

Ethnomedicinal Use and Phytochemical Analysis of Selected Medicinal Plants of Mizoram, India

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Abstract

Mizoram is hot spot of plant biodiversity and treasure for several medicinal plants. The elders of Mizoram use several plants for medicinal purposes and treatment of many human diseases. The present study was undertaken to document the ethnomedicinal uses of twenty plants and analyse their phytochemical constituents. The leaves of *Ageratum conyzoides* Linn. (Family: Compositae), *Ananas cosmosus* (L) Merr), *Blumea balsamifera* DC, *Blumea lanceolaria* Roxb., *Cannabis sativa* Linn., *Carica papaya* Linn., *Clerodendrum colebookianum* Walp., *Dillenia pentagyna* Roxb., *Dysoxylum gobara* Buch.-Ham, *Eryngium foetidum* Linn., *Hedyotes scandens* Roxb., *Helicia excelsa* Roxb., *Mikania micranta* Kunth. *Mimosa pudica* Linn, *Polygonum chinanse* Linn, *Smilax ovalifolia* Roxb., stem bark of *Oroxylum indicum* Vent., *Schima wallichii* (DC) Korth. and the whole plant of *Callicarpa arborea* Roxb., and *Centella asiatica* Linn., were dried and powdered. The alkaloid, flavonoid, cardiac glycoside, saponin, tannin, triterpenoid and phlobatannin contents in all these plants were estimated using standard methods. It was observed that all twenty plants contained alkaloids, flavonoids, saponins and tannins. The cardiac glycosides were present in all plants except *B. lanceolaria*, *C. sativa*, and *C. bookenium*. Ten plants showed the presence of phlobatannins and only four out of twenty plants showed the presence of all the phytochemicals screened. Our study indicates that the all ethnomedicinal plants selected in the present study showed the presence of phytochemicals like flavonoids, alkaloids, saponins, tannins, phlobatannins, terpenoids and cardiac glycosides and their medicinal properties may be due to the presence of these important phytochemicals.

Keywords: Ethnomedicinal plants, Alkaloids, Flavonoids, Tannins, Cardiac glycosides, Saponins

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Introduction

Plants have attracted the attention of humans since the advent of man on the earth. Plants also find innumerable uses in the human civilization since its inception. The plants also find their use as medicine in human healthcare. Several traditional systems have evolved in the world, which use plants to cater to the needs of healthcare and they are still in practice around the world. The use of plants and natural products received a fillip when World Health Organization recognized plant and natural products based medicinal systems as alternative and complimentary therapy in the year 2002 [1]. The use of medicinal plants for human healthcare is well documented in India, China, Egypt and Arab world [2]. The utility of plants and natural products was realized

in India since Vedic times that resulted in the development of system of medicine the Ayurveda, that describes various uses of botanicals and other natural products in the treatment of several diseases and this knowledge has been compiled as several samhitas. The Chark samhita and other texts give a threadbare account of various ailments and their treatment strategies using mainly natural products and plants as medicines [3].

It is also well known that there are several chronic diseases which cannot still be treated by the modern system of medicine and humans are left with no choice except to rely on the age old system of traditional medicine. The traditional system of medicine prescribes drug as single plant products or a mixture of several plants depending on the disease, which are mainly administered orally. Many of the herbs, oils and potions are

also applied topically depending on the disease [4]. The use of plants as medicine has come a long way of centuries of experimentation on humans based on trial and error leading to development of many traditional systems of medicine that are in vogue in the modern world [5]. Systematic research has led to the development of several modern day drugs from plants. It is known that 25% of modern drugs are derived from the plants and in case of cancer treatment this figure is as high as 75% [6]. The role of natural products in drug discovery can be understood by the fact that nearly 100 natural products or natural product derived drugs had entered various phases of clinical trials in the year 2013 [7].

