Chrysophyllum lanceolatum* Casar.	Aizawl	Theipabuan	Sapotaceae	Bark	Hazarika *et al*. 2012
16	*Clerodendrum bracteatum* Wall.ex Walp.	Aizawl, Kolasib, Lawngtlai, Lunglei, Saiha	Phuihnamchhia	Verbenaceae	Water from grounded leaves were squeezed, and root	Rai and Lalramnghinglova 2010b; Lalmuanpuii *et al*. 2013
17	*Curcumorpha longiflora* Wall.	Aizawl, Kolasib, Lawngtlai, Lunglei, Saiha	Ailaidum	Zingiberaceae	Rhizome infusion	Rai and Lalramnghinglova 2010b; Rai and Lalramnghinglova 2011
18	*Dysoxylum gobara* (Buch.-Ham) Merr.	Aizawl, Kolasib, Lawngtlai, Lunglei, Mamit, Saiha	Thingthupui	Meliaceae	Leaf and bud decoction	Rai and Lalramnghinglova 2010b; Lalfakzuala *et al*. 2007; Lalmuanpuii *et al*. 2013
19	*Dalbergia pinnata* Lour.	Lunglei	Tengtere	Fabaceae	Fruits	Lalmuanpuii *et al*. 2013
20	*Elaeocarpus tectorius* (Lour.)	Aizawl	Um-khal	Tiliaceae	Roots	Hazarika *et al*. 2012
21	*Eryngium foetidum* L.	Mizoram	Bahkhawr	Apiaceae	Leaf juice	Laldingsanga *et al*. 2019; Singh *et al*. 2014
22	*Garcinia cowa* Roxb.	Mizoram	Chengkek	Clusiaceae	Bark, boiled leaves with water at 50 ml twice daily	Rai and Lalramnghinglova 2010a; Hazarika *et al*. 2012
23	*Garcinia pedunculata* G.	Mizoram	Theipumlian	Clusiaceae	Acidic extract of pericarp mixed with sugar	Rai and Lalramnghinglova 2010a
24	*Hydrocotyle asiatica* L.	Aizawl	Lambak/ darbengbur	Apiaceae	Leaf juice	Sharma *et al*. 2001
25	*Lablab purpureus* L. Sweet.	Lunglei, Serchhip	Be-pui	Fabaceae	Leaf juice	Laldingsanga *et al*. 2019
26	*Laportea crenulata* Gaud.	Aizawl, Lunglei, Serchhip	Thak-pui	Urticaceae	Root decoction	Sharma *et al*. 2001; Laldingsanga *et al*. 2019

(Table 3: Contd.)...