Traditional healers have used several plants to treat various diseases over the years and use of many of these plants as medicine is described in Ayurvedic texts [8]. Many diseases including cancer, leprosy, syphilis, all types of fever, children's abdominal disorders, elephantiasis and hydrocele have been treated using botanical sources [9]. The plants synthesize several non-nutritive phytochemicals for different purposes and these have been reported to be beneficial as they possess various medicinal activities in humans [5]. These phytochemicals are primary or secondary metabolites with varying biological activities and they are usually the main active principles present in plants [10]. The primary metabolites are essential for the sustenance of normal plant's life, whereas the secondary metabolites including tannins, saponins, flavonoids, alkaloids, terpenoids, glycosides synthesized by plants for other purposes and are non-nutritive [5,11]. Despite the fact that they are non-nutritive these secondary metabolites play a crucial role in the life cycle of plants. They provide attractive colours to flowers, help in pollination, protect against the stress, and ward off against the predators and insects [12].

Many of the secondary metabolites are important therapeutic agents in humans, treatment of animal diseases, crop production, scientific research and numerous other areas [13]. It is also well known that around 80% of the world's population mainly relies on plants and natural products for their healthcare requirements, which emphasizes the need to analyse the chemical constituents of plants and put their traditional use on firm scientific footing. Considering the importance of non-nutritive phytochemicals in human healthcare it was desired to study the phytochemical constituents of various ethnomedicinal plants traditionally used as medicine in Mizoram, India.

Materials and Methods

Chemicals and reagents

Potassium iodide, bismuth nitrate, sulphuric acid, ferric chloride, hydrochloric acid, aluminium chloride, ammonium hydroxide, glacial acetic acid, chloroform, and olive oil were procured from Sd fine Chemical Ltd., Mumbai, India.

Collection and identification of plants

The uninfected leaves of *Ageratum conyzoides* Linn. (Family: Compositae), *Ananas cosmosus* (L) Merr (Family: Bromeliaceae), *Blumea balsamifera* DC (Family: Compositae), *Blumea lanceolaria* Roxb. (Family: Asteraceae), *Cannabis sativa* Linn. (Family: Cannabaceae), *Carica papaya* Linn. (Family: Caricaceae), *Clerodendrum colebrookianum* Walp. (Family: Verbanaceae),

Dillenia pentagyna Roxb. (Family: Dilleniaceae), *Dysoxylum gobara* Buch.-Ham (Family: Meliaceae), *Eryngium foetidum* Linn. (Family: Apiaceae), *Hedyotes scandens* Roxb. (Family: Rubiaceae), *Helicia excelsa* Roxb. (Family: Proteaceae), *Mikania micranta* Kunth. (Family: Asteraceae), *Mimosa pudica* Linn. (Family: Fabaceae), *Polygonum chinense* Linn (Family: Polygonaceae), *Smilax ovalifolia* Roxb. (Family: Libaceae), stem bark of *Oroxylum indicum* Vent. (Family: Bignoniaceae), and *Schima wallichii* (DC) Korth. (Family: Theaceae), and the whole plant of *Callicarpa arborea* Roxb. (Family: Verbenaceae), and *Centella asiatica* Linn. (Family: Mackinlayceae), were collected during winter season from Champhai, Mizoram (Table 1). The species collected were authenticated by the Department of Horticulture and Aromatics Medicinal Plants, Mizoram University, Aizawl. The plant samples were washed with clean water, shade-dried and ground into uniform fine powder using Lexus mixer grinder-MG2053E (USHA).

Preparation of extracts

Five grams (5 g) each of the plant powder was weighed and transferred into a beaker containing 200 ml of distilled water. The mixture was heated on a hot plate with continuous stirring at 60°-80°C for 30 minutes. The water extract was filtered through filter paper and the filtrate was used for the phytochemical analysis. The aqueous extracts were kept in refrigerator at 0°C until use.

Phytochemical analysis

The aqueous extract of all selected plants listed above were subjected to different phytochemical tests using standard procedures to identify the phytochemical constituents qualitatively as described earlier [10,14-16].

Test for alkaloids

The presence of alkaloids in the aqueous extracts of different plants was determined by mixing 1 ml of each plant extract with Dragendorff's reagent. The formation of reddish brown precipitate indicated the presence of alkaloids.

Test for flavonoids

The flavonoids were detected by mixing 5 ml of dilute ammonia solution to the aqueous filtrate of each plant extract followed by the addition of concentrated H₂SO₄. The development of yellow colour indicated the presence of flavonoids. The yellow colour disappeared on standing. A few drops of 1% aluminium solution were added to each plant filtrate and the development of yellow colour indicated the presence of flavonoids [17-20].

Test for cardiac glycosides (Keller-Killani test)

Five ml of each extracts was treated with 2 ml of glacial acetic acid containing one drop of ferric chloride solution, and underlaid with 1 ml of concentrated sulphuric acid (H₂SO₄). The appearance of a brown ring at the interface indicated a deoxysugar, which is characteristic of cardenolides.

Test for saponins

The presence of saponins in the aqueous extract of different plants was detected by mixing 2 ml of extract with 2 ml of distilled water and shaking it vigorously. The formation of a stable persistent froth indicated that the presence of saponins. The frothing was mixed with 3 drops of olive oil and shaken

vigorously. The formation of emulsion confirmed the presence of saponins in the extract.

Test for terpenoids (Salkowski test)

The terpenoids in aqueous extract of various plant were detected by mixing 5 ml of each extract with 2 ml of chloroform with the careful addition of 3 ml concentrated H₂SO₄ so as to allow the formation of a layer. The formation of a reddish brown colour at the interface confirmed the presence of terpenoids.

Test for tannins

The presence of tannins in different plant extracts was ascertained by mixing 5 ml of each aqueous extract with a few drops of 0.1% ferric chloride. The formation of brownish green or a blue-black colour indicated the presence of tannins [21-24].

Test for phlobatannins

The phlobatannins were detected by mixing each plant extract with hydrochloric acid. The deposition of a red precipitate after boiling was considered as the evidence for the presence of phlobatanins.

Results

The results of folklore use and phytochemical analyses of various medicinal plants are presented in **Tables 2 and 3**.

Traditional uses

The elders of Mizoram were contacted and a discourse with them revealed different traditional uses of the plants listed above which are described below.

Ageratum conyzoides: The fresh shoot juice of *Ageratum conyzoides* is applied on cuts and wounds for rapid healing.

The plant decoction mixed with pepper paste is administered in patients suffering from acute stomachache. The crushed leaves are also topically applied on itches, cuts and leprotic condition. The leaves and roots are used to cure cholera and stomach ulcers. The root juice and leaves are also used to treat skin diseases, caterpillar sting, ophthalmia, fresh cuts and sores (**Table 2**).

Ananas cosmosus: The fruit or fruit juice is administered in stomach ulcers, and typhoid to remove helminthic infection. A handful of white young leaves are given daily for at least one week to expel intestinal worms (**Table 2**).

Blumea balsamifera: Decoction and infusion of the leaves and bark is used as an expectorant (**Table 2**).

Blumea lanceolaria: Infusion or decoction of the leaves is administered orally to treat stomach ulcers and the leaves are topically applied to cure wounds. The leaves are also given during indigestion, asthma, tuberculosis and chronic dysentery. The leaf juice is also topically applied in the condition of scabies, skin diseases, sores and dandruff (**Table 2**).

Callicarpa arborea: The bark juice of *Callicarpa arborea* is orally taken to cure stomach pain, dysentery and vomiting. Bark also finds its use for skin diseases, scorpion sting. The fever, gastric diseases, giddiness and headaches are treated by giving leaf juice or leaf infusion. It possesses tonic and carminative properties and is also used in cutaneous diseases. Decoction of the leaf and bark is used to treat internal bleeding, stomach pain, flesh wound, abrasion, diabetes, colic, stomach ulcers and diarrhoea (**Table 2**).

Cannabis sativa: The whole plant is used to cure stomach pain, dysentery and as an analgesic. The dried leaves are also rolled like cigarettes and smoked (**Table 2**).