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27	*Lonicera macrantha* D. Don	Aizawl, Kolasib, Lawngtlai, Lunglei, Saiha	Leihruisen	Caprifoliaceae	Leaves, hot aqueous extract	Rai and Lalramnghinglova 2010b; Lalmuanpuii *et al*. 2013
28	*Mikania micrantha*	Aizawl, Lunglei, Serchhip	Japan-hlo	Asteraceae	Leaf juice	Sharma *et al*. 2001; Laldinsanga *et al*. 2019
29	*Musa paradisiaca* L. var. Sylvestris	Lunglei, Serchhip	Changel	Musaceae	Unripe fruits	Laldinsanga *et al*. 2019
30	*Myrica esculenta* Buch.-Ham.	Lunglei, Serchhip	Kei-fang	Myricaceae	Bark and unripe fruits	Laldinsanga *et al*. 2019
31	*Musa superba* Roxb.	Aizawl	Tumbu/ changel	Musaceae	Stem juice	Sharma *et al*. 2001
32	*Osbeckia rostrata* D.Don.	Lunglei	Builukhampa	Melastomaceae	Cold aqueous extract of root	Lalmuanpuii *et al*. 2013
33	*Oxalis corniculata* L.	Lunglei, Serchhip	Saik-thur or Pi-chhu-hmul	Oxalidaceae	Whole plant infusion	Laldinsanga *et al*. 2019
34	*Parkia roxburghii* G. Don	Aizawl, Lunglei	Zawngtah	Mimosaceae	Hot aqueous extract of stem bark	Lalmuanpuii *et al*. 2013; Bhardwaj and Gakhar 2005
35	*Picrasma javanica* Bl.	Lunglei	Thingdamdawi	Simaroubaceae	Boiled stem bark, and leaves	Lalmuanpuii *et al*. 2013
36	*Physalis minima* L.	Aizawl	Kelasairawphit	Solanaceae	Stem, leaves and fruit juice	Sharma *et al*. 2001
37	*Piper longum* L.	Lunglei, Serchhip	Voko-hrui	Piperaceae	Dried fruit infusion	Laldinsanga *et al*. 2019
38	*Rhus acuminate* Murr.	Mizoram	Chhimhruk	Anacardiaceae	Fruit	Rai and Lalramnghinglova 2010a
39	*Spondias pinnata* (L.f.) Kurz.	Aizawl, Lunglei, Serchhip	Tawitaw	Anacardiaceae	Bark decoction / bark juice	Hazarika *et al*. 2012; Laldinsanga *et al*. 2019; Lalmuanpuii *et al*. 2013
40	*Terminalia bellirica* Roxb.	Mizoram	Thingvandawt	Combretaceae	Fruit, flower decoction	Rai and Lalramnghinglova 2010a; Sharma *et al*. 2001
41	*Terminalia chebula* Retz.	Aizawl	Reraw	Combretaceae	Bark decoction	Sharma *et al*. 2001
42	*Xylia xylocarpa* (Roxb.) Taub.	Mizoram	Thinguk	Mimosaceae	Bark decoction	Rai and Lalramnghinglova 2010a; Lalfakzuala *et al*. 2007
43	*Zingiber purpureum* Rosc.	Mizoram	Pale	Zingiberaceae	Rhizome	Rai and Lalramnghinglova 2010a
44	*Ziziphus mauritiana* Lam.	Aizawl	Borai/ Kawrsunhlu	Rhamnaceae	Bark and fruit	Hazarika *et al*. 2012

*Mizoram is depicted if at least one / any of the cited author mentions the study area as Mizoram in their original research paper

Table 4: List of MPs Traditionally Used Against Diarrhea Available in Mizoram with their Possible Class of SMs