Carica papaya: Different parts of this plant are used for dysentery, jaundice, toothache, snake bite, ulcers, and eczema in the form of decoction or infusion (**Table 2**).

Table 1 General information on the certain medicinal plants of Mizoram.

S.No	Specimen voucher No. ^a	Botanical name	Family name	Vernacular name
	AC/mzu/zoo/018	<i>Ageratum conyzoides</i> Linn.	Compositae	Vailenhlo
	Ac/mzu/zoo/003	<i>Ananas cosmosus</i> (L) Merr	Bromeliaceae	Lakhuihthei
	BB/mzu/zoo/010	<i>Blumea balsamifera</i> DC	Compositae	Buarthau
	BL/mzu/zoo/005	<i>Blumea lanceolaria</i> Roxb.	Asterceae	Buarze
	CA/mzu/zoo/004	<i>Callicarpa arborea</i> Roxb.	Verbenaceae	Hnahkiah
	CS/mzu/zoo/007	<i>Cannabis sativa</i> Linn.	Cannabaceae	Tip
	CP/mzu/zoo/006	<i>Carica papaya</i> Linn.	Caricaceae	Thingfanghma
	CA/mzu/zoo/009	<i>Centella asiatica</i> Linn.	Mackinlayceae	Darbengbur
	CV/mzu/zoo/008	<i>Clerodendrum colebookianum</i> Walp.	Verbenaceae	Phuihnam
	DP/mzu/zoo/011	<i>Dillenia pentagyna</i> Roxb.	Dilleniaceae	Kaihawhl
	DG/mzu/zoo/012	<i>Dysoxylum gobara</i> Buch.-Ham	Meliaceae	Thingthupui
	EF/mzu/zoo/013	<i>Eryngium foetidum</i> Linn.	Apiaceae	Bahkhawr
	HS/mzu/zoo/014	<i>Hedyotes scandens</i> Roxb.	Rubiaceae	Kelhnamtur
	HE/mzu/zoo/015	<i>Helicia excelsa</i> Roxb.	Proteaceae	Sialhma
	MM/mzu/zoo/016	<i>Mikania micranta</i> Kunth.	Asterceae	Japan-Hlo
	MP/mzu/zoo/017	<i>Mimosa pudica</i> Linn.	Fabaceae	Hlonuar
	OI/mzu/zoo/002	<i>Oroxylum indicum</i> Vent.	Bignoniaceae	Archangkawm
	PC/ mzu/zoo/019	<i>Polygonum chinense</i> Linn	Polygonaceae	Taham
	SW/ mzu/zoo/020	<i>Schima wallichii</i> DC	Theaceae	Khiang
	SO/ mzu/zoo/021	<i>Smilax ovalifolia</i> Roxb.	Libaceae	Kaihapui

^aSpecimen voucher number obtained from Zoology department, Mizoram University, Aizawl-796004, Mizoram: India.

Table 2. Medicinal uses of certain traditional medicinal plants of Mizoram.

S. No.	Plants species	Part/s Used	Medicinal application	Mode of preparation	Mode of administration & References
	<i>A. conyzoides</i>	Leaves, roots	Cholera, Stomach ache & ulcer, leprosy, ophthalmia, wound, cuts & sores	Crushing of leaves. Decoction.	Topical and oral. [17-19].
	<i>A. cosmosus</i>	Fruit, peel, juice.	Stomach ulcer, typhoid, antihelminthic.	Crushing, squeezing, raw.	Oral. [17,20].
	<i>B. balsamifera</i>	Leaves, bark	Expectorant.	Decoction, infusion.	Taken orally [17]
	<i>B. lanceolaria</i>	Leaves	Stomach ulcer, wound, indigestion, asthma, tuberculosis, dysentery, scabies, skin diseases, sores, dandruff.	Pressed leaf, decoction, infusion, juice.	Orally and topically used [18,19].
	<i>C. arborea</i>	Leaves, bark	Internal bleeding, stomach pain & ulcer, flesh wound and abrasion, diabetes, diarrhoe, fever, gastric, headaches.	Decoction, infusion, juice.	Topical and oral [17-19,21,22].
	<i>C. sativa</i>	All parts	Stomach pain, analgesic, Dysentery.	Crushing and rolling like cigars.	Oral and Smoking [23].
	<i>C. papaya</i>	Leaves, fruits, latex, seeds	Dysentery, jaundice toothache, snake bite, ulcers, eczema.	Decoction of unripe fruit, infusion.	Orally and topically [17,23].
	<i>C. asiatica</i>	Whole	Arthritis, cancer, diarrhoea, asthma, eye problems, diabetes, jaundice, dysuria, pile, dysentery, high blood pressure, skin diseases, stomach ache,	Decoction, chewing/ crushing of fresh leaves, infusion.	Orally and topically [18,19,22,24].
	<i>C. colebookianum</i>	Leaves	Fever, Stomachache.	Decoction, infusion.	Oral [23].
	<i>D. pentagyna</i>	Leaves, roots	Stomach ulcer, rheumatic pain, gastric, asthma, dysentery, cancer.	Boiling, decoction.	Topical and oral [18,19].
	<i>D. gobara</i>	Leaves	Diarrhoea and dysentery.	Decoction of leaf and buds.	Oral [17,18].
	<i>E. foetidum</i>	Whole	Ulcer, piles, fever, antihelminth, food poisoning, malaria, diabetes, pneumonia, constipation.	Decoction.	Tropical [17,19].
	<i>H. scandens</i>	Leaves, roots	Sprain, skin disease, fever, kidney problems, sores, rheumatism, eye diseases,	Decoction, infusion, juice.	Topical and oral [17,19,22,23].
	<i>H. excelsa</i>	Leaves, stem bark	Fever, diarrhoea, Stomach ache.	Decoction.	Oral [17].
	<i>M. micranta</i>	Whole	Stomach pain, Fresh wound, fever, stomach ache, diarrhoea, insect bites, scorpion sting, dysentery.	Pressed leaf, infusion, juice, boiling.	Topical and orally [17-19,22].
	<i>M. pudica</i>	Whole, roots, leaves.	Antiseptic, skin diseases, liver & kidney diseases, piles, fistula.	Infusion, decoction.	Oral [18,19,22,23].
	<i>O. indicum</i>	Roots, stem bark	Stomach ulcer, diarrhea, dysentery, constipation, strangury, asthma, flatulence, sprains, inflammation, rheumatism, cough, hiccough, bronchitis, dyspepsia, leucoderm, piles, colic, headache.	Decoction, poultices, roasted pods.	Oral and topical [17-19].
	<i>P. chinanse</i>	Stem bark	Arthritis, diarrhoea, asthma, piles, bronchitis.	Decoction, infusion.	Orally taken [17].
	<i>S. wallichii</i>	Leaves	Astringent, diarrhoea, antiseptic, gastritis, insect bite & insect bite.	Decoction, Infusion.	Orally taken [18,22-24].
	<i>S. ovalifolia</i>	Stem bark, roots	Anti-venom, stomach ulcer, cuts and wounds, snake bite, rheumatism, pain, dysentery, urinary complaints.	Decoction.	Oral and topical [18,19].

Centella asiatica: The decoction of whole plant is used to treat arthritis, cancer, and diarrhoea. Leaf decoction is used to cure asthma and eye problems. The plant is chewed to get relief from heat and the root extract is applied to the affected part of the skin. It is used in diabetes, jaundice, dysuria, stomachache, piles,

dysentery, diarrhoea, high blood pressure, skin diseases and also to improve memory (Table 2).

Clerodendrum colebookianum: The leaf infusion or decoction is taken for fever and stomachache (Table 2).

Dillenia pentagyna: The boiled leaves and roots are used to treat stomach ulcers and rheumatic pain. Decoction of the bark/leaves is given to treat gastric trouble, asthma, dysentery, and cancer (Table 2).