Sl. No.	Scientific Name	Different Class of Secondary Metabolites	Citation
1	*Adhatoda zeylanica* Medic.	Alkaloids, flavonoids, glycosides, phytosteroids	Alam *et al*. 2010
2	*Aegle marmelos* (Correa) Linn.	Alkaloids, phenols, saponins, phytosteroids, tannins, terpenoids	Lamia *et al*. 2018; Khairnar and Kadam 2017
3	*Amomum subulatum* Roxb.	Alkaloids, flavonoids, glycosides, phenols, phytosteroids, tannins, terpenoids	Bisht *et al*. 2011
4	*Annona squamosa* L.	Alkaloids, flavanoids, glycosides, saponins, phytosteroids	Neethu-Simon *et al*. 2016
5	*Anogeisus acuminate* Roxb.	Alkaloids, glycosides, phenols, phytosteroids, tannins, terpenoids	Yadav *et al*. 2019b
6	*Bauhinia variegata* Linn.	Flavonoids, glycosides, saponins, phytosteroids, tannins, terpenoids	Irchhaiya *et al*. 2014
7	*Bergenia ciliata* (Haw.) Sternb.	Flavonoids, glycosides, saponins, phytosteroids, tannins, terpenoids	Ahmada *et al*. 2018
8	*Bergenia ligulata* Wall Engl.	Flavonoids, phenols, phytosteroids	Gurav and Gaurav 2014
9	*Bidens pilosa* (Lour.) Merr. & Sheriff.	Alkaloids, flavonoids, terpenoids	Bartolome *et al*. 2013
10	*Bombax ceiba* L.	Alkaloids, flavonoids, glycosides	Chakraborty *et al*. 2010
11	*Bruinsmia polysperma* (C.B.Clarke) Steenis.	-	-
12	*Canna indica* L.	Flavonoids, phytosteroids, tannins, terpenoids	Kumbhara *et al*. 2018
13	*Catunaregam spinosa* (Thunb.)	Alkaloids, flavonoids, glycosides, phenols, saponins, phytosteroids, tannins, terpenoids	Patil and Khan 2017
14	*Chromolaena odorata* (L.) R.M. King & H. Rob	Alkaloids, flavonoids, saponins, phytosteroids, tannins	Usunomena and Efosa 2016
15	*Chrysophyllum lanceolatum* Casar.	Alkaloids, tannins, terpenoids	Prashith Kekuda *et al*. 2014
16	*Clerodendrum bracteatum* Wall. ex Walp.	-	-
17	*Curcumorpha longiflora* Wall.	Flavonoids, phenols, tannins, terpenoids	Das *et al*. 2018; Sudsai*et al*. 2014
18	*Dysoxylum gobara* (Buch.-Ham) Merr.	Alkaloids, flavonoids, glycosides, saponins, tannins, terpenoids	Lalrinzuali *et al*. 2015
19	*Dalbergia pinnata* Lour.	Flavonoids, phenols, terpenoids	Zhou *et al*. 2020
20	*Elaeocarpus tectorius* (Lour.)	Alkaloids	Ezeoke *et al*. 2018
21	*Eryngium foetidum* L.	Flavonoids, saponins, tannins, terpenoids	Paul *et al*. 2011
22	*Garcinia cowa* Roxb.	Flavonoids, xanthones	Ritthiwigrom *et al*. 2013
23	*Garcinia pedunculata* G.	Flavonoids, phenols	Paul *et al*. 2017
24	*Hydrocotyle asiatica* L.	Flavonoids, saponins, phytosteroids, terpenoids	Gray *et al*. 2018
25	*Lablab purpureus* L. Sweet.	Alkaloids, flavonoids, glycosides, phytosteroids, tannins	Verma and Singh 2020
26	*Laportea crenulata* Gaud.	Alkaloid, phenol, phytosteroids, terpenoid	Khan *et al*. 2007; Khan *et al*. 2008
27	*Lonicera macrantha* D. Don	Flavonoids, saponins, phytosteroids, terpenoids	Shanga *et al*. 2011
28	*Mikania micrantha*	Flavonoids, glycosides, phenols, saponin, phytosteroids, tannins, terpenoids	Ishak *et al*. 2016
29	*Musa paradisiaca* L. var. Sylvestris	Alkaloid, glycoside, phytosteroids, tannin	Imam and Akter 2011

...(Table 4: Contd.)