Dysoxylum gobara: Decoction of leaves is used to cure diarrhoea and dysentery (Table 2).

Eryngium foetidum: Decoction of the whole plant is used in the treatment of ulcers, piles, and fever. The leaves are used to expel thread worms from the body and also as a remedy for food poisoning. The roots and leaves are boiled in water and are given for malarial fever, diabetes, pneumonia and constipation (Table 2).

Hedyotes scandens: Decoction or infusion of the leaves or roots is used for sprain, skin diseases and fever. The whole plant decoction of *Hedyotes scandens* is used to treat swelling and kidney problems. Juice of the crushed leaves is also externally applied to cure sores, rheumatism and eye diseases (Table 2).

Helicia excelsa: Decoction of the leaf or bark is taken orally in the conditions of fever, diarrhoea and stomachache (Table 2).

Mikania micranta: Pressed leaves are topically applied on fresh wounds and the infusion of the whole plant is given orally during stomach pain. Juice of the crushed leaves is used in fever, stomachache, diarrhoea, dysentery, insect bites, scorpion sting and also applied on fresh wounds. Leaf juice is used in dysentery and as a haemostatic agent. Leaves boiled with *Vitex peduncularis* are used to treat fever (Table 2).

Mimosa pudica: Infusion or decoction of the whole plant is used as an antiseptic and for skin diseases. Decoction of the roots and leaves is given in liver and kidney diseases. Leaves and roots of *Mimosa pudica* are used in the conditions of piles and fistula. The root decoction is useful in gravelliest complaint (Table 2).

Oroxylum indicum: Decoction of the roots and bark is used for

stomach ulcer, diarrhoea. The roasted pods are eaten in goitre. Decoction of the root bark is used to cure fever, colic, stomach ulcers, constipation, indigestion, intestinal worms, strangury, asthma, cough, hiccup, diarrhoea and dysentery. Poultice of the bark is topically applied during rheumatism, sprains, inflammations and skin diseases. Decoction of the leaves is also useful in headaches, flatulence, and ulcers. The fruits are used to treat colic, cough, heart diseases, bronchitis, dyspepsia, leucoderma and piles (Table 2).

Polygonum chinanse: Decoction or infusion of bark is used to treat arthritis, diarrhoea, asthma, piles, bronchitis orally (Table 2).

Schima wallichii: Decoction or infusion of leaf is used as an antiseptic. Fruit decoction of *Schima wallichii* is used to treat snake and insect bites. Bark powder is taken with water for the treatment of gastritis (Table 2).

Smilax ovalifolia: Decoction of the bark and root are used topically as anti-snake venom, and to treat cuts and wounds, and snake bite. It is given orally to treat stomach ulcers. The roots are given for dysentery and urinary complaints (Table 2).

Phytochemical analysis

The phytochemical analysis of aqueous extracts of all the plants showed the presence of alkaloids, tannins, saponins and flavonoids (Table 3). In addition to these phytochemicals, ten out of the 20 plants including *A. conyzoides*, *A. cosmosus*, *C. arborea*, *C. sativa*, *C. asiatica*, *D. pentagyna*, *D. gobara*, *H. scandens*, *O. indicum*, and *S. wallichii* showed the presence of terpenoids (Table 3). Phlobatannins were found in *B. lanceolaria*, *C. arborea*, *C. sativa*, *D. pentagyna*, *D. gobara*, *H. scandens*, *M. micrantha*, *M. pudica* and *S. acmella* and were absent in other plants (Table 3). The cardiac glycosides were present in most of the plants except *B. lanceolaria*, *C. sativa*, and *C. bookenium* (Table 3). Of all the plants screened, only *C. arborea*, *D. pentagyna*, *D. gobara* and *H.*

Table 3. Phytochemical constituents of some traditional medicinal plants of Mizoram.

Plants (Species)	Alkaloids	Flavonoids	Cardiac glycosides	Saponins	Terpenoids	Tannins	Phlobatannins
<i>A. conyzoides</i>	+	+	+	+	+	+	-
<i>A. cosmosus</i>	+	+	+	+	+	+	-
<i>B. balsamifera</i>	+	+	+	+	-	+	-
<i>B. lanceolaria</i>	+	+	-	+	-	+	+
<i>C. arborea</i>	+	+	+	+	+	+	+
<i>C. sativa</i>	+	+	-	+	+	+	+
<i>C. papaya</i>	+	+	+	+	-	+	-
<i>C. asiatica</i>	+	+	+	+	+	+	-
<i>C. colebookianum</i>	+	+	-	+	-	+	-
<i>D. pentagyna</i>	+	+	+	+	+	+	+
<i>D. gobara</i>	+	+	+	+	+	+	+
<i>E. foetidum</i>	+	+	+	+	-	+	-
<i>H. scandens</i>	+	+	+	+	+	+	+
<i>H. excelsa</i>	+	+	+	+	-	+	-
<i>M. micranta</i>	+	+	+	+	-	+	+
<i>M. pudica</i>	+	+	+	+	-	+	+
<i>O. indicum</i>	+	+	+	+	+	+	-
<i>P. chinanse</i>	+	+	+	+	-	+	-
<i>S. wallichii</i>	+	+	+	+	+	+	-
<i>S. ovalifolia</i>	+	+	+	+	-	+	-

+ = present, - = absent.

scandens were found to contain all the phytochemicals including alkaloids, cardiac glycosides, flavonoids, phlobatannins, saponins, tannins and terpenoids (Table 3).

Discussion

Use of botanicals for healthcare is as old as human civilization. They are considered non-toxic and safer than other exotic pure chemicals. This may be due to the fact that phytochemicals origin is biological and also they have been experimented since the advent of human history [12,25]. The wide spread use of medicinal plants in healthcare entails that their systematic phytochemical evaluation shall be undertaken for the reasons of safety and medicinal use. Therefore, an attempt has been made to analyse phytochemical constituents of certain plants which have been used traditionally for human healthcare in Mizoram.

The alkaloids are the class of nitrogenous compounds and a diverse array of alkaloids are produced by numerous plants as secondary metabolites. They are usually produced by plants for defence, herbivory, and to protect from pathogenic organisms and harmful insects [26]. More than 10,000 alkaloids are known to be produced by plants. Many of the alkaloids synthesized by plants are highly toxic to humans and they have been found to exert dramatic physiological activities in humans and hence they have been widely used as medicines to treat several human disorders [27]. The plant alkaloids have been reported to be active against hypertension, arrhythmia, malaria, cancer cardiovascular disorders and HIV [28-33]. All of the plants screened have shown the presence of alkaloids and presence of alkaloids shows that the medicinal activities of these plants in humans may be in part due their alkaloid contents. A similar observation has been made earlier [12].

Flavonoids are present in all vascular plants and about ten classes of them are recognized [14]. Approximately 8000 flavonoids have been reported in different plant species. The flavonoids are mainly responsible for the beautiful colours of flowers along with anthocyanins [34]. Many of the flavonoids serve as copigment/s contributing to variation in the flower colouration. The flavonoids are also essential in stimulation, protection, flavouring, pigmentation and in plant-microorganism communication in the plants [35]. The flavonoids are valued as antioxidants in plants as well as humans. They also protect plants against stress and aid in their development [36]. Consumption of flavonoids have been reported to exert several beneficial effects in humans [37]. Flavonoids have been reported to possess a diverse array of activities in humans. They act as antiallergic, anticancer, hepatoprotective, cardioprotective, anticarcinogenic, antiosteoporotic, antidiabetic, antibacterial, antiinflammatory, and antiviral [38-42]. All the plants tested contained flavonoids and various medicinal properties of these plants may be due to the presence of flavonoids and polyphenolic compounds in them.