30	*Myrica esculenta* Buch.-Ham.	Alkaloids, flavonoids, glycosides, phenols, saponins, phytosteroids, terpenoids	Sood and Shri 2018
31	*Musa superba* Roxb.	Alkaloids, phenolic compounds, terpenoids	Sethiya *et al*. 2019
32	*Osbeckia rostrata* D.Don.	Flavonoids	Yang *et al*. 2012
33	*Oxalis corniculata* L.	Flavanoids, glycosides, phenol, phytosteroids, tannins	Srikanth *et al*. 2012
34	*Parkia roxburghii* G. Don	Flavonoids, phenols, saponins, phytosteroids, tannins	Angami *et al*. 2017
35	*Picrasma javanica* Bl.	Alkaloids	Prema *et al*. 2019
36	*Physalis minima* L.	Alkaloids, flavonoids, phytosteroids, tannins	Sundari and Kulothungan 2018
37	*Piper longum* L.	Alkaloids, glycosides, saponins, phytosteroids	Khushbu *et al*. 2011
38	*Rhus acuminate* Murr.	-	-
39	*Spondias pinnata* (L.f.) Kurz.	Flavanoids, phenols, phytosteroids, tannins, terpenoids	Bora *et al*. 2014
40	*Terminalia bellirica* Roxb.	Alkaloids, flavonoids, glycosides, phenols, saponins, phytosteroids, tannins, terpenoids	Kumar and Khurana 2018
41	*Terminalia chebula* Retz.	Flavonoids, glycosides, tannins, terpenoids	Chattopadhyay and Bhattacharyya 2007
42	*Xylia xylocarpa* (Roxb.) Taub.	Alkaloids, flavonoids	Manimegalai 2017
43	*Zingiber purpureum* Rosc.	Alkaloids, flavonoids, phytosteroids, terpenoids	Singh *et al*. 2015.
44	*Ziziphus mauritiana* Lam.	Flavonoids, phenols	Alvesa*et al*. 2005; Ashraf *et al*. 2015

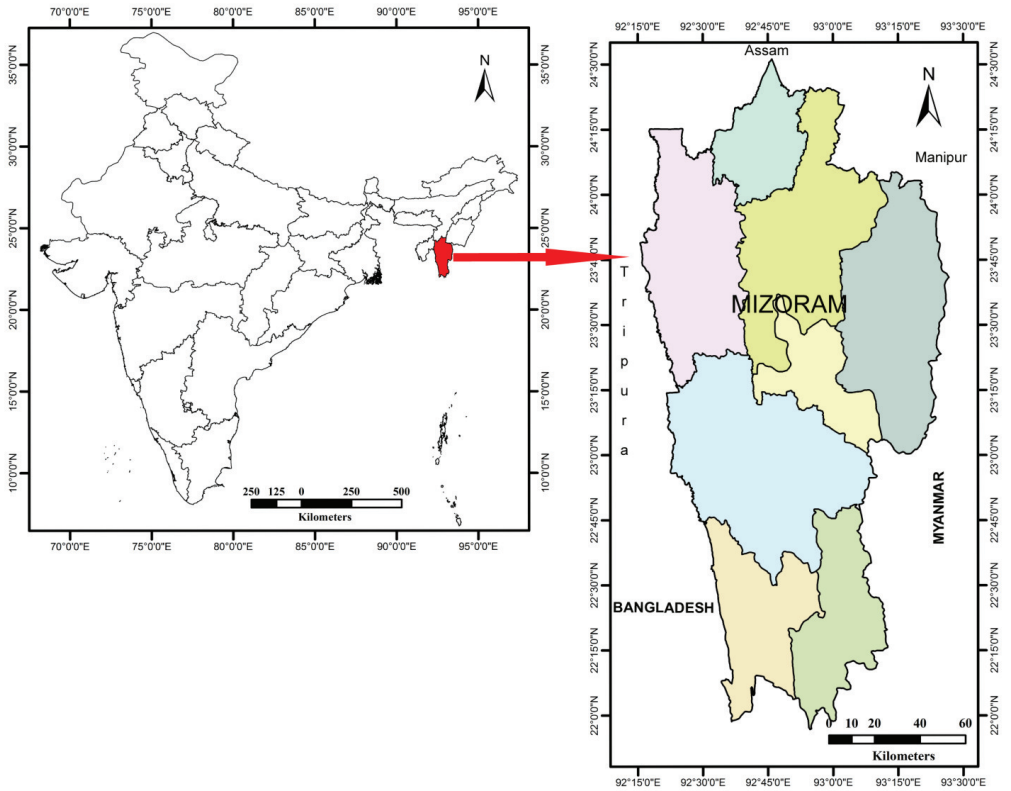

Fig. 1: An Outline of the Map of India Highlighting the State of Mizoram