Cardiac glycosides are another class of phytochemicals synthesized by plants, which have several medicinal properties. The anticancer effects of cardiac glycosides were realized as early as 1967 and the recent preclinical investigation in HT29, HCT116, and CC2 colon cancer cell lines proved their cytotoxic action *in vitro* [43]. The cardiac glycosides have also been found to act against, melanoma, breast, lung, prostate, pancreatic cancers, leukaemia, neuroblastoma and renal adenocarcinoma [44]. The

administration of a cardiac glycoside digoxin in combination with chemotherapy has been reported to increase the overall survival of patients receiving chemotherapy for the treatment of colorectal, breast, head and neck, and hepatocellular carcinoma [45]. The cardiac glycosides have been used in the treatment of cardiovascular diseases [46]. Most of the plants contained cardiac glycosides except *B. lanceolaria*, *C. sativa*, and *C. colebrookianum* and many of the medicinal properties may be related to these phytochemicals.

All the plants screened have shown the presence of saponins that are a vast group of glycosides, differentiated by their surface-active properties from other group of glycosides. They possess the property of foam formation as well as detergent ability, which account for their soap like behaviour in water and hence they can be used as detergents [47-49]. They are allelopathic and act as defence against insects and pathogens in plants [50]. Saponins have been found to be antimicrobial, antimalarial, antiplasmodial, antiproliferative, antipsoriatic, antiallergic, antiatherosclerosis, antidiabetic, insecticidal, molluscicidal, anti-inflammatory and anticancer activities. They have also been reported to be active against obesity [51-56]. Some of the medicinal activities exhibited by the evaluated plants may be attributed to the presence of saponins in them.

Terpenoids, were detected in half of the plants screened, and they are classified into different types based on the number of union of their C5 isoprene units. They are the primary constituents of the essential oils in many plants and they are synthesized for defence or as signals against indirect defence including herbivory and other enemies [57]. Plants synthesize nearly 40,000 terpenoid molecules as secondary metabolites and they have diverse applications as industrial chemicals, flavouring agents, pharmaceuticals, fragrance, pesticides and disinfectants [58]. The terpenoids have been reported to show a diverse array of medicinal activities including, antiviral, antibacterial antimalarial, antiinflammatory, anticancer and chemopreventive. They have been found to inhibit cholesterol synthesis [59-63]. The medicinal properties shown by ten of the twenty plants may also be due to their terpenoid contents.

Tannins are complex polyphenolic phytochemicals, which are synthesized by numerous plants as secondary metabolites [64,65]. The tannins protect plants against the attack by herbivores and insects by decreasing the availability of proteins or inducing toxicity [66,67]. They act as a barrier for microorganisms and protect the plants due to their ability to form complexes with protein, starches and other macromolecules [68]. Tannins have been reported to act as antioxidants in vertebrates, and pro-oxidants in the presence of oxygen [67]. The tannins have been reported to act as astringent, antibacterial, antiulcerogenic, antiviral, antitumour, antithrombogenic, and antiinflammatory [69-72]. These observations confirm the medicinal uses of all plants selected in the present study, which may be due to the presence of tannins.

Phlobatannins are coloured phenolic compounds and could be detected only in eight out of twenty plants subjected to phytochemical analysis. They have been reported to possess wound healing, anti-inflammatory, antioxidant and analgesic activities [73-75]. This suggests that the leaf and bark of above tested plants might have useful applications in ethnomedicinal practices.

Conclusions

Our results indicate that the extracts from twenty plants screened showed the presence of alkaloids, flavonoids, tannins and saponins, whereas cardiac glycosides were not detected in three plants. Terpenoids were detected in ten out of 20 plants analysed, whereas only eight plants showed the presence of phlobatannins. These secondary metabolites are synthesized by plants for varied activities that are essential for plants survival. The ethnomedicinal activities of these plants may be due to the presence of alkaloids, flavonoids, tannins, saponins, cardioglycosides, terpenoids and phlobatannins, which have been

found to possess numerous medicinal activities. Further the non-toxic nature of the ethnomedicines may lie in their composite nature and presence of some molecules may counter the toxic effect of the other when they are present together.

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